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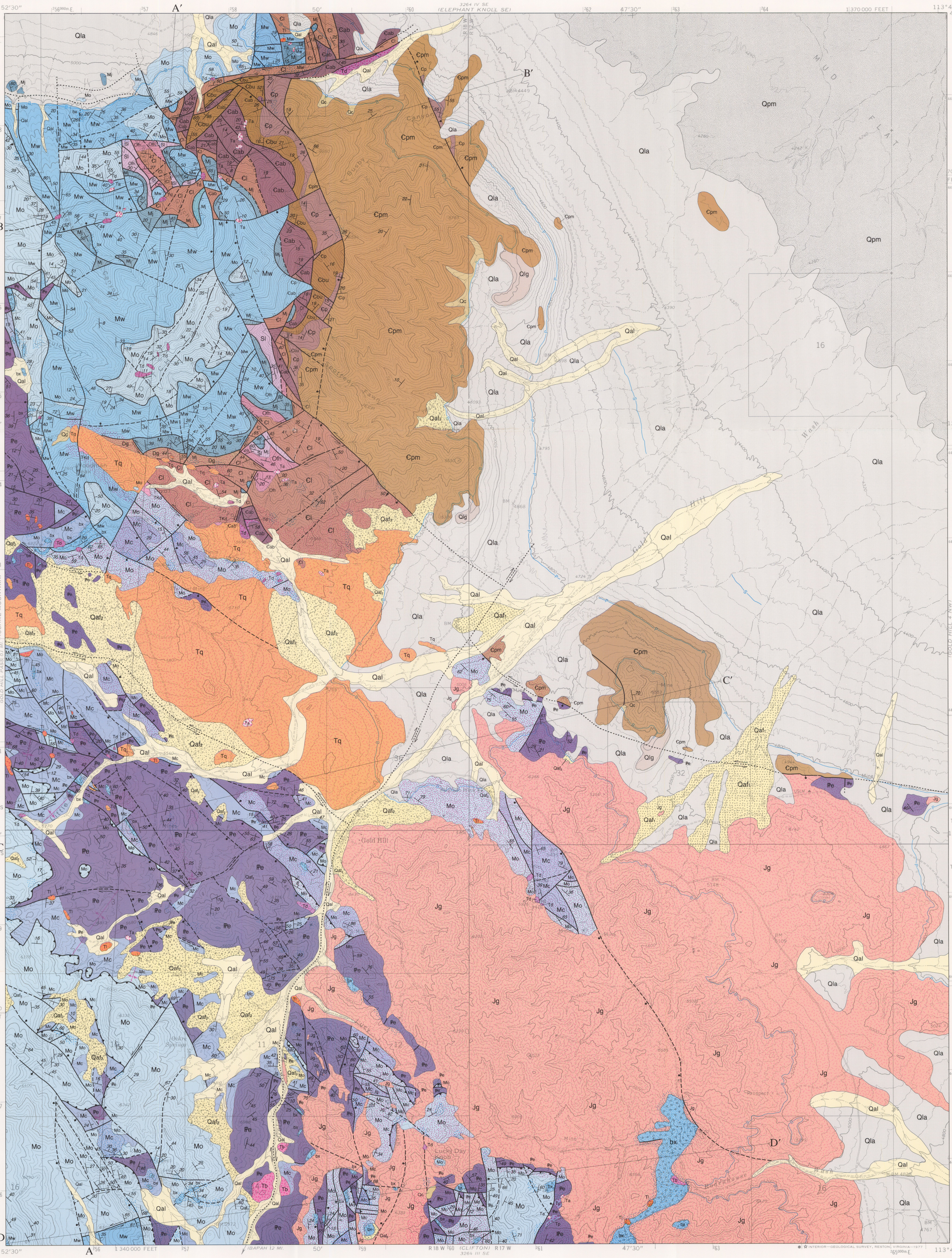
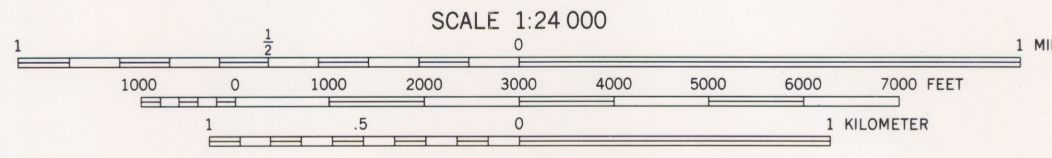
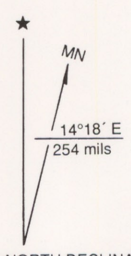


Base from U. S. Geological Survey Gold Hill 7.5′ Quadrangle, 1973

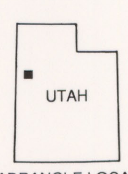


CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology by author from 1984 to 1988
J.Parker, Cartographer



1993 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



QUADRANGLE LOCATION

PROVISIONAL GEOLOGIC MAP OF THE GOLD HILL QUADRANGLE, TOOELE COUNTY, UTAH

by

James P. Robinson

1993

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

Qal ALLUVIUM - *Sand and silt in active streams and washes.*

Qpm PLAYA MUD - *Undifferentiated playa mud.*

Qaf1 YOUNGER ALLUVIAL-FAN DEPOSITS - *Fan deposits of cobble, gravel, sand, and silt found on piedmont slopes below Bonneville shoreline.*

Qlg LACUSTRINE GRAVEL - *Well-rounded and sorted cobble, gravel, and sand that form shoreline deposits of Lake Bonneville.*

Qla UNDIFFERENTIATED LACUSTRINE AND ALLUVIAL DEPOSITS - *Soft, white, calcareous clay and lacustrine silt, forming thin veneers over older alluvium and pediment surfaces.*

Qc COLLUVIUM - *Poorly sorted sand and silt, forming high slopes.*

Qaf2 OLDER ALLUVIAL-FAN DEPOSITS - *Poorly sorted boulder- to silt-sized deposits. Occurs on mountain fronts at or above piedmont slopes, separates bedrock from piedmont lacustrine and alluvial deposits.*

Tp PYROCLASTIC ROCKS - *Well-bedded, red and purple, poorly consolidated, tufaceous breccias and water-lain crystal lithic tuffs.*

Tb BASALT - *Black, aphanitic to cryptocrystalline, porphyritic plagioclase, clinopyroxene, and olivine basalt.*

Ta ANDESITE AND DIABASE DIKES - *Dark-green, aphanitic, porphyritic andesite dikes and dark-brown to black, highly weathered augite- and hypersthene-bearing diabase dikes.*

Tl LATITE AND TRACHYTE - *Dark-red to black, porphyritic, clinopyroxene- and orthopyroxene-bearing latite and light-green, porphyritic hornblende and clinopyroxene-bearing trachyte.*

Td QUARTZO-FELDSPATHIC DIKES - *Various ages and textures including leucogranite, quartz monzonite, granodiorite, granite, rhyolite, dacite, aplite, and quartz porphyry.*

Tq QUARTZ MONZONITE - *Light-pinkish-gray, medium- to coarsely crystalline, leucocratic to mesocratic, equigranular, locally porphyritic, biotite, hornblende quartz monzonite to granite.*

TKd DIORITE - *Finely to medium-crystalline, mesocratic to melanocratic, equigranular diorite.*

bx SILICIFIED BRECCIA - *Dense, resistant, variegated, commonly dark colored, brecciated jasperoid, silicified sandstone and carbonate rocks, including siliceous fracture and vug fillings.*

Jg GRANODIORITE - *Medium- to coarsely crystalline, mesocratic, violet to dark-purple alkali feldspars, equigranular, locally porphyritic, biotite, hornblende granodiorite to granite with minor quartz monzodiorite and monzodiorite.*

IPe ELY LIMESTONE - *Light-gray, cliff-forming, coarsely crystalline limestone and dolomitic limestone overlain by white to light-gray, fine- to medium-grained, limey, dolomitic, lithic arenite interbedded with limestone and dolomite.*

Mc CHAINMAN SHALE - *Predominantly light-gray to black, fine- to medium-grained quartzite; also includes black fissile shale, and dark-gray to black micritic limestone.*

Mo OCHRE MOUNTAIN LIMESTONE - *Cliff-forming, dark-blue to blue-gray, finely crystalline to micritic, thick-bedded, locally cherty, locally fossiliferous limestone.*

Mw WOODMAN FORMATION - *Basal phosphoritic siltstone, shale, and limestone overlain by light-brown to light-gray, platy, calcareous siltstone; upper portions consist of dark-gray, sandy, micritic, locally laminated limestone.*

Mj JOANA LIMESTONE - *Cliff-forming, dark-gray, medium- to coarsely crystalline, thin- to medium-bedded, cherty, locally very fossiliferous limestone.*

Dg GUILMETTE FORMATION - *Light-gray to blue-gray, finely to coarsely crystalline, structureless, recrystallized dolomitic marble.*

Sl LAKETOWN DOLOMITE - *Laminated, light- and dark-gray dolomite, succeeded by thick-bedded, finely to medium-crystalline, dark-gray dolomite and light-gray, sucrosic dolomite.*

Ofh FISH HAVEN DOLOMITE - *Thick-bedded, dark-gray to black, finely to medium-crystalline, vuggy, locally fossiliferous, locally mottled and bleached dolomite.*

Ꞓl LAMB DOLOMITE AND ORR FORMATION (UNDIFFERENTIATED) - *Light-gray to blue-gray dolomite, some black beds, medium- to coarsely crystalline, thick-bedded, sandy, locally vuggy pisolitic minor limestone and sandstone with some fossil hash.*

Ꞓab ABERCROMBIE FORMATION - *Heterogeneous unit with dark-brown, thick-bedded, medium- to coarsely crystalline dolomite, dark-blue, coarsely crystalline limestone and dark-gray to grayish-brown, platy, brittle, limey, trilobite-bearing siltstone.*

Ꞓbu BUSBY QUARTZITE - *Cliff-forming, grayish-brown, medium- to coarse-grained quartzite interbedded with fine- to medium-grained arkosic to lithic arenite, some argillaceous sandstone, quartzwacke, and dark-green shale.*

Ꞓp PIOCHE SHALE - *Slope-forming, dark-green to black, schistosic, chloritic, pyritic shale with finely laminated black shale, calcareous shale, and argillaceous sandstone.*

Ꞓpm PROSPECT MOUNTAIN QUARTZITE - *Cliff-forming, light-gray to white, fine-grained quartzite and variegated, fine- to medium-grained quartz arenite to subarkose; heavily iron-oxide stained and highly jointed; some pebble conglomerate .*

LITHOLOGIC COLUMN

SYSTEM	SERIES	FORMATION	SYMBOL	THICKNESS meters (feet)	LITHOLOGY
PENN.	MO. AT. DE.	Ely Limestone	IPe	±425 (±1,400)	
MISSISSIPPIAN	CHESTERIAN	Chainman Shale	Mc	±150 (±495)	
		Ochre Mountain Limestone	Mo	±450 (±1,475)	
	MERM.	Woodman Formation	Mw	±360 (±1,180)	
	OS. K.	Joana Limestone	Mj	112 (370)	
DEV.	FA.	Guilmette Fm.	Dg	<67 (<220)	
SIL.		Laketown Dolomite	Sl	±180 (±590)	
ORD.	UP.	Fish Haven Dolomite	Ofh	84 (275)	
CAMBRIAN	UPPER	Lamb Dolomite/ Orr Formation	Ꞓl	<485 (<1,590)	
	MIDDLE	Abercrombie Formation	Ꞓab	<570 (<1,870)	
		Busby Quartzite	Ꞓbu	137 (450)	
	LOWER	Pioche Shale	Ꞓp	149-160 (490-527)	
		Prospect Mountain Quartzite	Ꞓpm	>900 (>3,000)	

MAP SYMBOLS

CONTACT (dashed where approximate)

FAULTS (dashed where approximate, dotted where covered; arrows show relative movement; arrow and number indicate dip; queried where uncertain). *Cross section:* T=toward viewer, A=away from viewer.

Normal fault (bar and ball on downthrown side)

Fault of uncertain geometry

Low-angle normal fault #3 ((LANF-3)--ticks on upper plate)

Low-angle normal fault #2 ((LANF-2)--ticks on upper plate)

Low-angle normal fault #1 ((LANF-1)--ticks on upper plate)

Older low-angle normal fault (boxes on downthrown side)

Ochre Mountain thrust fault (barbs on upper plate)

FOLDS (single arrow is direction of plunge)

Anticlinal fold

Synclinal fold

STRIKE AND DIP OF BEDDING

GEOMORPHOLOGIC FEATURES

Trace of Bonneville shoreline

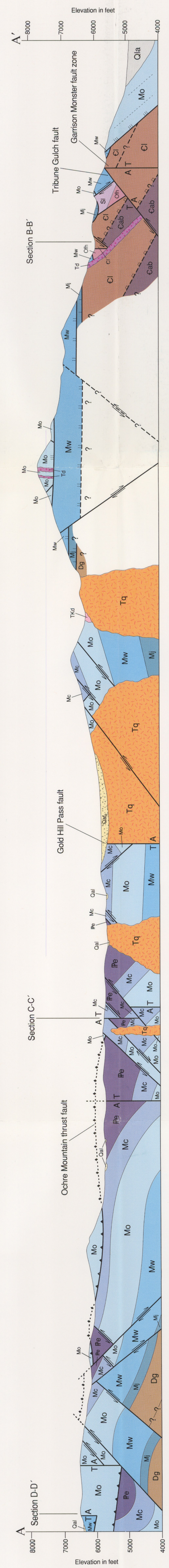
Trace of Provo shoreline

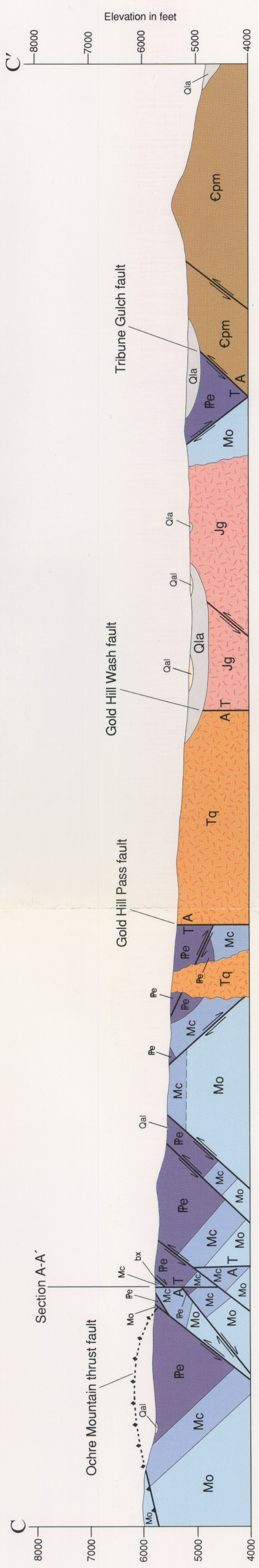
Trace of Stansbury shoreline

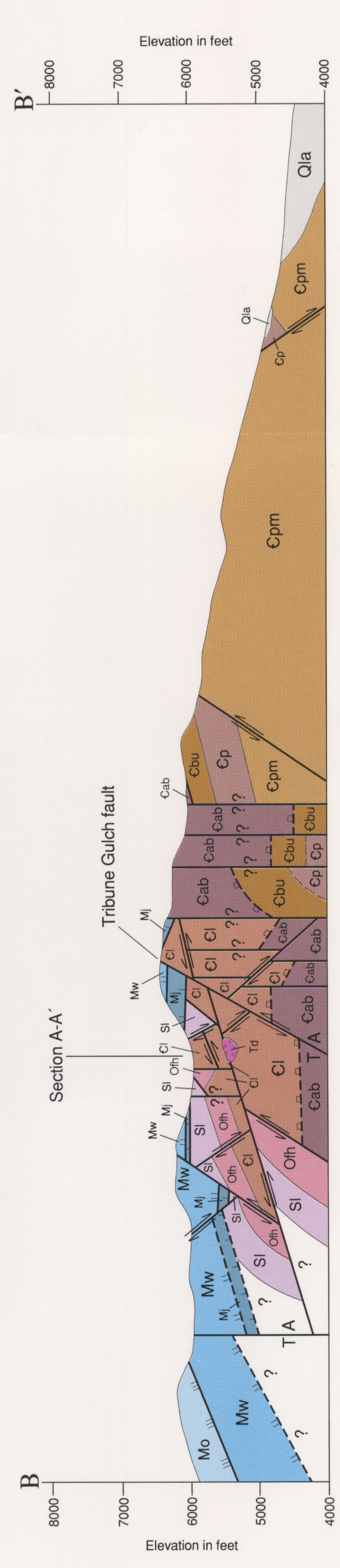
ALTERED ROCK (generalized)

