GEOLOGIC MAP OF THE FOUNTAIN GREEN SOUTH QUADRANGLE, SANPETE AND JUAB COUNTIES, UTAH

by
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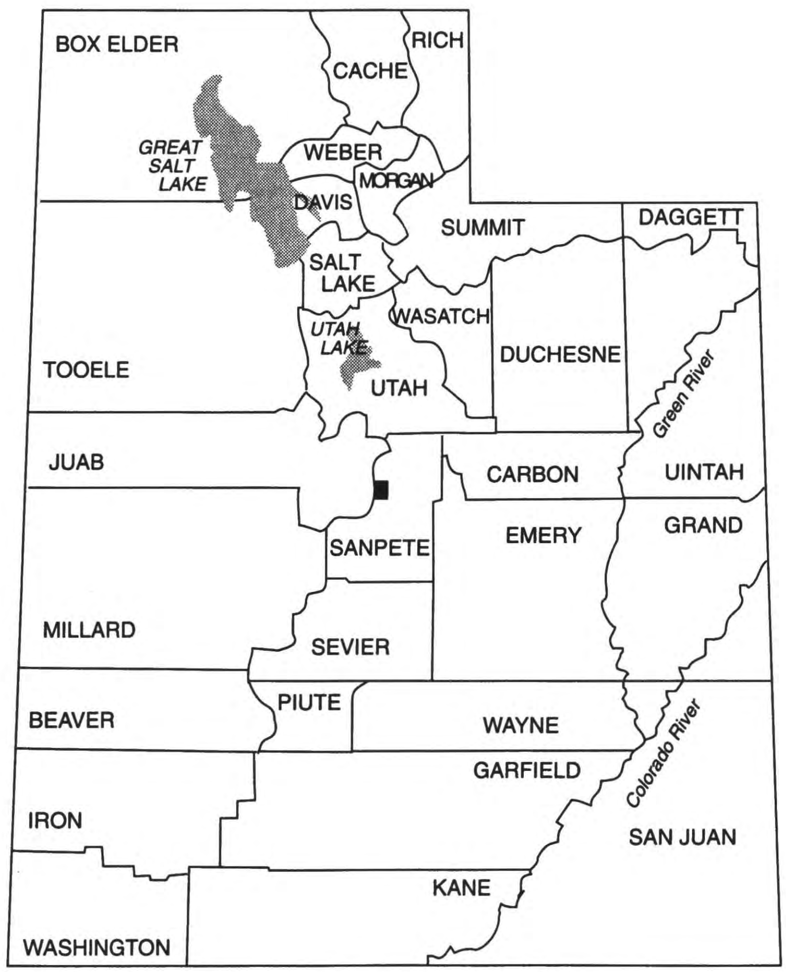

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ABSTRACT

The Fountain Green South quadrangle is on the eastern part of the San Pitch Mountains in central Utah. The oldest exposed rocks are the marine Upper Jurassic Twist Gulch Formation. They are overlain by poorly exposed rocks of the Lower Cretaceous Cedar Mountain Formation. Pulses of the Cretaceous Sevier orogeny are represented by the piedmont slope and marginal deposits of the Indianola Group and the South Flat Formation. The Price River and North Horn Formations represent the waning stages of the Sevier orogeny and the onset of the early Tertiary Laramide orogeny. The westward-thinning Flagstaff Formation was deposited in nearshore facies of Paleocene-Eocene Lake Flagstaff, whereas the overlying Colton Formation indicates a change in environment from lacustrine to more fluviatile conditions. Quaternary units include tufas, alluvial fans, mass movements, stream alluvium, and pediment alluvium.

Structures mapped in the quadrangle include folds, normal faults, fractures, and a possible scissor fault. Most folds were caused by the Sevier and Laramide orogenies, while most faults formed during basin-and-range extension.

Geologic hazards include Quaternary faults, landslides, debris flows, and flooding. Important economic resources are sand, gravel, and water. There is some potential for oil and gas, and thin coal beds exist in the area.

INTRODUCTION

The quadrangle is in central Utah in the transition zone between three physiographic provinces: the Basin and Range (Great Basin), the Colorado Plateau, and the Middle Rocky Mountains. Most of the quadrangle lies on the eastern part of the San Pitch Mountains (Gunnison Plateau), but the eastern fourth lies in the Sanpete Valley (figure 1). Access to the quadrangle is via Utah State Highway 132, which runs along the western half of Sanpete Valley, and by jeep roads and pack trails in the high country.

Elevations range from about 9,680 feet (2,950 m) to 5,540 feet (1,689 m). Local relief in rugged canyons and along a steep range front varies from approximately 4,000 feet (1,200 m) in the northern half to about 2,900 feet (870 m) in the southern half. The area is heavily vegetated with aspen, scrub oak, maple, and conifers.

The San Pitch Mountains are bounded by major normal faults, the Wasatch fault on the west and the Valley fault on the east. Both of these faults show evidence of movement in Quaternary time (Anderson and Miller, 1979; Hecker, 1993). Dips on strata in the quadrangle are mostly less than 25 degrees. Rocks have been affected by underlying thrust faults of the Cretaceous Sevier orogeny (Standlee, 1982; Neuhauser, 1988), by folding by the Late Cretaceous to Eocene Laramide orogeny

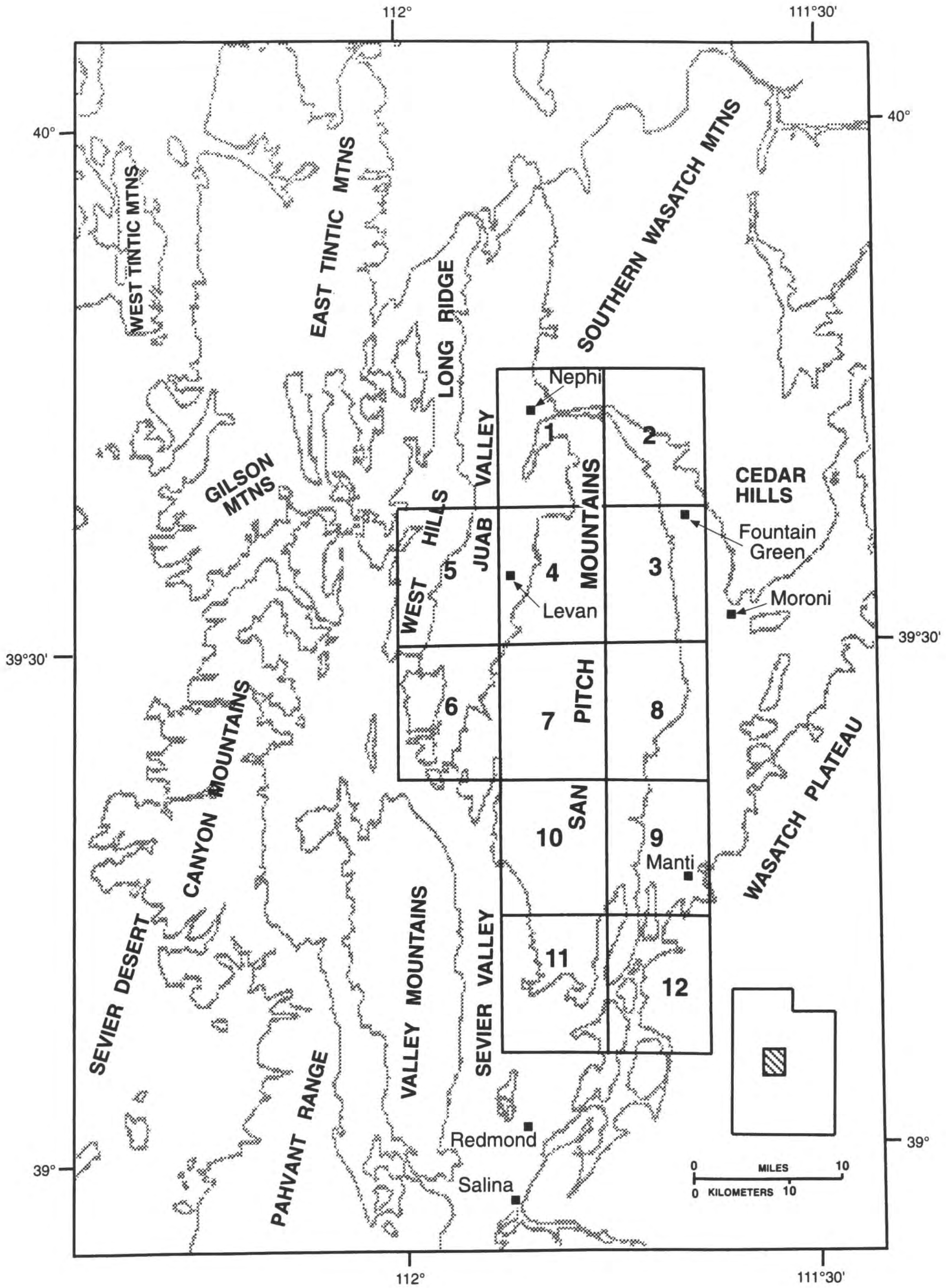

Figure 1. Location of 7.5′ quadrangle mapping projects on and near the San Pitch Mountains. 1 = Nephi (Biek, 1991), 2 = Fountain Green North (Banks, 1991), 3 = Fountain Green South (this map), 4 = Levan (Auby, 1991), 5 = Juab (Clark, 1991), 6 = Skinner Peaks (T.J. Felger, mapping in progress), 7 = Chriss Canyon (J.G. McDermott and M.P. Weiss, mapping in progress), 8 = Wales (Lawton and Weiss, 1994), 9 = Manti (M.P. Weiss and D.A. Sprinkel, mapping in progress), 10 = Hells Kitchen Canyon SE (Mattox, 1988), 11 = Gunnison (Mattox, 1992), 12 = Sterling (Weiss, 1994).

(Dickinson and others, 1986), and by faulting during late Cenozoic basin-and-range extension.

Spieker and Reeside (1925) were the first investigators to establish the regional stratigraphic framework of the area. Spieker (1936, 1946, 1949a, 1949b, 1956) correlated the age, lithology, thickness, and extent of rock units, and the structural relationships of major orogenic episodes within the region. Schwans (1988) studied the depositional framework of Lower Cretaceous conglomerates in the San Pitch Mountains. A number of studies were carried out to distinguish the fluvial Colton Formation from the underlying lacustrine Flagstaff Formation (LaRocque, 1960; Marcantel and Weiss, 1968; Peterson, 1976; Volkert, 1980). Shroder (1971) studied various aspects of landsliding in Utah. Several geologic mapping projects were completed within this area (Auby, 1987, 1991; Biek, 1987, 1991; Clark, 1987, 1991; Banks, 1986, 1991; Mattox, 1986, 1988, 1992) (figure 1). Witkind and others (1987) published a geologic map of the Manti 30′ x 60′ quadrangle.

Hunt (1950) studied the northern portion of the San Pitch Mountains, including the Fountain Green South quadrangle area, and differentiated the Indianola Group. He also defined the type section of the South Flat Formation (Hunt, 1954) in the quadrangle. Thomas (1960) expanded Hunt's work and redefined the South Flat Formation. Hays (1960) studied the petrology and palynology of the South Flat Formation in the quadrangle. Weiss (1982) prepared three cross sections of the quadrangle and interpretated the stratigraphy and tectonic history. Lawton (1982, 1985) studied unconformities, stratigraphic succession, and palynology of the Indianola Group to determine the timing of thrusting in central Utah. Fong (1989a; 1989b) studied the geology of the quadrangle as a master's thesis project.

STRATIGRAPHY

A succession of Middle Jurassic to Quaternary strata about 16,000 feet (4,800 m) thick is exposed in the Fountain Green South 7.5′ quadrangle (plate 2). The oldest exposed map unit is the undivided Upper Jurassic and Lower Cretaceous Twist Gulch and Cedar Mountain Formations, which consist of dark-red sandstones, shales, siltstones, and mudstones of tidal flat and fluvial-lacustrine origin.

The Indianola Group consist of coarse alluvial clastics that mark the onset of the Sevier orogeny. The South Flat Formation consists of subaqueous fine-grained clastics, and records a change from an active to a waning phase of the orogeny. The Price River Formation represents synorogenic deposition of the Laramide orogeny. The Cretaceous(?) to Tertiary North Horn Formation is comprised of reddish clastics that developed in a foreland basin east of the Sevier belt during a time of waning deformation (Stanley and Collinson, 1979; Fouch and others, 1983).

