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DEPARTMENT OF NATURAL RESOURCES
UTAH GEOLOGICAL AND MINERAL SURVEY

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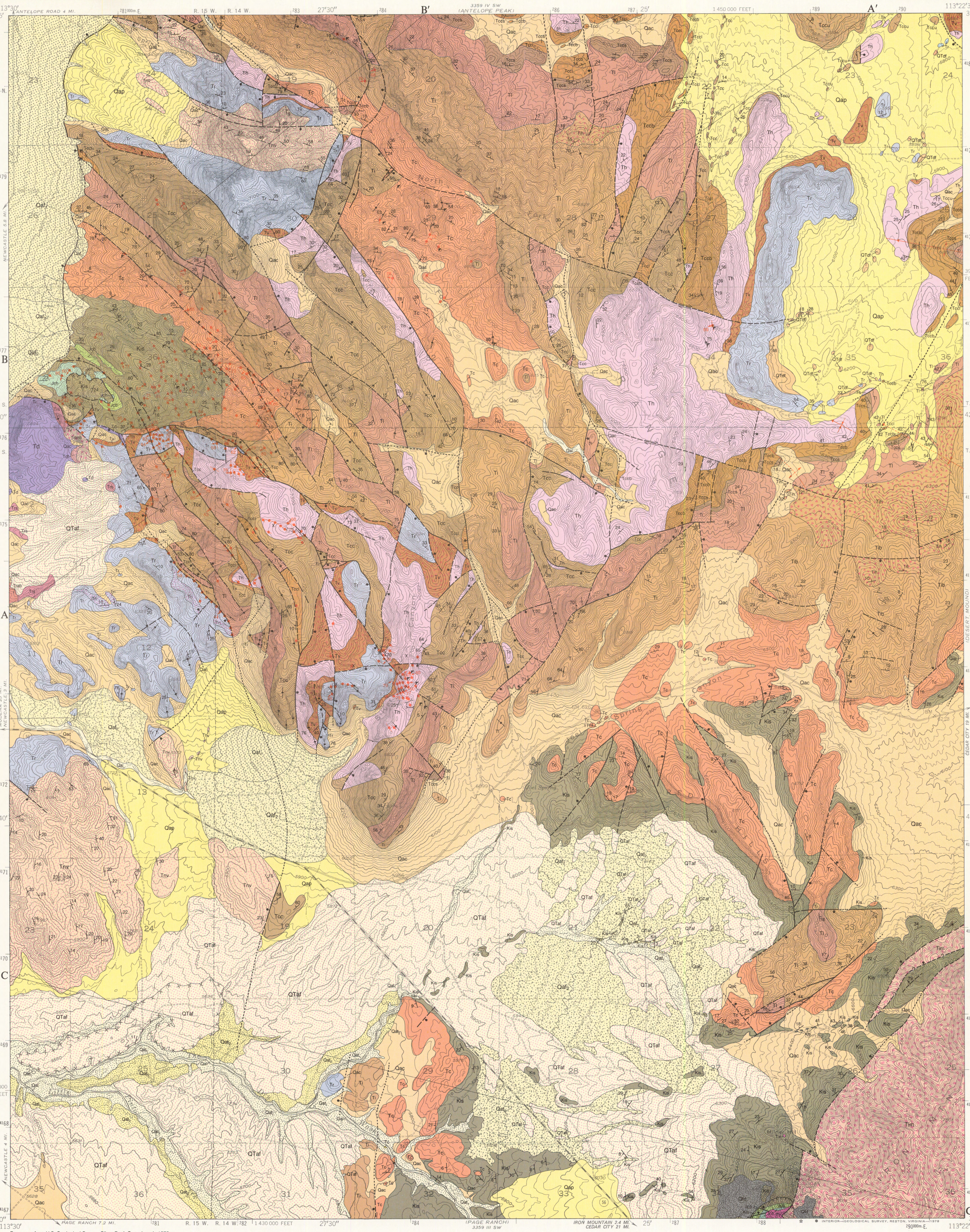
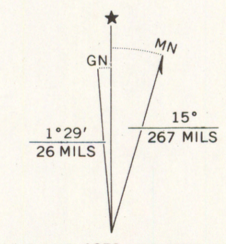


Base map form U.S. Geological Survey, Silver Peak Quadrangle,1978

(PINTO) 3259 II SE

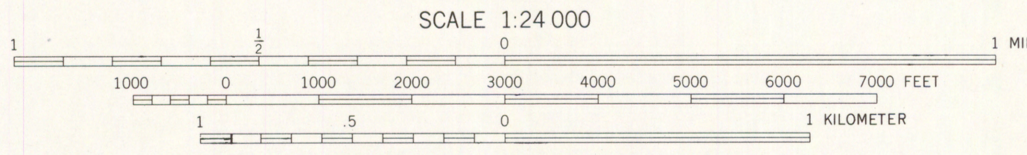
(STODDARD MTN.) 3359 III SE

Field mapping by authors 1985-86
Kent D. Brown, Cartographer

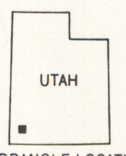


UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000



CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



QUADRANGLE LOCATION

GEOLOGIC MAP OF THE SILVER PEAK QUADRANGLE, IRON COUNTY, UTAH

by
Michael A. Shubat and Mary A. Siders
Utah Geological and Mineral Survey

1988

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
UTAH GEOLOGICAL AND MINERAL SURVEY

CONTACT

Dashed where approximate; dotted where inferred

FAULTS

Dashed where approximate; queried where uncertain; dotted where covered

Normal Fault

Bar and ball on downthrown side; dip indicated by arrow

Inferred Thrust Fault (on cross sections)

Gravity Slide Block
Dashed where inferred

TRACE OF AXIAL SURFACE OF FOLD

Anticline

Syncline

Outline of the oldest and highest alluvial terrace, T3. This is a cut terrace without associated sediments.