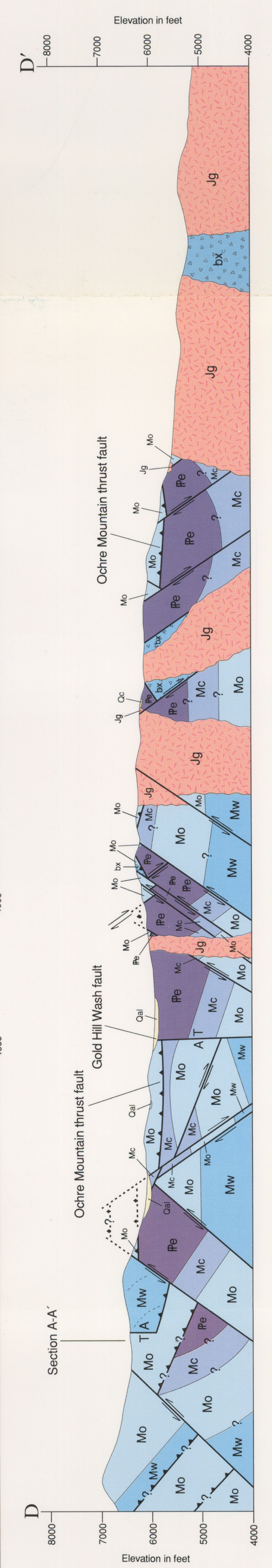
Undifferentiated contact metamorphism; includes marble, hornfels, and skarn.

Partial, variable silicification.









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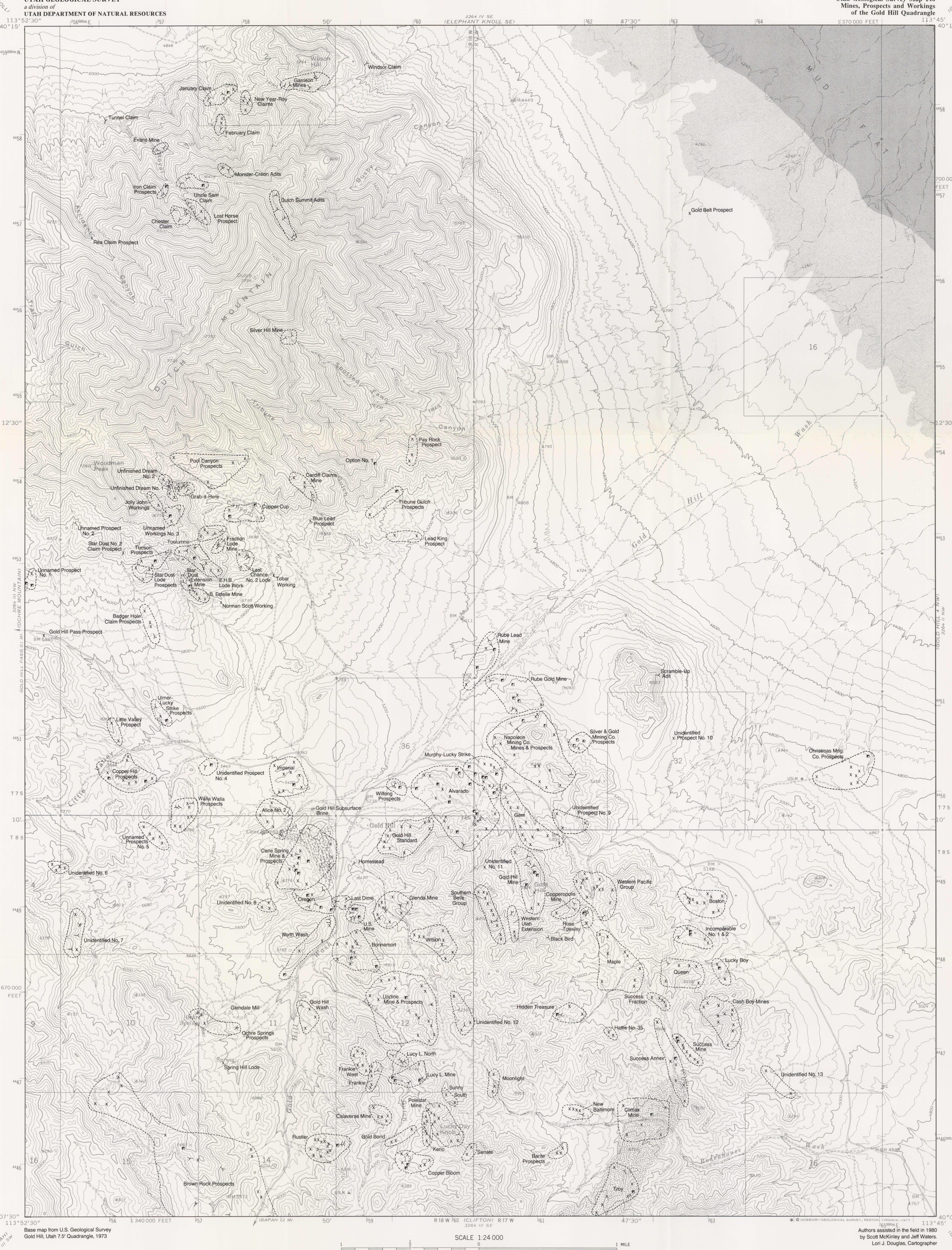

Base map from U.S. Geological Survey
Gold Hill, Utah 7.5′ Quadrangle, 1973

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Authors assisted in the field in 1980
by Scott McKinley and Jeff Waters.
Lori J. Douglas, Cartographer

SYMBOLS

- ADIT
- INACCESSIBLE ADIT
- SHAFT
- PROSPECT
- ASSOCIATED WORKINGS
- RODENHOUSE WASH BERYLLIUM DEPOSITS — *Hydrothermal, beryllium mineralization forming veins in carbonate rock, bertrandite - quartz - adularia veins associated with Mesozoic intrusive rocks.*
- ANDALUSITE HORNFELS (KYANITE-BEARING)
- SUBSURFACE BRINES

14°18′ E
254 mils

1993 MAGNETIC NORTH DECLINATION
AT CENTER OF SHEET

UTAH

QUADRANGLE LOCATION

MINES, PROSPECTS, AND WORKINGS OF THE GOLD HILL 7.5′ QUADRANGLE, TOOELE COUNTY, UTAH

by
H.M. Messenger and H.H. Doelling
compiled by
B.T. Tripp and M.E. Jensen
Utah Geological Survey
1993

Robinson PROVISIONAL GEOLOGIC MAP OF THE GOLD HILL QUADRANGLE, TOOELE COUNTY, UTAH UGS MAP 140

PROVISIONAL GEOLOGIC MAP OF THE GOLD HILL QUADRANGLE, TOOELE COUNTY, UTAH,

by

James P. Robinson

Consulting Geologist

with a plate of the

MINES, PROSPECTS, AND WORKINGS OF THE GOLD HILL QUADRANGLE

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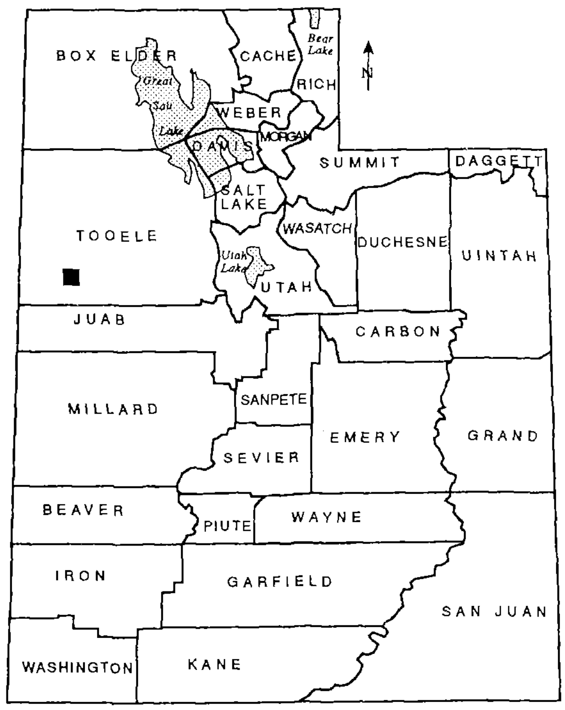
H.M. Messenger, H.H. Doelling, B.T. Tripp, and M.E. Jensen



MAP 140 1993

UTAH GEOLOGICAL SURVEY

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PROVISIONAL GEOLOGIC MAP OF THE GOLD HILL QUADRANGLE, TOOELE COUNTY, UTAH,

by
James P. Robinson
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with a plate of the

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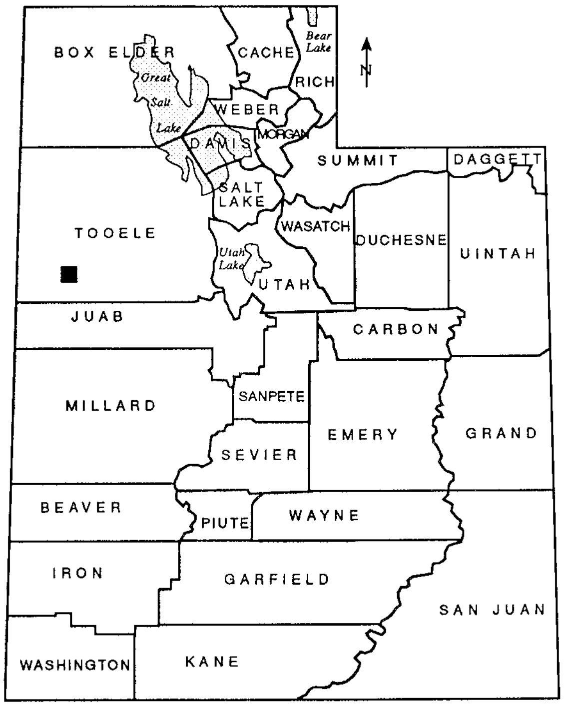

MAP 140 1993
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES

PROVISIONAL GEOLOGIC MAP OF THE GOLD HILL QUADRANGLE, TOOELE COUNTY, UTAH,

by

James P. Robinson

Consulting Geologist

Salt Lake City, Utah

ABSTRACT

The Gold Hill area of the northern Deep Creek Range of western Utah has undergone a diverse and complicated history of deposition, igneous activity, deformation, and mineralization.

Paleozoic strata, associated with the Cordilleran miogeocline, exposed at Gold Hill include: Cambrian Prospect Mountain Quartzite, Pioche Shale, Busby Quartzite, Abercrombie Formation, and Lamb Dolomite and Orr Formation (undifferentiated); Ordovician Fish Haven Dolomite; Silurian Laketown Dolomite; Devonian Guilmette Formation; Missisippian Joana Limestone, Woodman Formation, Ochre Mountain Limestone and Chainman Shale; and Pennsylvanian Ely Limestone. Cenozoic lacustrine, alluvial, and colluvial deposits unconformably overlie Paleozoic strata at various locations.

A general chronological sequence of igneous events in Gold Hill is: 1) intrusion of Late Jurassic granodiorite (152 m.y.), 2) intrusion of diorite that can only be constrained as pre-late Eocene, 3) intrusion of Late Eocene quartz monzite (42-38 m.y.), 4) eruption of latite (39 m.y.), 5) intrusion of andesite dikes, 6) eruption of basalt (14-12 m.y.), and 7) intrusion of aplite and granitic dikes.

Post-Pennsylvanian to pre-Late Jurassic deformation at Gold Hill includes: 1) NE-trending open folds, 2) emplacement of the Ochre Mountain thrust fault, a NE-vergent feature with 10 km (6.3 miles) of displacement, and 3) several events of high- and low-angle extensional faulting. Structures of Late Jurassic-late Eocene age are: 1) a low-angle normal fault at the base of the Joana Limestone, 2) a mosaic of strike-slip faults with principal displacement zones that strike NW and ENE, and 3) a low-angle normal fault at the base of the Woodman Formation. Post-late Eocene structures include: 1) a low-angle normal fault at the base of the Ochre Mountain Limestone, 2) ENE-striking, high-angle normal faults, 3) NW-striking, high-angle normal faults, and 4) the Gold Hill Wash fault, a NNW-striking, right-lateral, strike-slip fault.

The Gold Hill mining district is one of the oldest mining sites in the state of Utah, producing arsenic, gold, tungsten, lead, copper, silver, and zinc since 1857. Five ages of mineralization are proposed for the Gold Hill area: 1) Late Jurassic tungsten skarns and polymetallic replacement deposits, 2) pre-late Eocene Tertiary?) polymetallic veins rich in silver, lead, and zinc, 3) late Eocene tungsten skarns, 4) Tertiary polymetallic veins containing gold, silver, and base metals, and 5) Miocene beryllium-bearing veins.

Several deposit types occur at Gold Hill, including: 1) contact metasomatic (skarn) deposits, 2) polymetallic veins, 3) disseminated sediment-hosted deposits, and 4) anomalous beryllium in quartz-adularia dikes. Tungsten skarns are related to Jurassic and Eocene plutonism, middle Tertiary igneous activity unrelated to the Eocene pluton yielded base and precious metal deposits, and beryllium occurs in silcic volcanic rocks of middle and late Miocene age. In Gold Hill, the mineral suites associated with each age of mineralization are not mutually exclusive.

Geologic hazards of concern include earthquakes from nearby faults that show evidence of Quaternary movement, unstable mine tailings, contamination from mines and tailings, open shafts, adits and pits, as well as flash floods and debris flows.