Dominantly white-colored limestones of the upper Paleocene to lower Eocene Flagstaff Formation cover the south half of the quadrangle and are part of the Lake Flagstaff lacustrine complex (Stanley and Collinson, 1979). The lower to middle Eocene Colton Formation, which is represented by limestones, sandstones and mudstones, marks a change from lacustrine to more fluvial conditions.

Quaternary units include mass movement deposits, stream alluvium, pediment alluvium, alluvial fans, and spring tufa.

Jurassic and Cretaceous Systems

Twist Gulch and Cedar Mountain Formations, undivided (KJtc)

The Twist Gulch (Witkind and Hardy, 1984) and Cedar Mountain Formations are undivided on the map because the contact is unmappable due to poor exposures, similar lithology, similar color, and structural deformation. Most outcrops of this unit in the quadrangle are probably Twist Gulch Formation rather than Cedar Mountain Formation. At Wales Canyon (just south of the Fountain Green South quadrangle), Roche (1985) and Weiss and Roche (1988) assigned reddish-orange mudstone, red sandstone, and minor pebbly conglomerate at the top of the Twist Gulch Formation to the Cedar Mountain Formation. Air photo analysis suggests that the Cedar Mountain Formation may extend from the southern perimeter of the quadrangle north to the wall of Devils Gate. This interval is poorly exposed, consisting of float and rubble with thick cover, and is included with the Twist Gulch Formation as a map unit.

Rocks of this map unit are present along the eastern flank of the San Pitch Mountains where they form east-dipping blocks in the southern half of the quadrangle and west-dipping blocks in the northern half. The best exposures are in the vicinity of Devils Gate and in the mouths of Maple and Kern Canyons. Elsewhere in the quadrangle the unit is easily recognizable by thin, soft, cohesive, red, sandy clay soils.

Outcrops, which are probably Twist Gulch Formation, consist of sandstone (60%), mudstone (25%), calcareous siltstone (14%), and gritstone (1%). The sandstones and siltstones are typically pale reddish brown to white where fresh, and moderate reddish brown to dark reddish brown where weathered. The sandstones, classified as sublitharenites (Roche, 1985), are porous, friable, and generally medium- to fine-grained. They are cemented with sparry calcite and contain minor amounts of feldspar, hematite, limonite, and rock fragments. Both coarsening-upward and fining-upward sequences are prevalent. The sandstones and siltstones display cross-laminae up to 0.3 inches (.8 cm) thick and cut-and-fill structures. By contrast, the mudstones are dark greenish gray to greenish black where fresh and weathered. Some of the mudstones contain sparry calcite stringers less than 0.7 inch (1.8 cm) thick. Like the sandstones and siltstones, the mudstones tend to be friable. The gritstones are generally pale red where fresh and grayish red where weathered. They are friable and contain subangular to subrounded particles up to 0.23 inch (5.8 mm) in diameter. Lower and upper contacts are gradational with adjacent rock types. The lithology of the Twist Gulch is consistent except in Kern Canyon, where there are more unoxidized white sandstone beds.

A complete section of the undivided unit is not exposed within the quadrangle. The thickest extant exposure, near the mouth of Kern Canyon, is approximately 900 feet (270 m).

The thin beds of the Twist Gulch Formation suggest deposition in a hot, arid climate in a tidal flat environment interrupted by storm events. Paleocurrent studies performed by Kocurek and Dott (1983) indicated a western source area for sediment input, perhaps signaling the first pulse of the Sevier orogeny (Biek, 1987).

Working south of the San Pitch Mountains, Imlay (1980) placed the Twist Gulch in the Upper Callovian based on paleontologic evidence. He noted an abundance of *Meleagrinella curta* and *Ostrea* sp. in that area and suggested that this formation is correlative with the Curtis Formation of central Utah, the Preuss Sandstone of northern Utah, and the Entrada Sandstone of eastern Utah. Standlee (1982), based on fossils and lithologic logs, correlated the Twist Gulch with the Curtis and Stump Formations of northern Utah. On lithologic grounds, Standlee recognized the upper Twist Gulch as equivalent with the Summerville Formation of eastern Utah. Roche (1985) and Weiss and Roche (1988) suggested that the Cedar Mountain Formation was deposited in a floodplain environment and assigned a late Early Cretaceous age to the formation.

Indianola Group

Spieker (1946) recognized an assemblage of conglomerate, sandstone, shale, and limestone of both marine and continental origin in the Wasatch Plateau east of the quadrangle. He defined this assemblage as the Indianola Group and divided it into four formations. These divisions of the Indianola do not work for exposures farther west because of abrupt facies changes, hence, the term "Indianola Group undifferentiated" has been commonly used in the San Pitch Mountains and in the Cedar Hills. Hunt (1950) divided the Indianola Group undifferentiated into two members. Later, Thomas (1960) divided the Indianola into four members that he numbered in ascending order. I use Thomas' divisions and refer to them as units 1, 2, 3, and 4.

Regionally, Indianola Group strata represent an eastward thinning mass of mostly terrestrial clastics deposited in a foreland basin (Dickinson and others, 1986). Deformation of the basin occurred as a result of crustal loading from accumulating thrust sheets, sediment loading, and eustatic changes caused by the Sevier orogeny (Jefferson, 1982), which began in the Early Cretaceous and continued into the Tertiary (Heller and others, 1986; Fong, 1989b).

In the Sanpete Valley area, Fouch and others (1983) collected marine fossils and pollen of the Indianola Group that indicate an age range of Turonian to Campanian. Conversely, Lawton's (1982) lithofacies correlation of the Indianola Group strata in Utah yielded an age range from Cenomanian(?) to Campanian. Palynomorphs collected 120 feet (36 m) above the base of questionable Indianola strata in Chicken Creek, east of Levan, Utah, yielded an age of late Albian (Standlee, 1982). Additionally, Lawton (1982) obtained late Albian palynomorphs 1,970 feet (590 m) above the base of Indianola strata in Chicken Creek. However, I feel that Lawton's palynomorphs from the higher level may have been reworked from older material. Roche (1985) dated lower Indianola Group undifferentiated strata as Albian, using platinoid angiosperm leaves from a 39-inch (1 m) thick micrite bed exposed near the base of the Indianola on the north wall of Maple Canyon. In the quadrangle, the age of the upper part of the Indianola strata is constrained by an angular unconformity with the South Flat Formation, from which a palynomorph sample yielded a tentative Maastrichtian age.

Unit one (Ki_1): The Indianola Group outcrops trend north-south in the western portion of the quadrangle. Unit one forms massive steep cliffs and ledges bordering Fourmile, Moore, and Chicken canyons. In the southwestern portion of the quadrangle, the unit is partially covered by the unconformably overlying Flagstaff Formation.

Unit one consists predominantly of bimictic, polymodal conglomerate. Clasts are red, light gray, dark gray, yellow, green, brown, and pink. Clasts make up more than 80 percent by volume of the conglomerate and range from granule (0.28 inch; 0.71 cm) at Moore Canyon to cobble (10 inches; 25 cm) size at the head of Moore Canyon and in the Fourmile Creek area. Most clasts are quartzite with minor limestone and dolomite (Hunt, 1950, p. 45), which become more abundant in the upper part of the unit. Clasts are rounded to well-rounded, and the matrix consists of subangular to subrounded, fine- to medium-grained sand.

Interbedded with the conglomerate are three types of sandstone. The first type is very pale-orange-weathering, pale-yellowish-brown, moderately sorted, subangular, medium-grained sandstone. Cement is calcareous. The bedding is massive and is commonly lenticular. Maximum observable thickness of such beds is 2.1 feet (0.6 m) at Fourmile Creek.

The second type is pale-red sandstone, which is common at Chicken Creek. Sand grains are moderately sorted, subrounded, and fine-grained, with calcareous cementation. Bedding is wedge-shaped and locally indistinct, and attains a maximum thickness of 3.3 feet (1 m) at Moore Canyon.

The third type is grayish-yellow-green-weathering, dark-yellowish-orange sandstone and is prevalent at Moore Canyon and Fourmile Creek. It is poorly sorted, subrounded, and medium to fine grained, with calcareous cementation. The beds commonly form ledges and dip slopes and attain a maximum observable thickness of 7.4 feet (2.2 m) at Fourmile Creek. X-ray diffraction shows trace amounts of glauconite.

A complete section of unit one is not exposed in the quadrangle. I estimate the maximum exposed thickness to be about 1,500 feet (450 m), although Thomas (1960) postulated a maximum thickness of 1,800 feet (540 m).

The upper contact of unit one is exposed at Fourmile Creek, about 90 feet (27 m) east of the intersection with the north fork, where the contact is conformable with overlying unit two. Hunt (1950, p. 60) viewed this contact as an angular unconformity, although I disagree.

Unit 2 (Ki_2): Unit 2 is restricted to the northwest part of the quadrangle where it consists of sandstone, siltstone, shale, limestone, and coal. It is lenticular and pinches out at the headwaters of Fourmile Creek in NW¼ NW¼ section 8, T. 14 S., R. 2 E., and in Moore Canyon west of section 29, T. 14 S., R. 2 E. The unit is poorly exposed, but crops out in the stream channel in the NE¼ NW¼ and in the center of section 17, T. 14 S., R. 2 E.

Unit 2 contains two kinds of quartz arenite sandstone. The first is very pale orange, fine grained, and well sorted with subangular grains. The second is grayish yellow green, fine grained, and moderately sorted with subrounded grains. Both thin-section analysis and X-ray diffraction show glauconite that is micaceous in habit. Thomas (1960) reported shale, limestone, and minor coal in unit 2, but I could not verify the presence of the coal. The thickness of unit 2 varies from 0 to 200 feet (0-60 m).

The nature of the contact between unit 2 and overlying unit 3 is questionable. Thomas (1960), believed an angular unconformity separates the two units, based on non-parallel bedding altitudes. Non-parallel bedding does exist between the units, but Biek (1987), M.P. Weiss (personal commun., 1986), and I believe that it reflects the primary dip of the massive conglomerate sheets of unit 3.

Unit 3 (Ki_3): Unit 3 erodes into pinnacles, domes, and steep slopes along the western part of the quadrangle. The unit disappears beneath the Flagstaff Formation at the head of Death Hollow but reappears at Chicken Creek. The northern limit of unit 3 is a pinch-out in section 8, T. 14 S., R. 2 E. Thomas (1960, p. 40) indicated that unit 3 extends northward into the Fountain Green North 7.5′ quadrangle, based on a characteristic "rubble zone." I searched in sections 5 and 8, T. 14 S., R. 2 E., but found no evidence that the unit extends into the Fountain Green North quadrangle. Banks (1986) reached the same conclusion.

Unit 3 consists of clast-supported conglomerate and quartz arenite. The conglomerate is varicolored; the clasts are orange, red, and gray. These clasts make up more than 85 percent of the rock volume and range in size from pebbles (1 inch; 2.5 cm) to cobbles (6 inches; 15 cm). Clasts are mostly quartzite but include minor amounts of arkose and sandstone. Clasts are subrounded to well rounded and show a higher degree of sphericity than those in units 1 or 2. Matrix, less than 15 percent by volume, consists of grayish-orange sand that is poorly sorted, angular to subrounded, and fine to medium grained.

The quartz arenite is very pale orange, weathering either to a light brown or light red. Grains are poorly sorted, subangular to subrounded, and fine to medium grained. Beds are commonly 3 feet (90 cm) thick. In the head of Moore Canyon arenites display honeycomb weathering. From Mill Hollow to Chicken Creek a rapid facies change occurs in unit 3 from nearly all clast-supported conglomerate to all quartz arenite.

Outcrop patterns show the unit ranges from 0 to 1,000 feet (0-300 m) thick, reaching its maximum thickness in Maple Canyon. The contact between units 3 and 4 is exposed at Mill Hollow and is conformable. The extent of unit 3 in the quadrangle is due to deposition over a limited area rather than to erosion.

Unit 4 (Ki_4): Unit 4, like unit 1, forms steep cliffs and ledges. The best, but incomplete, exposure is at the junction of Reddick and Chicken Canyons in the southwest part of the quadrangle.