STRIKE AND DIP OF BEDDING AND ASH-FLOW TUFF LAYERING

10 Inclined

Vertical

STRIKE AND DIP OF JOINTS

15 Inclined

Vertical

STRIKE AND DIP OF SLICKENSIDES

15 Inclined; approximate plunge of grooves indicated

10 Horizontal; dip of surface indicated

VEIN

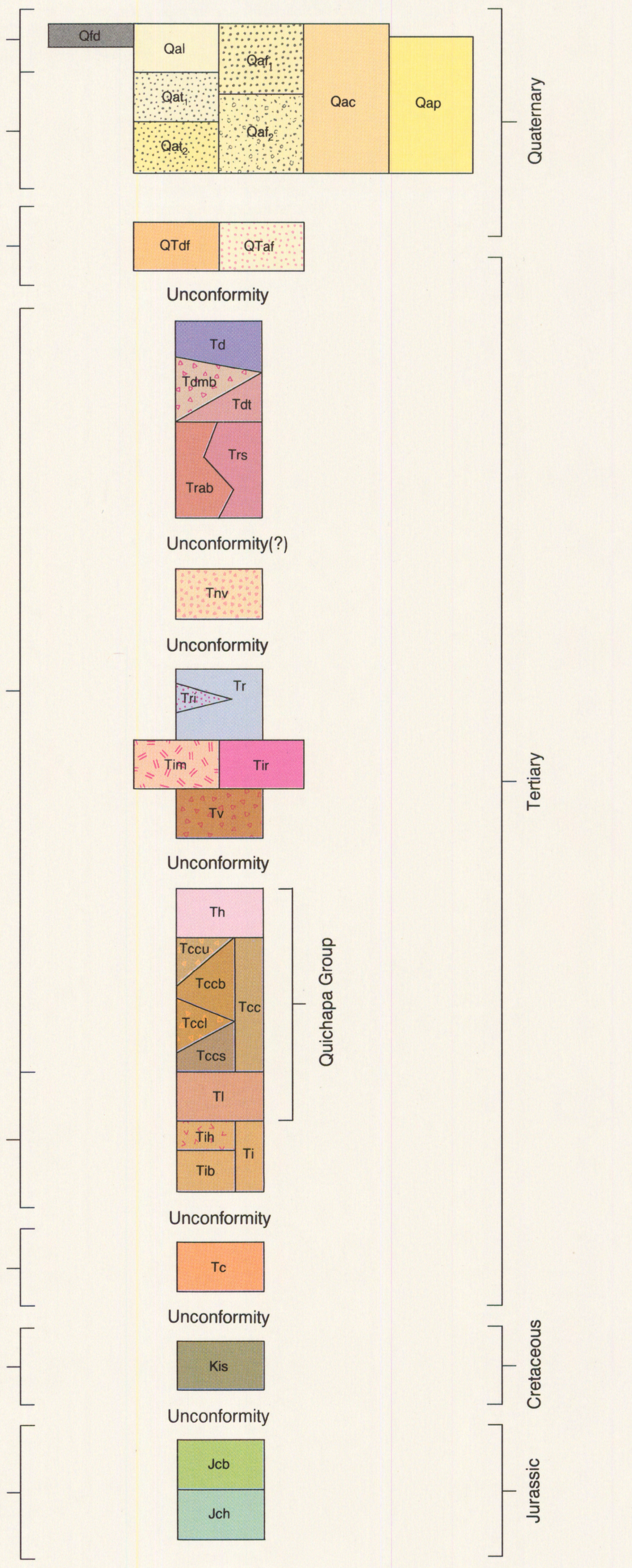
16 Dip indicated by arrow

MINE WORKINGS

adit shaft prospect trench

Margin of open pit (Burke mine)

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qfd Mine dump fill—*Mine dump fill flanking the northern pit of the Burke mine.*

Qal Modern alluvium—*Unconsolidated sand and gravel deposited in intermittent stream channels.*

Qat1 Young terrace deposits—*Unconsolidated sand, silt, and minor gravel deposits forming the lowest and youngest terraces along Dry Wash and Little Pinto Creek. Material dominantly composed of orangish silt and sand.*

Qat2 Terrace deposits—*Unconsolidated sand, silt, and minor gravel deposits forming fill terraces of intermediate age and elevation. Material dominantly composed of orangish silt and sand.*

Qaf1 Modern alluvial-fan deposits—*Unconsolidated sands and gravel deposited on active alluvial fans. Fans of this age postdate Quaternary faulting along the west margin of the Antelope Range.*

Qaf2 Alluvial-fan deposits—*Unconsolidated sand and gravel deposited in abandoned alluvial fans. Fans of this age are slightly dissected and partially covered by Qaf, deposits. This unit is cut by Quaternary faulting along the west margin of the Antelope Range.*

Qac Colluvial deposits—*Unconsolidated deposits of silt, sand, pebbles, and cobbles flanking steep areas of bedrock exposure and mantling lower slopes.*

Qap Pediment alluvium—*Unconsolidated deposits of sand, silt, and gravel forming a thin cover over bedrock. Outcrops common in stream cuts.*

QTaf Older alluvial-fan deposits—*Poorly consolidated deposits of silt, sand, gravel, and boulders covering a large area in the southwest corner of the quadrangle. Characterized by well-developed whaleback landforms, a thick (as much as 6 inches) calcrete horizon, and the presence of conspicuous magnetite cobbles derived from the periphery of the Iron Mountain pluton.*

QTdf Debris flows—*Poorly consolidated deposits of pebble or boulder conglomerate and lesser coarse sandstone. Clasts composed mostly of Racer Canyon Tuff and Harmony Hills Tuff. Deposited as debris flows with intercalated alluvium.*

Td Dacite of Bullion Canyon—*Purplish dacite porphyry with coarse (7 to 12 mm), abundant phenocrysts of quartz, sanidine, plagioclase, biotite, and opaques. Diktytaxitic texture represented by abundant, fine-grained, uniformly distributed void space. It forms a well-defined dome located in the southwest portion of the map area. Dome is about 3000 feet (900 m) in diameter with concentric, steeply dipping flow banding. Dated at 8.5±0.4 Ma.*

Tdt Dacitic air-fall tuff—*Air-fall tuff facies of the dacite of Bullion Canyon that locally underlies the dacite dome.*

Tdmb Dacitic mudflow breccia—*Mudflow breccia facies of the dacite of Bullion Canyon that locally underlies the dacite dome.*

Trs Rhyolite of Silver Peak—*Purplish-gray rhyolite to trachyte porphyry flow rocks with glassy matrix and medium-grained (3 mm) phenocrysts of quartz, sanidine, biotite, and trace opaques. Irregular vesicles (5 mm in diameter) comprise up to 17 percent of the rock. Consists of several coalescing volcanic domes located in the west-central portion of the map area. Dated at 8.4±0.4 Ma.*

Trab Autobrecciated rhyolite—*Autobrecciated facies of the rhyolite of Silver Peak.*

Tnv Volcaniclastic rocks of Newcastle Reservoir—*Brick-red, moderately well-bedded volcaniclastic conglomerate and sandstone. Clasts composed of Racer Canyon Tuff, Harmony Hills Tuff, a variety of volcanic rocks, and lesser limestone, chert, and quartzite. Hematitic matrix is ubiquitous. Complete section not observed, but exposed thicknesses range from 300 to 1200 feet (90 to 365 m). Equivalent to the "mine series" of Siders (1985a).*

Tr Racer Canyon Tuff—*Weakly to moderately welded, rhyolitic ash-flow tuff of whitish, gray, or pink color. Contains 30 to 35 percent crystals of quartz, plagioclase, sanidine, biotite, and minor Fe-Ti oxides, hornblende, and sphene. Lithic fragments are sparse. Thickness ranges from 300 to 1100 feet (90 to 335 m). Dated about 19 Ma.*

Tri Interbedded tuffaceous sandstone of the Racer Canyon Tuff— *Bedded quartz-rich tuffaceous sandstone that locally occurs near the top of the Racer Canyon Tuff and presumably separates two cooling units.*

Tir Replacement deposits of iron ore—*Massive bodies of iron ore composed of magnetite and hematite. Deposits formed by replacement of the Homestake Limestone Member of the Carmel Formation and the Iron Springs Formation. Replacement bodies mapped in two areas adjacent to the Iron Mountain pluton.*

Tim Iron Mountain pluton—*Porphyritic quartz monzonite composed of about 50 percent phenocrysts of plagioclase, clinopyroxene, amphibole, and biotite set in a fine-grained granitoid to granophyric matrix. Top of pluton is concordant with the base of the Carmel Formation. Exposed contacts appear to be intrusive faults. Dated at approximately 20 Ma.*