INTRODUCTION

As one of the oldest mining sites in the state of Utah, the Gold Hill area of the northern Deep Creek Range near the Utah-Nevada border has long attracted the attention of geologists. A comprehensive geologic study of Gold Hill by Thomas B. Nolan, published in 1935, illuminated the complicated depositional, intrusive, volcanic, mineralization, and deformational history of Gold Hill. The work of Nolan (1935) remains a classic in the literature of eastern Great Basin geology. The Gold Hill quadrangle includes sedimentary rocks typical of the Paleozoic Cordilleran miogeocline succeeded by Quaternary lacustrine and alluvial strata. Mesozoic folding, thrust faulting, low- and high-angle faulting, igneous intrusion, metamorphism, and mineralization affected the Paleozoic strata. These events were followed by Cenozoic low-angle faulting, strike-slip faulting, igneous intrusion, mineralization, volcanism, and high- and low-angle faulting.

The Gold Hill area provides an uncommon opportunity to examine the effects of Mesozoic extension and crustal shortening and superimposed Cenozoic low- and high-angle normal faulting within the framework of age constraints afforded by well-dated plutons of 152 m.y. and 38 m.y.. Much of the data presented here are from a study of structural geology based on comprehensive geologic mapping of the Gold Hill 7.5′ quadrangle from 1984 to 1988 (Robinson, 1990a). This study utilized the wealth of radiometric and biostratigraphic data not available to Nolan (1935).

The complex and diverse history of intrusion, volcanism, and metamorphism created an equally diverse and complicated suite of minerals at Gold Hill. At sporadic intervals, starting in 1857, various mines in the area have produced lead, copper, silver, gold, arsenic, zinc, and tungsten. Gold Hill remains an area with potential for the discovery of an unexploited deposit of these metallic commodities.

The Gold Hill quadrangle is on the northern end of the Deep Creek Range, approximately 65 kilometers (40 miles) south-southeast of Wendover, Utah and 20 kilometers (12 miles) east of the Nevada border. The Deep Creek Range is a north-trending fault-bounded range exemplifying the ranges in the northern Basin and Range physiographic province. Dutch Mountain, approximately 7.2 kilometers (4.5 miles) north-northwest of Gold Hill town, is the highest point in the Gold Hill quadrangle at 2,372 meters (7,794 feet). Lowlands, south of Dutch Mountain and west of Gold Hill town, range in elevation from 1,877 meters (6,160 feet) to 1,582 meters (5,190 feet) and are, in part, underlain by a pediment eroded on Eocene quartz monzonite and Paleozoic strata. In the northeastern corner of the quadrangle, surficial deposits of Pleistocene Lake Bonneville occur at elevations ranging from 1,591 meters (5,220 feet) to 1,292 meters (4,240 feet). Abrupt boundaries between the mountains and lowlands in the Gold Hill quadrangle are illustrative of Basin and Range physiography.

PALEOZOIC STRATIGRAPHY

Sedimentary rocks of Paleozoic age at Gold Hill, shown in figure 1, belong to the Cordilleran miogeocline. Nolan (1935) presented detailed descriptions of lithologic units in the Gold Hill quadrangle. Revisions of various aspects of the original stratigraphic nomenclature and regional depositional models were made by Langenheim (1960), Hodgkinson (1961), Bick (1966), Marcantel (1975), and Wardlaw and Collinson (1978).

Prospect Mountain Quartzite (Cambrian)

The Prospect Mountain Quartzite forms prominent cliffs and ridges along the lower elevations of the northern and northeastern flanks of Dutch Mountain and on the southeast side of Gold Hill Wash. This formation consist of mixtures of two compositional end members, locally interbedded. No dominant stratigraphic order exists between the different compositions. The most abundant end member is composed of rounded, fine-grained quartz sand. This member is light grey to white, thick bedded, siliceous, and extremely tight (non-porous). The quartzite commonly displays silica overgrowths and contains interstitial white mica, chlorite, and biotite. Micaceous minerals display local poorly defined preferred orientation. The second end member consists of variegated, fine- to medium-grained, quartz arenite to subarkose. The

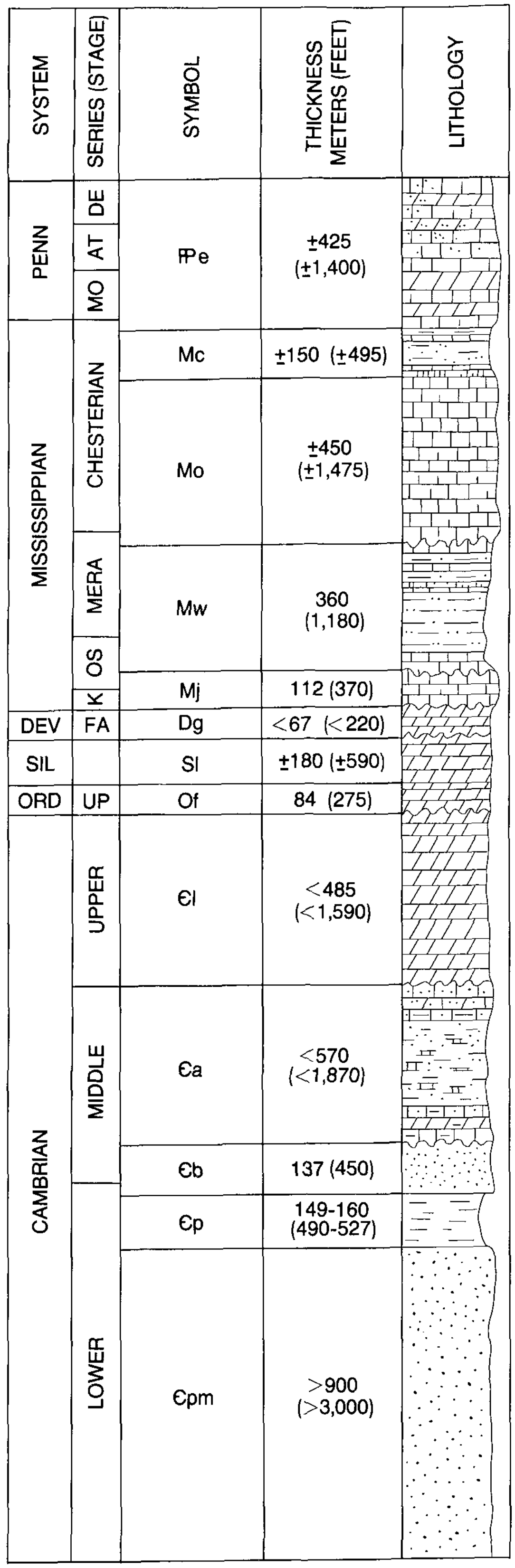

***Figure 1.** Stratigraphic column for Paleozoic formations in the Gold Hill quadrangle. Ꞓpm = Prospect Mountain Quartzite, Ꞓp = Pioche Shale, Ꞓb = Busby Quartzite, Ꞓa = Abercrombie Formation, Ꞓl = Undifferentiated Lamb Dolomite and Orr Formation, Of = Fish Haven Dolomite, Sl = Laketown Dolomite, Dg = Guilmette Formation, Mj = Joana Limestone, Mw = Woodman Formation, Mo = Ochre Mountain Limestone, Mc = Chainman Shale, ℙe = Ely Limestone. ~ = low-angle fault contact or contact of uncertain nature. Based on Hintze (1988).*

sandstone occurs in various shades of red, purple, and gray; is locally laminated; and displays a greater range of grain size than the former member. Sub-rounded to angular grains of feldspar, schist, and other lithic fragments are present in small quantities, as is cubic limonite after pyrite. Individual beds range in thickness from centimeters to tens of meters, although bedding is locally indiscernible due to extreme jointing throughout the formation. Weathered surfaces commonly display a pervasive deep-brown stain.

Conglomerate, composed of rounded, pebble-sized clasts of quartzite, schist, vein quartz, and granite in a fine-grained, hematitic quartz sand matrix, is common. Some conglomerate displays a reddish-brown, sandy shale matrix.

On the northern flank of Dutch Mountain, exposures of Prospect Mountain Quartzite measured perpendicular to strike display thicknesses of 1,860 meters (6,105 feet) or possibly greater. This cannot be considered true stratigraphic thickness due to poorly defined bedding, intraformational faults of undetermined displacements, a covered lower contact, and an upper contact which is locally a fault. Bick (1966) measured an 899-meter (2,950 feet) section of Prospect Mountain Quartzite in the Deep Creek Range, approximately 8 kilometers (5 miles) south of the Gold Hill quadrangle. Nolan (1935) estimated the formation to be over 914 meters (3,000 feet) thick on Dutch Mountain.

Pioche Shale (Cambrian)

The Pioche Shale consists of slope-forming, phyllitic, sandy shale which is dark grey, greenish-grey, and black. The shale commonly displays foliation or schistosity, usually parallel or subparallel to bedding. Preferred orientation of white mica and chlorite define the foliation, which is locally crenulated. Pseudomorphic limonite after cubic pyrite is common throughout the unit. Thin beds of finely laminated shale, calcareous shale, sandy shale, and argillaceous sandstone are interbedded in the Pioche Shale. Weathered surfaces of the shale exhibit iron-oxide stain in various shades from light reddish brown to black.

Nolan (1935) measured sections of 149.4 meters (490 feet) and 160.6 meters (527 feet) south of the Gold Hill quadrangle that he interpreted to approximate the true thickness of the formation. On Dutch Mountain, Pioche Shale is commonly thinned by faults and in a few locations thickened along the hinges of folds.

Busby Quartzite (Cambrian)

Busby Quartzite was named by Nolan (1930) for exposures in Busby Canyon on Dutch Mountain. The basal 15 to 25 meters (49-82 feet) of the formation consists of medium- to coarse-grained, grayish-brown, siliceous, cliff-forming quartzite, which locally includes thin beds of fine- to medium-grained, arkosic or lithic arenite. Above the basal section, quartz arenite is interbedded with thin shale and argillaceous sandstone. The quartz arenite is thick bedded, fine grained, and siliceous. Fresh surfaces are white, light gray and pink which weather light brown to reddish brown with locally heavy iron oxide stain. Also included in the upper part of the formation is slope-forming, fine- to medium-grained, light-gray, thin-bedded quartzwacke and dark green, foliated, micaceous, sandy shale. The upper shale of the Busby Quartzite strongly resembles portions of the Pioche Shale.

Nolan (1935) measured sections of 131.2 meters (430 feet) and 137.0 meters (450 feet) south of the Gold Hill quadrangle that he interpreted to approximate the true thickness of the formation. Complete sections of Busby Quartzite are rare on Dutch Mountain due to extensive faulting.

Abercrombie Formation (Cambrian)

The Abercrombie Formation is a heterogeneous unit that occurs only in incomplete and highly faulted sections on Dutch Mountain. The lower portion of the formation is in fault contact with Busby Quartzite along the northern flank of Dutch Mountain. There, the formation consists of platy, brittle, dark-gray siltstone and dark-gray shale. These fine-grained clastics are locally interbedded with subordinate thin-bedded, platy, dark-gray, micritic limestone and light- to dark-brown, argillaceous, fine- to medium-grained quartz sandstone. Middle Cambrian trilobites, including *Bathyuriscus productus*, *Etrathia* sp., and *Zacanthoides* (Nolon, 1935), are abundant in siltstone and shale between Royal Gulch and Wilson Hill.

The siltstone and shale grade into a sequence dominated by sandy dolomite. The dolomite is thick bedded, medium to coarsely crystalline and weathers to a distinctive, uniform dark brown. Locally interspersed with dolomite is coarsely crystalline, dark-blue to blue-gray limestone. Contacts between dolomite and limestone are quite irregular and do not follow bedding. Cliff-forming limestone, up to 30 meters (100 feet) thick, occurs in scattered locations. The limestone is thick bedded, coarsely crystalline, dark gray to dark blue, and contains no dolomite.

A true thickness of Abercrombie Formation cannot be determined in the Gold Hill quadrangle as the lower and upper contacts are faults. Fault-shortened sections with approximate thicknesses of 510 meters (1,673 feet) and 570 meters (1,870 feet) occur north of Busby Canyon.

Lamb Dolomite and Orr Formation (Undifferentiated) (Cambrian)

An incomplete section of Upper Cambrian dolomite crops out north of Pool Canyon and in Royal Gulch on Dutch Mountain. Nolan (1935) named this sequence "Undifferentiated Upper Cambrian" as the contact between Lamb Dolomite and Orr (Hicks) Dolomite proved to be undiscernible. Nolan (1935) applied the name Hicks Formation to the unit which overlies the Lamb Dolomite. However, the name Orr Formation is now employed for this formation in the Gold Hill area (Hintze and Palmer, 1976).

The most common lithology in this undifferentiated section is dolomite which is medium to coarsely crystalline, thick bedded, vuggy, sandy, and mottled. Fresh surfaces are light gray to blue-gray and weather to light gray. Layers of pisolitic dolomite are locally interbedded with massive dolomite and in some localities pisolitic dolomite is the dominant lithology. The pisolites are commonly elliptical and have diameters up to 3 centimeters. Thin (<3 centimeter [1.2 inch]) iron-rich shale, black chert lenses, and fossil hash composed predominately of crinoids are also interbedded with massive dolomite. Dark-gray to black, thick-bedded dolomite is included in the upper parts of the section. In some places the contact between the black and light-gray dolomite is sharp, elsewhere it appears irregular and indefinite. Near the mouth of Pool Canyon outcrops of light-gray, micritic limestone and light-gray dolomite interbedded with pale-yellow to white, sandy shale are assigned to this formation.

This section of undifferentiated carbonate strata is estimated to be 485 meters (1,590 feet) thick, based on exposures between Tribune Gulch and Pool Canyon. A complete section of Lamb Dolomite and Orr Formation is not present in the Gold Hill quadrangle.

Fish Haven Dolomite (Ordovician)

Fish Haven Dolomite occurs in small outcrops, generally in highly faulted sections, at several locations on Dutch Mountain. The dolomite is thick bedded, finely to medium crystalline, vuggy, and locally fossiliferous with abundant brachipod fragments. Fresh and weathered surfaces are dark gray, although a mottled and bleached appearance is common. Nolan (1935) reported a suite of fossils from the Fish Haven Dolomite on eastern Dutch Mountain, including *Halysites gracilis,* indicative of a Late Ordovician age.

Nolan (1935) measured an 84.2-meter (275 feet) section of Fish Haven Dolomite on southern Dutch Mountain which is interpreted to represent a true thickness of the formation.

Laketown Dolomite (Silurian)

The Laketown Dolomite overlies the Fish Haven Dolomite at several locations on Dutch Mountain. The lower portion of the Laketown Dolomite is commonly thin bedded to laminated with alternating light- and dark-gray dolomite beds. Above the laminated section is approximately 30 meters (100 feet) of thick-bedded, dark-gray, fine- to medium-crystalline dolomite. The dark dolomite is succeeded by as much as 60 meters (200 feet) of thick-bedded, light-gray, finely to crystalline dolomite with a sucrosic texture.

All exposures of Laketown Dolomite in the Gold Hill quadrangle are vertically shortened by faults. Maximum thickness of Laketown Dolomite at Gold Hill is approximately 180 meters (590 feet) in Pool Canyon.