Unit 4 is characterized by orthoquartzite conglomerate with abundant limestone pebbles and cobbles. Thomas (1960) indicated that sandstone, shale, and coal are present at the top of the formation. The conglomerate is polymictic and polymodal and is subangular to rounded. Clasts are orange, red, pink, white, brown, or gray and make up 80 to 85 percent of the conglomerate, increasing in percentage from north to south. Clasts range in size from pebbles (less than 1 inch; 2.5 cm) to cobbles (8.5 inches; 22 cm), with the larger sizes more prevalent in the southern part of the quadrangle. Near the head of Fourmile Creek, quartzite, sandstone, and limestone occur in a ratio of 30:30:40, respectively. However, near Chicken Creek, only quartzite and sandstone clasts are present in a ratio of 90:10. The amount of matrix varies from 5 to 20 percent. In the south half of the quadrangle, the sand that makes up the matrix is poorly sorted, medium to coarse grained, and subangular to subrounded. Calcareous cement is prevalent in the matrix in the north half of the quadrangle.

Light-brown-weathering, arkosic sandstone occurs in the unit at the head of Fourmile Creek. It is poorly sorted and contains subangular to subrounded grains of fine to coarse sand. The unit is calcareous and commonly shows gradational upper and lower contacts with the conglomerate.

Thomas (1960) recorded a thickness of 1,426 feet (435 m) for the unit in the Fourmile Creek area, a maximum in the quadrangle. The contact between unit 4 and the overlying South Flat Formation at Birch Creek is an angular unconformity, with unit 4 striking N. 40° W. and dipping 10 degrees southwest, and the South Flat striking N. 40° E. and dipping 13 degrees southeast. Elsewhere in the quadrangle, the contact is obscured by colluvium. At Chicken Creek, the contact between unit 4 and the overlying Price River Formation is a 23 degree angular unconformity.

Indianola Group undifferentiated (Kiu): I was unable to differentiate the Indianola Group east of the East Gunnison fault because of facies changes. The undifferentiated unit forms well-exposed, steep, northeast-trending cliffs that face Sanpete Valley south of Maple Canyon. North of Maple Canyon, the unit is brecciated, slumped, and obscured by heavy vegetation (figure 2).

Locally, three kinds of rock, sandstone, conglomeratic sandstone, and conglomerate, comprise the Indianola Group undifferentiated. Sandstone is the most abundant rock type and forms laterally continuous pale-red to light-gray sheets. Weathered colors vary from grayish orange pink to light brown. Fine-grained, moderately to poorly sorted, angular to subrounded sand is most common; however, well- to poorly sorted, angular- to subrounded sand is also present. The upper and lower contacts of the sandstones are gradational with adjacent units. At the head of the unnamed stream immediately north of Squaw Spring, the undifferentiated unit contains blocks of brecciated sandstone. The sandstone blocks are similar to the sandstone in the Twist Gulch Formation.

Conglomeratic sandstone is the second most abundant rock type. Outcrops are commonly white to moderate orange pink where fresh, and dark yellowish orange to pale red where weathered. Large quartzite pebbles (up to 2 inches; 5 cm) are contained in a matrix of poorly sorted, angular to subrounded, fine- to very fine-grained sand. Conglomeratic sandstone beds form steep slopes and have gradational upper and lower contacts.

The least abundant rock type is clast-supported, bimictic, polymodal conglomerate observed in Wales Canyon just south of the map area. Clasts are commonly red, brown, and gray. Clast size varies from pebble (0.9 inch; 2 cm) to cobble (3 inches; 8 cm). The quartzite and limestone clasts show no preferred orientation. The unit is poorly sorted, with subrounded to rounded clasts. Up to 30 percent of the matrix is fine to medium sand.

Figure 2. Steep, overturned, east-dipping strata in the eastern half (right) of the photo are Cretaceous Indianola Group undifferentiated. West-dipping strata in the western half (left) of photo are Cretaceous Price River Formation. View to north from south side of Maple Canyon.

Undifferentiated Indianola strata thin from north to south. In the northeast corner of the quadrangle the unit is approximately 3,000 feet (900 m) thick. It is 966 feet (290 m) thick at Devils Gate, and in Wales Canyon it is 163 feet (49 m) thick.

The upper contact of the Indianola Group undifferentiated is locally well exposed in the eastern part of the quadrangle. At Maple Canyon, overturned, east-dipping Indianola strata are unconformably overlain by moderately dipping Price River strata (figure 2). The contact is an angular unconformity at Kern Canyon and at Devils Gate.

South Flat Formation (Ksf)

Hunt (1950) named a 2,850-foot (855 m) thick assemblage of conglomerate, sandstone, limestone, and coal the South Flat Formation. His type section extends from the SW¼ section 9 to the center of section 21, T. 14 S., R. 2 E., and lies unconformably on unit 4 of the Indianola Group. The best exposures are in the steep cliffs northeast of benchmark 9548, SW¼ section 9, where a sequence of sandstone beds are exposed. To the east, the formation abruptly terminates against the East Gunnison fault. The South Flat Formation pinches out southwest of Hog Gulch in the west-central portion of the quadrangle.

South Flat strata have not been recognized outside the Fountain Green South quadrangle (Mattox, 1986, 1992; Auby, 1991; Biek, 1991; Clark, 1991; J.G. McDermott and M.P. Weiss, unpublished mapping). Banks (1986), suggested that the South Flat Formation is present in the subsurface of the Fountain Green North quadrangle.

A diverse lithology characterizes the South Flat Formation, which was deposited in an alluvial environment (Hays, 1960; Fong, 1989b). Sandstone, sandy micrite, pebbly sandstone, and carbonaceous shale make up the bulk of the formation. Fresh sandstone is pinkish gray to dark yellowish orange. The weathered surface is commonly pale brown to pinkish gray. The sandstone is fine- to medium-grained, well-sorted quartz arenite and is generally thick bedded (greater than 5 feet thick; 1.5 m) or massive. Quartz grains are commonly crystalline and are cemented with calcite. Most samples contain a few plagioclase feldspar and authigenic hematite grains. Potassium feldspar grains are rare.

Sandy micrite is the dominant carbonate of the South Flat Formation. Fresh colors vary from light gray to grayish orange, whereas weathered colors vary from grayish orange to pale yellowish brown. Weathered colors of the rock indicate the presence of limonite. Beds are either parallel-laminated or cross-laminated. Sand grains of monocrystalline quartz are loose and subrounded.

Pebbly sandstones lie 216 feet (65 m) below the top of the formation. They are generally light brown where fresh and moderate yellowish brown where weathered. Particle sizes range from fine sand to pebbles (up to 1 inch; 2.5 cm), with the pebbles being ironstone concretions. The concretions are well-rounded, but the fine sand is subangular. Cement is calcareous and the unit is massive.

Carbonaceous shale makes up a small part of the South Flat Formation. Approximately 850 feet (255 m) from the base of the South Flat, a continuous one inch-thick (2.5 cm) carbonaceous shale unit is observable in the head of a landslide scarp just northeast of benchmark 9548 in NE¼ SW¼ section 9, T. 14 S., R. 2 E. There, the shale is medium dark gray, weathering to light gray. A coaly unit, about 0.6 foot (1.8 cm) thick, is exposed about 200 feet (60 m) south of the center of section 21, T. 14 S., R. 2 E. on the west side of the road. It consists of black, coaly, carbonaceous mud that weathers dark gray.

In most exposures in the quadrangle, an angular unconformity exists between the South Flat and Price River Formations. The South Flat Formation is folded by a broad syncline near the center of the San Pitch Mountains (Hunt, 1950; Gilliland, 1963; Weiss, 1982), whereas, the Price River strata were deposited over the fold. At Dutchman Flat, the dips of the two formations differ (South Flat strata dip southwest, whereas Price River strata dip southeast), suggesting an angular unconformity.

Douglas Nichols of the U.S. Geological Survey interpreted palynomorphs described by Hays (1960), as latest Santonian to earliest Campanian (T. D. Fouch, personal communication to M.P. Weiss, 1987). Several fresh samples collected from a one-inch (2.5 cm) carbonaceous bed approximately 850 feet (255 m) above the base of the formation yielded an age no younger than Maastrichtian, based on the diagnostic *Proteacidites*. Samples from a carbonaceous mud 100 feet (30 m) from the top of the formation contained a diverse terrestrial palynomorph assemblage that yielded nearly the same date as the lower sample. The sample from near the formation top "comes close to the Cretaceous-Tertiary boundary, but slightly below it in the Maastrichtian" (Fred May, written communication, 1987).

I correlate the top 4,875 feet (1,463 m) of the sandy/pebbly fluvial facies of the Sixmile Canyon equivalent in the Cedar Hills (Jefferson, 1982, p. 68) with the South Flat Formation. T.D. Fouch (personal communication to M.P. Weiss, 1987) correlated the South Flat with the Sixmile Canyon Formation in Sanpete Valley or the Blackhawk Formation of the Wasatch Plateau on lithologic and biostratigraphic grounds.

Price River Formation (Kp)

Along the eastern front of the San Pitch Mountains, the Price River Formation forms a nearly vertical ridge that extends southward from Maple Canyon. Cliffs of Price River occur in Maple Canyon, Box Canyon, and Mill Hollow (figure 2). Differential weathering of Price River strata has created natural arches and honeycombs near the Right Fork of Maple Canyon. Lawton and Weiss (1994) recently correlated at least part of this interval with the North Horn Formation. In the quadrangle, the Price River Formation is dominated by conglomerate (>99%) with minor sandstone (<1%). Clast-supported, polymodal conglomerate is the dominant rock type. Varicolored clasts are purple, gray, brown, orange, pink, red, or olive, with red and orange dominant. The sizes of the clasts are variable, from granules (0.25 inch; 6.4 mm) to boulders (12 inches; 30 cm), although the majority of the clasts are cobble sized. The dominant clast is quartzite. Both banded and nonbanded clasts are present at the junction of Box and Maple Canyons, with the banded-to-nonbanded ratio being 17:1. At Chris Canyon the ratio is 8:1 (figure 3). In the Maple Canyon area, matrix comprises 5 to 10 percent of the volume of the conglomerate. Matrix sand grains are very pale orange, medium to coarse grained, poorly sorted, and subangular to subrounded. Southwestward, in Chris Canyon, clasts comprise only 10 to 15 percent of the conglomerate, and the matrix grain size ranges from granule to fine sand.

Quartzose sandstones are pale yellowish orange, yellowish gray, and very pale orange. The weathered surface is grayish orange to pale yellowish brown. Grain size is extremely variable, from fine to coarse, with fine sand being more conspicuous in the sandstones at Chris Canyon. Poorly sorted, subangular to subrounded grains are common. Planar cross-beds, observed at Chris Canyon, show current flow in two directions. The sandstone units are either lenses or tongues and are rarely laterally continuous. Lens thicknesses range from 0.5 to 6 feet (0.15-1.8 m).

Lateral variations in the Price River Formation are evident within the quadrangle. To the east, Price River conglomerates have larger clasts, less matrix, and fewer sandstone beds than Price River conglomerates to the southwest. Also, interbedded sandstones are thicker to the southwest than those found along the eastern front of the San Pitch Mountains.

The Price River Formation is not well exposed and varies in thickness. Hunt (1950) reported a maximum thickness of 1,000 feet (300 m) in the quadrangle. At Box Canyon, the unit is about 800 feet (240 m) thick. Hunt (1950) reported a thickness of 350 feet (105 m) in Chicken Creek, but it is probably as thin as 200 feet (60 m) thick in that area.

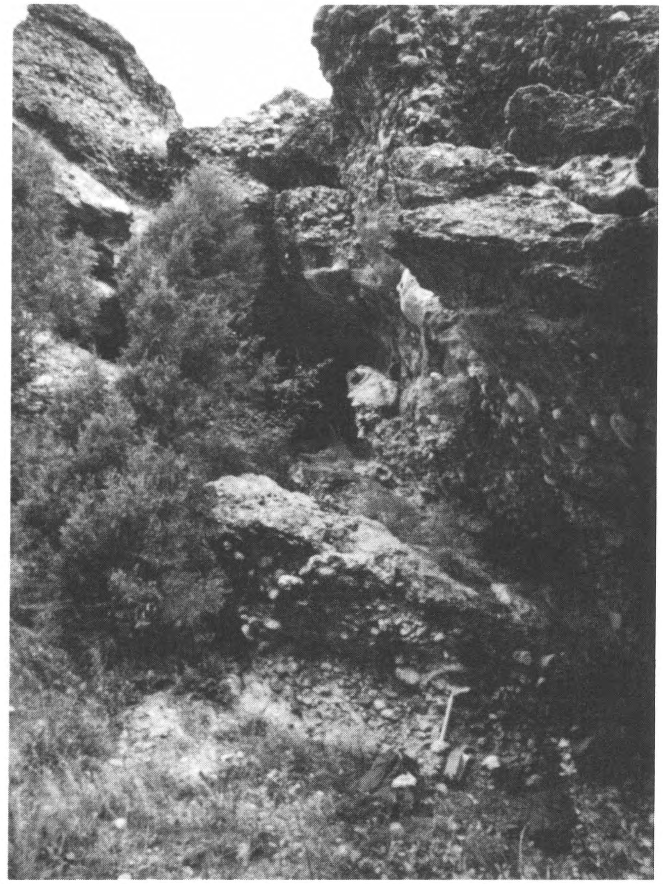

Figure 3. *Price River conglomerate exposed in NE¼SW¼NE¼ section 18, T. 15 S., R. 2 E., east of the junction of Chris Canyon and Chicken Creek. The ratio of matrix to clasts is greater than at Maple Canyon. View is to the northwest from Chris Canyon.*

The upper contact of the Price River Formation is well exposed at the head of Box Canyon, where a 25-foot (7.5 m) thick pebbly quartzose sandstone of the North Horn Formation lies conformably above the Price River conglomerate. South of Maple Canyon, along the eastern front of the plateau, red colluvial muds of the North Horn obscure the top of the Price River strata. Heavy vegetation and colluvium also cover the upper contact in the southwest part of the quadrangle near Chicken Creek. In both areas, the North Horn and the Price River show a discordance in dip.

