PROVISIONAL GEOLOGIC MAP OF THE SKINNER PEAKS QUADRANGLE, JUAB AND SANPETE COUNTIES, UTAH

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ABSTRACT

The Skinner Peaks quadrangle is located in central Utah, just west of the leading edge of the Sevier fold-and-thrust belt, and in the transition zone between the Colorado Plateau and the Basin and Range. The stratigraphy and structure of the quadrangle reflect several tectonic events, including the Sevier Orogeny, formation of the Colorado Plateau, and Basin and Range extension. Local diapiric movement of the Arapien Shale, which probably was initiated by these major tectonic events, further modified the structure and affected the stratigraphy.

Exposed bedrock units in the quadrangle include sedimentary, pyroclastic, and intrusive rocks that range in age from Middle Jurassic to Late Oligocene. An unconformity separates Middle Jurassic marine strata of the Arapien Shale from the overlying Cretaceous-Tertiary strata. These Cretaceous-Tertiary strata include, in ascending stratigraphic order, the North Horn, Flagstaff, Colton, Green River, and Goldens Ranch Formations.

Strata of the North Horn, Flagstaff, and Colton Formations represent the alluvial fan and plain, lacustrine, and fluvial conditions that dominated the Sevier foreland basin during the Late Cretaceous and Early Eocene. Eocene Green River strata record inundation of the basin by Lake Uinta, and the volcaniclastic Goldens Ranch Formation is representative of the widespread volcanism that was occurring throughout Utah during Oligocene time. Two small igneous intrusions also were mapped as were unconsolidated surficial lacustrine, fluvial, colluvial, alluvial fan, and landslide deposits ranging in age from Late Tertiary to Recent.

Major structures in the quadrangle are the Sage Valley Fault, the Western Juab Valley Fault Zone, the Wasatch Fault Zone, the West Gunnison Monocline, the Juab Valley Graben,and Flat Canyon Graben.

Economic deposits include sand and gravel, gypsum, tuff, carbonate rock, manganese, and water. Earthquakes, mass movements, karst development, and groundwater contamination are potential geologic hazards in the Skinner Peaks quadrangle.

INTRODUCTION

The Skinner Peaks 7.5 minute quadrangle is located approximately 100 miles south of Salt Lake City in Juab and Sanpete Counties, central Utah. The quadrangle extends from 39° 22' 30" to 39° 30' North Latitude, and from 111° 52' 30" to 112° West Longitude. It lies in the transition zone between the Colorado Plateau and Basin and Range Provinces; the Colorado Plateau

Province is represented by the Gunnison Plateau, which terminates just east of Utah Highway 28. In addition to the Gunnison Plateau, the Skinner Peaks quadrangle also includes the southern end of the West Hills, Mills Gap, the South Hills, and part of Juab Valley. Total relief in the quadrangle is approximately 1,700 feet; base elevation is 5,000 feet above sea level.

The first geologic map of the Skinner Peaks quadrangle was made by James W. Vogel of Ohio State University in 1957. Vogel mapped the geology at a scale of 1:31,680 on an imprecise planimetric base map constructed from aerial photos; no suitable topographic map of the area existed at that time. Witkind and others (1987) included the Skinner Peaks quadrangle as part of the Manti 30' x 60' quadrangle, although most of the geology that appears on the Manti Sheet was compiled from Vogel's original work.

Other early investigations of the structure and stratigraphy of central Utah were conducted by E. M. Spieker (1946, 1949) and his students from Ohio State University (e.g., Zeller, 1949; Muessig, 1951; Vogel, 1957). Faculty and students from Ohio State, Brigham Young, and Northern Illinois Universities have continued to expand and modify Spieker's earlier work.

STRATIGRAPHY

Sedimentary, pyroclastic, and igneous rocks ranging in age from Middle Jurassic to Late Oligocene are exposed in the Skinner Peaks quadrangle. These rocks consist of the Arapien Shale, North

Horn, Flagstaff, Colton, Green River, and Goldens Ranch Formations, and two igneous intrusions. Unconsolidated lacustrine, fluvial, colluvial, alluvial fan, and mass-movement sediments ranging in age from Late Tertiary to Recent were mapped in addition to the bedrock units.

Precambrian and Paleozoic strata are not exposed as bedrock in the quadrangle, but they are exposed in the nearby Valley Mountains, Canyon Range, and southern Wasatch Mountains (Hintze, 1975); well data indicate these strata also underlie the study area (Standlee, 1982). Although Precambrian and Paleozoic strata are not exposed in the study area, clasts of Precambrian and Paleozoic strata are prevalent in the conglomerates of the North Horn, Flagstaff, Colton, Green River, and Goldens Ranch Formations, and in the various unconsolidated Tertiary-Quaternary deposits.

JURASSIC

Arapien Shale

The Arapien Shale, which was deposited in a narrow seaway during Callovian time, is exposed east of Utah Highway 28 along the west flank of the Gunnison Plateau. It underlies Skinner Peaks, and it also is exposed in and adjacent to Little Salt Creek Canyon.

The Arapien is composed of grayish-green, thinly-bedded limestone, micrite, and calcareous siltstone; thinly-bedded, rippled, calcareous sandstone, and grayish-green or red calcareous mudstone with locally occurring pods of gypsum. These rock types are representative of units B and C of Hardy (1952).

Thinly-bedded siltstone, shale, and rippled sandstone matching the description of unit C occurs in both the Little Salt Creek Canyon and Skinner Peaks vicinity. These beds locally contain fossils tentatively identified as *Ostrea* sp., an observation that is congruent with that of Zeller (1949, p.19), who noted the occurrence of *Ostrea* sp. in unit C sandstone in upper Little Salt Creek Canyon.

In outcrop the Arapien shale "...generally occurs as highly folded, contorted and faulted strata..." (Vogel, 1957, p. 32) that weathers to form steep, rugged, sparsely vegetated, gray hills. Most of the units within the Arapien weather into small chips or thin plates; ledges occur locally where more resistant sandstone or siltstone is present.

Stratigraphic relationships between the Arapien and adjacent units are complex. The base of the formation is not exposed within or adjacent to the study area; however, data collected from drill-holes in SE Juab County indicate that the Arapien is underlain conformably by the Twin Creek Limestone (Sprinkel, 1982). This relationship can be observed in outcrop in the Mona quadrangle, 15 miles NE of the Skinner Peaks quadrangle. In normal sequences the Arapien is overlain conformably by the Twist Gulch Formation; however, in the Skinner Peaks quadrangle the Arapien is most commonly overlain unconformably by the Green River Formation. Locally it is overlain unconformably by the North Horn Formation, or the Goldens Ranch Formation. These unconformable relationships are best observed immediately south of Little Salt Creek Canyon and on the Skinner Peaks themselves.

Determination of an accurate thickness for the Arapien has been hampered by poor exposure (Sprinkel, 1982) and the intense deformation of the strata (Sprinkel, 1982; Standlee, 1982); estimates range from 3,000 to 11,000 feet throughout the area of its exposure (Spieker, 1946; Hardy, 1952; Eardley, 1933; Standlee; 1982). In this study a thickness of approximately 440 feet was calculated from an incomplete, undeformed section of Arapien south of Little Salt Creek Canyon in. Approximately 2,000 feet of Arapien was logged in a test hole in the NW corner of the quadrangle.

CRETACEOUS-TERTIARY

North Horn Formation

Large quantities of coarse-grained, clastic sediments were eroded from the Sevier Highland during the Late Cretaceous and Early Tertiary and deposited as a series of alluvial fans in the foreland basin to the east. These alluvial fans formed a conglomerate sequence that is represented by the Indianola Group, Price River Formation, and North Horn Formation. This sequence of conglomerates is almost 10,000 feet thick on the Gunnison Plateau (Hintze, 1988).

In the Skinner Peaks quadrangle, beds that tentatively have been identified as North Horn Formation are exposed in a narrow band on the NE side of Skinner Peaks. The North Horn Formation is not exposed anywhere else in the quadrangle, although it does crop out in the West Hills just north of the NW corner of the quadrangle (in the Juab quadrangle). It also occurs in the subsurface in Juab Valley (Clark, 1987).

Outcrops of North Horn Formation in the Skinner Peaks quadrangle are composed of poorly sorted, bimictic, cliff- and ledge-forming conglomerate. Clasts are subangular to subrounded pebbles, cobbles, and boulders of purple and tan quartzite and dark blue-gray carbonate. Purple clasts were derived from the Precambrian Mutual Formation, and tan clasts were derived from the Cambrian Tintic Quartzite; dark blue-gray carbonates represent a variety of Paleozoic formations. Matrix is poorly-sorted, medium- to fine-grained, calcareous sandstone.