Tv Volcaniclastic rocks—*Dark-colored, poorly-sorted, crudely bedded, cobble-rich, volcaniclastic mudflow breccia with local sandstone interbeds. Clasts composed dominantly of andesite and Harmony Hills Tuff. Unit is widely distributed and about 100 feet (30 m) thick.*

Th Harmony Hills Tuff—*Purplish, red, or brown (where altered) to light tan (where fresh), moderately welded, dacitic, crystal-rich ash-flow tuff. Contains about 50 percent crystals of plagioclase, quartz, biotite, amphibole, and Fe-Ti oxides. Thickness ranges from 200 to 400 feet (60 to 120 m). Dated at about 21 Ma.*

Condor Canyon Formation

Tcc Condor Canyon Formation—*Individual members mapped outside of the Antelope Range mining district but undifferentiated within the district.*

Tccu Upper volcaniclastic and tuffaceous rocks—*Over 200 feet (60 m) of volcaniclastic and tuffaceous rocks cap the Condor Canyon Formation in the northwest corner of the quadrangle. Four volcaniclastic horizons were identified (from top to bottom): coarse andesitic mudflow breccia, lithic-rich volcaniclastic rock containing about 90 percent Bauers Tuff clasts in a pale gray matrix, volcaniclastic rock containing 30 to 40 percent Bauers Tuff clasts and 15 percent crystals of plagioclase, biotite and trace quartz, and a white, non-welded, porous, massive, lithic-crystal tuff.*

Tccb Bauers Tuff Member—*Densely welded, rhyolitic, vitric-crystal ash-flow tuff with abundant, distinctive, light-gray flattened lenticules. Contains about 15 percent crystals of plagioclase, sanidine, bronze biotite, and minor Fe-Ti oxides. Black basal vitrophyre commonly present. Thickness ranges from 200 to 600 feet (60 to 180 m). Dated at 23 Ma.*

Tccl Lower volcaniclastic rocks—*Andesitic volcaniclastic horizon separating the Bauers and Swett Tuff Members throughout most of the quadrangle. Consists of volcanic mudflow breccia containing pebble- to boulder-sized clasts of andesite. Approximately 30 to 70 feet (9 to 20 m) thick.*

Tccs Swett Tuff Member—*Densely welded, rhyodacitic, vitric-crystal ash-flow tuff, with flattened lenticules. Contains about 15 percent crystals of plagioclase, biotite, and minor Fe-Ti oxides. Black basal vitrophyre commonly present. Thickness is less than 100 feet (30 m). Dated at 24 Ma.*

Tl Leach Canyon Tuff—*Pale cream to gray, moderately welded, ash-flow tuff containing 20 to 30 percent crystals of quartz, plagioclase, sanidine, and minor biotite and opaques. Contains conspicuous reddish lithic fragments. Table Butte and Narrows Members not distinguished. Thickness is about 500 feet (150 m). Dated at about 25 Ma.*

Isom Formation

Ti Isom Formation—*Dark-brown, densely welded, crystal-poor ash-flow tuff with distinctive, flattened, light-gray lenticules. Sparse crystals of plagioclase, minor clinopyroxene and Fe-Ti oxides. Mapped as a single unit in the Antelope Range district and as two members (below) outside of the district. Total thickness ranges from 300 to 1200 feet (90 to 365 m).*

Tih Hole-In-The-Wall Tuff Member—*Densely welded, purplish-gray to reddish, crystal-poor ash-flow tuff. Contains light gray, flattened lenticules and locally has a black basal vitrophyre.*

Tib Baldhills Tuff Member—*Several cooling units of densely welded, brown, crystal-poor ash-flow tuff. Contains flattened vesicles, light gray lenticules, and rare, thin sedimentary interbeds. Black basal vitrophyres rarely exposed.*

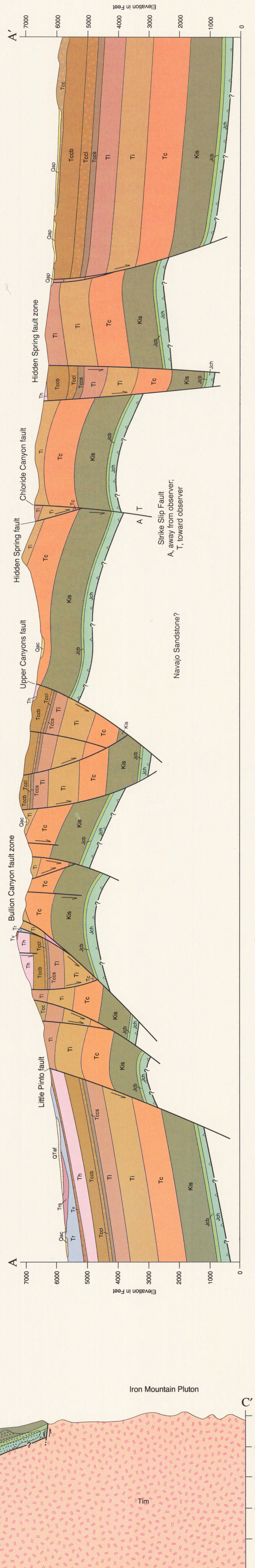
Tc Claron Formation—*Composed of fluvial and lacustrine shale, siltstone, sandstone, limestone, and conglomerate. Lower portion dominated by red siltstone, sandstone, and conglomerate. Upper portion is mostly light-gray to mottled, freshwater limestone (with sparse leaf fossils), limestone-clast conglomerate, and lesser sandstone. Thickness ranges from 500 to 950 feet (150 to 290 m).*