The Price River was deposited in an alluvial-fan environment. Clast size and volume decrease from east to west across the quadrangle, indicating a local source area to the east. The Sanpete-Sevier Valley anticline, which had its inception before deposition of Price River strata (Gilliland, 1963), may have been the local source, although regionally the Sevier thrust belt was the primary source (Lawton, 1983).

Fouch and others (1983) collected palynomorphs at the type section of the Price River Formation, and of the Sixmile Canyon Formation at Sixmile Canyon, that yielded late Campanian ages. Palynomorphs collected from the underlying South Flat strata and regional fossil evidence from the overlying North Horn Formation suggest that the age of strata in the quadrangle mapped as Price River Formation is Maastrichtian.

Cretaceous and Tertiary Systems

North Horn Formation (TKnh)

The North Horn is the most widely exposed formation in the quadrangle and is best exposed in the Box Canyon area, where ledge-forming sandstone and conglomerate lap over Price River strata. Ledge-forming sandstone also occurs west of Death Hollow east of Marble Hill. Cliffs of North Horn conglomerate are exposed along a spur east of the unnamed valley immediately southeast of Marble Hill, whereas, to the southeast, south of The Basin, ledges of micrite and coal are prevalent. Elsewhere in the southern half of the quadrangle, exposures of the formation are poor due to extensive soil and colluvium. Generally, deep red soils above Price River strata hint at the presence of the North Horn Formation.

I could not determine total thickness of the North Horn Formation because of the poor surface exposures in the quadrangle. Mapping indicates a gradual thinning of North Horn strata from north to south. Hunt (1950) measured a thickness of 3,168 feet (950 m) on the north side of Wales Canyon in the Wales 7.5' quadrangle. The North Horn is conformably overlain by the Flagstaff Formation.

The North Horn Formation was deposited during the waning phases of the Sevier orogeny in a foreland basin bounded by the Sevier orogenic belt to the west and the San Rafael Swell to the east (Biek, 1987). Within this basin, smaller basins developed that were bounded by structural highs (Fouch and others, 1983). Regionally, the North Horn may have had more than one source area, but within the quadrangle, the Sanpete-Sevier Valley anticline was the major source.

Spieker (1946) and Griesbach and MacAlpine (1973) assigned a Late Cretaceous-Paleocene age to the North Horn Formation in the Wasatch Plateau. West of the Wasatch Plateau, however, documentation of the age of the North Horn is inconclusive. Peck and Forester (1979) and Forester (personal communication, 1989) identified the Maastrichtian to Paleocene charophyte *Platychara compressa* in North Horn coals in Wales Canyon (north of the center of section 26, T. 15 S., R. 2 E.). Fouch and others (1983) assigned a Paleocene to Eocene age to the formation, based on palynomorphs collected near the intertonguing North Horn-Flagstaff boundary in Sanpete Valley.

In the quadrangle, the North Horn Formation consists of five lithologic types: sandstone (61%), micrite (14%), mudstone (13%), conglomerate (9%), and coal (3%) that occur in two lithofacies: Sandstone-conglomerate facies and sandstone-mudstone facies. Part of the sandstone-mudstone facies is differentiated as an informal map unit called the coal member (TKnhc).

The sandstone or pebbly sandstone of the sandstone-conglomerate facies is grayish yellow, weathering to grayish orange. Quartz comprises 75 percent of the grains, and rock fragments comprise 25 percent. The sand grains are subangular to subrounded, whereas the quartzite pebbles are subrounded to rounded. The silt matrix and calcareous cement make up 5 percent of the rock. The massively bedded and laterally continuous sandstone and pebbly sandstone is poorly sorted and forms beds up to 25 feet (7.5 m) thick.

Two kinds of conglomerate predominate in this facies. The first occurs in beds up to 5 feet (1.5 m) thick and is polymodal, clast supported, and is observed above Box Canyon. Clast colors include pink, red, and orange. The clasts comprise 85 percent of the unit and range from pebbles to cobbles, but rare boulders up to 15 inches (38 cm) long are present. Clasts are subrounded to well rounded and are very poorly sorted. Most of the quartzite clasts are unbanded. The matrix is grayish-yellow, pale-yellowish-orange-weathering, medium to coarse, subangular to subrounded, poorly sorted sand. The matrix is composed of 80 percent quartz and 20 percent lithic fragments. Calcareous cement accounts for less than 3 percent of the volume of the unit.

An exposure of polymictic, bimodal, clast-supported conglomerate that is less coarse and has more lithologic variety than the conglomerate above Box Canyon is present east of Marble Hill. Clasts (80 to 85% of the volume) are gray, orange, pink, and red, and range in size from pebbles to small cobbles up to 3 inches (8 cm) in length. The clasts are banded and unbanded quartzite (50%), limestone (45%), and sandstone (5%) and are subrounded to rounded and poorly sorted. The matrix is medium-grained sand to granules that are subangular to subrounded. Quartz comprises 70 percent of the matrix, the lithic fragments account for 25 percent, and calcareous cement makes up less than 5 percent.

Two kinds of sandstone are present in the sandstone-mudstone facies. The first is a lithic sandstone exposed west of Death Hollow that is moderate orange pink and weathers light brown. Eighty-five percent of the rock consists of fine to medium grains that are subangular to subrounded and poorly sorted. Quartz comprises 70 to 75 percent of the grains, whereas lithic fragments, which include chert, sandstone, and quartzite, account for 25 to 30 percent. A clay matrix comprises 15 percent of the rock. Limonite stains give the rock a distinct light-brown color. Rare iron concretions up to 1 inch (2.5 cm) in diameter were observed in the unit. Bedding is up to 5 feet (1.5 m) thick. The contact between adjacent rock units is obscured by colluvial cover.

The second sandstone type, argillaceous lithic sandstone, is poorly exposed in a landslide scar northeast of Rees Valley in SE¼ SE¼ SW¼ section 17, T. 15 S., R. 2 E. The sandstone is commonly pink, weathering to light brown. It is composed of 80 percent fine- to very fine-grained, subangular to subrounded, moderately sorted quartz grains, 10 percent lithic fragments of chert and sandstone, and 10 percent clayey matrix. The sandstone may be discontinuous laterally. Bedding thicknesses range from 5 to 9 feet (1.5-2.7 m).

Interbedded mudstones are medium dark gray, weathering to grayish orange or moderate red. The grayish orange is due to the presence of limonite on the surface of the mudstones. The mudstones are very lumpy or matted in appearance and are poorly exposed. In the Rees Valley region, bedding ranges from 1 to 8.3 feet (0.3-2.5 m) thick.

Coal member (TKnhc): The coal member consists of interbedded micrite and coal. Micrite is grayish orange, weathering to grayish orange pink or medium light gray. The rock contains numerous vugs and rare, well-preserved molds of gastropods of the genus *Lioplacodes*, a freshwater, gill-breathing form (LaRocque, 1956).

The coal is medium gray, weathering to very light gray, and is platy and fissile. Thin-section analysis of the coal reveals trace amounts of detrital minerals and a diverse assemblage of fossils. Detrital minerals include subrounded quartz and zircon. Disarticulated ostracode valves are very abundant within the durain (the dull material in coal). Associated with the ostracode shells are long, straight shell fragments up to 0.06 inch (0.15 cm) in length of an unidentified non-marine bivalve. Chara, a green algae, was not observed, but may be present (T.D. Fouch, personal commun., 1985). In the NE¼ section 23, T. 15 S., R. 2 E., the coal seam is 2.5 feet (0.75 m) thick. Northward, the seam is not exposed, but float suggests this seam may extend as far north as the center of section 14, T. 15 S., R. 2 E.

The member is discontinuous and pinches out just north of the center of section 14, T. 15 S., R. 2 E. At Wales Canyon the coal member is nearly 40 feet (12 m) thick. In NE¼ section 23, T. 15 S., R. 2 E., the unit is almost 10 feet (3 m) in exposed thickness, whereas north of the center of section 14, the unit is less than 5 feet (1.5 m) thick.

Tertiary System

Flagstaff Formation (Tf)

The Flagstaff Formation is widespread in central Utah. Locally, it covers much of the southern half of the quadrangle where it forms ledges. In the Reddick Canyon-Death Hollow-Hardscrabble Creek areas, the formation thins to a feather edge over the Indianola Group. Poorly exposed, cream-colored soils and colluvium mark its presence. The absence of Flagstaff in the northern half of the quadrangle may be due to post-Flagstaff erosion. Banks (1986) reported Flagstaff remnants north of the quadrangle.

The Flagstaff Formation consists of limestone (58%), mudstone (32%), shale (8%), sandstone (1.4%), conglomerate (0.4%), and bentonite (0.2%) in the quadrangle. Five kinds of limestone are recognized in the Flagstaff: (1) micrite or marly limestone, (2) pelletal limestone, (3) silicified limestone, (4) cherty limestone and oncolitic limestone, and (5) coquina. The micrite or marly limestone is olive gray to very pale orange, weathering to very light gray or very pale orange to white. It forms thick sets of thin beds, although massive bedding is locally present. The thin beds are 1.5 to 3 inches (3.8-7.6 cm) thick. The rock is locally vuggy and silicified. The pelletal limestone is pale yellowish orange to yellowish gray, weathering to pale yellowish brown to very pale orange. It is microgranular and microvuggy, and some beds contain silicified layers greater than 0.13 inch (3.3 mm) thick. Silicified limestone is light gray, weathering to light brown to yellowish gray. Many beds contain spar-filled vugs.

Cherty limestone makes up 1 percent of the formation. It is pale yellowish brown, weathering to yellowish gray. Mud pellets up to 0.2 inch (5 mm) long are present and are similar to those in the pelletal limestone units. Irregular chert nodules are up to 14 inches (36 cm) in diameter. Coquina is light olive gray, weathering to yellowish gray. Most shell fragments are poorly preserved and locally silicified; however, a freshwater, lung-breathing gastropod of the genus *Physa* was identifiable.

In the Marble Hill vicinity, oncolite-bearing pelletal limestone is exposed at benchmark 8245. The rock is pale yellowish brown and weathers to dark yellowish brown. Rare black angular intraclasts, up to 0.25 inch (6.4 mm) long, and spar-filled vugs up to 0.3 inch (7.6 mm) long are present. Pellets make up about 15 percent of the rock and average 0.06 to 0.13 inch (1.5-3.3 mm) in diameter. Rare pisoliths greater than 0.13 inch in diameter (3.3 mm) have been observed in this unit, and oncolites the size of golf balls are common.

Mudstone, shale, and sandstone comprise the clastic portion of the Flagstaff. The mudstone is yellowish gray to very pale orange, weathering to grayish yellow to yellowish gray, and is commonly thick bedded. Shale is commonly pale red to light olive gray where fresh and brownish gray to very pale orange where weathered. The rock forms in beds 0.25 to 11.0 feet (0.08-3.3 m) thick. Sandstone is limy or calcareous and yellowish gray, and is grayish yellow where weathered. M.P. Weiss (unpublished notes, 1961) observed bed thicknesses of 3 to 4 feet (0.9-1.2 m). The thickness of the Flagstaff Formation in the quadrangle varies from 415 to 931 feet (125-279 m).

The contact with the overlying Colton Formation is poorly exposed in the quadrangle. It is locally gradational and is placed at: (1) a marked increase in the clastic nature of the rock, (2) a color change of the soil and rock from pale gray or pale brownish gray to red and green, and (3) a significant decrease in carbonate beds (Marcantel and Weiss, 1968).