Guilmette Formation (Devonian)

The Guilmette Formation crops out in northern Pool Canyon. The formation was not recognized on Dutch Mountain until Harmala (1982) correlated strata in Pool Canyon with a stratigraphic section in Guilmette Gulch, approximately 19 kilometers (12 miles) to the south-southwest. Most of the exposed Guilmette Formation in Pool Canyon consists of recrystallized dolomitic marble. The marble is light gray, blue-gray, and grayish white and varies between finely and coarsely crystalline. The unit is mostly structureless, although foliation which probably parallels bedding is displayed in a few locations. Hydrous copper minerals, predominantly malachite, are diffused throughout the formation and limonite after pyrite and chalcopyrite occurs locally. Fossils are limited to algal mats near the base of the section (Harmala, 1982).

The only exposure of Guilmette Formation in the Gold Hill quadrangle is an incomplete section in Pool Canyon with a maximum thickness of 67 meters (220 feet).

Joana Limestone (Mississippian)

The Joana Limestone forms prominent cliffs along the north side of Pool Canyon and several other locations on Dutch Mountain. The limestone is finely to coarsely crystalline, fetid, and thin to medium bedded. Fresh surfaces are dark gray to blue gray and weather to light gray. Dark-brown to reddish-brown iron-oxide stain is locally heavy on weathered surfaces. Beds of fossil hash, as much as 10 meters (33 feet) thick, are composed mostly of crinoid and coral fragments. These occur throughout the unit as do elongate light-gray and black chert nodules as much as 30 centimeters (1 foot) in diameter. Most exposures of Joana Limestone are highly fractured with calcite and minor siderite fracture filling.

Joana Limestone on the northeastern side of Royal Gulch is locally dolomitized. The dolomite is light to medium gray and medium to coarsely crystalline. Elongate lenses of black chert, several centimeters thick, are abundant. Dark-gray to blue-gray, coarsely crystalline limestone, typically consisting of crinoid, brachiopod, and bryozoan fragments, occurs within the dolomite. Contacts between limestone and dolomite are highly irregular and commonly oblique to bedding. The abundance of chert and the presence of fossiliferous limestone distinguish these rocks from other bedded dolomite in the area.

Joana Limestone is 112.2 meters (370 feet) thick in a section measured by Harmala (1982) in Pool Canyon. Harmala interpreted this to represent a complete thickness of Joana Limestone, based on comparisons of the formation across the region. The upper and lower contacts of Joana Limestone are low-angle faults everywhere in the Gold Hill quadrangle and the thickness of the formation varies from 112 meters (370 feet) to 15 meters (50 feet) due to these faults.

Deposition of the Joana Limestone began in middle Kinderhookian time and ended in early Valmeyeran time (Harmala, 1982) (table 1) (note: Valmeyeran is equivalent to Osagean).

Woodman Formation (Mississippian)

The Woodman Formation was named by Nolan (1930) for exposures on Woodman Peak in the Gold Hill quadrangle. A stratigraphic equivalent to the Deseret Limestone and Humbug Formation of eastern Utah, the Woodman Formation is restricted to west-central Utah (Hintze, 1973).

This formation consists of a lower section of micritic limestone overlain by phosphatic siltstone, shale, and phosphorite, succeeded by a section of siltstone and fine-grained clastics, and an upper limestone sequence.

The phosphatic section at Gold Hill was first described by Harmala (1982) and is assigned to the Delle Phosphate member of the Woodman Formation (Sandberg and Gutschick, 1984). This section consists of a basal black, fossiliferous encrinite containing horn coral, brachiopod, and bryozoan fragments. Bedded, pelletal to oolitic phosphorite, dark-gray to black radiolarian chert, and silty, cherty, organic-rich limestone comprise the remainder of the phosphatic section (Harmala, 1982).

The siltstone is commonly quartzose, slightly calcareous, brittle, and thin bedded with local spaced cleavage oriented parallel and sub-parallel to bedding. Limonite after pyrite is locally abundant. Fresh surfaces of siltstone are light brown to light gray and weather light brown and reddish brown. Fine- to medium-grained quartz arenite is locally interbedded with siltstone, as are thin beds of platy, light-gray, micritic limestone, and dark-gray shale. The siltstone section grades into a sequence of limestone which is commonly dark gray to black, thin bedded, micritic to finely crystalline, and contains fine-grained quartz sand. The limestone displays local stockwork calcite veins and in some places is heavily stained with dark-red to black iron oxide. In the south-central portion of the quadrangle, the Woodman carbonate sequence is interbedded with light-brown, fine- to medium-grained, calcareous sandstone which gives some outcrops a laminated appearance. On Dutch Mountain, the upper limestone is coarsely crystalline, thick bedded, locally fossiliferous with brachiopod and crinoid fragments, and is commonly cherty.

A complete thickness of Woodman Formation does not occur in the Gold Hill quadrangle (Nolan, 1935; Harmala, 1982). Woodman Formation on Dutch Mountain reaches an estimated thick-

Table 1.

Biostratigraphic and paleontological data from upper Paleozoic strata in the Gold Hill area.

FORMATION	LOCATION	FOSSILS	AGE	REFERENCE
Joana Limestone	40° 12' 21" N 113° 51' 00" W	*Clydagnathus cf. cavusformis* *Pseudopolygnathus multistriatus*	Middle Kinderhookian- Early Valmeyeran	Harmala (1982)
Woodman Formation (basal phosphate member)	40° 12' 21" N 113° 51' 00" W	*Doliognathus latus* *Eotaphrus burlingtonensis* *Gnathodus typicus (?)* *Pseudopolygnathus oxypageous* *Polygnathus communis communis*	Early Valmeyeran	Harmala (1982)
Woodman Formation (needle siltstone member)	40° 12' 21" N 113° 51' 00" W	Barren		Harmala (1982)
Woodman Formation (upper member)	40° 12' 21" N 113° 51' 00"	*Paragnathodus commutatus* *Cavusgnathus* sp.	Early Valmeyeran- Middle Chesterian	Harmala (1982)
Ochre Mountain Limestone	SE1/4 sec. 16 & NE1/4 sec. 21 T.8 S., R.19 W	*Faberophyllum* sp. *Cavusgnathus unicornis* *Anthracospirifer increbescens* *Stratifera brazeriana*	Meramecian Chesterian	Chamberlain (1981)
Ely Limestone	40° 8.1' N 113° 50.3' W	*Idiognathodus* sp. indet.	Late Morrowan- Wolfcampian	A.G. Harris (1984, personal communication)
Ely Limestone	40° 17' N 113° 48.5' W	*Hindeous cf. H. Minutus* *Streptognathus Elegantulus*	Desmoinesian- late Wolfcampian	A.G. Harris (1984, personal communication)

ness of 288 meters (950 feet) which consists predominately of the lower phosphatic and fine-grained clastic members of the formation. In the southwest corner of the study area, the upper limestone member of Woodman Formation displays a thickness of approximately 72 meters (236 feet). This implies that the total thickness of Woodman Formation in the Gold Hill quadrangle is at least 360 meters (1,180 feet).

The phosphatic member of the Woodman Formation was assigned an early Valmeyeran age and the upper portions of the unit represent early Valmeyeran to possibly early middle Chesterian deposition (Harmala, 1982) (table 1).

Ochre Mountain Limestone (Mississippian)

The Woodman Formation in Gold Hill is conformably overlain by the Ochre Mountain Limestone (Chamberlain, 1981). Nolan (1935) recognized the Ochre Mountain Limestone as equivalent in age and lithology to the Great Blue Limestone of central Utah. Despite this correlation, the name Ochre Mountain Limestone is used in west-central Utah (Hintze, 1973; Chamberlain, 1981).

A relatively uniform unit throughout the quadrangle, this formation is finely crystalline limestone with local micritic and coarse-grained beds. The limestone is generally thick bedded to massive and dark blue to blue gray on fresh and weathered surfaces. Stringers of light-gray and black chert, mostly less than 7.5 centimeters (3 inches) thick, are common and locally abundant, particularly in the lower portion of the unit. Thin beds of fine-grained quartz arenite, and shale which weather pinkish red or pale yellow are interbedded with the limestones.

Outcrops of Ochre Mountain Limestone are generally highly fractured and riddled with calcite veins. Intraformational breccias, probably of tectonic origin based on the lack of conformity of breccias with bedding, occur throughout the unit. Bleaching and silicic alteration alter the appearance of the limestone in many locations.

The contact between Ochre Mountain Limestone and the underlying Woodman Formation is conformable in the extreme southwest corner of the study area (Chamberlain, 1981). However, the lower contact of Ochre Mountain Limestone is commonly a subhorizontal fault, either the Ochre Mountain thrust or a low-angle normal fault. This complicates the determination of the true thickness of the formation. Biostratigraphic studies of the Ochre Mountain Limestone, including Chamberlain (1981)and Harmala (1982), revealed that a complete thickness of Ochre Mountain Limestone has yet to be discovered. However, both of these authors concluded that the true thickness of the formation is less, by at least half, than the 1,220 meters (4,000 feet) estimated by Nolan (1935). Ochre Mountain Limestone is estimated to be 450 meters (1,475 feet) thick in the Gold Hill quadrangle, based on the thickness of a section exposed in the southwest corner of the area. This is interpreted to be a rough estimate and does not represent a true thickness of the formation.

A section in the extreme southwestern corner of the Gold Hill quadrangle yielded a fossil suite indicative of Meramecian-Chesterian deposition (Chamberlain, 1981) (table 1).

Chainman Shale (Mississippian)

The Chainman Shale consists of quartzite, shale, and intercalated limestone. Due to its resistance to weathering, quartzite is the most common lithology in outcrop. The quartzite is fine to very fine grained, tightly compacted, siliceous, and light gray, dark gray, and black on fresh surfaces. Weathered surfaces are commonly stained light reddish brown, dark red, and black. Outcrops of shale are rare as these members typically erode to flats and gentle slopes. The shale is black, carbonaceous, and fissile. In some places slaty cleavage is developed parallel or sub-parallel to bedding and displays crenulation or slip along cleavage planes. On southern Dutch Mountain, the shale is dark gray, sandy, platy, and micaceous. Several types of limestone occur in the Chainman Shale, although they are volumetrically insignificant. South of Pool Canyon, a sequence of limestone, shale, and sandstone is in apparent depositional contact with the Ochre Mountain Limestone. The Chainman limestone is dark gray, micritic, thin bedded, and weathers reddish orange. In the upper part of the formation, dark-gray to black, micritic, laminated limestone is interbedded with thin (>15 centimeters [6 inches]), fine-grained, reddish-pink, quartz arenite. The formation includes several lenses of pebble conglomerate consisting of rounded to subrounded clasts of limestone and quartzite in a reddish-brown, fine- to very fine-grained, quartz sand matrix. Thermal alteration of shale to structureless or spotted hornfels which are light brown to pale orange is common near the plutons. These hornfels locally contain adularia (chiastolite), white mica and chlorite, and tourmaline depending on the degree of metamorphism (Christensen, 1975).

The total thickness of Chainman Shale at Gold Hill is estimated to be 150 meters (495 feet) which is not interpreted to represent a true thickness of the formation. This figure is derived from the sum of the thicknesses of two lithologically dissimilar sections of Chainman Shale. Approximately 60 meters (196 feet) of shale, sandstone, and limestone occur above a depositional (?) contact with Ochre Mountain Limestone south of Pool Canyon. In the Little Valley area, an estimated 90 meters (295 feet) of black shale and sandstone occur beneath the Ely Limestone.

Ely Limestone (Pennsylvanian)

The Ely Limestone is a heterogeneous unit with limestone, dolomite, and sandstone constituents. West of Gold Hill Wash and extending to the western edge of the quadrangle, the Ely Limestone includes lithic arenite interbedded with subordinate limestone and dolomite. This section is interpreted to be in depositional contact with the underlying Chainman Shale although this contact is nowhere exposed. The lithic arenite varies between white, light gray, and light brown on fresh surfaces and weathers shades of red and brown. The sandstone is fine to medium grained, calcareous, poorly consolidated, generally structureless, and typically contains limestone and dolomite grains. Slope-forming, light gray biosparite is the dominant limestone although more-resistant, dark-blue to blue-gray micrite occurs locally. Dark-gray to black chert stringers are commonly interbedded with limestone as are thin, fine-grained sandstone lenses. The dolomite is generally coarsely crystalline, thick bedded, and limey. Quartz sand lenses and chert are commonly minor constituents. Fresh and weathered surfaces are light to medium gray. Intraformational conglomerate lenses are scattered throughout the formation in the western portion of the study area. These include angular to subrounded clasts, up to 18 centimeters (7 inches) in diameter, of limestone, dolomite and chert. The clasts are incorporated either in a fine- to very fine-grained quartz sandstone matrix or in a dark-gray to black micrite matrix.

Coarsely crystalline, calc-silicate hornfels is assigned to Ely Limestone north of Gold Hill Pass. This interpretation is based on the stratigraphic position of the hornfels which overlies Chainman Shale sandstone. The hornfels commonly resembles unaltered Ely Limestone in color and weathering profile. The mineralogy of the hornfels was not examined in detail. Diopside and wollastonite are interpreted to be major constituents, although the hornfels appears quite heterogeneous. Calcite is absent or a very minor constituent.

In the eastern portion of the study area, the dominate lithology is cliff-forming limestone which is thick bedded to massive, coarsely crystalline, dolomitic, and light to dark gray on fresh and weathered surfaces. This is interpreted to represent the upper portion of the Ely Limestone. The limestone is locally fossiliferous and is commonly interbedded with black chert, fine-grained quartz arenite lenses, and dolomite. Dolomite strongly resembles the limestone and is light to dark gray, coarsely crystalline, sandy, limey, locally fossiliferous, with dark-gray and black chert. Some limestone beds appear dark blue to blue-gray and may be difficult to distinguish from the Ochre Mountain Limestone. The thickness of outcrops of dark-blue limestone ranges from 10 to 50 meters (33-165 feet).

A thickness of 425 meters (1,400 feet) is proposed for the Ely Limestone in Gold Hill quadrangle which is a rough estimate and not interpreted to represent a complete thickness. This estimate was determined from the total of approximately 330 meters (1,083 feet) of sandstone and dolomite above Chainman Shale in the western portion of the study area and 95 meters (313 feet) of limestone in the eastern part of the study area. The thickness of Ely Limestone in Gold Hill was also estimated to be 425 meters (1,400 feet) by Hintze (1988).

Conodonts from samples of Ely Limestone were dated as early late Morrowan through Wolfcampian (A.G. Harris, 1984, written communication) (table 1).

IGNEOUS ROCKS AND ALTERATION

A very general chronological sequence of igneous events in Gold Hill, with age estimates proposed by Moore and McKee (1983) included in parentheses, is: 1) intrusion of Late Jurassic granodiorite (152 m.y.), 2) intrusion of diorite which can only be constrained as pre-Eocene, although could be pre-Jurassic, 3) intrusion of Eocene quartz monzonite (42-38 m.y.), 4) eruption of latite (39 m.y.), 5) intrusion of andesite dikes, 6) eruption of basalt (14-12 m.y.), and 7) intrusion of aplite and granitic dikes. Cross-cutting relationships and xenolithic inclusions indicate that granitic dikes probably intruded the area during several periods, possibly starting before the granodiorite intrusion. A quartz-adularia dike from Rodenhouse Wash yielded an adularia K/Ar age of 8 Ma (table 2), although it is not known if this is the age of emplacement or a reheating event.