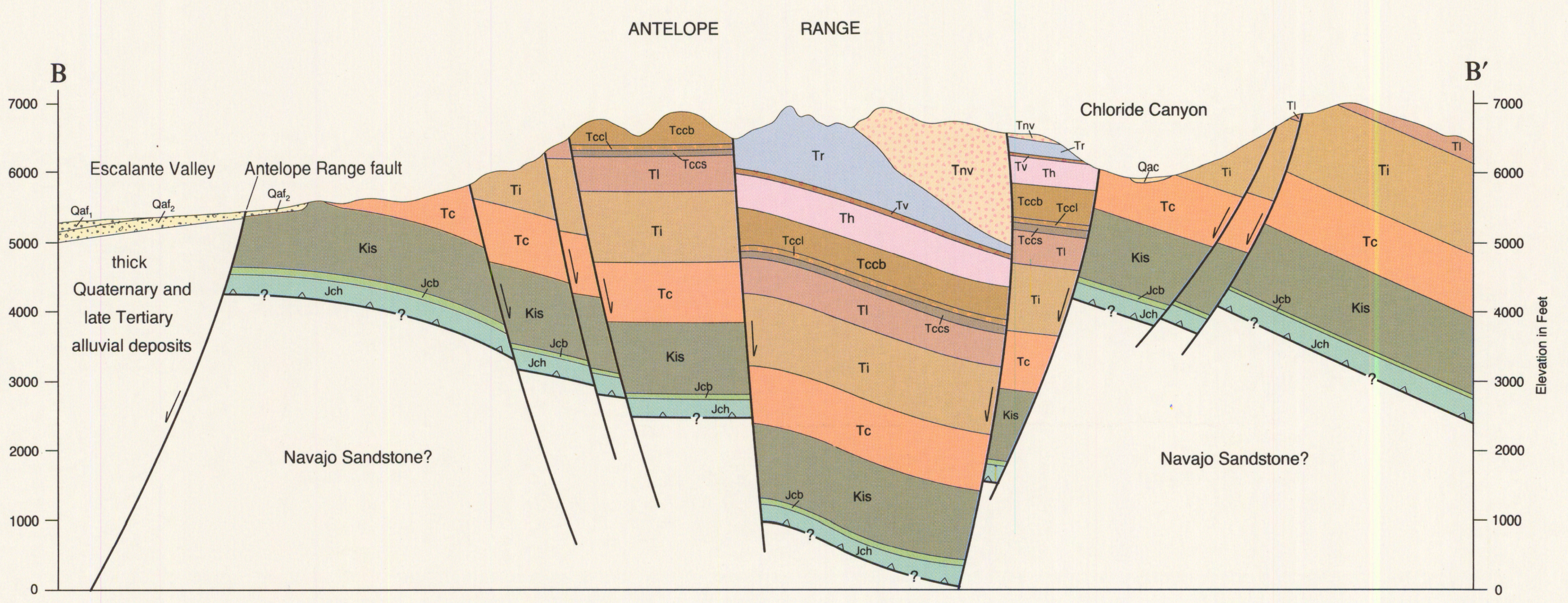
Kis Iron Springs Formation—*Fluvial and lacustrine, light- to dark-brown, thin- to thick-bedded, continental sandstone and pebble- to cobble-conglomerate, with lesser interbedded siltstone, shale, and limestone. Base of unit includes a thin, discontinuous, basal conglomerate containing abundant quartzite clasts. Thickness ranges from about 1050 to 3600 feet (320 to 1100 m).*

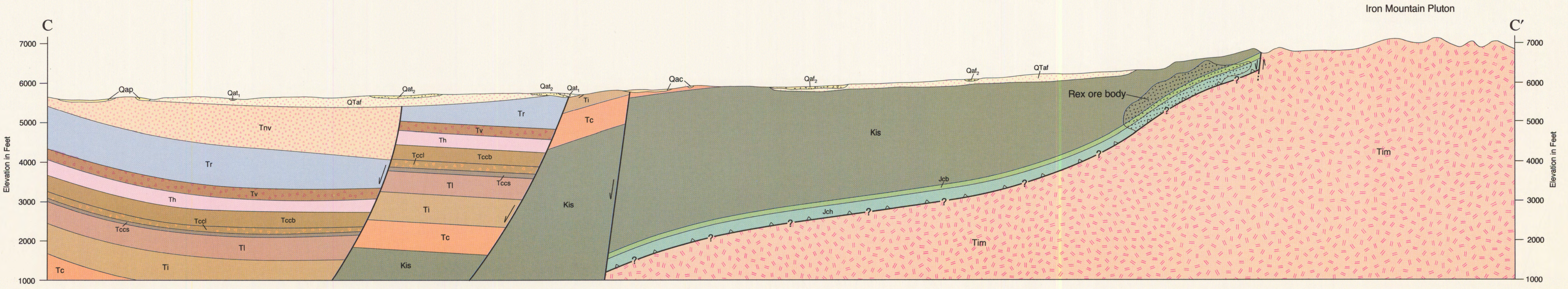
Carmel Formation

Jcb Upper banded member—*Alternating bands of gray and maroon shale and siltstone. Between 0 and 100 feet (0 to 30 m) thick.*

Jch Homestake Limestone Member—*Resistant, massive to thick-bedded, blue-gray limestone containing sparse invertebrate fossils. Upper portion is a thin-bedded, argillaceous limestone. Base is not exposed in the quadrangle. A minimum thickness of 160 feet (50 m) is indicated.*

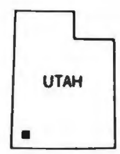






GEOLOGIC MAP OF THE SILVER PEAK QUADRANGLE, IRON COUNTY, UTAH

By Michael A. Shubat and Mary A. Siders



UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
MAP 108 **1988**

UTAH GEOLOGICAL AND MINERAL SURVEY

606 Black Hawk Way
Salt Lake City, Utah 84108-1280

THE UTAH GEOLOGICAL AND MINERAL SURVEY is one of eight divisions in the Utah Department of Natural Resources. The UGMS inventories the geologic resources of Utah (including metallic, nonmetallic, energy, and ground-water sources); identifies the state's geologic and topographic hazards (including seismic, landslide, mudflow, lake level fluctuations, rockfalls, adverse soil conditions, high ground water); maps geology and studies the rock formations and their structural habitat; and provides information to decisionmakers at local, state, and federal levels.

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GEOLOGIC MAP OF THE SILVER PEAK QUADRANGLE, IRON COUNTY, UTAH

By Michael A. Shubat[1] and Mary A. Siders[2]

ABSTRACT

Geologic mapping of the Silver Peak quadrangle focused on the volcanic stratigraphy, mineral resource potential, and structural geology. Pre-Tertiary rocks crop out in the quadrangle and record a brief marine invasion in Middle to Late Jurassic time, followed by continental sedimentation throughout the Cretaceous. Tertiary volcanic rocks are the dominant lithology. Ash-flow tuffs of the Isom Formation, Quichapa Group, and Racer Canyon Tuff are the most voluminous products of calc-alkaline volcanism, and local rhyolite to dacite flows represent late Miocene bimodal volcanism. Structural events recorded in the quadrangle include Sevier-age thrusting, deformation related to mid-Miocene intrusion, and Neogene extensional tectonism. Middle to late Miocene extensional deformation produced west-northwest-trending folds, northwest-striking normal faults, strike-slip faults, and oblique-slip faults. Late Miocene to Quaternary basin-range style faulting produced as much as 9800 feet (3 km) of offset along the western-bounding fault of the Antelope Range.

The Antelope Range mining district consists of a system of quartz and calcite veins hosting epithermal-type base- and precious-metal mineralization and is located in the west-central portion of the quadrangle. Two stages of mineralization occur, an early base-metals sulfide stage and a later silver sulfosalt stage. Fluid inclusion studies indicate that ore minerals precipitated from boiling solutions over a temperature range from 198° to 205°C. Ore minerals probably precipitated in the upper levels (boiling zone) of a hydrothermal convection cell generated by the emplacement of the rhyolite of Silver Peak and associated dacite. Replacement iron ore deposits of the Pinto mining district lie adjacent to the Iron Mountain pluton in the southeast corner of the quadrangle. Exploration by private industry located three ore bodies in the quadrangle, including the Rex ore body, probably the largest single deposit of iron ore in the state with reserves in excess of 100 million tons.

INTRODUCTION

The Silver Peak quadrangle lies along the southeastern margin of the Escalante Desert, approximately 18 miles (11 km) due west of Cedar City, Utah, in south-central Iron County (figure 1). The quadrangle encompasses most of the Antelope Range, which has a relief of 2000 feet (610 m) and a maximum elevation of 7416 feet (2260 m).