The Flagstaff Formation in the quadrangle was deposited in a shallow lake and mudflat environment, with lake level fluctuations producing the different lithofacies (Godo, 1979). Mollusks reported by LaRocque (1960) in the upper part of the formation in the San Pitch Mountains, Valley Mountains, and Pahvant Range suggest an early Eocene age. Rich and Collinson (1973) discovered a jawbone of the early Eocene mammalian fossil *Vulpavus australis* in a limestone boulder in the Flagstaff in the southern San Pitch Mountains (NE¼ SW¼ section 19, T. 17 S., R. 2 E.). Palynomorphs collected by Fouch and others (1987) also indicate an early Eocene age at the intertonguing boundary between the Flagstaff and the North Horn Formations.

Colton Formation (Tco)

The Colton Formation is exposed in the south-central part of the quadrangle where it forms slopes with subdued ledges of gray limestone. It consists of mudstone (33%), biomicrite (18%), sandstone (18%), micrite (16%), siltstone (7.5%) and claystone (7.5%). In contrast to the Flagstaff Formation, terrigenous clastics make up a large percentage of the Colton.

The mudstone is light olive gray to grayish orange where fresh, and pale olive to grayish orange where weathered. It is laterally continuous and generally friable.

The biomicrite is pale yellowish brown to yellowish gray, weathering to very pale orange to grayish orange. It contains a diverse fossil assemblage that includes disarticulated ostracode valves, fragments of gastropod shells, and fragments of unidentifiable silicified pelecyopods. Using LaRocque's (1956, 1960) guides to molluscan fossils, I was able to identify *Goniobasis tenera* (Hall), *Physa pleromatis* (White), *Elliptio mendax* (White), and *Gyraulus aequalis* (White) in one of the biomicrite beds. Well-preserved casts of *Gyraulus aequalis* are also present. According to LaRocque (1960), the above-named species prefer a shallow-water environment with abundant vegetation.

The sandstone beds are dusky yellow to grayish orange, weathering to yellowish gray to dark yellowish orange. The grains are very fine, subrounded, and well sorted. The sandstones consist mostly of monocrystalline feldspar, quartz, and carbonate rock fragments, with lesser amounts of chert, hematite, and limonite.

The micrite is moderate brown to yellowish gray, weathering to moderate brown to pale yellowish orange. It forms scattered ledges in the south-central portion of the quadrangle. Minor lithologies in the Colton include light-olive-gray micaceous siltstone and very pale-orange claystone.

The upper part of the Colton Formation is not preserved in the quadrangle; the thickest preserved section is about 220 feet (66 m) thick. Southward, in the Wales quadrangle (in Axhandle Canyon), Volkert (1980) measured 887 feet (266 m) of Colton strata. The apparent predominance of clastics over carbonate units during Colton time suggests a change in depositional environment from lacustrine to mixed fluvial-lacustrine, as alluvial muds and sands eventually filled Lake Flagstaff (Marcantel and Weiss, 1968; Stanley and Collinson, 1979; Zawiskie and others, 1982). The thin beds of micrite and biomicrite and fossils support Volkert's (1980) contention of deposition in shallow freshwater lakes and ponds with marginal mudflats developed on floodplains. The source areas are a subject of speculation (Volkert, 1980). Spieker (1946) assigned an early Eocene age to the Colton based on sparse paleontologic evidence. Subsequent work by LaRocque (1960) verified Spieker's age assignment. Fouch and others (1983) indicated that Colton strata range from late Paleocene to Eocene in eastern Utah, but are early Eocene in Sanpete Valley.

Quaternary System

Pediment-Mantle Alluvium (Qap)

Two small deposits near the southeast side of the quadrangle are mapped as pediment-mantle alluvium. The exposure in N½ section 23, T. 15 S., R. 2 E., consists of angular fragments 0.75 inch to 3 feet (1.9 - 90 cm) long of siliceous limestone, limestone, mudstone, and clay derived from the Flagstaff and North Horn Formations. The fine material is composed of highly plastic clay and is dark yellowish brown wet and pale yellowish brown dry.

Eastward, another small patch of pediment-mantle alluvium occurs west of benchmark 6570. The coarse material consists of angular to rounded fragments 0.5 inch to 1 foot (1.3 - 30 cm) long eroded from the North Horn, Flagstaff, and Price River Formations. The unconsolidated fine material ranges from silt to silty sand that is pale yellowish brown where dry and dark yellowish brown where wet.

Alluvial Fans

Alluvial fans have been divided into four map units in the quadrangle based upon their elevation, morphology, composition, and relative age. The older two units consist of large coalesced alluvial fans while the younger two units consist of small, isolated fans. They are called, from oldest to youngest: (1) older coalesced alluvial fans ($Qafc_4$), (2) younger coalesced alluvial fans ($Qafc_3$), (3) older alluvial fans (Qaf_2), and (4) younger alluvial fans (Qaf_1). Both alluvial-fan units (Qaf_1 and Qaf_2) rest on the coalesced alluvial fans.

Older coalesced alluvial fans ($Qafc_4$): Major alluvial fans were deposited at the mouths of four large canyons on the east side of the San Pitch Mountains. These four fans eventually coalesced, forming a bajada. Most of the town of Fountain Green lies on the coalesced alluvial fans.

In the northern half of Sanpete Valley, coarser material in the proximal part of the fans consists mostly of poorly sorted, angular to subrounded, pebble- to cobble-size sandstone fragments that originated from the undifferentiated Indianola Group and the South Flat Formation. The finer material, which has been extensively cultivated, is mainly fine sand to silt and is moderate red where dry and grayish red where wet.

The coarser material in the southern half of Sanpete Valley consists of pebble- to cobble-size fragments of sandstone and quartzite derived from the undifferentiated Indianola Group, Twist Gulch, Price River, and North Horn Formations.

The thickness of the coalesced fans in the quadrangle is uncertain. A water well drilled in the town of Wales, less than one mile (1.6 km) south of the quadrangle, penetrated a minimum of 250 feet (75 m) (Robinson, 1971).

Younger coalesced alluvial fans ($Qafc_3$): A younger coalesced fan deposit overlies the older coalesced fans at the mouths of Kern and Maple Canyons. There is a considerable lateral variation in the size and composition of material; the fan at Kern Canyon contains much more clay than at Maple Canyon. The maximum thickness of the younger coalesced alluvial fans is a few tens of feet.

Older alluvial fans (Qaf_2): Two older alluvial fans are present in the quadrangle. The smaller one is a remnant at the mouth of an unnamed stream valley 0.75 mile (1.2 km) north of Squaw Spring. The other fan is at the mouth of Birch Creek. The material was derived from the undifferentiated Indianola Group and was deposited by numerous debris flows. The material ranges from sandstone boulders up to 3 feet (90 cm) in length to silty clay. Grains are fine or medium, subrounded, and are moderately to well sorted.

Younger alluvial fans (Qaf_1): Younger, presently active alluvial fans are deposited by debris flows and floods along the western margin of Sanpete Valley. The contacts of these fans with older fan and mass-movement deposits are gradational.

Younger alluvial-fan deposits at Basin Canyon consist of material ranging from boulders to clay. At the proximal end of the fan, the deposit consists of angular to subrounded pebbles to boulders as much as 7 feet (2 m) in diameter of sandstone and conglomerate eroded from the undifferentiated Indianola Group and the Price River Formation. The younger alluvial fans at the mouths of Fountain Green Pole, Moroni Pole, and Birch Canyons are cultivated and are composed predominantly of sand and silt. The thicknesses of these fans probably range from a few feet to a few tens of feet.

Mass-Movement Deposits

Mass-movement deposits in the quadrangle include: (1) landslide deposits, (2) debris-flow deposits, (3) rock-avalanche debris, and (4) colluvium. The classification scheme of Varnes (1978) was used, with some modifications.

Based on sparse vegetation and well-defined morphology, most of the mass movements in the quadrangle are Holocene in age. The heavy precipitation received in central Utah from 1983 to 1986 initiated or reactivated many of the mass movements. Most major landsliding involved the South Flat Formation, Indianola Group units 1 and 4, and the North Horn Formation, and the surficial deposits eroded from these formations.

Landslide deposits (Qms_1, Qms_2): At least three old and several young landslides are found in the quadrangle. The subdued but characteristic morphology of the older landslides indicates they may be Pleistocene in age. Two old landslide scars are present in the lower reaches of Dandelion Flat, northeast of Hamburger Lake. Both involved strata of the Price River Formation. These two slides now appear to be stable. Younger landslides are generally smaller and involve surficial deposits. Many are gradational with debris flows.

Debris-flow deposits (Qmf_1, Qmf_2): One of the most conspicuous types of mass-movement deposits within the quadrangle is the shallow debris flows eroded from the steep slopes of the North Horn Formation. These flows are very prominent on the south wall of Maple Canyon and at the head of The Basin. They involved high plastic clays (characteristic of the North Horn) that rapidly expand in volume and become mobile when wet. On the south wall of Maple Canyon the flows occupy shallow ravines, with the base of the flows terminating at a major break in slope.

On South Flat, in the north-central part of the quadrangle, a large flow composed of light-brown loamy soil has a hummocky surface that has been modified by stream erosion. No historical reactivation of this flow has occurred.

Debris slides and debris flows (mapped together as debris-flows) are common in the South Flat Formation (figure 4) along Birch Canyon. Southwest of Fountain Green Pole Canyon is a large debris block slide that reactivated after 1965 (based on examination of 1965 and 1971 air photos and field observations in 1987.) Much of the slide movement was translational.

The Indianola Group was also the source of many debris slides and flows during the wet years. Many occurred within unit 1 of the Indianola Group on the steep slopes north of Fourmile Creek.

Rock-avalanche debris (Qma_1, Qma_2): The largest mass-movement deposits in the area are older (Qma_2) and younger (Qma_1) rock-avalanche debris deposits in the northern half of Sanpete Valley. Cedar Hill is formed by old avalanche deposits composed of boulders up to 25 feet (7.5 m) long and minor cobbles of sandstone derived from the Indianola Group undifferentiated.

A younger avalanche-debris deposit near the mouth of Moroni Pole Canyon consists of coarse material ranging from pebbles to boulders up to 5 feet (1.5 m) in length derived from the Price River Formation and the Indianola Group undifferentiated. There is a subtle coarsening of particle size toward the proximal end of the deposit. Presently, the avalanche debris is stabilized by heavy shrub cover.

Northward, another young, much larger avalanche debris mass covers an area from Birch Creek to Squaw Spring. The coarse material is similar in composition, shape and size to the avalanche debris at Moroni Pole Canyon, except that no Price River rocks exist in this larger avalanche debris.

The thicknesses of the avalanche deposits in the three areas ranges from a few feet to a few tens of feet.

Colluvium (Qc): Colluvium was mapped in an unnamed valley north of Squaw Spring. Angular fragments of red and orange sandstone 1 inch to 3 feet (2.5 - 90 cm) across, derived from the Indianola Group undifferentiated, comprise the coarsest material. The red sandstone consists of subrounded, fine sand grains that display good sorting. The finer material is fine sand to silt, and is moderate red where dry and grayish red where wet. Similar colluvial deposits are present near the mouth of Bulge

Figure 4. *Debris-block slide in the South Flat Formation northeast of benchmark 9548, section 9, T. 14 S., R. 2 E. Hills in the middle background are in Fountain Green North quadrangle. Mt. Nebo is in the far background. View to N. 20° W. from crown of landslide.*

Hollow and near the mouth of an unnamed stream channel to the south. The rock debris at Bulge Hollow is derived from both the undifferentiated Indianola Group and the Twist Gulch Formation, whereas that at the unnamed stream channel originated from the Twist Gulch.

Spring Tufa (Qst)

Three isolated tufa mounds occur in the eastern portion of the quadrangle at the base of the mountain front; in the S½SW¼ section 12, T. 15 S., R. 2 E.; in the NE¼ NW¼ section 24, T. 15 S., R. 2 E.; and in the S½ NE¼ section 23, T. 14 S., R. 2 E. The two southern mounds are oval, with long axes aligned roughly parallel with the down-to-the-east Valley fault, which separates Sanpete Valley from the San Pitch Mountains (figure 5). The tufa unit in the northern portion of the quadrangle is mantled by younger alluvial-fan units so that its orientation is uncertain. This tufa is exposed near where a road crosses the creek, but it is not shown on the map due to its limited size (figure 5).