Jasperoid and Silicified Rocks (Age Uncertain)

Following Lovering (1972), the definition of jasperoid is a rock composed dominantly of silica, most commonly quartz, that formed primarily by epigenetic replacement. In general, jasperoid is most abundant in carbonate strata but also occurs in pelitic strata, igneous rocks, and metamorphic rocks (Lovering, 1972).

Cliff-forming, distinctive, dark-red to black outcrops of jasperoid occur throughout the quadrangle. The outcrops are generally brecciated, locally vuggy, and locally contain clasts of unaltered rock in a silica matrix. Jasperoid breccias are commonly associated with Carboniferous strata. The silicified breccias which form roof pendants in granodiorite along Rodenhouse Wash are white to light brown and weather light brown, much lighter in color than the

Table 2.

Published K/Ar radiometric data from the Gold Hill 7.5' quadrangle. Constants used for analyses after 1977, according to Moore and McKee (1983), are: $^{40}K/K_{total} = 1.167 \times 10^{-4}$ mol mol, $\lambda_e = 0.572 \times 10^{-10} yr^{-1}$, $\lambda_\beta = 4.963 \times 10^{-10} yr^{-1}$.

ROCK TYPE	LOCATION	SAMPLE MINERAL	AGE	REFERENCE
Quartz Monzonite	40° 10' 00" N 113° 49' 40" W	Biotite-Hornblende-Chlorite	42.5± 0.8 Ma	Armstrong (1968)
Dike (Quartz-Adularia)	40° 8.2' N 113° 47.3' W	Adularia	8.0 ± 0.8 Ma	Whelan (1970)
Quartz Monzonite	40° 11.3' N 113° 52.8' W	Biotite	37.4 ± 1.3 Ma	Stacey and Zartman (1978)
Quartz Monzonite	40° 11.3' N 113° 50.9' W	Biotite	39.7 ± 1.4 Ma	Stacey and Zartman (1978)
Granodiorite	40° 4.5' N 113° 49.5' W	Biotite	151 ± 5.0 Ma	Stacey and Zartman (1978)
Granodiorite	40° 6.6' N 113° 49.1' W	Biotite	153 ± 5.0 Ma	Stacey and Zartman (1978)
Quartz Monzonite	40° 10' 00" N 113° 49' 30"	Hornblende-Biotite	43.9 ± 0.8 Ma	Moore and McKee (1983)
Granodiorite	40° 8' 40" N 113° 48' 50" W	Hornblende	134.9 ± 4.0 Ma	Moore and McKee (1983)

other jasperoid in the area. These breccias include clasts of white quartzite and marble of uncertain origin. Jasperoid commonly occurs along normal faults of various ages and orientations. This possibly indicates several periods of jasperoid formation. However, there are no data to quantify the number or the ages of the periods.

Granodiorite (Jurassic)

Much of the southeastern quarter of the quadrangle is underlain by a heterogeneous, medium- to coarsely crystalline pluton with an average composition of granodiorite. Detailed petrography was not done across the entire granodiorite, therefore no attempt was made to map the various textures and modes which occur within the pluton. However, it appears that this pluton includes distinct quartz-rich and quartz-poor phases. Therefore, the Jurassic granodiorite could actually be an intrusive complex composed of rocks of more than one age, although such a statement cannot be made without supporting radiometric or geochemical data. Modally, the Jurassic pluton contains hornblende and biotite with accessory clinopyroxene, magnetite, sphene, zircon, and apatite. Tourmaline, stilpnomeline, and allanite occur in trace amounts. Because of variations in alkali feldspar/plagioclase ratio and quartz content, the rocks range in composition from the dominant granodiorite to granite, quartz monzodiorite, and rarely monzodiorite. It is mesocratic to melanocratic, commonly with distinctive violet to light-purple alkali feldspars. Most samples are equigranular, although in some places alkali feldspar and plagioclase occur as phenocrysts. Chlorite in the granodiorite is a hydrothermal alteration product and thus unrelated to weathering of primary biotite (Downey, 1976).

This unit yielded an average biotite K/Ar age of 152 Ma (Stacy and Zartman, 1978) (table 2). Moore and McKee (1983) determined a biotite K/Ar age of 135 Ma, interpreted as reset by the intrusion of a younger pluton (table 2).

Diorite (Pre-Late Eocene)

Small outcrops of diorite occur in Pool Canyon. The diorite is fine to medium crystalline, mesocratic to melanocratic, and equigranular. Plagioclase and hornblende are the major constituents with minor alkali feldspar and biotite and trace amounts of quartz. Xenoliths of diorite are abundant in the Eocene quartz monzonite at several locations, indicating a pre-Eocene age of emplacement of the diorite. No maximum age constraint exists for the diorite.

Quartz Monzonite (Eocene)

The quartz monzonite pluton is considerably smaller than the granodiorite and is restricted to the north-central portion of the quadrangle. This rock is medium to coarsely crystalline and ranges in composition from quartz monzonite to granite. Biotite and/or hornblende compose up to 20 percent of the rock and accessory magnetite, apatite, epidote, sphene, and zircon are common. Light pinkish grey is the dominant color and samples range from leucocratic to mesocratic. Feldspars commonly exhibit a white chalky appearance due to deuteric alteration. Most samples are equigranular although they are locally porphyritic with alkali feldspar phenocrysts. This unit yielded biotite K/Ar ages from 37.4 to 43.9 Ma (table 2).

Quartzo-Feldspathic Dikes (Mesozoic-Tertiary)

Aphanitic and phaneritic dikes including leucogranite, granite, quartz monzonite, granodiorite, rhyolite, dacite, aplite, and quartz porphyry occur throughout the quadrangle. Finely crystalline granitic dikes, mostly equigranular although locally porphyritic, contain biotite, hornblende or muscovite, clinopyroxene, epidote, allanite, apatite, magnetite, zircon, and sphene, and are most common. Cross-cutting relationships indicate that several episodes of granitic dike intrusion occurred between the Late Jurassic and late Tertiary.

Aplite dikes are most abundant on, but not restricted to, southern Dutch Mountain. In most cases, they are too small to show at the scale of this map. Aplite contains accessory biotite, magnetite, pyrite, apatite, sphene, and garnet. These dikes probably represent late stages of the quartz monzonite intrusion.

Latite and Trachyte (Oligocene ?)

Small outcrops of dark-red, dark-gray, and black porphyritic latite occur in the western portion of the quadrangle. Phenocrysts form as much as 50 percent of the rock. Subhedral, white to yellow plagioclase and euhedral to subhedral clinopyroxene and orthopyroxene are the dominant phenocrysts with minor biotite, magnetite, apatite, and hornblende. Nolan (1935) identified a volcanic vent, approximately 8 kilometers (5 miles) west of this study area, which he proposed as the source for all latite in the vicinity. Moore and McKee (1983) reported a whole rock K/Ar age of 39 ± 5 Ma for latite approximately 19 kilometers (12 miles) northwest of the town of Gold Hill.

Trachyte is interpreted to be age-equivalent to the latite. The two lithologies are commonly in near geographic proximity and no age data are available for trachyte in the area. The trachyte is light green, porphyritic, and structureless. Alkali feldspar is the most common phenocryst with abundant biotite and minor hornblende, clinopyroxene, and quartz. Lithic fragments composed of volcanic tuff also occur.

Andesite and Diabase Dikes (Oligocene-Miocene ?)

Andesite dikes are widespread, though volumetrically insignificant. They are commonly slope-forming, dark green to greenish gray, and porphyritic with abundant biotite, plagioclase, and brown hornblende. Clinopyroxene is locally dominant. Quartz is present but in quantities less than 5 percent. Andesite commonly intrudes normal faults and is probably of mid-Tertiary age.

Microcrystalline diabase dikes are reddish brown, dark brown, or black and either slope forming or resistant. Clinopyroxene, orthopyroxene, and plagioclase are the dominant minerals with accessory brown hornblende, biotite, and iron oxides.

Basalt (Miocene)

Outcrops of basalt occur along Rodenhouse and Gold Hill Washes. The basalt is dark gray, reddish brown, or black on weathered surfaces and dark gray to black on fresh ones. Texture commonly varies from microcrystalline porphyry to cryptocrystalline, although locally it is glassy, vesicular, or amygduloidal. Porphyritic samples contain plagioclase, clinopyroxene, and olivine as the most common phenocrysts, with accessory magnetite, apatite, and biotite.

The basalt is interpreted to be equivalent in age to basalt and/or bimodal volcanic suites in other areas of northwestern Utah, dated 14 to 12 Ma (Moore and McKee, 1983).

Pyroclastic Rocks (Miocene ?)

Restricted to the Rodenhouse Wash area, volcanic tuffs and tufaceous breccias are reddish purple, reddish brown, and dark purple. They are generally thin bedded. Cross-bedding and small-scale cut-and-fill structures probably indicate deposition in a fluvial environment. Individual layers are generally fine grained and equigranular, although locally containing larger clasts of volcanic rock fragments. Mineral constituents include quartz, plagioclase, alkali feldspar, and hornblende. These rocks are interpreted to be the same age as basalt in the area.

QUATERNARY SYSTEM

The northeastern quarter of the Gold Hill quadrangle is underlain by Lake Bonneville sediments. Lake Bonneville fluctuated at levels as high as 1,552 meters (5,092 feet) above sea level during the Pleistocene Epoch, between 32,000 and 10,000 years ago (Currey and Oviatt, 1984). Quaternary strata at Gold Hill record the occurrence of at least three stillstands of Lake Bonneville (D.R. Currey, 1986, personal communication): 1) the Stansbury shoreline at an elevation of approximately 1,372 meters (4,500 feet) which occurred roughly 23,000 to 21,000 years ago, 2) the Bonneville shoreline at an approximate elevation of 1,552 meters (5,092 feet) which occurred intermittently between 16,400 and 15,900 years ago, and 3) the Provo shoreline at an approximate elevation of 1,444 meters (4,737 feet) which occurred between 15,000 and 14,000 years ago. The level of Lake Bonneville fluctuated both regionally and locally which created complicated coastal landscapes. Later isostatic rebound, although not documented at Gold Hill, locally deformed Lake Bonneville geomorphic features further complicating the interpretation of lake history (Currey and Oviatt, 1984).

Older Alluvial-Fan Deposits (Pleistocene)

Alluvial-fan, debris-flow, and sheet-wash deposits form slopes above 1,570 meters (5,150 feet), the maximum level of the high stand of Lake Bonneville approximately 16,400 years ago (Currey and Oviatt, 1984). Deposits consist of poorly sorted sand and gravel with cobble-sized clasts of variegated sedimentary and igneous rocks. Light-brown to gray-brown, calcareous silt occurs with the sand and gravel. Hintze (1988) estimated a variable thickness as much as 300 meters (1,000 feet) for pre-Lake Bonneville alluvium in the Gold Hill area. No data were discovered in this study to indicate a more definite thickness for the alluvium.

Colluvium (Pleistocene ? and younger)

Undifferentiated sand and silt, mostly poorly consolidated, was deposited on relatively steep slopes at elevations above approximately 1,570 meters (5,150 feet) in the northeast portion of the quadrangle and in the southwest on topographic highs and steep slopes. This unit is equivalent in age or younger than the older alluvial-fan deposits described above. Colluvial deposits differ from the older alluvial-fan deposits by lacking fan-shaped geometry in plan view. The maximum thickness of this unit is unknown, although unpublished drill data indicate that it is commonly less than 30 meters (100 feet) thick.

Undifferentiated Lacustrine and Alluvial Deposits (Pleistocene)

This unit uncomformably succeeds the older alluvial-fan deposits at elevations below approximately 1,570 meters (5,150 feet) in the northeast portion of the quadrangle. These deposits consist of older alluvial-fan deposits described above reworked by wave action in Lake Bonneville and mixed with fine-grained lacustrine sediments. The topographically highest portion of the lacustrine sediments consists of poorly sorted sand representing beach deposits along the Bonneville shoreline. Similar beach deposits occur below the elevation of the Provo shoreline at 1,444 meters (4,737 feet) from which the lake began receding approximately 1,400 years ago (Currey and Oviatt, 1984). Small wave-cut benches are common between the Bonneville and Provo shorelines. The benches are most abundant at approximately 30 meters (100 feet) below the elevation of the Bonneville shoreline. These could have formed during a minor stillstand between 16,770 and 16,000 years ago (Currey and Oviatt, 1984). Lacustrine sediments at Gold Hill are estimated to be less than 60 meters (200 feet) thick (Hintze, 1988).

Lacustrine Gravel (Pleistocene)

Spits formed along the shoreline at the high stand (Bonneville level) of Lake Bonneville consisting of sub-rounded to well-rounded, moderately to well-sorted, quartz sand with variegated, cobble-sized clasts of sedimentary and igneous rocks. Light-brown to gray-brown, calcareous silt locally forms the matrix of this unit. A rough estimate for the thickness of the gravel is less than 30 meters (100 feet), based on the topographic expression of the deposits.

Younger Alluvial-Fan Deposits (Pleistocene-Holocene)

Alluvial-fan, debris-flow, and sheet-wash deposits unconformably overlie older alluvial-fan and Lake Bonneville deposits. They commonly include older alluvial-fan deposits and undifferentiated lacustrine deposits that have been reworked and redeposited. Younger alluvial-fan deposits consist of poorly sorted, quartz sand with cobble-sized clasts of variegated sedimentary and igneous rocks in a light-brown to gray-brown, calcareous, silt matrix. Thickness of this unit is variable and is estimated to be less than 60 meters (200 feet) thick (Hintze, 1988).

Playa Mud (Holocene)

Areas of low elevation in the northeast corner of the quadrangle contain undifferentiated playa mud. The mud consists of calcareous silt and clay in shades of brown and locally includes caliche and light-colored evaporite minerals.

Alluvium (Holocene)

Sand and silt in active streams and washes. Sand is fine to coarse grained, moderately to well sorted, and sub-rounded to well rounded. Pebble-sized gravel occurs in channels and bars of braided steams.

STRUCTURAL GEOLOGY

Deformation at Gold Hill falls into the broad categories of Mesozoic compression followed by Cenozoic extension similar to the entire Cordillera of the western United States. However, the sequence of events at Gold Hill includes at least one, and possibly several periods of Mesozoic extension which differs from much of the region. A general sequence of deformational events at Gold Hill is shown in figure 2. Ages of deformational events based on relationships between structures and the two plutons fall into the general time categories of pre-Late Jurassic, Late Jurassic-Eocene, and post-Eocene.