STRATIGRAPHY

JURASSIC

Carmel Formation

The Homestake Limestone Member and upper banded member of the Carmel Formation are the oldest rocks exposed in the Silver Peak quadrangle. Resistant beds of the blue-gray, generally massive to thick-bedded Homestake Limestone Member account for most of the formation. In the nearby Iron Springs district, where it locally hosts replacement iron ores, this member is 180-270 feet (55-82 m) thick (Mackin and others, 1976). Sparse invertebrate marine fossils occur throughout the Homestake, the upper portion of which is locally a light gray to buff, thin-bedded argillaceous limestone. The Homestake Limestone Member has been tentatively correlated with the limestone member (Cashion, 1967) or Kolob Limestone Member (Thompson and Stokes, 1970) of the Carmel Formation on the Colorado Plateau. Small exposures of the Homestake Member occur near the mouth of Bullion Canyon (in the west-central portion of the quadrangle) and in the Burke mine in the southeastern corner of the quadrangle. An upper banded member (Jcb), less than 100 feet (30 m) thick, overlies the Homestake Member. This unit consists of alternating bands of gray and maroon shale and siltstone and is correlated with the Crystal Creek Member of the Carmel Formation on the Colorado Plateau (Thompson and Stokes, 1970).

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[2] currently, Ph.D. candidate, University of Colorado, Boulder

CRETACEOUS

Iron Springs Formation

Clastic sedimentary rocks of the Upper Cretaceous Iron Springs Formation overlie the Carmel Formation. Deposition of the Iron Springs Formation took place in braided fluvial and lacustrine environments, forming an easterly prograding clastic wedge shed from the Sevier orogenic highland. Mackin (1947) defined the type locality near plutons in the adjacent Iron Springs district. A thin, discontinuous conglomerate, containing abundant quartzite and lesser limestone clasts, underlies the Iron Springs Formation and is tentatively correlated with the conglomerate at the base of the Dakota Formation in the Colorado Plateau. Most of the formation consists of a resistant, thick- to thin-bedded continental sandstone with lesser amounts of interbedded shale, conglomerate, and limestone. Exposures of the Iron Springs Formation occur in an arcuate zone cored by the Iron Mountain pluton and in the Bullion Canyon area. Inferred thicknesses of the formation range from 1050 feet (320 m) in the Bullion Canyon area to 3600 feet (1100 m) along the southern edge of the quadrangle.

TERTIARY

Claron Formation (Oligocene-Paleocene?)

The Claron Formation (Tc), consisting of fluvial and lacustrine shale, sandstone, limestone, and conglomerate, was deposited unconformably on a beveled Late Cretaceous surface of low local relief (Mackin, 1954; 1960). The formation is dominantly white in its upper part and red in the lower. Non-resistant shale of the formation forms bright red slopes interspersed with gray cliffs of massive limestone. The limestone is non-fossiliferous, and often exhibits a mottled appearance. Exposures of the Claron Formation occur in the southeast corner (forming the Red Hills) and along the south-central margin of the quadrangle. Other exposures located in the Bullion and Chloride Canyon areas have thicknesses of 500 to 950 feet (150 to 290 m). The formation is 1400 feet (430 m) to more than 1700 feet (520 m) thick near the Iron Springs district (Mackin and others, 1976).

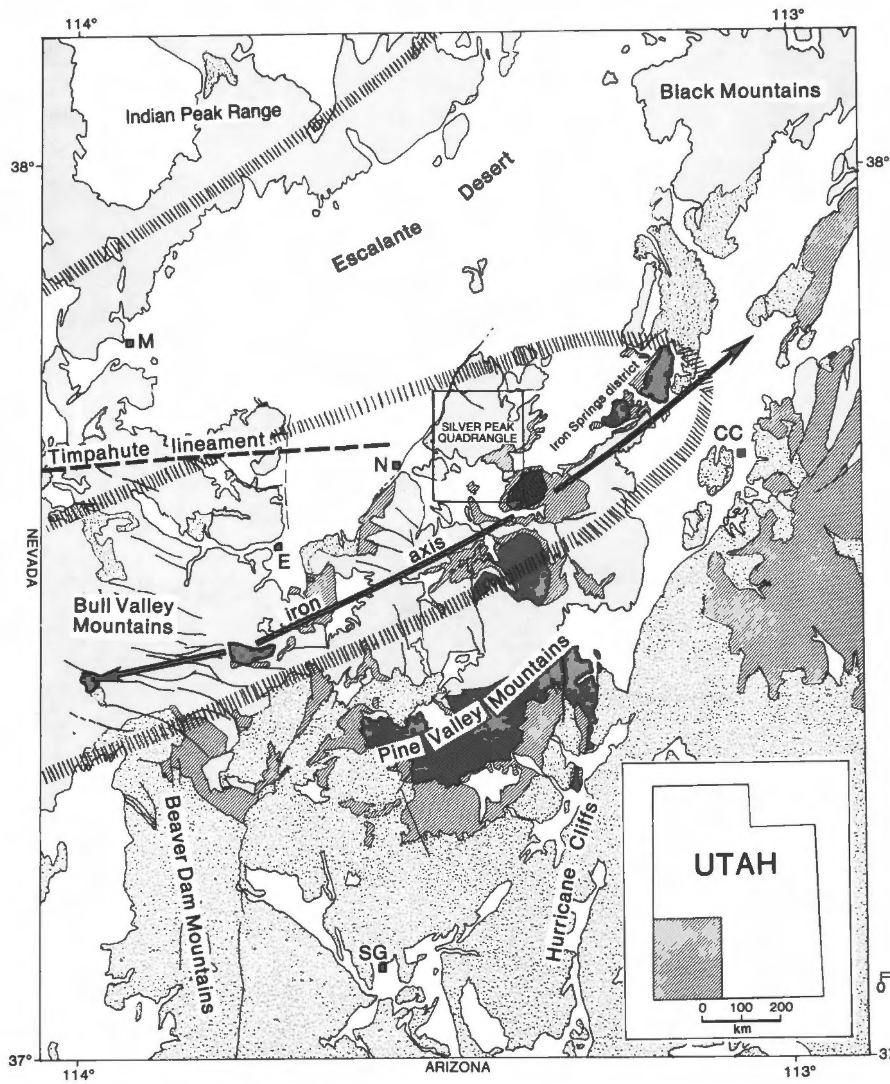

Figure 1. General geology and structural features of southwestern Utah. Light areas include Tertiary lavas, ash-flow tuffs, and volcaniclastic units. Diagonal line pattern represents the Claron (Oligocene-Paleocene?) and Iron Springs (Cretaceous) Formations. Dark shaded areas are Miocene plutons; mineralized plutons lie along the iron axis. Stippled areas include all other rocks from Precambrian through Mesozoic and some Quaternary basalt. Hachured lines enclose the Pioche mineral belt (north) and the Delamar-Iron Springs mineral belt (south). M, Modena; E, Enterprise; N, Newcastle; CC, Cedar City; SG, St. George. Geology modified from Hintze (1980), structural features from Rowley and others (1979) and Tobey (1976).