Clast size decreases up-section; the top of the section consists of interbedded conglomerate and sandstone. There is also an increase in the quartzite-to-carbonate clast ratio up-section; the lower part of the section has a 0% / 100% carbonate/ quartzite clast ratio, whereas the top of the section has a 75% / 25% carbonate/ quartzite clast ratio. The color of the unit also varies in an up-section direction; it is gray at the base, red in the middle, and gray at the top. The description of this section of North Horn is similar to Mattox's (1986, p. 80) description of "high escarpment and inner canyon" North Horn strata.

In most sections, especially farther east, the North Horn Formation lies conformably on top of the Price River Formation, and is in turn conformably overlain by the Flagstaff Formation;

however, in the Skinner Peaks quadrangle the North Horn Formation lies unconformably on top of the Jurassic Arapien Shale, and the relationship between it and the overlying strata is unclear.

The thickness of the North Horn Formation is also anomalous. The exposed section on Skinner Peaks is only 300 feet thick; however, only six miles to the west in the West Hills Clark (1987) reported a thickness of approximately 800 feet, and approximately 1,700 feet of North Horn Formation was logged in a test hole just south of Chicken Creek Reservoir.

The drastic thickness variations and the relationship between the North Horn Formation and adjacent units is discussed in detail in the "Interpretation of the Stratigraphy of Skinner Peaks".

TERTIARY

Flagstaff Formation

The Flagstaff Formation represents a major lacustrine phase of deposition that occurred between the alluvial fan and floodplain conditions represented by the North Horn Formation and the Colton Formation. Strata of the Flagstaff Formation range in age from Paleocene to Eocene; this age range is based primarily on paleontologic evidence that has been gathered by various workers throughout central Utah (LaRocque, 1951; Newman, 1974; Fouch and others, 1982).

In the Skinner Peaks quadrangle the Flagstaff Formation is exposed in the east-dipping cuestas of the West Hills in the NW corner of the quadrangle. Beds tentatively identified as Flagstaff Formation also are exposed along the NE side of Skinner Peaks, and are discussed in the "Interpretation of the Stratigraphy of Skinner Peaks".

A section of Flagstaff Formation was measured in the West Hills north of Mills Gap. Calcareous mudstone, sandstone, sandy limestone, limestone, and conglomerate (listed in order of decreasing abundance) are the major rock types in this section. These strata are equivalent to the carbonate-clastic facies defined by Clark (1987) in the Juab quadrangle to the north.

The color of the strata varies from grayish-yellow to pale reddish-orange, with various hues of yellow being most common. The calcareous mudstone is massive; it weathers to a slope and ranges from 20-80 feet in thickness. The sandstone is usually calcareous and composed of medium- to coarse-grained quartz and lithic sand; locally it is cross-bedded. Compositionally, the sandstones are quartz arenites, sublitharenites, and lithic arenites (Clark, 1987; Auby, 1985). Beds of sandstone form ledges that are 1-4 feet thick, and commonly are laterally discontinuous. Massive beds of sandy limestone and limestone form resistant ledges 2-20 feet thick; locally these carbonate units are platy, weathering to slopes with local ledges. Beds of clast-supported conglomerate and conglomeratic sandstone occur locally throughout the section. These units are laterally discontinuous, often channel-form in shape, and 1-10 feet thick. Clasts are subangular to subrounded, poorly-sorted pebbles and cobbles of quartzite and sandstone. The matrix is medium- to coarse-grained calcareous sandstone that is composed of quartz and lithic sand.

The relative abundance of coarse-grained clastic material, the presence of cross-bedded sandstone, and the lateral discontinuity of the sandstone and conglomerate beds suggests that the Flagstaff Formation in the Mills Gap section was deposited in a near-shore, shallow-water environment. This interpretation is consistent with those of Muessig (1951), Lambert (1976), and Clark (1987).

The base of the Flagstaff Formation is not exposed in the West Hills within the Skinner Peaks quadrangle; however, it is exposed in the Juab quadrangle to the north, and there the contact with the underlying North Horn is conformable and gradational (Clark, 1987), as is the contact between the Flagstaff and the overlying Colton Formation. The Flagstaff Formation is approximately 525 feet thick.

Colton Formation

Fluvial and alluvial plain sediments, which are assigned to the Colton Formation, represent the final infilling of the Sevier foreland basin which occurred during the Early Eocene.

In the Skinner Peaks quadrangle the Colton Formation is exposed in a conspicuous red swath in the east-dipping cuestas of the West Hills. Beds that tentatively have been identified in this study as Colton Formation are exposed on Skinner Peaks; and are discussed in the "Interpretation of the Stratigraphy of Skinner Peaks".

In the West Hills in the Skinner Peaks quadrangle the Colton Formation is composed of reddish-brown mudstone, sandstone, and conglomerate; thin beds of limestone occur locally throughout the section, and are considered to be the deposits of short-lived local lakes. The Colton Formation as a whole is not well indurated, and it weathers to form a saddle between the more resistant Flagstaff Limestone and Green River Formation. The mudstone is calcareous and weathers to a slope. The sandstone is friable, and weathers to a slope with locally occurring ledges. It is calcareous, and is composed of subrounded, medium- to coarse-grained quartz, feldspar, lithic fragments, and mica. Studies by Marcantel and Weiss (1968) and Stanley and Collinson (1979) show that Colton sandstones are commonly finer grained and contain greater amounts of mica and feldspar than the sandstones in the Flagstaff Formation. Beds of limestone are sandy, and they occur locally as low, discontinuous ledges.

The conglomerate (Figure 1) is clast-supported, moderately sorted, and bimictic; clasts are subrounded pebbles of approximately equal amounts of purple and tan quartzite (from the Mutual Formation and Tintic Quartzite), and dark blue-gray Paleozoic limestone. This suite of clasts indicates derivation from the Sevier Highland to the west. The matrix, which comprises approximately 20 percent of the rock, is sandstone that is calcite-cemented and composed of medium- to coarse-grained, quartz and lithic sand. Conglomerate beds are 5-10 feet thick, channel-form, and laterally discontinuous; they occur as ledges and cliffs. Regionally, conglomerate is rare in the Colton and it occurs here only because the area was close to the edge of the basin.

The high percentage of mudstone, laterally discontinuous beds of conglomerate, sandstone, and limestone, and the red color of the strata attest to the fluvial (floodplain and channel) origin of the Colton Formation (Marcantel and Weiss, 1968).

In the West Hills in the Skinner Peaks quadrangle the Colton Formation is underlain conformably by the Flagstaff Formation, and overlain conformably by the Green River Formation. The formation is approximately 300 feet thick.

Green River Formation

Sediments that were deposited in Lake Uinta from the Early through Late Eocene formed the strata of the Green River Formation. In the Skinner Peaks quadrangle strata of the Green River Formation reflect the lake-marginal location of the quadrangle, and four distinct lithofacies are recognized; from the base of the unit upward they are the mudstone, clastic, and mudstone-micrite lithofacies of Clark (1987), and the Tawny facies of Zeller (1949).

The best exposures of strata of the mudstone, clastic, and mudstone-micrite lithofacies of the Green River Formation are in the cuestas of the West Hills, while the best exposures of the Tawny facies are found in the vicinity of Skinner Peaks.

Mudstone facies - The mudstone lithofacies is composed mostly of thinly bedded, grayish-yellow mudstone that is very incoherent and subsequently weathers to a slope. Thin, laterally discontinuous beds of quartzite pebble conglomerate and sandy limestone also occur locally throughout the unit. The unit is capped by a resistant bed of stromatolitic limestone that contains brown and gray chert nodules. The stromatolites occur as laterally-linked hemispheroids up to 2 feet in diameter.

Clastic facies - The calstic facies consists of conglomerate, conglomeratic sandstone, mudstone, and sandstone. The conglomerate and conglomeratic sandstone is reddish-brown or grayish-yellow; it is bimictic with poorly-sorted pebbles and cobbles of quartzite and carbonate in a medium- to coarse-grained sandstone matrix. These conglomerate and conglomeratic sandstone units are poorly indurated, and laterally discontinuous. Mudstones are reddish brown, thinly laminated slope-formers. Sandstones are gray, calcite-cemented, and composed of quartz and lithic fragments; compositionally these sandstones are sublitharenites, lithic arenites, and lithic wackes (Clark, 1987). Sandstone beds form low ledges that are laterally discontinuous. Beds of oolitic limestone that have been replaced by silica also occur locally throughout the clastic facies; ripple marks commonly are preserved on the tops of these oolitic beds.