AGE CONSTRAINT	STRUCTURE	
~10 Ma(?)	(4) NNW-trending, right-lateral fault (Gold Hill Wash fault) (3) NW-trending, high-angle normal faults (2) ENE-trending, high-angle normal faults (1) Low-angle normal fault #3 (LANF-3)	
Eocene quartz monzonite (38 Ma)	(4) Low-angle normal fault #2 (LANF-2) (3) ENE-trending, right-lateral fault system (Garrison Monster fault system) (2) NW-trending, left-lateral fault system (Pool Canyon fault system) (1) Low-angle normal fault #1 (LANF-1)	
Jurassic granodiorite (152 Ma)	(6) Microscopic, bedding-parallel, shortening	-? Vertical Shortening -?
	(5) NW-trending, high-angle normal faults (4) NW-trending, left-lateral faults (3) Ochre Mountain thrust fault (2) Faults with unknown geometry (1) Open folds with NE-trending axes	

Figure 2. Chronological list of deformational events at Gold Hill (from Robinson, 1990a).

Pre-Late Jurassic

The interpretable sequence of deformation in the Gold Hill quadrangle began during or after the late Early Triassic with a period of folding which produced open folds with northeast-trending axes in Paleozoic strata in the southwest portion of the quadrangle.

The folding was followed by northeast-vergent movement along the Ochre Mountain thrust fault (figure 3). Robinson (1990a) used balanced cross sections to determine displacement of 10 kilometers (6.2 miles) and total shortening of 49 percent for this fault. The Ochre Mountain thrust fault juxtaposed Ochre Mountain Limestone over folded strata of Mississippian through Pennsylvanian age in the southern part of the quadrangle. A duplex above a ramp-and-flat decollement at or near the base of the Ochre Mountain Limestone best fits the geometry of the Ochre Mountain thrust fault.

Several moderate-angle (~45°) reverse faults placed Chainman Shale over Ely Limestone in the area between Little Valley and Cane Springs. These faults have a limited lateral extent and locally exhibit siliceous alteration. It is probable that this stratigraphic inversion exists beneath the alluvium in the valley just east of the Ochre Mountain thrust. These faults are interpreted to be imbricates along a decollement at the base of the Ely Limestone. The decollement at the base of Ely Limestone is interpreted to be an out-of-sequence thrust in the Ochre Mountain thrust system. Displacement along this feature was minor compared to the decollement at the base of the Ochre Mountain Limestone.

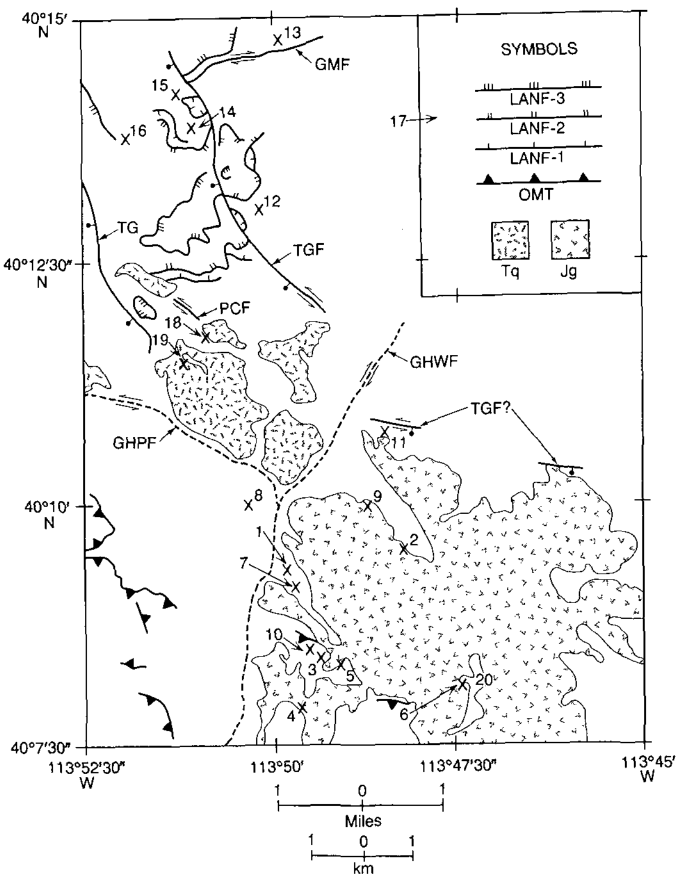

Figure 3. *Map of the Gold Hill 7.5' quadrangle showing the location of the two plutons, major structures, and mines mentioned in the text. GMF = Garrison Monster fault, GHPF = Gold Hill Pass fault, GHWF = Gold Hill Wash fault, Jg = Jurassic granodiorite, LANF-1 = low-angle normal fault #1, LANF-2 = low-angle normal fault #2, LANF-3 = low-angle normal fault #3, OMT = Ochre Mountain thrust fault, PCF = Pool Canyon fault, TG = Trail Gulch fault, TGF = Tribune Gulch fault, Tq = Tertiary quartz monzonite. Numbers and arrows refer to locations of selected mines and prospects that are listed in table 3. Bar and ball symbols are on the down-thrown block of normal faults. The Tribune Gulch fault is interpreted to have undergone both normal and strike-slip movement.*

Regionally, the Ochre Mountain thrust fault is one of several early- to middle-Mesozoic contractional features with displacements on the order of 10 kilometers (6.2 miles) or less in the eastern Basin and Range (Allmendinger and others, 1984). These faults differ from each other in interpreted depth to detachment and age of allochthonous rocks. The tectonic environment in which these faults were active is uncertain (Allmendinger, 1990).

A minor episode of northwest-striking faulting with right-lateral, strike separation ensued, followed by the formation of at least two generations of northwest-striking, high-angle normal faults. Northwest-striking faults of this age do not occur north of Gold Hill Pass. This indicates that the Gold Hill Pass fault (figure 3) or a precursor could have been a zone of accommodation between an area of extension to the south and a static area to the north.

An enigmatic period of extensional deformation probably occurred either during or soon after the period of northwest-striking normal faulting. This extension resulted in the vertical shortening of the Lower Paleozoic stratigraphic section. The total thickness of Cambrian through Devonian strata on Dutch Mountain is approximately 60 percent of that in the Deep Creek Mountains, 15 kilometers (9.4 miles) to the south. The vertical shortening was probably manifested by low-angle normal faults at the base of the Abercrombie Formation and Lamb/Orr Formations as well as other high- and low-angle normal faults. Although this extension and subsequent vertical shortening is interpreted to have occurred prior to the emplacement of the Jurassic pluton, definite age constraints do not exist (figure 2). Attenuated stratigraphic sections are common in ranges across the eastern Basin and Range (Hintze, 1978). Vertical shortening occurred locally in the region during both the Mesozoic and Cenozoic, although the mechanicsm of extension for these events is uncertain (Hintze, 1978; Wernicke and Burchfiel, 1982).

All of the above structures are interpreted to have formed prior to the intrusion of a Late Jurassic (152 m.y.) granodiorite pluton. The pre-Late Jurassic deformation at Gold Hill was apparently relatively localized as this sequence of deformation has yet to be recognized anywhere else in the eastern Great Basin, with the possible exception of the Newfoundland Mountains and Crater Island 120 kilometers (75 miles) to the north (Allmendinger and Jordan, 1984).

Late Jurassic-Eocene

Major contractional deformation occurred in the Sevier orogenic belt in central Utah, east of Gold Hill, during the late Mesozoic and early Tertiary. However, deformation in the hinterland of the thrust belt (Armstrong, 1968), which includes Gold Hill, was quite subtle. Minor, bedding-parallel shortening recorded in strained calcite crystals in the vicinity of the Late Jurassic pluton is the only deformation assigned a Late Jurassic to early Tertiary age at Gold Hill. The orientation of strain recorded in the microstructures indicates that it probably represents intrusion-related extension in the wall or cover rocks of the pluton. In this case, the Gold Hill area would have been static during active shortening in the foreland thrust belt. This is in spite of probable east-directed rafting of the Gold Hill area above a deep-seated detachment associated with crustal shortening in the Sevier belt (Allmendinger and Jordan, 1984).

Movement along the oldest of the three most aerially extensive low-angle normal faults (LANF-1) in the study area is interpreted to have occurred during the middle Tertiary prior to 38 m.y. This fault juxtaposed Joana Limestone over older strata on Dutch Mountain. LANF-1 is interpreted to have been active after the low-angle faulting which caused the vertical shortening described above. This is based on the highly variable amounts of stratigraphic omission beneath allochthonous Joana Limestone, as opposed to the consistent amount of stratigraphic omission at the base of the Abercrombie Formation and Lamb /Orr Formations. The interpretation is that an event of high-angle faulting and/or erosion occurred between the movement of low-angle faults in Cambrian strata and LANF-1. The high-angle faulting could have been a late stage of the extensional deformation which caused the pre-Late Jurassic low-angle faulting and vertical shortening.

LANF-1 forms the lower contact of the Joana Limestone everywhere in the quadrangle. Although the normal stratigraphic sequence of Joana Limestone over Guilmette Formation occurs in Pool Canyon it is not conformable (Harmala, 1982). Along Tribune Gulch, Joana Limestone is juxtaposed over Ordovician dolomite and in Royal Gulch the footwall of the LANF-1 consists of Cambrian and Silurian strata. The thickness of Joana Limestone varies from 112 meters (368 feet) in Pool Canyon to an estimated 15 meters (50 feet) based on highly brecciated float on northern Dutch

Table 3.

List of mining properties shown in figure 3, giving the name, commodity, host rock, and possible age of mineralization for each property. It should be noted that mineralization described here as post-Late Jurassic and pre-late Eocene are both interpreted to be Tertiary in age, although they are not interpreted to be the same event. Many of these properties probably underwent several periods of mineralization, especially those in the contact aureole of the Jurassic pluton. The age given here represents the interpreted age of mineralization which produced the most abundant or important commodity.

LOCATION ON FIGURE 3	MINE NAME	COMMODITY	HOST ROCK	PROBABLE AGE OF MINERALIZATION
1	United States	As, Ag, Au, Cu, Pb, Zn, Sb	Ochre Mountain Ls	Late Jurassic
2	Gold Hill	As, Ag, Au, Ba, Cu, Pb, W	Ochre Mountain Ls	Late Jurassic
3	Frankie	W, Cu, Pb, Ag, Au	Ely Limestone	Late Jurassic
4	Rustler	Mo, W, Cu, Au	Ely Ls & Granodiorite	Late Jurassic
5	Lucy L	W, Cu, Bi, Te, Au	Granodiorite	Late Jurassic
6	Climax	Ag, Cu, Pb, Zn	Granodiorite	Late Jurassic
7	Bonnemort	Au	Ely Limestone	Post-Late Jurassic
8	Cane Springs	Au, Ag, As	Ochre Mtn Ls & Ely Ls	Post-Late Jurassic
9	Alvarado	Au, Ag, Cu	Ochre Mountain Ls	Post-Late Jurassic
10	Frankie West	Au, Cu	Ochre Mountain Ls	Post-Late Jurassic
11	Rube Gold	Au, Ag, As, Cu, Mo, Pb, Zn	Ochre Mountain Ls	Post-Late Jurassic
12	Spotted Fawn (Silver Hill)	Ag, Pb, Au, Ba	Abercrombie Fm	Pre-Late Eocene
13	Garrison	Ag, Pb, Au, Cu, Ba, Zn	Abercrombie Fm & Lamb/Orr Fm	Pre-Late Eocene
14	Uncle Sam	Ag, Pb, Ba	Lamb/Orr Fm	Pre-Late Eocene
15	Evans	Ag, Pb, Ba	Laketown Dolomite & Joana Ls	Pre-Late Eocene
16	Rea	Ag, Cu	Woodman Formation	Pre-Late Eocene
17	Gold Belt	Pb	Prospect Mountain Qtzte	Pre-Late Eocene
18	Timm	W	Ochre Mountain Ls	Late Eocene
19	Stardust	W	Ochre Mountain Ls	Late Eocene
20	Quartz-adularia Veins	Be	Granodiorite	Miocene

Mountain. At some locations, LANF-1 is estimated to form angles between 15° and 25° with bedding in the Joana Limestone. However, this relationship is complicated by variable bedding in the limestone and poor exposure of the fault.

Movement along LANF-1 was probably generated by a gravitational instability. It is uncertain if this instability was on a local scale, possibly caused by upwelling prior to Eocene volcanism several kilometers west of the Gold Hill quadrangle, or on a regional scale related to gravitational collapse in a proposed zone of overthickened crust in eastern Nevada (e.g., Coney and Harms, 1984; Best, 1988).

A period of northwest-striking, left-lateral, strike-slip faulting on Dutch Mountain, including movement along the Pool Canyon, Gold Hill Pass, and Tribune Gulch faults (figure 3), came after LANF-1. This was followed by an east-striking, right-lateral strike-slip fault system, Garrison Monster fault (figure 3). The total displacement along the strike-slip fault systems is estimated to be on the order of several kilometers. Strike-slip faulting on Dutch Mountain produced an intricate fault mosaic which invites alternative interpretations.

The second major low-angle normal fault, LANF-2, moved after the strike-slip faulting. LANF-2 juxtaposed Mississippian Woodman Formation over Mississippian, Silurian, and Cambrian strata on Dutch Mountain (figure 3). The normal stratigraphic sequence of Woodman Formation over Joana Limestone occurs along segments of this fault, although the contact is nowhere conformable and is locally defined by a zone of jasperoid. The subhorizontal orientation of the fault is expressed by the fairly consistent elevation above sea level (2,000 meters (6,560 feet)) that the fault maintains around Dutch Mountain in places where it is not disrupted by faults. Bedding in the Woodman Formation above the LANF-2 generally dips 20° to 30° eastward, although it is locally variable.

Slickensides along LANF-2 indicate movement to the northeast or southwest, of which the former is preferred. The relationship between LANF-2 and the Eocene quartz monzonite is complicated by lack of outcrop and presence of float of several igneous rock types and variably metamorphosed Woodman Formation. The preferred interpretation is that LANF-2 moved synchronously with the emplacement of the quartz monzonite, which differs from an earlier interpretation (Robinson, 1987). In this model, based on Rehrig (1986), dilation and extension above the intrusion generated movement along LANF-2.

On a regional scale, LANF-1 and LANF-2 in Gold Hill are older than the Oligocene-Miocene low-angle faults associated with the core complexes to the west. However, Eocene low-angle normal faults such as those at Gold Hill are not unique within the region (e.g., Miller and Lush, 1981). There is no evidence from Gold Hill to indicate that middle Tertiary extension is older than 43 m.y., an approximate maximum age of Tertiary extension for the region (Elston, 1984). The occurrence of middle Tertiary strike-slip faulting at Gold Hill is somewhat unusual. This faulting is interpreted to represent primary deformation as opposed to a boundary between areas which underwent different amounts of extension. The strike-slip faulting occurred in simple shear having a configuration with the least principal stress oriented to the north. This is consistent with the regional state of stress for the middle Tertiary (Eaton, 1982), although it contradicts the state of stress implied by the predominately eastward-vergence of the regional low-angle normal faulting event which was in operation at the time. This contradiction possibly adds credence to an idea proposed by Best (1988) that the low-angle normal faulting throughout the region was a process confined to a zone of gravitationally unstable crust and thus unrelated to the state of stress which affected the entire North American lithospheric plate.