Isom Formation (Oligocene)

Mackin (1960) defined the Isom Formation as a sequence of ash-flow tuffs and lavas, with some intercalated sedimentary rocks, and designated a type locality in the northwestern part of the Iron Springs district. The Isom Formation consists of densely welded, crystal-poor, ash-flow tuffs present throughout much of southwestern Utah. The lower Baldhills Tuff Member (Tib) consists of several cooling units of purplish brown, chocolate brown, or dark gray densely welded tuff. Sparse phenocrysts of plagioclase, minor clinopyroxene, and magnetite comprise about 10 percent of the rock (figure 3). It exhibits a strong platy parting or blocky fracturing and weathers to form cubic granules. Stretched vesicles (as much as 1 foot in length) formed by flowage, and flattened light gray lenticules (as much as 2 feet) occur locally. Several cooling units have black basal vitrophyres (Mackin, 1960; Mackin and others, 1976). The upper Hole-in-the-Wall Tuff Member (Tih) is typically less than 40 feet (12 m) thick. Like the Baldhills Tuff Member, it is a sparsely porphyritic (plagioclase, clinopyroxene, and magnetite), densely welded tuff. The unit is characterized by its generally purplish-gray to reddish color, light-gray flattened lenticules, and a rarely exposed basal vitrophyre. A composite thickness of the formation of over 1000 feet (305 m) occurs in the Chloride Canyon area of the Antelope Range.

K-Ar ages of the Isom Formation are about 26 Ma (Rowley and others, 1979; new decay constants applied). A vent for the tuff has not been discovered; however, the source caldera (if one exists) is suspected to lie adjacent to or underneath the Escalante Desert. A dramatic thickening of the unit near Hamlin Valley (Best, 1986) and in the Chloride Canyon area lends additional credence to the suspected location of the Isom vent.

Quichapa Group

Ranging in age from about 25 to 21 Ma, tuffs of this group are widely distributed throughout southwestern Utah and eastern Nevada. Formations comprising the group are, in ascending order, the Leach Canyon Tuff, Condor Canyon Formation, and the Harmony Hills Tuff. Probable origins of the Quichapa tuffs are suspected to lie within the Caliente depression of Lincoln County, Nevada (Ekren and others, 1977).

Leach Canyon Tuff (Oligocene)

Mackin (1960) first defined the Leach Canyon Tuff as a member of the Quichapa Formation and Williams (1967) later elevated it to formational rank and divided it into a lower Narrows Tuff Member and an upper Table Butte Member. Both members are rhyolitic vitric-crystal or crystal-vitric tuffs that contain conspicuous reddish lithic fragments in a light-colored matrix. Crystal content of these moderately welded tuffs is usually 20 to 30 percent. Phenocrysts include plagioclase, quartz, and sanidine, with minor biotite, Fe-Ti oxides, hornblende and sphene. Modal analyses are shown graphically in figure 3. Mapped as a single unit in the Silver Peak quadrangle, the Leach Canyon Tuff is as much as 500 feet (150 m) thick. The Narrows Tuff Member is about 25 Ma (Rowley and others, 1979; new decay constants applied).

Condor Canyon Formation (Miocene)

The Condor Canyon Formation consists of two members; the Bauers Tuff and Swett Tuff (Mackin, 1960; Cook, 1965; Williams, 1967). Both the Bauers and Swett tuffs are vitric-crystal tuffs of rhyolitic to rhyodacitic composition. A sequence of volcanic mudflow breccias, containing pebble- to boulder-sized clasts of dominantly andesitic volcanic rocks, lies between the two tuff members throughout the Antelope Range and Iron Springs district (Tccv unit of Mackin and others, 1976). This andesitic mudflow breccia and two similar units (Tccu and Tv) are interpreted to be distal debris flow deposits that thicken toward the northeast.

The Swett Tuff Member (Tccs) is a densely welded rhyodacitic tuff (figure 3) that ranges in thickness from 30 to 450 feet (9 to 137 m) throughout its distribution in Nevada and Utah (Cook, 1965). A black basal vitrophyre underlies the tuff in many localities, including exposures in the Silver Peak quadrangle where the unit is about 100 feet (30 m) thick. The K-Ar age of the Swett Tuff is about 24 Ma (Rowley and others, 1979; new decay constants applied).

The Bauers Tuff Member (Tccb) is a densely welded rhyolitic tuff, reddish brown in color, with abundant and distinctive light-gray flattened lenticules. Phenocrysts, which comprise about 15 percent of the rock, include plagioclase, sanidine, bronze biotite, and minor Fe-Ti oxides (figure 3). A black basal vitrophyre is commonly present and often strongly magnetic. The Bauers Tuff is approximately 200 to 600 feet (60 to 180 m) thick. The K-Ar age of the tuff is about 23 Ma (Rowley and others, 1979; new decay constants applied).

Over 200 feet (60 m) of volcaniclastic and tuffaceous sediments lie between the Bauers and Harmony Hills tuffs in the extreme northeastern corner of the Silver Peak quadrangle, and are tentatively included in the Condor Canyon Formation (upper volcaniclastic and tuffaceous rocks, Tccu). Four separate volcaniclastic horizons were recognized and consist of (from top to bottom) a coarse andesitic mudflow breccia; a lithic-rich volcaniclastic composed of approximately 90 percent Bauers Tuff Member clasts set in a pale-gray, ashy matrix; a volcaniclastic consisting of 30 to 40 percent Bauers Tuff Member clasts in a pale-gray ashy matrix containing 15 percent crystals of plagioclase, biotite and trace amounts of quartz; and a white, nonwelded, porous, massive, lithic-crystal tuff with sparse volcanic clasts and crystals of biotite and plagioclase. These rocks are suspected to have filled a paleochannel eroded into lower members of the Condor Canyon Formation.

Harmony Hills Tuff (Miocene)

The Harmony Hills Tuff (Th) is a moderately welded, crystal-rich, dacitic ash-flow tuff. It contains about 50 percent crystals, dominantly plagioclase with lesser biotite, hornblende, quartz, and pyroxene, set in a pink to red- or purple-brown matrix (figure 3). Mackin (1960) noted a thickness range of 300 to 350 feet (90 to 110 m) in the Harmony Hills and about 180 to 250 feet (55 to 75 m) in the Iron Springs district. Within the Silver Peak quadrangle, the thickness ranges between 200 to 400 feet (60 to 120 m). Ages for the tuff range from 19.8 to 21.3 Ma (Rowley and others, 1979; new decay constants applied) with a best estimate of about 21 Ma.

FORMATION				SYMBOL	THICKNESS FEET (METERS)
Dacite of Bullion Canyon			8.5	Td	0-400 (0-120)
Rhyolite of Silver Peak			8.4	Trs	0-200 (0-80)
Volcaniclastic rocks of Newcastle Reservoir				Tnv	300-1200 (90-365)
Interbedded tuffaceous sandstone				Trt	
Racer Canyon Tuff			19	Tr	300-1100 (90-335)
Replacement deposits of iron ore				Tir	Replacement
Iron Mountain pluton				Tim	Intrusion
Volcaniclastic rocks				Tv	30-70 (9-20)
Quichapa Group	Harmony Hills Tuff		21	Th	200-400 (60-120)
Quichapa Group	Condor Canyon Formation	Upper volcaniclastic rocks		Tccu	200+ (60+)
Quichapa Group	Condor Canyon Formation	Bauers Tuff Member	23	Tccb	200-600 (60-180)
Quichapa Group	Condor Canyon Formation	Lower volcaniclastic rocks		Tccl	30-70 (9-20)
Quichapa Group	Condor Canyon Formation	Swett Tuff Member	24	Tccs	30-100 (9-30)
Quichapa Group	Leach Canyon Tuff		25	Tl	500 (150)
Isom Formation	Hole-in-the-Wall Tuff Mbr.			Tih	300-1200
Isom Formation	Baldhills Tuff Member			Tib	(90-365)
Claron Formation				Tc	500-950 (150-290)
Iron Springs Formation				Kis	1050-3600 (320-1100)
Carmel Formation	Upper banded mbr.			Jcb	160+
Carmel Formation	Homestake Limestone Mbr.			Jch	(50+)