Mudstone-micrite facies - Alternating beds of red or yellow mudstone, and yellow or gray micrite dominate the mudstone-micrite lithofacies. The mudstones are very thinly-bedded, poorly indurated, and consequently they weather to slopes; mudstones total over 50% of the mudstone-micrite facies (Clark, 1987). The micrite beds are relatively coherent, and consequently they form a resistant cap over the easily-eroded mudstones. These micrite beds are commonly platy and fossiliferous; fossils include plant fragments, gastropods, and Clark (1987) noted pelecypods and ostracodes as well.

A thickness of 1,200 feet was calculated from outcrop width and bedding attitude for the Green River Formation in the West Hills of the Skinner Peaks quadrangle. This thickness is approximately 300 feet greater than thicknesses calculated by Vogel (1957) and Clark (1987) for the same general area. This suggests the presence of a fault in the section, but no evidence for a fault was seen in the field.

Tawny facies - Tawny Beds consist of green, red, and variegated mudstone, and yellowish-tan coarse-grained sandstone, conglomerate, conglomeratic sandstone, and limestone. The sandstone is very coherent; it is usually cemented with calcite, and composed of quartz and minor amounts of lithic fragments. Sandstone beds form ledges that are several feet thick and laterally discontinuous; numerous vertebrate fossils are contained in sandstone beds near the top of the section. Channel-form beds of conglomerate and conglomeratic sandstone also are very coherent. Clasts are subrounded to rounded pebbles of dark blue-gray carbonate (>75%), and tan and purple quartzite (<25%); matrix is sandstone similar to that described above. Limestone is very dense and commonly fossiliferous, containing teeth and bone fragments, as well as gastropods of the species *Australorbis* (LaRocque, 1960). Strata of the Tawny facies match the description of strata in Millen's (1982) alluvial facies, which represents an alluvial or delta plain environment of deposition.

Complex stratigraphic relationships separate the Tawny Beds from adjacent units. With the exception of Hunt (1950), all workers (Vogel, 1957; Millen, 1982; Norton, 1986) agree that the contact between the Tawny Beds and the underlying Green River Formation is conformable and gradational; this relationship was confirmed in this study as well. Tawny Beds also unconformably overlie the Arapien Shale south of Little Salt Creek Canyon. They are, in turn, overlain conformably by strata of the Goldens Ranch Formation.

Interpretation of the Stratigraphy of Skinner Peaks

The stratigraphy on Skinner Peaks is complex and abnormal, and thus, poorly understood. Approximately 550 feet of conglomerate, conglomeratic sandstone, sandstone, sandy limestone, and oncolitic limestone grade vertically into strata of the Tawny facies of the Green River Formation. Vogel (1957), and Witkind and others (1987) mapped these strata as part of the Tawny facies of the Green River Formation. A closer evaluation of these units indicates that they more accurately represent Late Cretaceous-Early Tertiary strata as suggested by Douglas A. Sprinkel of the Utah Geological and Mineral Survey (UGMS).

Evidence to support this interpretation is cited throughout the following section. Unit numbers (e.g., unit 4) correspond to the unit numbers found in the Skinner Peaks Section in the Appendix.

A section of poorly sorted conglomerate and conglomeratic sandstone, which is approximately 300 feet thick, lies unconformably on the Arapien Shale. These conglomerates were described in detail in the section on the North Horn Formation; only a summary description is presented here.

The conglomerate in the lower 220 feet of the section (unit 4) is massive, clast-supported, poorly-sorted, and bimictic. Clasts include subangular to subrounded pebbles, cobbles, and boulders of purple and tan quartzite, and a small percentage of dark blue-gray carbonate; matrix is poorly-sorted, medium- to fine-grained lithic sandstone. Clast size, and quartzite/carbonate clast ratio decreases up-section. The color of the unit also changes from gray to red up-section. This unit, which represents an alluvial fan deposit, is overlain by 55 feet of interbedded conglomerate and sandstone (unit 5).

The conglomerate of unit 5 is gray, clast-supported, moderately-sorted, and bimictic. Clasts are subangular to subrounded cobbles of carbonate (75%) and quartzite (25%). The sandstone is composed of quartz; it is light-gray, medium-grained, well-sorted, and locally cross-bedded. This unit is indicative of an alluvial plain environment.

The conglomerate sequence is overlain by approximately 100 feet of limestone (unit 6) and oncolitic limestone (unit 8; Figure 2).

The limestone is light-gray, massive, and finely-crystalline; it forms a ledge that is 10 feet thick. The oncolitic limestone, which contains oncolites up to three inches in diameter, forms cliffs and is 80 feet thick.

The oncolitic limestone is overlain by 110 feet of interbedded sandy limestone and sandstone (unit 9), and interbedded sandstone and conglomerate (unit 10). The interbedded sandstone and sandy limestone is reddish-brown. The sandstone in this unit is calcareous and is composed of medium-grained quartz and minor amounts of lithic fragments; it forms local ledges throughout the slope-forming sandy limestone. This sequence is overlain by interbedded sandstone and conglomerate. The sandstone in this unit is also calcareous and is composed dominantly of medium-grained, well-sorted quartz sand. It also contains algal mat pieces and oncolites that may have been derived partially from the underlying oncolitic limestone. The conglomerate is clast-supported, moderately-sorted, and bimictic. It is composed of approximately equal amounts of subrounded pebbles of dark-blue-gray carbonate and purple and tan quartzite. Approximately 20% of the rock is matrix which is is composed of quartz sandstone. Strata of these units represent a lake-marginal and fluvial environment, which was typical of both the Flagstaff Formation and Colton Formation in this area; these strata grade vertically into the overlying Tawny Beds. The contacts between the lower units appear to be conformable.

The section is a fining-upward sequence that represents a transition through the following environments: alluvial fan (unit 4), alluvial plain (unit 5), lake-marginal and shallow-water lacustrine (units 6-10). The lithology and stratigraphy of the units described above are characteristic of the North Horn, Flagstaff, and Colton Formations. It is difficult, however, to assign each unit to a specific formation. The conglomerates of units 4 and 5 match the regional description of North Horn strata. The limestone and oncolitic limestone of units 6-8 could be placed in either the North Horn Formation or the Flagstaff Formation. The sandy limestone, sandstone, and conglomerate of units 9 and 10 could be placed in either the Flagstaff Formation or Colton Formation, although the lack of a distinctive red color and abundant mudstone suggests that these strata are more representative of the Flagstaff Limestone than they are of the Colton. Regardless of which formation each unit is assigned to, this section is far more representative of the regional sequence of Late Cretaceous-Early Tertiary strata than it is representative of Tawny Beds.

Based on this interpretation of the stratigraphy, very attenuated sections of North Horn Formation and Flagstaff Formation are present on Skinner Peaks. The North Horn Formation is 300-400 feet thick depending on where the North Horn/Flagstaff contact is drawn. Likewise, the Flagstaff Formation is 110-220 feet thick. These thickness values are significantly less than values from the West Hills to the west and from the Gunnison Plateau to the east. The most logical explanation for the drastic thickness variations that occur over such a short distance is that welts of Arapien Shale formed local topographic highs in the basin during Late Cretaceous-Middle Tertiary time. This conclusion is supported by the presence of an unconformity between the Arapien Shale and Late Cretaceous-Early Tertiary strata, and the presence of the oncolitic limestone. Oncolites, which are concretions of algae and sediment, form in shallow water, near-shore lacustrine environments. Weiss (1969) has shown that oncolites within the North Horn and Flagstaff Formations occur preferentially along what were actively-rising tectonic ridges.

Because the units described above were identified only tentatively, the strata of this section were mapped as Cretaceous-Tertiary undivided.

Goldens Ranch Formation

The onset of wide-spread volcanism in Utah occurred during the Early Oligocene. This volcanism produced deposits, such as the volcaniclastic Goldens Ranch Formation, which occurs throughout approximately one-third of the area of the Skinner Peaks quadrangle. In the western half of the quadrangle the formation can be traced southward from the Chicken Creek Reservoir through the South Hills and into the outcrops that flank the eastern side of the Sevier Bridge Reservoir. In the eastern half of the quadrangle it occurs south of Chriss Canyon, and forms a "moat" that surrounds Skinner Peaks. Potassium-argon dates ranging from 38.5-29.9 m.y (Evernden and James, 1964; Witkind and Marvin, 1989) were obtained from samples collected from various units within the Chicken Creek Tuff Member. These dates confirm the Oligocene age of the formation.

In the Skinner Peaks quadrangle the Goldens Ranch Formation is separated into five distinct, mappable units (Units I-V, this study). Units I through IV correspond to the Chicken Creek Tuff Member of Meibos (1983), and unit V is the Hall Canyon Conglomerate, or its equivalent.