The tufa is very pale orange to grayish orange pink where fresh, and pinkish gray to pale yellowish brown where weathered. The rocks are very porous, lightweight, and contain a sponge-like network of vesicles. Near Birch Creek, the tufa is multilayered and contains several streaky layers of charcoal mixed with carbonaceous sand that are typically less than 0.25 inch (6 mm) thick. Near the fault trace at Birch Creek is a discontinuous layer 0.5 foot (15 cm) thick of broken woody twigs 1.5 feet (50 cm) below the top of the 35-foot-thick (11 m) tufa mound. A 0.25-inch-thick (6 mm) charcoal layer is 14.5 feet (4.4 m) below the top of the mound.

The exact thicknesses of the tufa units are uncertain. The exposed tufa at the mouth of Basin Canyon approaches 60 feet (18 m) in thickness (figure 5), whereas the smaller exposure south of Bulge Hollow is less than 10 feet (3 m) thick. At Birch Creek tufa is more than 35 feet (11 m) thick, and westward, at the mouth of an older alluvial valley, the tufa is nearly 40 feet (12 m) thick (figure 6).

The spring tufa is overlain or surrounded by surficial debris. The base of the two deposits in the southeastern part of the quadrangle is not exposed, but I believe the deposits cover the Valley fault trace. These deposits are thickest above the fault trace and the long axes of the units parallel the trend of the fault. The tufa at Birch Creek displays similar relationships.

The previously described wood layer at Birch Creek has a radiocarbon age of 370 ± 50 years and the thin charcoal layer is dated at 3,250 ± 130 years (Fong, 1989a). Therefore, the older (Qaf_2) and the younger alluvial fans (Qaf_1) must be younger than 370 ± 50 years. The three tufa mounds are probably about the same age. From the two dated intervals, the depositional rate of this tufa averaged 0.06 inch/year (1.5 mm/yr).

Alluvium (Qal)

Chicken Creek, Chris Canyon, and Sanpete Valley contain extensive alluvial deposits. The composition and size of the material vary considerably. In Chicken Creek, the coarser material ranges from pebble- to cobble-size quartzite derived from the Price River Formation; however, the finer material varies from silty clay to silty sand. The alluvial deposits at Chris Canyon are similar to those at Chicken Creek. An exposed thickness of 10 feet (3 m) was observed at one location. The alluvium in Sanpete Valley east of Cedar Hill is predominantly silty clay that has been reworked and cultivated.

STRUCTURE

The Fountain Green South quadrangle contains complex structural relationships and stratigraphic facies changes. They are a consequence of at least three events: compression during the Mesozoic Sevier orogeny, compression and uplift during the Tertiary Laramide orogeny (Dickinson and others, 1986; 1988), and Oligocene to Holocene basin-and-range extensional faulting.

Figure 5. Photo of the northern extent of the tufa unit at Basin Canyon and of the fault-bounded range front of the San Pitch Mountains. View is to the north.

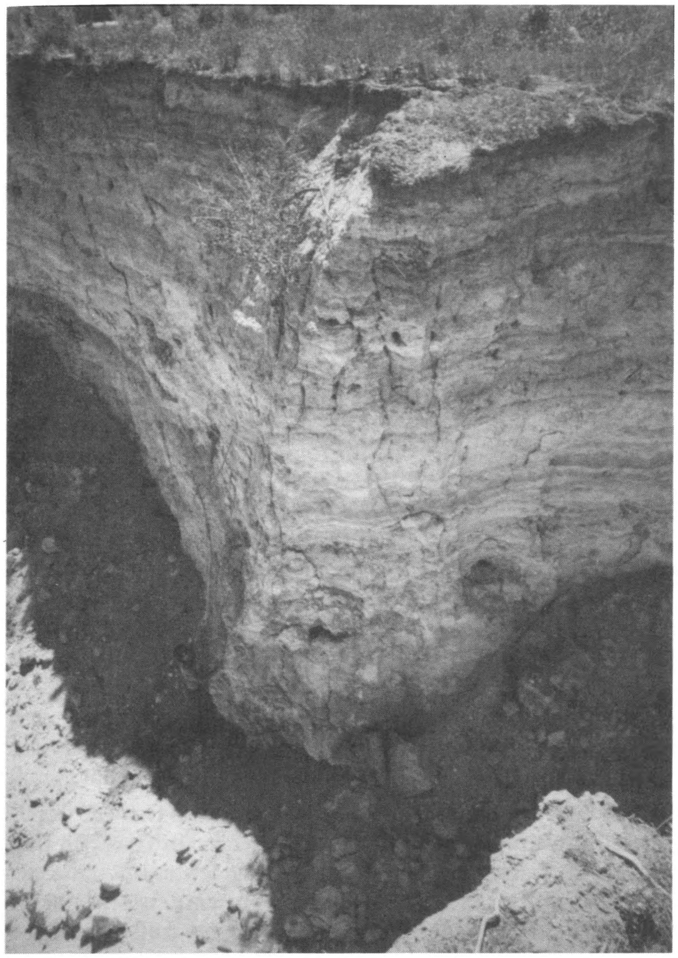

Figure 6. *Photo of the multilayered spring tufa at the interpreted fault trace at Birch Creek. The layering is perpendicular to fault trace. Note geologist (lower left in shadow) for scale.*

Folds

The San Pitch Mountains have two overlapping synclines that plunge gently to the south (Gilliland, 1963, plate 2; Weiss, 1982). The older syncline has its axis toward the center of the plateau. The younger syncline is subparallel to the older syncline but its axis is offset to the southeast and is in the eastern portion of the plateau (plate 1). The older syncline folds the Twist Gulch to South Flat Formations (cross sections A-A′ and B-B′, plate 2). The younger syncline folds rocks as young as the Green River Formation (south of the quadrangle), but most of the folding predates deposition of the Flagstaff and Colton Formations, which are only slightly warped (cross section B-B′). The older syncline has more closure than the younger syncline. Because of the lack of exposures, there are little or no data to justify extending these synclinal axes farther than shown on plate 1.

A third fold may locally fold the Twist Gulch Formation near the eastern margin of the plateau (cross section B-B′). Previous investigators indicated that the formation is overturned from about Moroni Pole Canyon southward to the southern edge of the quadrangle (Hunt, 1950; Thomas, 1960; Roche, 1985). T.F. Lawton of New Mexico State University and M. Kirschbaum of the U.S. Geological Survey (1987, personal communication) believe that the east-dipping Twist Gulch at Maple Canyon is right-side-up, based upon their analysis of cross-bedding structures. Lawton proposed a local isoclinal anticline faulted against Indianola strata to the west. However, I have seen only planar cross-beds within the Twist Gulch strata at Maple Canyon and cannot ascertain the correct orientation of the Twist Gulch. Therefore, I show the strata as overturned similar to the earlier workers and do not show a fault contact. Weiss (1982) determined the Twist Gulch, Cedar Mountain, and Indianola strata are overturned at Wales Canyon (south of the quadrangle), and this relationship may continue north of Maple Canyon.

The eastern part of the quadrangle encompasses the buried north end of the Sanpete-Sevier Valley anticline as described by Gilliland (1963). This anticline is nearly 70 miles (110 km) long, with a structural relief as great as 20,000 feet (6,000 m). Standlee (1982) showed the core of the anticline is composed of mobile Arapien Shale, based on seismic reflection data. This fold is the Sanpete-Sevier Valley diapiric fold of Witkind (1982, 1983). I did not see any surface evidence of this fold in the quadrangle.

Faults and Fractures

East Gunnison Fault

A major north-south-trending fault, the East Gunnison fault, (Thomas, 1960) (figure 7), extends from Wales Canyon north to the northern edge of the Fountain Green South quadrangle. It offsets the North Horn Formation, but the fault is probably much younger. The minimum stratigraphic separation of 320 feet (96 m) occurs at Maple Canyon. Separation may exceed 1,000 feet (300 m) at the base of Tidds Ridge.

The observed fault plane dips more than 70 degrees at Maple Canyon and is nearly vertical at the bases of South Flat and Tidds Ridge. The attitude of the fault at depth is uncertain due to lack of subsurface information. Standlee (1982) showed faults on the eastern portion of the San Pitch Mountains, about 8 miles (13 km) southwest of the quadrangle, as imbricate eastward-flattening listric faults, some with two opposite senses of movement.

The relative sense of displacement along the East Gunnison fault is controversial; Thomas (1960), Weiss (1982), and Banks (1986) determined the East Gunnison fault to be a down-to-the-west normal fault. I agree that the fault is down to the west in most of the mapped area (figure 7), but offset at the bases of Tidds Ridge and South Flat indicates down-to-the-east displacement (Fong, 1989b). I propose that the East Gunnison fault is a scissor fault with the western block rotated to the south about ten degrees more than the eastern block (dips are southwest to west).

Valley Fault

A major down-to-the-east normal fault that separates the San Pitch Mountains from Sanpete Valley was named the "Valley fault" by Banks (1986). Regionally, the Valley fault extends from just north of Sevier Valley at the southern terminus of the range (Gilliland, 1963), to Salt Creek in the northeastern portion (Banks, 1986) (figure 1). Weiss (1982) named the Valley fault the "Gunnison fault," but his terminology could be confused with

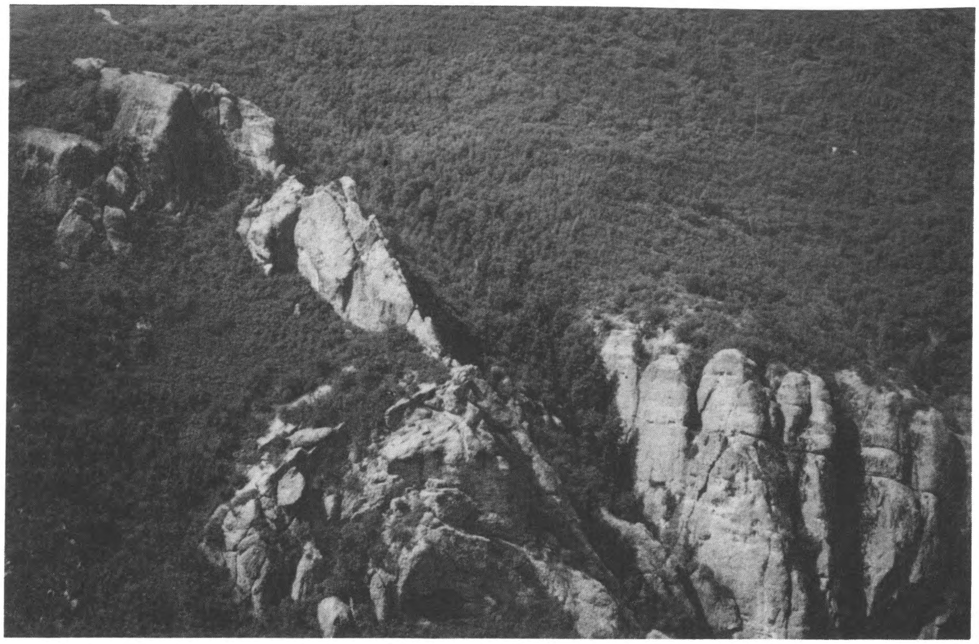

Figure 7. Segment of the East Gunnison fault cutting Price River Formation and showing down-to-the-west relative movement. View is of the south wall of Maple Canyon.

the East Gunnison fault, so I prefer the term "Valley fault." The displacement along the fault varies considerably, but generally decreases southward, from 8,000 feet (2,400 m) at Big Mountain (Gilliland, 1963) in the Wales 7.5′ quadrangle, to none at the southern end of the San Pitch Mountains (Weiss, 1982).

The Valley fault last moved in the Quaternary (figure 5). Hecker (1993) shows it having late Pleistocene to Holocene movement. The fault trace is dashed on this map because scarps are generally poorly defined. The tufa beneath the alluvial fan at Birch Creek is displaced, suggesting the Valley fault moved less than 370 ± 50 years ago, the age of an offset wood layer 1.5 feet (45 cm) below the top of the tufa unit (Fong, 1989a). At the northern edge of the quadrangle, at Kern Canyon, and at Devils Gate, the fault appears to displace alluvial fans about 80 feet, 40 feet, and 80 feet (24, 12, 24 m), respectively.

A complex relationship exists between the Valley fault and the East Gunnison fault. Banks (1986, 1991) reported that the East Gunnison fault is truncated by the Valley fault west of the town of Fountain Green at an angle of 30 degrees.