LITHOLOGY

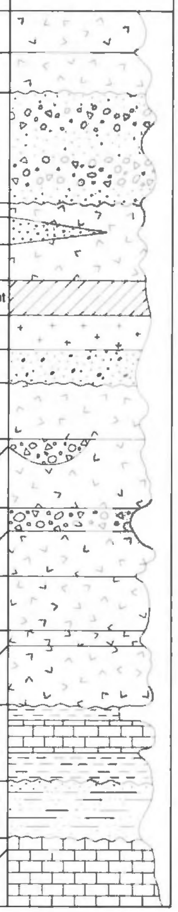

Figure 2. Stratigraphy of the Silver Peak quadrangle. K-Ar ages of dated volcaniclastics shown in left column (in Ma). Wavey lines in column represent unconformities.

Volcaniclastic Rocks (Miocene)

In many localities the Harmony Hills Tuff is unconformably overlain by an andesitic debris flow and volcaniclastic beds. Mapped throughout the quadrangle as Tv, this unit seldom exceeds 80 to 100 feet (24 to 30 m) in thickness. Cobble-sized clasts of andesitic lava and abundant crystal fragments derived from the underlying Harmony Hills Tuff compose this unit and indicate a period of erosion prior to deposition of the overlying Racer Canyon Tuff.

Iron Mountain Pluton (Miocene)

A portion of the Iron Mountain pluton, one of the three plutons of the Iron Springs district, occupies the southeast corner of the Silver Peak quadrangle. The pluton is part of a northeast-trending linear belt of middle Miocene (approximately 20 Ma) intrusions extending from the Bull Valley district through the Iron Springs district to the southern Red Hills, which together form the "iron axis" (figure 1; Tobey, 1977; Blank, 1959; Rowley and Barker, 1978). Plutons of the Iron Axis are laccolithic to stock-like bodies of quartz monzonite and are frequently associated with deposits of iron ore. Gravity (Cook and Hardman, 1967) and aeromagnetic (Blank and Mackin, 1967) studies show that the subsurface extent of these plutons is much larger than their surface expression, possibly forming a nearly continuous intrusive arch of batholithic dimensions at depth.

In general, quartz monzonite of the Iron Mountain pluton contains about 50 percent phenocrysts of plagioclase, clinopyroxene, amphibole, and biotite in a fine-grained granitoid to granophyric matrix. Groundmass minerals include quartz, anorthoclase, apatite, sphene, zircon, magnetite, ilmenite, and chlorite (Rowley and Barker, 1978). Two phases of the Iron Mountain pluton identified by previous workers (Rowley, written communication, 1985) consist of a peripheral shell phase and interior phase with selvage joints (Rowley and Barker, 1978; Mackin, 1947; Mackin and others, 1976).

Replacement Deposits of Iron Ore (Miocene)

Two areas of massive, replacement iron ore occur in the Silver Peak quadrangle: a small exposure capping Milner Hill (hosted by the Iron Springs Formation) and the remnant of a large body at the bottom of the northern pit of the Burke mine. These deposits consist of nearly massive magnetite with lesser hematite and minor quartz. Replacement ore in the northern Burke pit is hosted by the Homestake Limestone Member of the Carmel Formation. The Burke ore body, straddling the southern boundary of the Silver Peak quadrangle, is now largely mined out but originally extended about 1000 feet (305 m) down-dip and had an average thickness of 150 feet (45 m) (Bullock, 1970).

Racer Canyon Tuff (Miocene)

The youngest regional ash-flow tuff present in the quadrangle is the Racer Canyon Tuff (Tr). It is a weakly to moderately welded rhyolitic ash-flow tuff of whitish, gray, or pink color. The crystal-vitric tuff is a composite sheet containing 30 to 35 percent crystals of quartz, plagioclase, sanidine, and biotite, plus minor Fe-Ti oxides, hornblende, and sphene, as well as sparse lithic fragments in an ashy matrix (figure 3). Locally, a quartz-rich tuffaceous interbed (Tri) occurs near the top of the unit, presumably separating two cooling units. The tuff is altered extensively throughout the Antelope Range mining district. Total thickness of the unit ranges from 300 to 1100 feet (90 to 335 m), the range in thickness being the result of paleotopography or a product of erosion prior to deposition of the volcaniclastic rocks of Newcastle Reservoir. K-Ar analyses of the Racer Canyon Tuff yielded discordant ages of 18.7 and 20.8 Ma (Noble and McKee, 1972), and a recently analyzed sample from the Mount Escalante quadrangle gave a K-Ar age of 19.2 Ma (Siders, 1987).

Volcaniclastic Rocks of Newcastle Reservoir (Miocene)

A thick volcaniclastic sequence unconformably overlies the Racer Canyon Tuff in the Silver Peak quadrangle and is informally named the volcanicastic rocks of Newcastle Reservoir (Tnv). This unit was previously termed the Newcastle volcaniclastics (Siders and Shubat, 1986) and is equivalent to the "mine series" of Siders (1985a). Exposures of the volcaniclastic unit form an east-trending belt through the Pinon Point, Beryl Junction, and Silver Peak quadrangles (M. Siders, 1985a, b; G.L. Galyardt, U.S. Geological Survey unpublished mapping, 1977). Excellent exposures of the unit occur in the Chloride Canyon area of the Silver Peak quadrangle, near Newcastle Reservoir, and in the hills southwest of the Escalante silver mine. In the Silver Peak quadrangle, the unit is composed of volcanic conglomerate with lesser sandstone. Clasts are dominantly volcanic in composition, with clasts of the Racer Canyon Tuff and Harmony Hills Tuff being the most abundant. Reworked cobbles of limestone, chert, and quartzite derived from the Claron and Iron Springs Formations are also present. In the Beryl Junction quadrangle (Siders, 1985a) the unit was found to consist of a heterogeneous assortment of crudely bedded volcanic conglomerate, possible fanglomerate deposits, water-lain volcanic sandstone, volcanic mudflows, and other tuffaceous sediments. Rocks of this unit are reddish-brown due to their typically hematitic cement and locally exhibit cross-bedding in outcrop. The age of this unit has been constrained between 19 and 11.6 Ma (Siders and Shubat, 1986).

Rhyolite of Silver Peak (Miocene)

The informally named rhyolite of Silver Peak (Trs) consists of several coalescing flows and domes of rhyolite and trachyte that form an eruptive complex straddling the Silver Peak-Newcastle quadrangle boundary. A textural variant of this unit, consisting of autobrecciated flows, was also mapped (Trab). A thin, discontinuous, partially reworked air-fall tuff locally underlies the rhyolite of Silver Peak in the Newcastle quadrangle. Phenocrysts present in the rhyolite of Silver Peak include variable amounts of quartz, sanidine, minor biotite, and traces of Fe-Ti oxides (figure 3). Phenocrysts are less than 3 mm in diameter and are set in a purplish-gray, largely devitrified matrix. Irregular vesicles comprise as much as 17 percent of the rock. The rhyolite of Silver Peak covers approximately 2.5 square miles (6.5 km^2) mostly within the Newcastle quadrangle. Truncation of the rhyolite complex by the range-front fault of the Antelope Range has limited its exposed size. The K-Ar age of the unit is 8.4±0.4 Ma.