Unit I - Unit I is an epiclastic conglomeratic sandstone (Figure 3). The thickness of this unit is variable, ranging from 100 to approximately 500 feet thick. The contact between it and the underlying Eocene Green River Formation is gradational wherever it is exposed, as in the NE 1/4 of section 27, T. 16 S., R. 1 W.

Unit I forms slopes, ledges, and cliffs, and is either blue, gray or green in color. It contains a variety of sedimentary structures, including laminae, trough and tabular cross-bedding, channels, pebble/cobble lenses, scour-and-fill structures, and normally and reversely graded beds.

Just above the contact with the Green River Formation, Unit I is composed of bentonitic shales interbedded with thin, platy limestone. This unit grades upward into sandstone, and finally into conglomeratic sandstone, forming a coarsening-upward sequence.

The upper three-quarters of Unit I are composed of sandstone and conglomeratic sandstone. The sandstone and matrix of the conglomeratic sandstone is most commonly a poorly-sorted lithic or arkosic sandstone. Grains are subangular, and range in size from

0.5-10 mm, with an average of 1 mm. The cement is typically calcareous, and the rock is friable to moderately coherent.

Clasts in the conglomeratic sandstone are angular to subrounded, and poorly sorted, ranging in size from 1.5-7.0 cm, with an average size of 5 cm. Approximately 90% of these clasts are volcanic in origin, and were probably derived from ash and lava flows of the East Tintic District. The other 10% are quartzite clasts that were derived from the Precambrian Mutual Formation and the Cambrian Tintic Quartzite, or from pre-existing conglomerates.

The coarsening-upward sequence of Unit I represents a shallow lacustrine/marginal lacustrine/fluvial environment of deposition that marks the end of Lake Uinta (De Vries and others, 1988).

Unit II - Unit II is a crystal vitric tuff that is 40-70 feet thick. The contact between Unit I and Unit II is concordant and sharp. This tuff is slightly welded, pink (weathered and fresh), and usually forms slopes. It is composed of 30-35% crystals and 65-70% glassy matrix. The crystals are euhedral and average 1 mm in size. Approximately 60% of these crystals are biotite, 40% are bipyramidal quartz, and sanidine occurs in trace amounts. The matrix is composed of pumice fragments (25%-30%), which range in size from 0.5-20 mm, and ash (70%-75%). Bubble wall shards are visible in thin section.

Unit III - Unit III is coarse-grained epiclastic sandstone that is 50-90 feet thick. This unit is red or gray in color, forms resistant ledges and cliffs, and displays cross-bedding and channels. It is composed of approximately 60% bipyramidal quartz crystals, 5-15% lithic fragments, 15% sanidine, and traces of hematite. The lithic fragments are subrounded, and range in size from 2-15 mm. The quartz crystals, hematite, and sanidine are subhedral to euhedral, and average 2 mm in size. This unit is cemented by both silica and calcite, and is moderately to very coherent.

Unit II and Unit III are separated by an erosional contact. The nature of the contact and the presence of clasts of Unit II within Unit III suggest that Unit III was derived at least in part from the top of Unit II. Unit III represents a period of volcanic quiescence that occurred between the eruptive episodes that deposited Unit II and Unit IV.

Unit IV - Unit IV is an orange- or tan-colored vitric lithic tuff that is approximately 70-100 feet thick. The contact between it and Unit III is sharp and concordant. This tuff is less welded at the base where it weathers to form slopes; the upper part of the unit is better welded and it weathers to form vertical cliffs that commonly are cavernous.

The tuff of Unit IV is composed of 75% matrix, 20% lithic fragments, and 5% crystals. The matrix is composed of 50% ash, and 50% pumice that ranges in size from 1-10 cm, and is commonly flattened in the bedding plane. The pumice forms a coarsening-upward sequence within the tuff. The lithic fragments are subangular to round, range in size from 0.5-2 cm, and are composed of volcanic rocks and quartzite. Biotite, bipyramidal quartz, and a trace of sanidine constitute the crystal fraction of the tuff. These crystals are euhedral, and range in size from 0.5-2 mm.

Unit V - Unit V is the Hall Canyon Conglomerate or its equivalent. It is an epiclastic sandstone/conglomeratic sandstone of unknown thickness. In the Skinner Peaks quadrangle the base of the unit is exposed in only one place, the top is not exposed at all, due to erosion, and the section is further complicated by faulting. Clark (1987) reports that the thickness of the Hall Canyon Conglomerate varies from 0-400 feet in the Juab quadrangle. The contact between Unit V and Unit IV is erosional and sharp.

The basal part of Unit V is an epiclastic sandstone that is very similar to Unit III; however, it is thin (rarely greater than 10 feet thick), and contains sand-sized grains of Unit IV. The rest of Unit V is very similar to Unit I in terms of texture and composition. The principal difference between Units I and V is the presence of angular clasts of Unit IV within Unit V. Unit V also contains more sandstone and less conglomeratic sandstone than Unit I. The sandstone is relatively homogeneous in terms of grain-size and composition (medium- to coarse-grained lithic sandstone); it contains very large-scale, tabular cross-bedding. The sedimentary structures, thickness, and overall stratigraphy of this unit suggest that it is an alluvial fan or a fan-delta deposit.

Igneous Intrusions

Two small intrusions of hornblende monzonite porphyry occur in the Arapien Shale. One is located in the NW 1/4, NE 1/4 of section 36, T. 15 S., R. 1 W., and the other is located in the SW 1/4, SE 1/4 of section 25, T. 15 S., R. 1 W. These intrusions are not very resistant, and they weather to a grus-like talus that is black or dark-gray due to the abundance of hornblende. These and other intrusions in the vicinity were classified as dikes by Vogel (1957), Zeller (1949) and Hunt (1950).

Two thin sections of the intrusions were examined under a petrographic microscope. Approximately 65% of the rock is composed of phenocrysts, and the other 35% is a light-colored, aphanitic groundmass of highly altered plagioclase and orthoclase. Approximately 75% of the phenocrysts are hornblende; feldspar and magnetite make up the remaining 5%. The hornblende phenocrysts occur as euhedral to subhedral laths that range from 0.01 to 2.5 cm in length. Most feldspar phenocrysts are blocky, subhedral to euhedral, highly altered plagioclase crystals.

These intrusions are post-Jurassic in age based on the cross-cutting relationships in the Skinner Peaks quadrangle. Witkind and others (1987) cite an Oligocene(?) to Upper Eocene age for similar intrusions in the vicinity; however, the relationship of these intrusions to Tertiary units is not exposed in the Skinner Peaks quadrangle.

TERTIARY-QUATERNARY

A variety of alluvial, colluvial, and lacustrine deposits blanket extensive areas of the Skinner Peaks quadrangle. These sediments range in age from Late Tertiary to Recent. They were deposited in response to tectonic and climatic events such as the development of the Gunnison Plateau and West Gunnison Monocline, the onset and continuation of Basin and Range faulting, and the advance and retreat of Lake Bonneville.

Older Alluvial Fans and Pediment Alluvium - Sediment that was eroded from the Gunnison Plateau and West Gunnison Monocline was shed off to the west in a series of alluvial fans much like those that have formed in present-day Juab Valley. The uplifted remnants of the old alluvial fans are exposed along the flank of the West Gunnison Monocline in an area that extends from Broad Canyon to the southern end of the quadrangle. The material that forms these deposits is semiconsolidated, massive to poorly-stratified, poorly-sorted (ranging in size from sand to boulders), and yellowish-gray in color. It is composed predominantly of sandstone, limestone, and conglomerate derived from the Green River Formation, and includes clasts of pebbly sandstone from the Crazy Hollow Formation, and volcanic clasts derived from the Goldens Ranch Formation.

The remnants of the old alluvial fans overlie the Goldens Ranch Formation, Green River Formation and Arapien Shale at various elevations, reflecting deposition over irregular paleotopography. This paleotopography may have been due in part to episodic Basin and Range faulting, which began in the Miocene shortly after development of the plateau and monocline. The thickness of these older alluvial fans varies from a few feet to 300 feet (Vogel, 1957). It is possible that these drastic thickness variations also reflect deposition over irregular paleotopography, with the thickest deposits representing paleo-lows and the thinner deposits representing paleo-highs.