Fountain Green Pole Canyon Fault

Banks (1991) named the fault that extends 0.65 mile (1 km) into section 11, T. 14 S., R. 2 E. in the northeast part of the Fountain Green South quadrangle the "Fountain Green Pole Canyon fault." It is poorly defined in the Fountain Green South quadrangle. To the north, it is a down-to-the-east fault with a displacement of 1,500 feet (450 m)(Banks, 1991).

Other Faults

Various other normal faults have been mapped near the north-south-trending East Gunnison fault. South of The Basin, the East Gunnison fault is cut or abutted by four normal faults that form horst and graben blocks and that strike at angles from 40 to 90 degrees to the East Gunnison fault. The minimum displacement along these faults is 20 feet (6 m).

A group of northeast-trending normal faults is present in the south-central part of the quadrangle. The two southernmost faults extend from Quaking Aspen Creek to Devils Gate Basin, show a minimum displacement of 40 to 45 feet (12-14 m), and cut Flagstaff strata on the south wall of Quaking Aspen Canyon. A fault in Death Hollow and similar faults in nearby quadrangles parallel the bedding in the Indianola Group. Other similar faults may be present where no cover of North Horn or Flagstaff strata exists to help define them.

Fractures

At Maple and Box Canyons, long vertical to nearly vertical fracture sets are exposed in Price River strata. One set trends generally northwest, whereas the other trends northeast. In Box Canyon, the fractures cut conglomerate and lenses of sandstone. Beds are not offset and no fault gouge or breccia exists to indicate movement along a fault. The fractures roughly follow the same trend as the normal faults in the quadrangle.

Structural Synthesis

Two schools of thought have developed to explain the evolution of structures in central Utah: regional compression by eastward-directed thrusting during the Sevier orogeny, followed by later back-thrusting and extensional faulting (Standlee, 1982; Villien, 1984; Lawton, 1985), and diapirism (Stokes, 1952, 1956, 1982; Witkind, 1982, 1983). A more comprehensive discussion of structural hypotheses can be found in Banks (1986) and Fong (1989b).

The mechanisms initiating local faulting are not well understood. Some of these faults may flatten at depth and merge with an east-dipping backthrust beneath Sanpete Valley that had early east-directed and later west-directed motion (Standlee, 1982). Proponents of diapirism (Stokes, 1952, 1956, 1982; Witkind, 1982, 1983), however, argue that this series of faults is attributable to the gravity-driven movement of salt and ductile mudstones in the Arapien Shale, followed by collapse of these deposits by salt dissolution. Weiss (1982, p. 49) stated that the drop of Sanpete Valley "may have formed by collapse of a linear diapir of evaporites and mudstone." Similarly, the East Gunnison fault might have resulted from dissolution of the salt and mudstone beneath the southern part of the west block.

Witkind (1982, 1983) attributed the location and shape of "diapiric" folds in central Utah to deep-seated normal faults. He also claimed that most of the major anticlinal folds (including the Sanpete-Sevier Valley anticline) in central Utah were subjected to three episodes of diapirism culminating in the Pleistocene. Whether or not the East Gunnison fault and the Valley fault resulted from a diapiric episode is questionable, but these and the minor north- and northeast-trending faults do follow the regional trend of the Sanpete-Sevier Valley anticline (Lawton, 1985). Perhaps a combination of diapirism, eastward-directed thrusting, and extension are responsible for the structures in this part of central Utah (Mattox, 1986; Willis, 1986; Biek, 1987).

The age of normal faulting in the quadrangle is only partly constrained. Rotational, scissor-like movement along the East Gunnison fault was followed by down-to-the-east normal faulting on the Valley fault that raised the San Pitch Mountains relative to Sanpete Valley. The East Gunnison fault may have some Quaternary offset. Recent movement along different segments of the Valley fault is shown by the late Quaternary fault scarps described earlier and the faulted tufa at Birch Creek. The Fountain Green Pole Canyon fault may also have Quaternary movement (Banks, 1986, 1991).

The ages of the numerous northeast-trending normal faults in the southwestern and south-central portions of the quadrangle, and those in the foothill belt, are poorly constrained. Most of these faults are post-Colton Formation (late Eocene?) in age, but whether these faults are contemporaneous or formed at different times is unknown.

GEOLOGIC HAZARDS

Earthquakes

The quadrangle is located within the Intermountain seismic belt (Smith, 1978), and there have been two moderate earthquakes, both M = 4.4, near the quadrangle in historic time. The first was centered near the town of Levan, about 5 miles (8 km) west of the quadrangle, on July 7, 1963, and the second was in Goshen Valley, 25 miles (40 km) northwest of Fountain Green, on May 24, 1980. The potential for larger earthquakes, especially along the Valley fault, which has experienced Holocene movement, is a cause for concern to the residents of the area. Historical, small-magnitude earthquakes (less than magnitude 2.8) have occurred in the quadrangle but are not readily associated with mapped faults (McKee and Arabasz, 1982).

Mass Movements

The combination of steep slopes and high relief in the quadrangle make mass movements a continuous hazard. Many recent landslides and debris flows (Qms_1, Qmf_1) were initiated during a period of high precipitation from 1983 to 1986. Formations prone to mass movements include unit 1 of the Indianola Group, the undifferentiated Indianola unit, the South Flat Formation, and the North Horn Formation. Mass movements in the South Flat Formation and undifferentiated Indianola strata warrant careful attention since they pose a threat to the town of Fountain Green and to isolated farming structures to the south. Several debris flows from undifferentiated Indianola strata overlooking Fountain Green occurred in 1983, 1984, and 1985, when local annual rainfall was 17, 14, and 12 inches (43, 36, and 30 cm), respectively (National Oceanic and Atmospheric Administration, 1983, 1984, 1985). Rock-avalanche debris covers the valley floor at Cedar Hill, Moroni Pole Canyon, and at the base of the foothill belt north of Birch Creek. There is high potential for future rock avalanches, especially below the massive cliffs of South Flat strata on the east side of the San Pitch Mountains, between Birch Creek and the base of South Flat. Earthquakes could initiate such rock avalanches. In South Maple Canyon, the potential for rock avalanches exists in the towering cliffs of the undifferentiated Indianola strata and the Price River Formation that overlook the town of Freedom.

Flash Floods

Flash floods are common throughout Utah. The towns of Fountain Green, Jerusalem, and Freedom all lie on alluvial fans or alluvial plains. Near the mountain front, high rainfall or surface runoff can produce floods capable of transporting boulders, sand, silt, and mud from the mountains into these towns.

One such event took place in Fountain Green in spring 1984. Parts of a major north-south paved road were covered with mud and ponded water, and parts of the road in Maple Canyon were destroyed by the flood (Mike Johnson, personal communication, 1988).

ECONOMIC GEOLOGY

Sand and Gravel

The most abundant economic resource within the quadrangle is the sand and gravel in the alluvial fans that blanket this part of Sanpete Valley. One gravel pit is located in an alluvial fan east of Moroni Pole Canyon in NE¼ SE¼ section 25, T. 14 S., R. 2 E. The pit is 12 feet (3.6 m) deep and the estimated reserve in 1966 was 190,000 cubic yards (145,000 m^3). Most particles (90%) are about 1 inch (2.5 cm) in length, with a few percent over 1 inch (2.5 cm) but less than 3 inches (7.6 cm) in length (10%). The clasts are quartzite and sandstone (Pratt and Callaghan, 1970).

Another gravel pit is located in a coalesced alluvial fan ($Qafc_3$) at the mouth of Maple Canyon in W½ NE¼ section 36, T. 14 S., R. 2 E. The pit is 10 feet (3 m) deep, and the estimated reserve in 1966 was 250,000 cubic yards (190,000 m^3). The material includes boulders (7%), gravel (53%), and sand, silt and clay (40%). The gravels are poorly cemented by calcium carbonate and contain lenses of silt. The composition of the gravel is mainly quartzite (96%), with subordinate amounts of sandstone (2%), and volcanic rock (2%) (Pratt and Callaghan, 1970).

Another gravel pit also lies in the coalesced fan ($Qafc_3$) in NE¼ NE¼ section 1, T. 15 S., R. 2 E. The pit is 10 feet (3 m) deep, and the estimated reserve in 1966 was 250,000 cubic yards (190,000 m^3). Most clasts are less than 1 inch (2.5 cm) in diameter (99.5%), with a small percent (0.5%) greater than 1 inch (2.5 cm) but less than 3 inches (7.6 cm) in length (Pratt and Callaghan, 1970).

Coal

The only known significant coal in the quadrangle is the 2.5-foot (75-cm) thick coal seam in the North Horn coal member in the southeastern portion of the map area. It is low-grade lignite and is not laterally extensive. The remains of two possible coal prospects were found north of Hamburger Lake. Only resinous carbonaceous mudstone is now observable at the sites. In 1857, some of the first coal mined in Utah was from these seams near Wales (Clark, 1914), less than one mile (1.6 km) south of the Fountain Green South quadrangle.

Oil and Gas

Oil and gas wells have not been drilled in the quadrangle. Drill stem tests on the J.W. Irons #1 well (conducted by the Tennessee Gas and Transmission Company), 4.5 miles (7.2 km) southeast of Devils Gate, yielded slight shows of oil and gas. The well was drilled to a depth of 9,995 feet (2,999 m) (Preston and Campbell, 1959) and bottomed in the "Morrison Formation" (now considered Cedar Mountain Formation). Potential oil-and-gas bearing units include the Ferron and Tununk Sandstone Members of the Mancos Shale (Indianola Group equivalent) (Ritzma, 1972). The Nielson-Seager #1 well in the E½ NE¼ section 1, T. 13 S., R. 2 E., was drilled to a total depth of 9,000 feet (2,700 m). It bottomed in the Sixmile Canyon Formation of the Indianola Group, but showed no oil or gas (Banks, 1986).

Water Resources

Springs

Many springs issue from the Indianola Group, and from the Twist Gulch, South Flat, and Price River Formations in the Fountain Green South quadrangle. Many are likely fracture- or fault-controlled, especially the springs in the foothills of the San Pitch Mountains. Nearly all of the springs encountered in the quadrangle are "pocket springs" of Hunt (1950). A "pocket spring" is small, intermittent, displays erratic flow, and issues where unconsolidated materials overlie less pervious units (Banks, 1986). A perennial spring in the NW¼ section 9, T. 14 S., R. 2 E., called "Cold Spring" by local inhabitants, discharged 5 gallons (19 l) per minute in August, 1988.

Surface Water

The three major sources of surface water in the quadrangle are northwest-flowing Chicken Creek, the east-flowing creek in Maple Canyon, and Hamburger Lake. According to Gates (1982), Chicken Creek has a drainage area of 27.9 square miles (72 km^2) and an average annual discharge of 4,820 acre-feet (5.9 x 10^6 m^3) (measured between 1963 and 1980). The distal portion of the creek near Levan (see Auby, 1987) is diverted for irrigation, but within this quadrangle the creek is used for watering livestock. No data exist concerning the chemistry of Maple Canyon or Hamburger Lake. Hamburger Lake is the only lake in the San Pitch Mountains.

Ground Water

The potential for ground water in this part of Sanpete Valley is based on studies by Pratt and Callaghan (1970), Robinson (1971), and Gates (1982). Gates showed that the water table slopes to the southeast in the north half of Sanpete Valley. The water table is in unconsolidated valley fill and generally can be reached at depths between 60 and 100 feet (18-30 m) on the higher alluvial fans at the base of the mountains and at less than 60 feet (18 m) in the valley lowlands (Robinson, 1971). Robinson noted that the water table declines from March to October, but rises again from October to March of the following year. The drawdown is mainly due to the pumping of irrigation wells, down-valley drainage, and evapotranspiration. In Sanpete Valley, Gates (1982) estimated annual recharge to be 160,000 acre-feet (1.0 x 10^8 m^3); annual discharge, 180,000 acre-feet (2.2 x 10^8 m^3); and ground water in storage, 3,000,000 acre-feet (3.7 x 10^9). The ground water in storage is in the upper 200 feet (60 m) of the saturated zone in valley fill.