POST EOCENE

A third major low-angle normal fault on Dutch Mountain, LANF-3, moved after LANF-2 and after emplacement of the quartz monzonite. Nolan (1935) named this fault the Dutch Mountain thrust. Although rarely exposed, LANF-3 is defined by the unconformable nature of the lower contact and brecciation near the base of the Ochre Mountain Limestone. Several faults define dip domains in upper plate strata and sole into LANF-3, a common observation in extended terrains (e.g., Rehrig, 1986). The relatively consistent elevation, between 2,194 meters (7,200 feet) and 2,255 meters (7,400 feet), that the fault maintains around Dutch Mountain indicates a subhorizontal orientation of LANF-3. LANF-3 is younger than the underlying fault at the base of the Woodman Formation (LANF-2), as faults that rotate strata of allochthonous Woodman Formation in the Royal Gulch area do not affect the overlying Ochre Mountain Limestone. There are no contacts between the quartz monzonite and LANF-3. However, Ochre Mountain Limestone in the Pool Canyon and Woodman Peak area near the pluton is recrystallized and bleached, while the formation south of Woodman Peak, interpreted to be part of the allochthon, is dark blue to blue gray and micritic. This is interpreted to indicate a post-intrusion age for LANF-3.

The oldest set of faults clearly younger than LANF-3 strike east and northeast on northwestern Dutch Mountain and display minor offsets of undetermined geometry. These faults are truncated by north-striking, high-angle normal faults. The north-striking faults are offset by east-striking, down-to-the-north, normal faults which apparently formed with conjugate north-striking strike-slip faults. The youngest faults on Dutch Mountain are the Trail Gulch and Tribune Gulch faults (figure 3) which strike to the northwest. Down-to-the-west normal offset along these faults was on the order of hundreds of meters, greater than normal offset along other faults of any age in the area.

The Tribune Gulch fault is a particularly enigmatic structure. Along its length from southeast to northwest, this fault juxtaposes Lower Cambrian strata against younger Paleozoic strata, offsets all three major low-angle normal faults, and again displaces LANF-3 before disappearing into alluvium. A segment of this fault which juxtaposes Lamb Dolomite over Prospect Mountain Quartzite is exhumed in a prospect pit on southeastern Dutch Mountain. Although the prospect pit leaves much to interpretation, a rough estimate can be made that the fault strikes northwest and dips 50° to the west. This is the only location where a three-dimensional orientation of the fault can be measured.

In this paper, four distinct ages of movement and senses of displacement have been attributed to the Tribune Gulch fault: 1) pre- late Eocene left-lateral strike-slip, 2) down-to-the-west movement between the emplacements of LANF-2 and LANF-3, 3) post-LANF-3 right-lateral strike separation conjugate with north-directed extension, and 4) down-to-the-west dip separation.

It seems unlikely that the successive offsets for the Tribune Gulch fault were accommodated by a single fault plane. It was almost certainly compensated along a zone of several sub-parallel planes of weakness that probably existed since at least the early Mesozoic. This cannot be substantiated due to poor exposure, lack of subsurface data, and complex contact relationships.

The Trail Gulch and Tribune Gulch faults were most likely active between 18 and 10 m.y. as indicated by the northwest strike of the faults which is perpendicular to the orientation of the direction of regional least principal stress for the time period (Zoback and others, 1981). This extension was confined to the northwest quarter of the Gold Hill quadrangle and a fault through Gold Hill Pass apparently underwent strike separation to compensate for the different amounts of extension on either side of the fault. This contrasts with the period prior to the Late Jurassic when extension occurred only south of Gold Hill Pass. The age of this normal faulting at Gold Hill is possibly further constrained by the occurrence of basalt, estimated to be of 14 to 12 m.y. age, which extruded along the Gold Hill Pass fault. The basalt probably erupted while the fault was active. Similar basalt occurs along the north-trending, right-lateral, strike-slip fault through Gold Hill Wash. The most recent movement along the Gold Hill Wash fault is interpreted to be younger than the Gold Hill Pass fault and possibly formed in response to a shift in the regional state of stress which was complete by 10 m.y. (Zoback and others, 1981). This shift changed the orientation of least principal stress from ENE to ESE (Zoback and others, 1981).

Robinson (1987) argued for the existence of the Gold Hill Wash fault. This fault forms the contact between the Eocene and Jurassic plutons and continues south of the granodiorite/quartz monzonite interface, closely following Gold Hill Wash. Stacey and Zartman (1978) and Moore and McKee (1983) assumed this to be an igneous contact, though clearly stated that the contact was nowhere exposed. Stacey and Zartman (1978) reported an increase in granodiorite xenoliths within the quartz monzonite near the contact and Moore and McKee (1983) noted that thermal effects occur in the older pluton in the vicinity of the contact, neither of which preclude a fault contact between the plutons. Right-lateral, strike-separation of approximately 750 meters (2,460 feet) is estimated for this fault, based on apparent offset of the Tribune Gulch fault.

The Gold Hill Wash fault marks the western extent of the Jurassic granodiorite and seems to be a boundary which segregates different styles of pre-granodiorite deformation. These observations probably indicate that the Gold Hill Wash fault was a zone of weakness, a fault, or some type of mechanical discontinuity since the early Mesozoic. Although it is not the preferred interpretation, possibly the Gold Hill Wash fault underwent a period of left-lateral, strike separation after activity along the major NW-trending strike-slip faults on Dutch Mountain and prior to the Miocene. However, there is no strong evidence for displacement along the fault prior to the post-Eocene, right-lateral strike-slip.

Although the entire Basin and Range underwent widespread extensional deformation, there are no structures recorded in the bedrock of the Gold Hill quadrangle interpreted to be younger than 10 million years.

ECONOMIC GEOLOGY

The complex tectonic, igneous, and structural history of Gold Hill yielded an equally complex record of mineralization. Since 1857, various mines in the quadrangle produced arsenic, gold, tungsten, lead, copper, silver, and zinc. Although 25,849 Troy ounces of gold were produced from the district between 1892 and 1961 (Tripp and others, 1989), precious metals were generally byproducts from mines which produced arsenic, tungsten, copper, and zinc. The largest mining operations in the Gold Hill quadrangle were the U.S. and Gold Hill mines (all mines mentioned in this section are shown in figure 3) which produced arsenic during World Wars I and II (El-Shatoury and Whelan, 1970). The Gold Hill district is also the largest producer of tungsten in the state of Utah, although the total amount of tungsten produced has been relatively small (Tripp and others, 1989). The arsenic mines and most of the tungsten mines occur in the contact aureole of the Jurassic pluton.

Several deposit types occur at Gold Hill, including: (1) contact metasomatic (skarn) deposits, (2) polymetallic veins, (3) disseminated sediment-hosted depostis, and (4) anomalous beryllium in quartz-adularia dikes. Robinson (1990b) argued that as many as five events of mineralization occurred at Gold Hill. These are:

(1) Late Jurassic tungsten skarns and polymetallic replacement deposits.
(2) Post-Late Jurassic (Tertiary ?) polymetallic veins containing gold, silver, copper, and base metals; possibly restricted to the area east of Gold Hill Wash.
(3) Pre-late Eocene (Tertiary ?) polymetallic veins containing silver, lead, gold, copper, barium and other base metals, possibly restricted to Dutch Mountain. This is distinct from (2) by lower Au/Ag ratio and higher base-metal content.
(4) Late Eocene tungsten skarns.
(5) Miocene beryllium-bearing veins.

Mineralization at Gold Hill is roughly consistent with regional trends for northwestern Utah reported by Moore and McKee (1983). Tungsten skarns are related to Jurassic plutonism (although Tertiary tungsten skarns occur at Gold Hill and in eastern Nevada (Stager and Tingley, 1988)), middle Tertiary igneous activity yielded base and precious metal deposits, and beryllium occurs in silicic volcanic rocks of middle and late Miocene age. In Gold Hill, the mineral suites associated with each age of mineralization are not mutually exclusive.

This section presents a general overview of selected ore bodies based on probable age of the deposit. Although the interpretation of age of mineralization presented here is unique, this discussion relies heavily on detailed descriptions and maps of individual mines presented in Nolan (1935) and El-Shatoury and Whelan (1970). A comprehensive list of mining properties in Gold Hill is shown as plate 3 and was presented in another version by Tripp and others (1989).

LATE JURASSIC MINERALIZATION

Deposits within or along contacts of the Jurassic granodiorite include (1) contact metasomatic tungsten, gold, copper, and other metal deposits, (2) replacement-type lead, copper, and precious metal deposits, and (3) veins containing tungsten, copper, and gold.

Contact metasomatic deposits occur in the Frankie mine where the ore is in Pennsylvanian limestone in contact with the granodiorite (El-Shatoury and Whelan, 1970). Ore in the Frankie mine consists of chalcopyrite, malachite, bornite, scheelite, and conichalcite. Associated gangue minerals include pyrite, wollastonite, actinolite, quartz, garnet, apatite, and tourmaline. During 1917-1919, the Frankie mine produced 3,057 tons of ore averaging 0.008 oz/ton gold, 1.5 oz/ton silver, 4.8 percent copper, and 9.7 percent lead.

Replacement deposits in Mississippian limestone along contacts with granodiorite were the sites of the largest mining operations in the quadrangle, the Gold Hill and United States arsenic mines. The ore in both mines consists of arsenopyrite with a complex variety of associated minerals including pyrite, sphalerite, chalcopyrite, galena, jamesonite, aikinite, and stibnite. Between 1917 and 1926, the Gold Hill mine yielded approximately 8,000 tons of arsenic, 1,286 ounces of gold, 680,000 ounces of silver, and minor copper and lead. The United States mine operated from 1923 to 1927 producing an unreported amount of ore that averaged 26 percent arsenic, 0.03 oz/ton gold, 1.6 oz/ton silver, and minor copper, lead, and zinc (Nolan, 1935). After reopening during World War II, the United States mine produced 98,784 tons of 15.2 percent arsenic ore (El-Shatoury and Whelan, 1970).

The molybdenum deposits of the Rustler claims represent another type of replacement deposit. This ore occurs as irregular and gradational altered zones along fractures within the granodiorite. Molybdenite, powellite, chalcopyrite, and pyrite with associated quartz, tourmaline, and apatite constitute the Rustler ore.

Vein deposits within the granodiorite include the Lucy L and Climax mines. These represent "hydrothermal-type vein deposits directly related to the intrusive body" according to El-Shatoury and Whelan (1970), as no veins with this mineralogy or economic potential occur away from the pluton. Quartz veins in the Lucy L mine contain scheelite, chalcopyrite, native bismuth, and native gold. These veins are near the contact metasomatic deposits of the Frankie mine. The Lucy L mine produced 500 tons of ore containing 1 percent WO3. The Climax mine contains veins of quartz, pyrite, arsenopyrite, galena, and sphalerite that yielded minor amounts of lead and silver.

TERTIARY MINERALIZATION

Unlike the Mesozoic ore bodies, Tertiary deposits are not restricted to the age-equivalent pluton. Middle Tertiary lead ores in Gold Hill have no genetic relationship to the Eocene quartz monzonite according to lead-isotope studies (Stacy and Zartman, 1978). There is not a collinear relationship between lead isotopes in feldspars from the quartz monzonite and lead ores sampled at the Rube, Spotted Fawn, and Garrison mines and other locations on Dutch Mountain. This contrasts with the colinearity of feldspar and lead-ore isotopes from the Jurassic pluton (Stacy and Zartman, 1978).

Several mines in the contact aureole of the Jurassic pluton, including the Alvarado, Wilson, Frankie West, and Bonnemort, produced gold with minor amounts of copper, silver, and base metals. A similar metallic suite occurs at the Cane Springs mine, although it is not included in the granodiorite contact aureole (figure 3). This geochemical suite differs from that commonly associated with tungsten skarns (e.g., Mo, Zn, Cu, Sn, Bi, Be, and As) in the contact aureole of the same pluton (Tripp and others, 1989). Although Jurassic gold deposits occur in the eastern Basin and Range, they are rare. Of 67 gold and silver deposits in the Great Basin described by Wilkins (1984), only three were interpreted to have formed during the Jurassic. This, coupled with the spatial relationships of gold versus tungsten mineralization in several mines described by El-Shatoury and Whelan (1970) indicate that the gold formed after the Late Jurassic. Gold deposits within the contact aureole of the Jurassic pluton occur in veins and along fractures which locally crosscut older metamorphic fabrics (El-Shatoury and Whelan, 1970) and in some cases crosscut older mineralization. Unpublished geochemical analyses corroborate that there is no consistent spatial relationship between gold and tungsten mineralization. An early to middle Tertiary age is interpreted for this mineralization, although no quantitative age data exist.

Felsic dikes of assumed mid-Tertiary age occur in all the above mines. Ore minerals include native gold, chalcopyrite, bornite, chalcocite, galena, and covellite in a gangue of pyrite, wollastonite, garnet, vesuvianite, zoisite, and diopside. Twelve samples of ore from the Cane Springs mine yielded from 0.0 to 0.52 oz/ton gold and 0.0 to 0.20 oz/ton silver (El-Shatoury and Whelan, 1970). The same report included 18 ore samples from the Alvarado mine varying from trace to 0.17 oz/ton gold and trace to 11.30 oz/ton silver.

The Rube Gold Mine contains a different mineral suite than that listed above, although this deposit is interpreted to have formed in the same event. Ore occurs as replacement deposits in Ochre Mountain Limestone near the contact of Jurassic granodiorite (El-Shatoury and Whelan, 1970). A hornblende andesite dike forms the upper boundary of the ore zone in the Rube Gold mine. This mine exhibits three types of ore occurring as shoots in hematitic and silicified limestone including: (1) anglesite and cerussite with native gold, (2) galena with native gold, and (3) sulfide ore with pyrite, galena, sphalerite, chalcopyrite, and molybdenite. Between 1921 and 1927, the Rube Gold mine produced 22 (unquantified) shipments of ore averaging 7.0 oz/ton gold and in 1931 shipped 37 tons of 10.0 oz/ton gold ore (El-Shatoury and Whelan, 1970).

On Dutch Mountain, early to middle Tertiary mineralization is concentrated along strike-slip faults in rocks below LANF-2 and is most common in pre-Mississippian rocks below LANF-1. Ore bodies on Dutch Mountain generally occur as lead- and silver-rich replacement deposits in limestone along faults and fractures or in quartz veins bearing tetrahedrite, galena, and sulfides.

The Spotted Fawn (Silver Hill) mine consists of replacement quartz, barite, galena, pyrite, and other sulfides in Abercrombie (?) Formation limestone. From 1901 to 1917 this mine produced 78 tons of 0.038 oz/ton gold, 25.1 oz/ton silver, and 18.1 percent lead ore (Nolan, 1935).

The Garrison Monster (Consolidated) mine occurs within a mosaic of strike-slip faults. Dikes consisting of quartz phenocrysts in a deuterically altered, white, aphanitic groundmass are common. The ore occurs in veins in Upper and Middle Cambrian strata beneath a low-angle fault at the base of the Woodman Formation. Cerussite and plumbojarosite with minor hemimorphite and malachite (Nolan, 1935) constitute the ore. Walls of ore zones are replaced with barite, galena, and limonite afte pyrite. The mine produced approximately 700 tons of ore which assayed 0.004 oz/ton gold, 2.38 oz/ton silver, 0.63 percent copper, and 15.3 percent lead, from 1917 to 1920 (Nolan, 1935). Thirty-five (unquantified) carloads of ore were shipped between 1924 and 1927 with silver content from 1.16 to 6.2 oz/ton and 6.7 to 40.4 percent lead (Nolan, 1935).