Pediment alluvium, which caps the Goldens Ranch Formation in the South Hills, reflects an old erosional surface that developed during and after uplift of the South Hills area. The pediment alluvium, which is 0-20 feet thick, is very similar in texture and composition to the material that forms the old alluvial fans to the east. The most noticeable difference is the increased abundance of volcanic clasts, and the local occurrence of red, semi- to moderately consolidated, pebbly sandstone and sandy limestone. The red, pebbly sandstone and sandy limestone, which occur locally as pods between the Goldens Ranch Formation and the poorly consolidated upper pediment alluvium, may represent local ponds that formed on the erosional surface (Oviatt, per. comm., 1989). Like the old alluvial fans, the pediment alluvium occurs at relatively high elevations, reflecting the uplift and dissection that occurred after deposition.

The distribution of the pediment alluvium and the alluvial fans reflects Lustig's (1969) prediction that areas with larger highlands favor alluvial fan development, and areas with lower highlands favor pediment development.

The age of the older alluvial fans and the pediment alluvium is not known for certain. They are no older than Early Miocene because they formed after the development of the plateau and the onset of Basin and Range faulting. They are no younger than Earliest Pleistocene because Lake Bonneville sediments locally surround the bases of hills that these old alluvial deposits cap.

A solitary alluvial fan (mapped as Qaf in this study) corresponding to Qaf_3 of Clark (1987) was mapped in the NW corner of the quadrangle. This fan is very dissected, faulted, and higher in elevation than a younger fan which surrounds it. It is composed of light-brown, poorly-sorted, clay- to boulder-size material that is subangular to subrounded. The poorly-sorted nature of the deposit, plus its proximity to the mouth of a deeply incised canyon that cuts through the Flagstaff Formation indicate that this fan is a debris flow as Clark (1987) suggested. Clark (1987) estimates that the fan is at least 50 feet thick. Based on its relatively high elevation, and on the very dissected and faulted nature of the fan, it formed either in the Latest Tertiary or Earliest Quaternary.

QUATERNARY

Older Coalescing Alluvial Fans - Areas covered by old alluvial fans and pediment alluvium were differentially uplifted by Basin and Range faulting and then eroded, leaving only remnants of these old alluvial deposits capping the hills along the flank of the monocline and in the South Hills. The material that was eroded from these uplifted areas was deposited as a series of coalescing alluvial fans that fill present-day Juab Valley. Material that was derived from the South and West Hills was shed primarily to the east, although some was deposited in the low spots to the west of the South Hills. Material derived from the Gunnison Plateau was shed into Juab Valley to the west. As Clark (1987) noted, the fans from the Gunnison Plateau are significantly larger than those emanating from the West and South Hills; consequently the convergence line of the two fan systems lies west of the center of Juab Valley.

Coalescing fan alluvium is reddish-brown to yellowish-gray, unconsolidated, poorly-sorted, and massive to crudely bedded; local channels suggest a fluvial environment of deposition. Material is clay- to boulder-size, although sand- and pebble-size material is most common; grain size decreases in a down-fan direction. Quartzite, limestone, sandstone, and volcanic rocks form the majority of the pebble- and cobble-size clasts. Data from a gravity survey (Zoback, 1983) across northern Juab Valley indicates that alluvial fan deposits are approximately 3,900 feet thick in that portion of the valley. Since Juab valley shallows to the south, the equivalent deposits in the Skinner Peaks area to the south are probably thinner than those to the north.

The youngest sediment contained in the coalescing fans was deposited on the fan surfaces during Recent time; the oldest sediment contained in these fans was probably deposited in the Late Tertiary, although there is no observable evidence to confirm this. Lake Bonneville sediments overlap coalescing fan deposits in the southwest corner of the quadrangle, indicating that the deposits must be at least as old as Earliest Pleistocene.

Lake Bonneville Sediments - During the high stand of Lake Bonneville, which occurred approximately 16,000 - 17,000 years ago, water from the lake spilled through Leamington Canyon, drowning the Sevier River and forming a fresh-water estuary (Oviatt, personal comm., 1989) that extended almost as far south as Redmond (Currey, 1982). The eastern shore of this estuary cut across the southwestern corner of the Skinner Peaks quadrangle. Sediments deposited in the estuary are exposed in the low, gently-sloping, dissected, fan-shaped patches in the Washboard and in wave-cut cliffs along the Sevier Bridge Reservoir. These sediments occur up to an elevation of 5,090 feet, which was the overflow elevation of the lake during the Bonneville Stage (Currey, 1982). A change in vegetation pattern that is best observed on aerial photos also occurs between 5,090-5,100 feet. It is presumed, based on this elevation, that this change in vegetation marks the shoreline of Lake Bonneville. It also is presumed, on the basis of elevation, that water from Lake Bonneville spilled through Mills Gap and flooded the Chicken Creek Reservoir area. There are no deposits or shoreline features to substantiate this, but it is possible that Lake Bonneville sediments and shoreline features were there once but have been obliterated since by present-day Chicken Creek Reservoir.

Although exposures are poor except along the Sevier Bridge Reservoir, the sediments themselves are fairly distinctive (especially on aerial photos) and can be distinguished from the surrounding alluvium without much difficulty. Poor exposures obscure the nature of the contact between the Lake Bonneville sediments and the surrounding alluvium, but at one location (section 30, T. 16 S., R. 1 W.) the lake sediments clearly overlap the Quaternary-Tertiary pediment alluvim. Elsewhere (e.g., on the Washboard), the Bonneville sediments are slightly higher than the adjacent alluvium which suggests deposition of the Lake Bonneville sediments on top of the adjacent alluvium. This observation is consistent with the relationships observed by Mattox (1986) in the Hells Kitchen Canyon SE quadrangle, 10 miles southeast of the present study area.

The Bonneville sediments are light brown, unconsolidated, coarse- to fine-grained sand, silt, and mud. These sediments form a fining-upward sequence that is 30-60 feet thick, and composed mostly of silt and mud. Deposits are finely laminated and cross-laminated; soft-sediment deformation structures and ripple cross-lamination are common near the base of the exposed section. These characteristics, combined with the lack of foreset and bottomset beds, fit Oviatt's (1984) description of underflow fan deposits, which are similar to deltaic deposits.

Younger Coalescing Alluvial Fan - A series of younger coalescing alluvial fans rests on top of older coalescing alluvial fans north of Little Salt Creek Canyon. The younger fans are very similar to their older counterparts; however, they are considerably smaller in size, and they slope more steeply toward the valley. The composition of these younger fans is also different from their older counterparts; most of the material is angular, pebble-size fragments of limestone that were derived from the Arapien Shale. These deposits are only 50-100 feet thick.

Younger alluvial fans, such as those that are found north of Little Salt Creek Canyon, form in response to climatic or tectonic changes that lower base level (Pazzaglia and Wells, 1989; Bull, 1990). In the Skinner Peaks area base level could have been lowered by the retreat of Lake Bonneville, continued Basin and Range faulting or a combination of both of these events.

The very local occurrence of the younger alluvial fans suggests that they formed in response to renewed uplift along a fault segment and not in response to the regional lowering of base level that would have resulted from the retreat of Lake Bonneville. This hypothesis is supported by the presence of Recent fault scarps that cut the older coalescing alluvial fans; however the older coalescing alluvial fans in Juab Valley and the Lake Bonneville sediments are incised by gullies that are as much as 15 feet deep, which suggests a regional lowering of base level. Perhaps the deep gullies are an expression of a regional lowering of base level that was due to the retreat of Lake Bonneville, and the younger alluvial fans reflect Recent Basin and Range activity on a local fault segment. Assuming that these younger alluvial fans are related to the Basin and Range faulting that produced the fault scarps, the age of these fans is Late Pleistocene to Recent.

Colluvium, Alluvium, and Landslide Deposits - The youngest sediments in the quadrangle are colluvium, alluvium, and landslide deposits, which are all Recent in age. The colluvium forms steeply-sloping, cone-shaped deposits along the base of the slopes from which it was derived. It is unconsolidated, very angular, very poorly-sorted, clay- to boulder-size material. The color and composition of these deposits reflect the formation or formations from which they were derived. These deposits are 0-15 feet thick.

The alluvium occurs along most drainages; at higher elevations, such as Flat Canyon and the South Hills, it forms broad, even surfaces of low relief. Like the colluvium, the composition and color of the alluvium reflect the local bedrock from which it was derived. In most cases it is unconsolidated, gray or brown in color, and massive to poorly stratified. Alluvial material is clay- to cobble-size, subangular to subrounded, and poorly- to well-sorted. These deposits are generally less than 30 feet thick.