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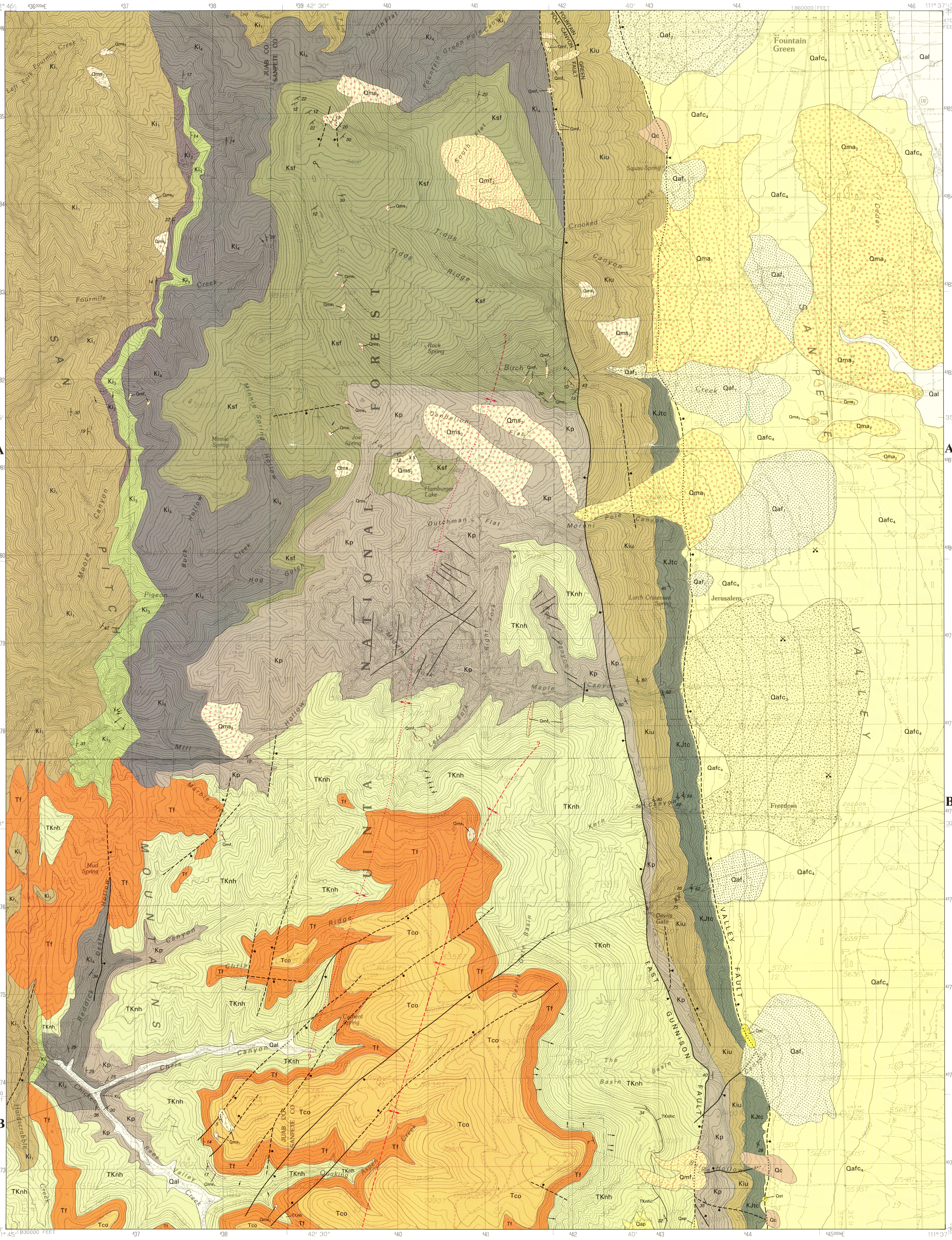

Base from U.S.G.S. Fountain Green South Quadrangle, Provisional Edition, 1988

The Miscellaneous Publication series provides an outlet for authors who are not Utah Geological Survey staff. Not all aspects of this publication have been reviewed by UGS.

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
SUPPLEMENTAL CONTOUR INTERVAL 20 FEET

Field work by author, 1988
Cartography by J. Parker

13°40′ E
243 MILS

1995 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Nephi
2 Fountain Green North
3 Big Hollow
4 Levan
5 Moroni
6 Chris Canyon
7 Wales
8 Chester

ADJOINING 7.5′ QUADRANGLE NAMES

GEOLOGIC MAP OF THE FOUNTAIN GREEN SOUTH QUADRANGLE, SANPETE AND JUAB COUNTIES, UTAH

by

Alan W. Fong

1995

UTAH GEOLOGICAL SURVEY
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Plate 2
Utah Geological Survey Miscellaneous Publication 95-1
Geologic Map of the Fountain Green South Quadrangle

DESCRIPTION OF MAP UNITS

QUATERNARY UNITS

- **Qal** Alluvium-- *Poorly to moderately sorted silty clay to cobble-sized material deposited in active streams and washes.*
- **Qst** Spring tufa-- *Tan, calcareous tufa with streaks of charcoal and carbonaceous sand.*
- **Qc** Colluvium-- *Unconsolidated material deposited at the foot of slopes; moderately sorted; reflects local lithologies.*
- **Qma$_1$** Younger rock-avalanche debris-- *Similar to older rock-avalanche debris; remobilized or deposited during the wet period of 1983-1985.*
- **Qma$_2$** Older rock-avalanche debris-- *Very poorly sorted, cobbles to boulders up to 25 feet (8 m) in diameter deposited at the base of steep chutes; Pleistocene to Holocene in age.*
- **Qmf$_1$** Younger debris-flow deposits-- *Similar to older debris-flow deposits; remobilized or formed during the wet period of 1983-1985.*
- **Qmf$_2$** Older debris-flow deposits-- *Poorly sorted silt and clay with minor coarser material that flowed as a viscous fluid; Pleistocene to Holocene in age.*
- **Qms$_1$** Younger landslide deposits-- *Similar to older landslide deposits; remobilized or formed during the wet period of 1983-1985.*
- **Qms$_2$** Older landslide deposits-- *Very poorly sorted, boulder- to clay-sized material with a hummocky surface morphology; Pleistocene to Holocene in age.*
- **Qaf$_1$** Younger alluvial fans-- *Similar to older coalesced alluvial fans; four ages of alluvial-fan deposits are distinguished by relative position; the youngest alluvial fans are presently active.*
- **Qaf$_2$** Older alluvial fans-- *Similar to older coalesced alluvial fans.*
- **Qafc$_3$** Younger coalesced alluvial fans-- *Similar to older coalesced alluvial fans.*
- **Qafc$_4$** Older coalesced alluvial fans-- *Fine- to coarse-grained alluvial deposits with a fan morphology deposited in the valley near the mountain front; coarser materials present near the mountains and finer materials dominate the distal parts; includes some loess deposits.*
- **Qap** Pediment-mantle alluvium-- *Poorly sorted, clay to angular boulder deposits blanketing an elevated, erosional surface.*

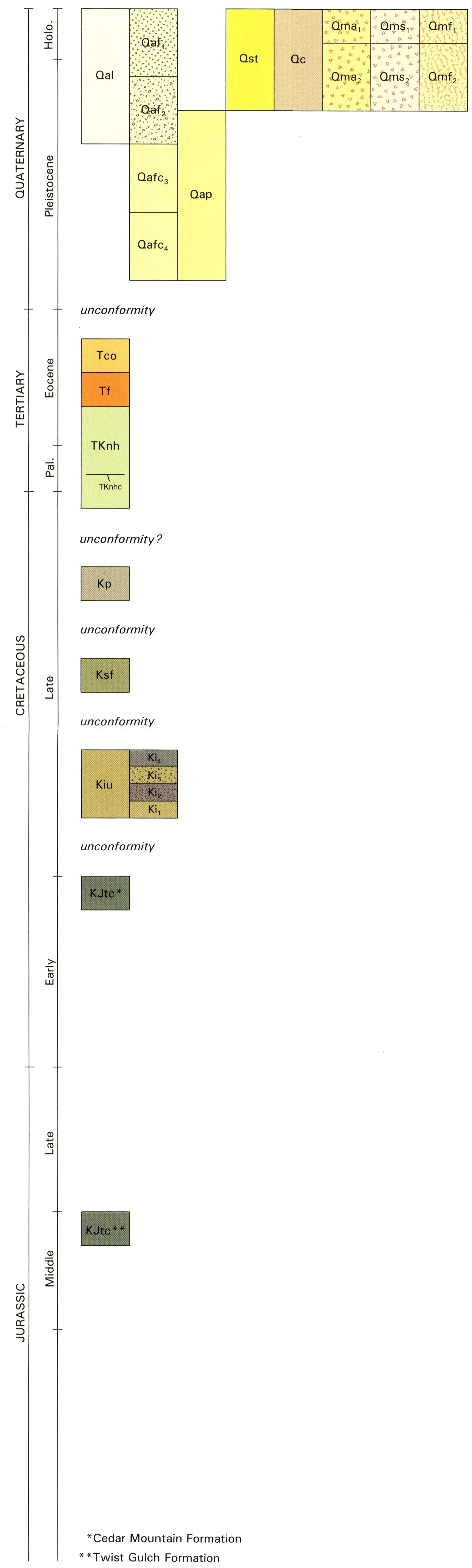
BEDROCK UNITS

- **Tco** Colton Formation-- *Gray to orange mudstone, limestone, sandstone, and siltstone; sparse gastropods and pelecypods.*
- **Tf** Flagstaff Formation-- *White and gray limestone (silicified and fossiliferous in some places), mudstone, shale, sandstone, conglomerate, and bentonite; oncolites and gastropods.*
- **TKnh / TKnhc** North Horn Formation-- *Yellow, pebbly sandstone at base; varicolored conglomerate, pale orangish-tan sandstone, and gray mudstone. Coal member (TKnkc) consists of grayish-orange micrite and coal.*
- **Kp** Price River Formation-- *Varicolored, polymodal, clast-supported conglomerate with orange to gray sandstone; absence of limestone pebbles and cobbles.*
- **Ksf** South Flat Formation-- *White and pink sandstone with interbeds of micrite, carbonaceous shale, and carbonaceous mud.*
- **Kiu** Indianola Group undifferentiated-- *White to red sandstone and conglomeratic sandstone.*
- **Ki$_4$** Indianola Group, unit 4-- *Varicolored, polymictic, polymodal, clast-supported conglomerate with subordinate sandstone and shale; abundant limestone pebbles and cobbles.*
- **Ki$_3$** Indianola Group, unit 3-- *Varicolored conglomerate with minor arkose and sandstone.*
- **Ki$_2$** Indianola Group, unit 2-- *Green glauconitic sandstone with minor limestone and shale.*
- **Ki$_1$** Indianola Group, unit 1-- *Varicolored conglomerate with sandstone; limestone pebbles and cobbles in upper part.*
- **KJtc** Twist Gulch Formation and Cedar Mountain Formation, undivided-- *Brown, white, red, and gray calcareous sandstone, siltstone, mudstone, and minor gritstone; undivided because of poor exposures.*
- **Ja** Arapien Shale-- *Shown only on the cross section.*

MAP SYMBOLS

- Contact
- Major unconformity (shown on cross section only)
- Normal fault-- *Dashed where approximately located, dotted where concealed; bar and ball on downthrown side.*
- Joint or fracture
- Syncline axial trace-- *Dashed where approximately located; dotted where concealed.*
- Coal prospect pit
- Gravel or road fill pit
- 34 62 Strike and dip of bedding (inclined, vertical, overturned)
- Spring
- Landslides, debris flows, and slumps (too small to map separately)

CORRELATION OF MAP UNITS



*Cedar Mountain Formation
**Twist Gulch Formation

LITHOLOGIC COLUMN

SYSTEM	SERIES/ STAGE	FORMATION			SYMBOL		THICKNESS feet (meters)		LITHOLOGY
QUATERNARY	Pleistocene to Holocene	Unconsolidated deposits			Q		0-250 (0-75)		
		Spring tufa			Qst		60+ (18+)		
TERTIARY	Eoc.	Colton Formation			Tco		220 (66)		
	Paleocene to Eocene	Flagstaff Formation			Tf		40-930 (12-280)		
		North Horn Formation			TKnh		0-3,100 (0-940)		
		Coal member			TKnhc		0-40 (0-12)		
CRETACEOUS	Maastrichtian	Price River Formation			Kp		0-800 (0-240)		
		South Flat Formation			Ksf		0-2,826 (0-860)		
	Turonian to Campanian	Indianola Group	(West)	(East)			400-3,000 (120-900)		
			Unit no. 4	Undifferentiated	Ki$_4$	Kiu		1426 (435)	
			Unit no. 3		Ki$_3$			0-1,000 (0-300)	
			Unit no. 2		Ki$_2$			0-200 (0-60)	
			Unit no. 1		Ki$_1$			1,500 (450)	
JUR.		Twist Gulch and Cedar Mountain Fms., undivided			KJtc		850-900 (260-270)