Smaller ore bodies on Dutch Mountain include replacement deposits in the Uncle Sam and Evans mines in Royal Gulch. The Uncle Sam ore consists of plumbojarosite and the Evans mine contains barite with galena. Both of these deposits occur along LANF-1. Quartz veins with silver-bearing tetrahedrite intruded the Evans mine and the Rea mine in Accident Canyon. The Gold Belt mine on the northeast edge of Dutch Mountain exposed replacement deposits consisting of white quartz with galena and other sulfides within a breccia zone in Prospect Mountain Quartzite.

Tungsten skarns occur in Pennsylvanian and Mississippian strata along the contact of the Eocene quartz monzonite at several locations including the Timm and Stardust mines (Tripp and others, 1989). The skarn formation is interpreted to postdate the Pb-Ag mineralization on Dutch Mountain, although the relationship remains ambiguous.

MIOCENE MINERALIZATION

Griffitts (1965) reported anomalously high (> 500 ppm) concentrations of beryllium in quartz-adularia-carbonate veins varying in length from several centimeters to 455 meters (1,500 feet) in Rodenhouse Wash. These veins yielded an adularia K-Ar age of 8 Ma (Whelan, 1970)(table 2). El-Shatoury and Whelan (1970) determined that adularia contains beryllium and that no bertrandite is present. Common mineral constituents in these veins include quartz, adularia, siderite or calcite, pyrite, hematite, magnetite, and rare chalcopyrite (El-Shatoury and Whelan, 1970). There has been no commercial production of beryllium from Gold Hill.

GEOLOGIC HAZARDS

The Gold Hill area is approximately 120 kilometers (75 miles) west of the seismically active Intermountain seismic belt (Smith and Sbar, 1974), which trends roughly north-south through central Utah. The Basin and Range of western Utah, including Gold Hill, is characterized by widely spread, small-magnitude earthquakes (Christenson and others, 1987). A fault with late Quaternary movement bounds the Deep Creek Mountains several kilometers east and southeast of the Gold Hill quadrangle (Nakata and others, 1982). However, no clear relationship exists between earthquake epicenters and Quaternary faults in western Utah (Christenson and others, 1987). Soil liquefaction created by ground shaking is possible in the Gold Hill area. However, the greatest potential for soil liquefaction in the Basin and Range occurs in the central parts of valleys and therefore east of the Gold Hill quadrangle (Christenson and others, 1987). The potential for significant damage in the Gold Hill area from seismic activity is slight.

Alluvial fans bordering Dutch Mountain and Gold Hill Peak and alluvial deposits in canyons were emplaced primarily by debris-flow and flash-flood mechanisms. These processes could potentially affect much land in the Gold Hill quadrangle. Gold Hill Wash and Rodenhouse Wash are major intermittent streams and have the potential to carry large volumes of water. Roads and property adjacent to these washes may be subjected to flood damage. Floods occur intermittently in the mud flats in the northeast corner of the quadrangle.

The presence of exposed mine tailings at the United States, Gold Hill, and other mines which are high in arsenic and other soluble elements poses the potential for ground-water contamination through surface leaching. Cyanide solutions used in milling operations could also seep into the ground water.

Mineral exploration and exploitation has left innumerable pits, adits, and shafts in the Gold Hill quadrangle, many of which are not marked on the topographic map. The potential for serious personal injury exists from collapse of abandoned mine workings or encountering an unmarked hole in the ground. The hazard is particularly great in roof pendants of the granodiorite, near mines.

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MINES, PROSPECTS, AND WORKINGS OF THE GOLD HILL QUADRANGLE

by

H.M. Messenger and H.H. Doelling, compiled by B.T. Tripp and M.E. Jensen

MINE/PROSPECT GROUP	LOCATION	DEPOSIT DESCRIPTION	PRINCIPLE COMMODITIES
Alice No. 2	NWNE 2-7S-18W	Contact metasomatic, replacement vein	Cu
Alvarado Mine	SWSW 31-7S-17W	Contact metasomatic	Ag Au Cu
Badger Hole	NWSE 27-7S-18W	Vein	Unknown
B. Estelle Mine	SENE 27-7S-18W	Contact metasomatic	W Zn
Black Bird	SWSE 6-8S-17W	Fissure vein	Unknown
Blue Lead	SESE 23-7S-18W	Replacement	Pb
Bonnemort Mines	NENW 12-8S-18W	Vein	Au Cu
Boston	NWSE 5-8S-17W	Fissure vein	Ag As Au Pb
Brown Rock	SENE 15-8S-18W	Fissure vein, replacement vein	Ba Fe
Calaveras Mine	NENW 13-8S-18W	Shoots and veins, replacements	Ag Au Cu
Cane Springs Mine	SWNE 2-8S-18W	Replacement vein, contact metasomatic	Ag As Au Cu Mo Pb Zn
Cardiff Mine	NESE 23-7S-18W	Fissure vein	Ag Pb
Cash Boy Mine	NESW 8-8S-17W	Vein	Ag Au Cu Pb
Chester	NESE 10-7S-18W	Replacement	Cu
Christmas Mining Co.	SENE 33-7S-17W	Fissure vein	Ag Ba Cu Pb Sb
Climax Mine	NENW 17-8S-17W	Quartz veins	Ag Be Cu Pb Zn
Copper Bloom	NWSE 13-8S-18W	Veins and replacements	Ag Au Bi Cu W
Copper Cup	NWSW 23-7S-18W	Contact metasomatic, fissure vein	Cu W
Copper Hill	NESW 34-7S-18W	Contact metasomatic	As Au Cu Pb
Copperopolis Mine	NESE 6-8S-17W	Shoots and pipes	Ag Au Cu Pb W
Dutch Summit Adits	NWSE 11-7S-18W	Bedding replacement; replacement vein	Unknown
E.H.B. Lode	NENE 27-7S-18W	Contact metasomatic	Cu W Zn
Evans Mine	NWNE 10-7S-18W	Replacement vein	Ag Ba Pb
February	NWNW 11-7S-18W	Fissure vein	Cu
Fraction Lode Mine (Timm)	NWNW 26-7S-18W	Contact metasomatic	W
Frankie Mine	SESW 12-8S-18W	Replacement	Ag Au Cu Pb W
Frankie West	SWSW 12-8S-18W	Vein	Au Cu
Garrison Mines	NESE 2-7S-18W	Replacement vein; bedding replacement	Ag Au Ba Cu Pb Zn
Gem	NENW 6-8S-17W	Fissure veins and contacts	Au
Glenda Mine	NESW 1-8S-18W	Fissure vein	As Au Cu Pb
Gold Belt	NWSE 8-7S-17W	Fissure vein	Pb
Gold Bond	SWNE 13-8S-18W	Fissure - replacement	B Cu F
Gold Hill Mine	SENW 6-8S-17W	Vein	Ag As Au Ba Cu Pb W
Gold Hill Pass	NESE 28-7S-18W	Replacement vein	Unknown
Gold Hill Standard	NENW 1-8S-18W	Fissure vein	Ag As Mo Pb Zn
Gold Hill Wash	SENE 11-8S-18W	Fissure vein	Au
Grab-It-Here	NESE 22-7S-18W	Fissure vein	Pb
Hattie No. 35	NESE 7-8S-17W	Fissure vein	Au
Hidden Treasure	SWNE 7-8S-17W	Fissure vein	Cu
Homestead	SWNW 1-8S-18W	Fissure vein	Unknown
Incomparable Nos. 1 & 2	SWSE 5-8S-17W	Fissure vein	Ag As Au Pb
Iron Claim	SENE 10-7S-18W	Replacement vein	Ag Cu Pb
Imperial	SWSE 35-7S-18W	Contact metasomatic	Au Cu Pb
January	SWSW 2-7S-18W	Fissure vein	Ba
Jolly John	NWSE 22-7S-18W	Fissure vein, replacement vein	Unknown
Keno Mines	SWNE 13-8S-18W	Vein	Ag Au Cu
Last Chance No. 2	NENW 26-7S-18W	Contact metasomatic	W
Last Dime	NWSW 1-8S-18W	Vein	Au Cu
Lead King	SESW 24-7S-18W	Replacement vein, fissure vein	Unknown
Little Valley	SENW 34-7S-18W	Contact metasomatic	Unknown

Lost Horse	NESE 10-7S-18W	Replacement vein							Cu							
Lucky Boy	NENE 8-8S-17W	Fissure vein	Unknown													
Lucy L Mine	SWSE 12-8S-18W	Quartz vein			Au			Bi	Cu				Te	W		
Lucy L North	SESW 12-8S-18W	Vein			Au											
Maple	SESE 6-8S-17W	Fissure veins	Ag		Au				Cu							
Monster-Creon adits	SWNW 11-7S-18W	Fissure vein				Ba						Pb				
Moonlight	SWSW 7-8S-17W	Vein, replacement			Au											
Murphy-Lucky Strike	NWSW 31-7S-17W	Contact metasomatic	Ag	As	Au				Cu							
Napoleon Mining Co. Mine	NENW 31-7S-17W	Replacement lode	Ag		Au				Cu			Pb			Zn	
New Baltimore Mine	NENE 18-8S-17W	Fissure vein and replacement	Ag		Au				Cu			Pb			Zn	
New Year-Roy	SESW 2-7S-18W	Fissure veins							Cu							
Norman Scott	SWNW 26-7S-18W	Contact metasomatic												W		
North Wash	SESE 2-8S-18W	Contact metasomatic							Cu							
Ochre Springs	SENE 10-8S-18W	Fissure vein				Ba										
Option No. 1	SENW 24-7S-18W	Fissure vein							Cu							
Oregon	NESE 2-8S-18W	Contact metasomatic, replacement vein		As					Cu							
Pay Rock	SWNE 24-7S-18W	Fissure vein		As								Pb				
Polestar Mine	SENE 13-8S-18W	Fissure veins	Ag		Au				Cu					W		
Pool Canyon	NWSW 23-7S-18W	Replacement vein, fissure vein	Unknown													
Queen	NENW 8-8S-17W	Shear zone			Au											
Rea	SWSW 10-7S-18W	Fissure vein	Ag						Cu							
Rose Towsley	NESE 6-8S-17W	Vein			Au				Cu							
Rube Gold Mine	SWSW 30-7S-17W	Replacement	Ag	As	Au				Cu		Mo	Pb			Zn	
Rube Lead Mine	NWSW 30-7S-17W	Replacement vein	Ag									Pb				
Rustler	SWNW 13-8S-18W	Replacement along fissure			Au				Cu		Mo			W		
Scramble-up adit	SESW 29-7S-17W	Fissure vein	Unknown													
Section 18 Barite	SWNE 18-8S-17W	Replacement				Ba										
Senate	SENE 13-8S-18W	Fissure vein			Au											
Silver and Gold Mining Co	SENE 31-7S-17W	Fault fissure	Ag	As	Au							Pb			Zn	
Silver Hill	NWSE 14-7S-18W	Fissure veins	Ag		Au	Ba						Pb				
Southern Belle	NWSW 6-8S-17W	Veins			Au											
Spring Hill Lode	SWSW 11-8S-18W	Fissure vein				Ba										
Star Dust Extension Mine	SENE 27-7S-18W	Contact metasomatic												W		
Star Dust Lode	NWNE 27-7S-18W	Contact metasomatic												W		
Star Dust No. 2	NENW 27-7S-18W	Contact metasomatic												W	Zn	
Success Annex	SESW 8-8S-17W	Fissure veins			Au											
Success Fraction	SENW 8-8S-17W	Fissures			Au											
Success Mine	NWSE 8-8S-17W	Quartz vein	Ag		Au				Cu			Pb			Zn	
Sunny South	NENE 13-8S-18W	Fissure vein			Au											
Tobar	SWNE 26-7S-18W	Contact metasomatic, fissure vein							Cu					W		
Tribune Gulch	NESW 24-7S-18W	Replacement vein	Unknown													
Troy	NWSW 17-8S-17W	Fissure vein			Au		Be		Cu			Pb				
Tucson	NWNE 27-7S-18W	Contact metasomatic; replacement vein			Au				Cu					W		
Tunnel	SESW 3-7S-18W	Replacement vein				Ba										
Tuolomne	SWSW 23-7S-18W	Contact metasomatic			Au				Cu					W		
Ulmer-Lucky Strike	NWNE 34-7S-18W	Contact metasomatic	Unknown													
Uncle Sam	SENE 10-7S-18W	Replacement veins	Ag			Ba						Pb				
Undine	SWNE 12-8S-18W	Replacement, contact	Ag		Au				Cu	Fe		Pb				
Unfinished Dream No. 1	NESE 22-7S-18W	Vein							Cu			Pb				Vermiculite
Unfinished Dream No. 2	NWSE 22-7S-18W	Contact metasomatic, fissure vein							Cu			Pb				
Unidentified No. 1	SENE 28-7S-18W	Replacement vein, contact metasomatic		As					Cu							
Unidentified No. 2	SWSW 22-7S-18W	Contact metasomatic	Unknown													
Unidentified No. 3	SESE 22-7S-18W	Contact metasomatic, fissure vein							Cu						Zn	
Unidentified No. 4	NWSW 35-7S-18W	Contact metasomatic	Unknown													
Unidentified No. 5	NWNE 3-8S-18W	Fissure vein	Unknown													
Unidentified No. 6	SENE 4-8S-18W	Fissure vein				Ba										
Unidentified No. 7	SWSW 3-8S-18W	Vein	Unknown													
Unidentified No. 8	NESW 2-8S-18W	Fissure vein	Unknown													

Unidentified No. 9	SWSE 31-7S-17W	Fissure vein	Ba
Unidentified No. 10	SENW 32-7S-17W	Replacement vein	Unknown
Unidentified No. 11	SWNW 6-8S-17W	Fissure vein	Unknown
Unidentified No. 12	NESE 12-8S-18W	Fissure vein	Cu
Unidentified No. 13	SWSW 9-8S-17W	Fissure vein	Au Cu
U.S. Mine	NWSW 1-8S-18W	Replacement	Ag As Au Cu Pb Sb Zn
Walla Walla	SESE 34-7S-18W	Replacement vein	Ag As Au Pb Zn
Western Pacific	SENE 6-8S-17W	Fissure vein	Au
Western Utah Extension Mine	NESW 6-8S-17W	Fissure vein	Ag As Au Cu Fe
Wilfong	SESW 36-7S-18W	Contact metasomatic	Mo W
Wilson	SWSE 1-8S-18W	Fissure veins	Au
Windsor	NWSW 1-7S-18W	Replacement	Unknown

KEY TO COMMODITY CODES

AG	=	Silver	CU	=	Copper	TE	=	Tellurium
AS	=	Arsenic	F	=	Fluorite	UNK	=	Unknown
AU	=	Gold	FE	=	Iron	V	=	Vanadium
B	=	Boron	KYN	=	Kyanite	VRM	=	Vermiculite
BA	=	Barite	MO	=	Molybdenum	W	=	Tungsten
BE	=	Beryllium	PB	=	Lead	ZN	=	Zinc
BI	=	Bismuth						

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