Two landslides are the only mass-movement deposits that were observed in the Skinner Peaks quadrangle. One of the landslides occurred on the north side of Chriss Canyon in the SE 1/4 of section 11, T. 16 S., R. 1 W., the other is located south of Skinner Peaks in the SE 1/4 of section 22, T. 16 S., R. 1 W. Both of these landslides occurred in strata of the Green River Formation and consequently are composed of very angular, poorly-sorted blocks of carbonate and sandstone in a matrix of mudstone. The Chriss Canyon landslide occurred in 1984 (Weiss, per. comm., 1989) after a period of heavy rain. Presumably the Skinner Peaks landslide, which is as fresh as the Chriss Canyon landslide, also occurred in 1984.

STRUCTURE

The structural geology of the Skinner Peaks quadrangle is the result of Sevier thrusting, formation of the Colorado Plateau, Basin and Range faulting, and local diapirism of the Arapien Shale. The structures that were produced during one tectonic event were superimposed on the structures that formed during the previous tectonic event. This resulted in complex and confusing geologic relationships.

Sevier Thrusting

The Sevier Orogeny, which began in the Late Jurassic and continued into the Paleocene (Armstrong, 1968), was the first tectonic event that affected the Skinner Peaks quadrangle. It was characterized by eastward-directed thrusting which placed Precambrian, upper Paleozoic, and lower Mesozoic strata over strata as young as Middle Jurassic. Middle Jurassic marine shales such as the Arapien are structurally incompetent and consequently acted as glide planes for the thrusting that built the Sevier Highland.

There is very little surface evidence of Sevier thrusting in the Skinner Peaks quadrangle; however, substantial subsurface evidence (Standlee, 1982; Lawton, 1985; Clark, 1987) indicates that some surface features can be attributed to the event. Data collected from drill-holes in and adjacent to the study area reveal several stratigraphic repititions. These repetitions indicate thrust faults that formed during Sevier thrusting (Standlee, 1982; Lawton, 1985). Drastic variations of the thickness of the Arapien Shale and adjacent units are also attributed to thrusting.

The only surface evidence that can be attributed directly to Sevier thrusting is the highly contorted strata of the Arapien Shale. It is possible, however, that the unconformity that occurs between the Arapien Shale and strata of the North Horn, Green River, and Goldens Ranch Formations may be related to the Sevier orogenic event.

A recent study by Sims and Morris (1989) indicates that thrusting of a competent unit over an incompetent unit (e.g., the Sevier fold-and-thrust belt) will cause the incompetent unit to shorten and thicken close to the hinterland, and uplift will occur over the thickened region. As a result, the incompetent unit should be highly deformed, as is the Arapien Shale. Another possible result of this process is the formation of topographic highs in the area of thickening. Standlee (1985, per. comm. to S. Mattox) suggested that thrusting and folding indirectly may have caused the local Indianola highs observed by Weiss (1969) and Mattox (1986).

It is also possible that the paleo-highs are the result of diapiric movement of the Arapien Shale. Differential loading or tectonic activity is often necessary to initiate diapirism (Lemon, 1985; Jackson and Talbot, 1986); the influx of coarse-grained clastic material from the highland to the west, and the eastward directed thrusting that was occurring at this time would have provided both of these mechanisms. The presence of a thick section of oncolitic limestone on Skinner Peaks supports the theory that this area was actively rising during deposition.

Regardless of which explanation is correct, it is certainly reasonable to conclude that the unconformity that occurs between the Arapien Shale and strata of the North Horn, Green River, and Goldens Ranch Formations, is related to Sevier thrusting.

Formation of the Gunnison Plateau

West Gunnison Monocline - In the Skinner Peaks quadrangle the Colorado Plateau Province is represented by the Gunnison Plateau, which terminates as the West Gunnison Monocline inside the east edge of the quadrangle. The West Gunnison Monocline is approximately 18 miles long, and it extends from Fayette Wash in the Hells Kitchen Canyon SE quadrangle to Buck Canyon, north of Little Salt Creek Canyon (Mattox, 1986).

In the Skinner Peaks quadrangle the West Gunnison Monocline consists of Green River Formation and Goldens Ranch Formation strata which dip 25 to 30 degrees to the west or southwest. Dips of 55 degrees and greater were observed in Green River strata on Skinner Peaks, but these values are anomalously high and may reflect diapiric modification by the underlying Arapien Shale.

A thick section of Arapien Shale cores the monocline and extends eastward under the synclinal structure of the plateau. In general, the Arapien is highly deformed, and attitudes are quite variable. Attitudes measured in a relatively undeformed section below the Arapien-Green River unconformity south of Little Salt

Creek Canyon dip consistently 40 to 45 degrees SE; these attitudes are consistent with those observed by Zeller (1949) in Arapien strata east of the Skinner Peaks quadrangle.

Based on the interpretations of Standlee (1982) and Lawton (1985), the Arapien core of the monocline represents a ramp structure that formed during Sevier thrusting; it is likely that the variable attitudes of the Arapien strata reflect deformation due to the thrusting event, as well as later modification by tectonically activated diapirism.

The West Gunnison Monocline and the Gunnison Plateau formed during Late Oligocene or Early Miocene time. The timing of this event is constrained by the Oligocene Goldens Ranch Formation, which represents the youngest strata on the monocline. The conformable contact between the Green River Formation and overlying Goldens Ranch Formation indicates that monoclinal warping had not begun prior to deposition of the Goldens Ranch Formation.

Basin and Range Extension

The structural geology of the Skinner Peaks quadrangle is dominated by north-south trending, high-angle normal faults, including the Sage Valley Fault, the Western Juab Valley Fault Zone (WJVFZ), and the Wasatch Fault Zone (WFZ). Smaller normal faults also dissect the area.

Sage Valley Fault - The Sage Valley Fault is a high-angle, down-to-the-west fault which bounds the west side of the West Hills and the east side of Sage Valley. The fault trends approximately N10E; Clark (1987) states that the fault has at least 2,900 feet of throw. Triangular facets that have formed along the western side of the West Hills define the fault scarp. The fault does not cut any Quaternary units within the Skinner Peaks quadrangle.

Western Juab Valley Fault Zone - The Western Juab Valley Fault Zone (WJVFZ) bounds the West Hills on the east and Juab Valley on the west. This fault is thought to be part of a zone of concealed down-to-the-east, high-angle normal faults. Surface evidence for the WJVFZ is sparse. SE of Chicken Creek Reservoir the fault appears to place upper Goldens Ranch Formation against Green River Formation and lower Goldens Ranch Formation. The fault, which trends roughly N40°E, has an estimated throw of 1,000 feet.

Wasatch Fault Zone - The Wasatch Fault Zone (WFZ) bounds the west edge of the West Gunnison monocline, and the east edge of Juab Valley. It is a high-angle normal fault and is characterized by down-to-the-west movement. Triangular facets or faceted spurs of Arapien Shale south of Little Salt Creek Canyon Fault, and fault scarps in Pleistocene alluvial fans and attest to the presence of the fault. The fault scarps, which can be seen just west of Skinner Peaks, show approximately 5 to 10 feet of displacement. The Wasatch Fault trends approximately N20°E, and has an estimated throw of approximately 5,000 feet.

Recent gravity and seismic data presented by Zoback (1983) indicate that Juab Valley, which is bounded on the west by the Western Juab Valley Fault Zone and on the east by the Wasatch Fault Zone, is an asymmetric graben that contains up to 3,000 feet of alluvial fill.

Other Faults - Other faults that occur throughout the quadrangle include high-angle cross-faults such as those in the West Hills, and the fault which parallels Old Botham Road in the South Hills area. These structures are possibly related to local strain accomodation that occurred during Basin and Range extension.

Other Structures - Basin and Range normal faulting not only produced the structures described above, it also affected the structure of the West Gunnison Monocline by dissecting the west-dipping strata into a series of west-dipping fault-blocks that are bounded by north-south-trending normal faults. Strata in the southern end of the quadrangle have been affected most noticeably.

Vertical joints, which trend approximately 30 degrees west and east of north, are prevalent in Green River and Goldens Ranch strata. The joints, probably represent shear fractures that formed due to east-west extension.

Diapirism of the Arapien Shale

Evidence throughout the quadrangle indicates that diapiric movement of the Arapien Shale modified the structure of the area locally. This local, episodic diapirism was probably initiated by tectonic events such as Sevier thrusting, development of the West Gunnison Monocline, and Basin and Range extension.

Flat Canyon Graben and Skinner Peaks - Flat Canyon Graben is a structure that may represent an extensional graben that has been modified by diapiric collapse. This structure is approximately one mile wide. It begins near Timber Canyon in the Hells Kitchen Canyon SE quadrangle and extends north to Chriss Creek, where it bends to the west. This graben is bounded on the east by the high-angle, down-to-the-west normal fault which parallels the southwest front of the Gunnison Plateau. It places Hall Canyon Conglomerate against Flagstaff and Green River strata. The west edge of the graben is bounded by a down-to-the-east normal fault which places the Hall Canyon Conglomerate against Green River and Arapien strata.

The bend in the graben parallels the northwest trend of Skinner Peaks, which cuts across the otherwise north-south trending structures that are related to the Basin and Range-Colorado Plateau provinces. The graben, like Skinner Peaks, is underlain by Arapien Shale. The presence of the Arapien in the subsurface beneath the Flat Canyon graben is manifest in salty well water and sink holes (W. Jay Dalley, landowner, per. comm., 1989). It seems reasonable to assume from this evidence that the structure of the Flat Canyon Graben and the adjacent Skinner Peaks is controlled in part by diapiric collapse of the Arapien. It also seems reasonable to assume, based on the timing of the event, that the mobility of the Arapien was triggered by Basin and Range faulting.

Other Diapir Related Structures - Rootless fault blocks of Green River formation can be observed "floating" in Arapien Shale on the flanks of Skinner Peaks in the NE 1/4 of section 22, and the SW 1/4 of section 15 T. 15 S., R. 1 W.. These blocks are similar to the detached blocks of Colton and Green River Formation described by Willis (1986) approximately 30 miles to the south in the Salina quadrangle. I concur with Willis' (1986) interpretation that these detached blocks are slump blocks which, in this case, slid off of the Skinner Peaks block.

A small syncline in Green River strata that unconformably overlie the Arapien Shale in the NE corner of the Skinner Peaks quadrangle is also thought to have formed by diapiric movement of the Arapien (Sprinkel, per. comm., 1989). Contacts between the Arapien and overlying units are often sheared, with slickensides and well-foliated clays similar to those described by Willis (1986) in the Salina quadrangle. These contacts are also indicative of movement.

ECONOMIC GEOLOGY

Economic deposits in the Skinner Peaks quadrangle and vicinity include sand and gravel, gypsum, tuff, carbonate rock, manganese, petroleum products, and water. The sand and gravel occurs as alluvial, colluvial, and lacustrine deposits. Material ranges in size from clay to boulders; most material is sand and gravel composed of quartzite and carbonate clasts, with local concentrations of volcanic clasts. The sand and gravel, which is used primarily as road ballast, is quarried from numerous gravel pits throughout the quadrangle.

Active quarrying of gypsum from the Arapien Shale on the NE side of Skinner Peaks began in 1989. This gypsum can be used in the production of dry-wall or as a bonding agent in cement.

Tuff from Unit IV (Tvg_4) of the Goldens Ranch Formation formerly was quarried south of Skinner Peaks and in the Painted Rocks area for use as poultry grits, and soil mineralizer and conditioner (Vogel, 1957). This operation was run by the Azome Utah Mining Company of Sterling, Utah, and the products were marketed under the trade name "Azomite" (Vogel, 1957).

Carbonate rock that is found in the Flagstaff Limestone and Green River Formation possibly could be used as building or dimension stone. Unfortunately, in the Skinner Peaks quadrangle neither of these formations contain sufficient amounts of limestone or dolomite to make quarrying a profitable economic venture because both formations contain anomalously high amounts of coarse-grained clastic material.

Small amounts of manganese occur in fault zones within the volcaniclastic Goldens Ranch Formation. The manganese occurs as dendritic pyrolusite in a calcite matrix. Pyrolusite is a secondary mineral that results from the alteration of manganese minerals (Edwards and Atkinson, 1986) which are present in small amounts in most crystalline rocks (Hurlbut and Klein, 1971). The manganese that forms the pyrolusite was probably leached from the surrounding Goldens Ranch Formation and deposited with calcite along the fault zones.

Oil and gas exploration has taken place throughout central Utah because of the structural similarities between it and the producing overthrust belt of Wyoming (Clark, 1987). Several oil companies have drilled test wells in Juab Valley and on the Gunnison Plateau in SE Juab County; no productive reservoirs have been discovered to date.

WATER RESOURCES

Water resources are somewhat limited in the Skinner Peaks quadrangle. Surface water occurs in the Chicken Creek and Sevier Bridge Reservoirs, in Chicken Creek, and as small springs in the vicinity of the Skinner Peaks. Depth to the top of the water table is more than 100 feet (Bjorklund and Robinson, 1968) in the area of Juab Valley that lies between the South Hills and the west margin of the Gunnison Plateau.

GEOLOGIC HAZARDS

Earthquakes, mass movements, karst development, and groundwater contamination are the potential geologic hazards in the Skinner Peaks quadrangle and vicinity.

The Skinner Peaks quadrangle is centered roughly on the Wasatch Fault Zone, which is part of the Intermountain seismic belt (McKee and Arabasz, 1982); the potential for catastrophic earthquakes is high. Earthquakes may result in destructive ground shaking, surface rupture of alluvium, soil liquefaction, and differential settling (Clark, 1987); they also may trigger mass movements such as snow avalanches and landslides. Landslides also may occur simply because strata are incompetent or poorly consolidated. Heavy rain or large volumes of melt-water moving over steep, sparsely-vegetated mudstone slopes may result in mass wasting.

The development of karst topography and contamination of groundwater are both related to the Arapien Shale. The evaporite-rich Arapien underlies much of the Skinner Peaks quadrangle. Groundwater moving through the Arapien dissolves the evaporites, causing surface collapse and subsequent formation of sink-holes; evaporite dissolution also results in the contamination of the groundwater. Land-owner W. Jay Dalley reported the development of sink-holes and collapse structures in hay fields in Flat Canyon; he also reported salty water in a stock well in Flat Canyon. Vogel (1957) and Hunt (1950) cite similar reports from local residents concerning the quality of well water.

GEOLOGIC HISTORY AND INTERPRETATIONS

Aspects of the geologic history of the Skinner Peaks quadrangle were discussed throughout the stratigraphy and structural geology sections of this manuscript. A brief synopsis of the geological history is presented here along with interpretations concerning the structure and stratigraphy of the quadrangle.

The Precambrian through Early Jurassic interval was dominated by deposition of marine and continental sediments in the Cordilleran miogeocline. These rocks are not exposed as bedrock in the quadrangle, but they do occur in the subsurface, and as clasts in conglomerate of the North Horn, Flagstaff, Colton, Green River, and Goldens Ranch Formations. The oldest exposed strata are the marine shales of the Middle Jurassic Arapien Shale. The sediments that comprise these strata were deposited by a shallow arm of the sea which advanced from Canada, through central Utah and into northern Arizona. By the Late Jurassic this sea had retreated to the north. Compression caused by the subduction of the Pacific Plate under the North American Plate also started to affect central Utah around this time. Eastward-directed thrusting placed Precambrian, Paleozoic, and Mesozoic strata over the incompetent Arapien Shale which acted as a glide plane. This thrusting built the Sevier Highland and corresponding foreland basin.

In Middle and Late Cretaceous time, the Skinner Peaks quadrangle, which was located in the foreland basin just east of the Sevier Highland, began to receive sediment that was being eroded from the highland and deposited in the basin as alluvial fans. Continued thrusting to the east, and the differential loading that was caused by the influx of sediment from the west, initiated diapiric movement of the evaporite-rich Arapien Shale. This local, episodic diapirism produced local topographic highs of Arapien Shale within the basin. Consequently, unconformities developed between the Arapien and various Cretaceous-Tertiary units that were being deposited in the foreland basin. Based on the stratigraphic relationships and the abundance of oncolitic limestone on Skinner Peaks, this area was the site of an actively rising topographic high of Arapien Shale.

The unconformity between the Arapien and the Green River Formation indicates that tectonically activated diapirism continued through the Early Tertiary, during which time the foreland basin was dominated by alternating lacustrine and fluvial conditions which produced the strata of the Flagstaff, Colton, and Green River formations. In the Skinner Peaks quadrangle these formations have an anomalously high clastic fraction because the quadrangle was located along the western margin of the basin.

Wide-spread volcanism dominated the landscape of central Utah in the Oligocene, producing formations such as the volcaniclastic Goldens Ranch Formation. Episodic diapirism was still occurring, based on the unconformable contact between the Arapien and the Goldens Ranch Formation.

The Gunnison Plateau and the West Gunnison Monocline formed in the Late Oligocene after deposition of the Goldens Ranch Formation. Sediment was eroded from the plateau and monocline, and deposited into coalescing alluvial fans in the basin to the west.

Basin and Range extension began shortly after the formation of the monocline. The extension dissected the area with north-south trending normal faults such as the Sage Valley and Wasatch faults, and produced east- and west-dipping fault blocks. Uplifted areas were dissected and eroded, and the sediment was deposited as alluvial fans in present-day Juab Valley.

In the Pleistocene, Lake Bonneville reached the Bonneville Stage, flooding the Sevier River and depositing underflow fan sediments. Approximately 2,000 years later the lake retreated catastrophically, lowering the regional base level. Active down-cutting through the alluvial fans in Juab Valley, and in stream gullies attests to the change in base level; continued Basin and Range extension also steepened the average regional gradient. Fault scarps that cut alluvial fan deposits, and the formation of secondary alluvial fans are evidence of Recent Basin and Range faulting.

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FIGURE CAPTIONS

Figure 1: Clasts of Paleozoic quartzite and carbonate in conglomerate of the Colton Formationin the West Hills north of Mills Gap.

Figure 2: Oncolitic limestone in North Horn or Flagstaff strata on Skinner Peaks. (Photo by S. R. Mattox.)

Figure 3: Outcrop of epiclastic conglomeratic sandstone of Unit I of the Goldens Ranch Formation. Note the cross-bedding, pebble lenses, and typical blue-gray color. Hammer for scale in center of photo. Photo taken in the Painted Rocks area. (Photo by S. R. Mattox.)

SKINNER PEAKS SECTION

This section was measured on a southwest traverse beginning on the 5700 ft contour, just south of the jeep trail in the SE 1/4 of section 15, T. 16 S., R. 1 W.; strata dip approximately 30 degrees SW.

UNIT# & (SAMPLE3)	UNIT THICKNESS	CUMULATIVE THICKNESS	DESCRIPTION
13	17.0	745.0	Sandy limestone, grayish-yellow (5Y 8/4); slope-forming.
12	15.0	728.0	Calcareous sandstone, pinkish-gray (5YR 8/1), weathered and fresh; massive, ledge-forming; sand is 80% quartz, subangular to subrounded, moderately-sorted.

11	95.0	713.0	Sandy limestone, variable color; weathers into plates; sand is medium-grained, subrounded quartz.

GREEN RIVER FORMATION

FLAGSTAFF LIMESTONE or NORTH HORN FORMATION

10	50.0	618.0	Interbedded pebble conglomerate and sandstone lenses; sandstone contains algal mat pieces (up to 5 inches) and oncolites; composed of medium-grained, well-sorted, subangular to subrounded quartz; conglomerate clasts are 50% quartzite (rounded tan and purple from the Cambrian Tintic Quartzite, and the Precambrian Mutual Formation) and 50% carbonate (Paleozoic).
9	60.0	568.0	Sandy limestone and sandstone, pale-reddish-brown (10R 5/4); forms a slope with local ledges; sand is medium-grained quartz.
8 (SK-8)	81.0	508.0	Oncolitic limestone, yellowish-gray (5Y 7/2); cliff-forming; oncolites up to 3 inches in diameter.
7	15.0	427.0	Covered slope.

6 (SK-6)	10.0	412.0	Limestone, finely-crystalline, light-gray (N7); massive, ledge-forming.

FLAGSTAFF LIMESTONE or NORTH HORN FORMATION

NORTH HORN FORMATION (?)

5 (SK-5)	55.0	402.0	Conglomerate interbedded with sandstone; cliff and ledge-forming; sandstone is light-gray (N7); composed of medium-grained, subangular to subrounded, well-sorted quartz; locally cross-bedded; conglomerate is clast-supported; 80% of the clasts are subangular to subrounded cobbles composed of Paleozoic carbonates (75%) and Precambrian/Cambrian quartzite (25%); matrix is medium-grained, well-sorted, rounded quartz sand.

4	220.0	347.0	Conglomerate; cliff and ledge-forming; clasts are subangular to subrounded pebbles, cobbles, and boulders of purple and tan quartzite derived from the Precambrian Mutual Formation and Cambrian Tintic Quartzite respectively; matrix is coarse-grained quartz sand; unit is gray at base, and changes to red up-section.
3	90.0	127.0	Slope covered with rubble of quartzite boulders and cobbles; derived from the conglomerate that is up-slope.

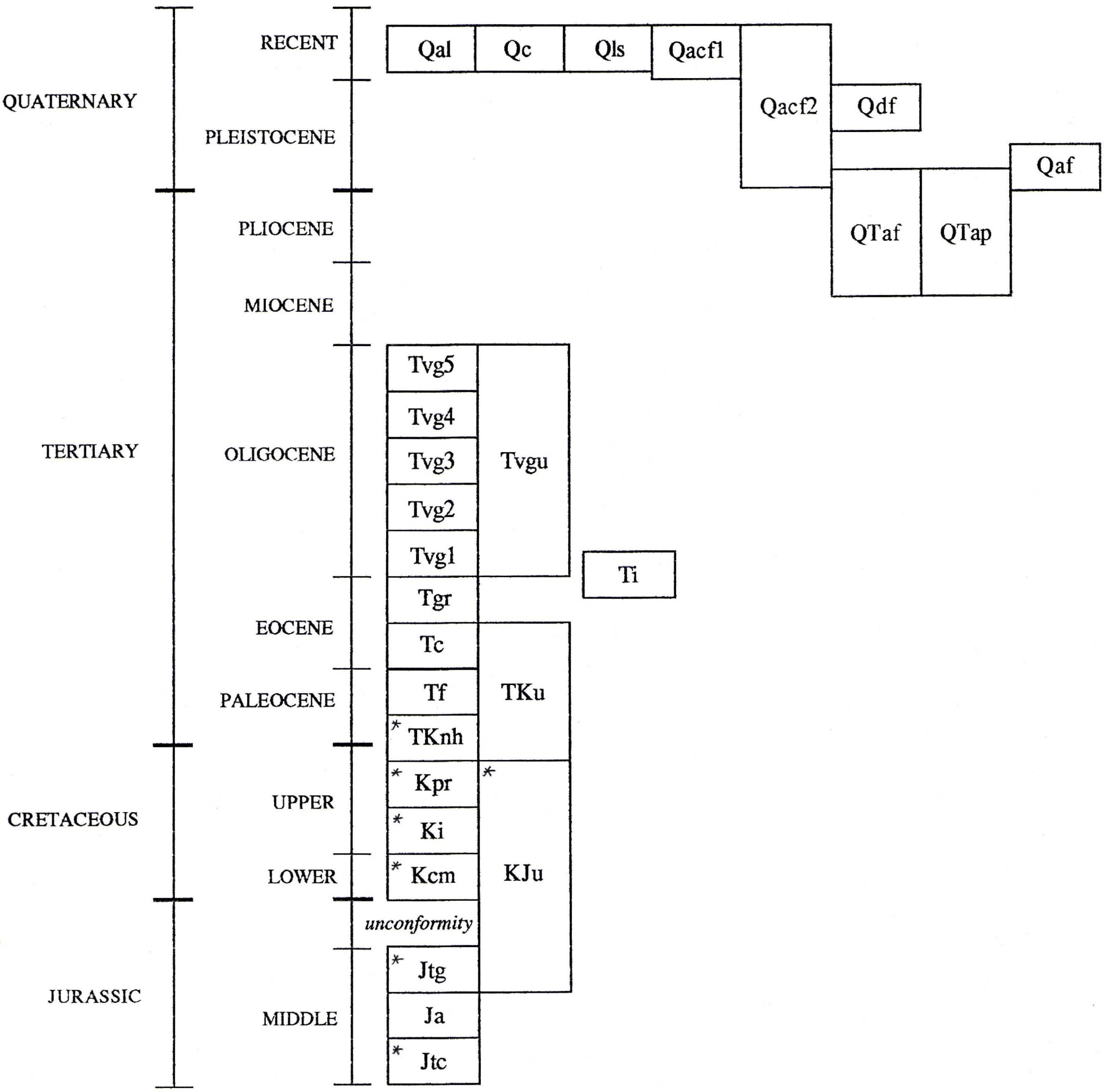
NORTH HORN FORMATION (?)

ARAPIEN SHALE

2	2.0	37.0	Limestone, finely-crystalline, grayish-green (10GY 5/2); ledge-forming; separated from unit 3 by a fault.
1	35.0	35.0	Calcareous mudstone, grayish-green (10GY 5/2).

for Plate 2

CORRELATION OF MAP UNITS



* on cross-sections only

MAP SYMBOLS

CONTACT

Dashed where inferred; dotted where concealed

FAULT

Dashed where inferred, dotted where concealed;

bar and ball on downthrown side

Test well

Tie-line (connects areas of like lithology)

Gravel pit

Open-pit gypsum mine

STRIKE AND DIP OF BEDS

Inclined Horizontal

Vertical