Dacite of Bullion Canyon (Miocene)

A dacite dome overlies the rhyolite of Silver Peak in the west-central portion of the quadrangle and is informally named the dacite of Bullion Canyon (Td). The dacite dome is locally underlain by a mudflow breccia of dacitic composition (Tdmb) and by a dacitic air-fall tuff (Tdt). Dacite flows have a purplish, devitrified matrix and coarse (7 to 12 mm) phenocrysts of quartz, sanidine, plagioclase, biotite, and Fe-Ti oxides (figure 3). Development of a diktytaxitic texture resulted in approximately 12 percent void space. The dacite dome is about 3000 feet (920 m) in diameter and is contiguous

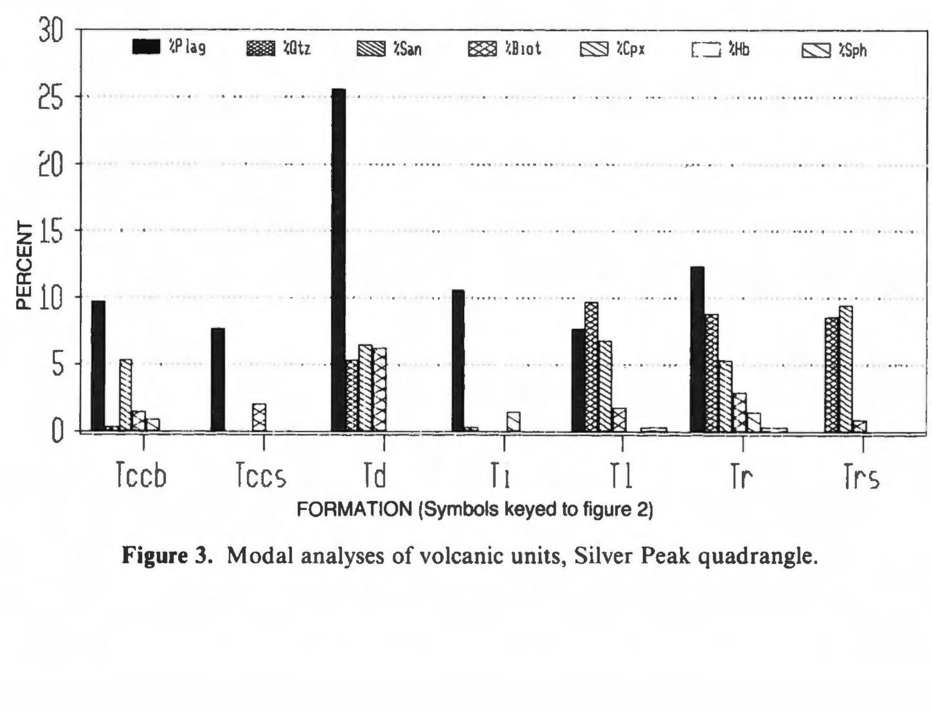

Figure 3. Modal analyses of volcanic units, Silver Peak quadrangle.

with another dome of identical composition and size in the adjacent Newcastle quadrangle. Flow banding in the dacite is steeply dipping and concentric to the dome outline. The K-Ar age of the dacite of Silver Peak is 8.5 ± 0.4 Ma.

Upper Tertiary to Lower Quaternary Debris-Flow Deposits (Pliocene to Pleistocene)

Poorly consolidated, heterogeneous, debris-flow deposits of Pliocene to Pleistocene age form this unit (QTdf), and exposures are restricted to the northeast corner of the quadrangle. The deposits consist of pebble to boulder conglomerate and lesser coarse sandstone. Clasts are composed mostly of Racer Canyon and Harmony Hills Tuffs. This unit was presumably deposited as debris flows and intercalated alluvial fans, but only scattered erosional remnants now exist.

QUATERNARY DEPOSITS

Older alluvial fan deposits (Pleistocene?)

The oldest and most widespread Quaternary unit in the quadrangle consists of unconsolidated alluvial fan deposits of gravel, sand, and silt of Pleistocene(?) age. The unit lies in the southwestern part of the quadrangle and is characterized by the ubiquitous presence of a calcrete horizon as much as 6 inches thick. Erosion of the calcrete contributes abundant caliche (calcium carbonate) rubble to the soil, yielding a light-colored soil that is easily discernible on aerial photography. Erosion of the unit produced "whaleback" landforms in several locations. The highest alluvial terrace in the quadrangle (plate 1) was cut on QTaf material along the northern side of the Dry Wash-Little Pinto Creek drainage. Black magnetite cobbles, presumably derived from the margin of the Iron Mountain pluton, are a common and conspicuous constituent of the deposit. A complete section of the unit is not exposed; however, a thickness of several hundred feet is probably attained.

An isolated area of older fan material (located in SW ¼ sec. 1, SE ¼ sec. 2, and NE ¼ sec. 11, T. 36 S., R 15 W.) is tentatively correlated with older fan deposits described above. This correlation is based on (1) similar extent of calcrete development, (2) presence of whaleback landforms, and (3) the presence of magnetite cobbles.

Pediment alluvium (Pleistocene to Holocene)

Unconsolidated deposits of gravel, sand, and silt of this unit (Qap) form a thin cover over bedrock. In many areas the stream cuts expose bedrock.

Colluvial deposits (Pleistocene to Holocene)

Colluvial deposits (transitional to alluvial deposits) of unconsolidated silt, sand, pebbles, and cobbles form the Qac unit. These colluvial deposits commonly flank steep areas of bedrock exposure, mantle slopes and small valleys, and include some alluvial deposits in lower slopes.

Alluvial fan deposits (Pleistocene to Holocene)

This unit (Qaf_2) consists of unconsolidated sand and gravel deposited in alluvial fans, now abandoned and undergoing erosion. Fans of this age are weakly dissected and partially covered by modern fan deposits. Along the western margin of the quadrangle, these fans are cut by the range-front fault of the Antelope Range. Scarps produced by this faulting are prominent on aerial photography and provide evidence for Quaternary displacement along the range-front fault.

Modern alluvial fan deposits (Pleistocene to Holocene)

Unconsolidated sand and gravel deposited on active alluvial fans form the modern fan unit (Qaf_1). Fans of this age post-date Quaternary faulting along the western margin of the Antelope Range.

Terrace deposits (Pleistocene to Holocene)

Unconsolidated sand, silt, and minor gravel form the alluvial terraces of intermediate age and elevation (Qat_2). Terraces of this age lie adjacent to Dry Wash and Little Pinto Creek and are dominantly composed of sand and silt with a distinctive orange color. These are fill terraces developed on older alluvial fan material (QTaf). An older terrace (T_3) occurs above Qat_2 and is a cut terrace developed on QTaf material. The older terrace is defined by geomorphic evidence and does not have associated deposits.

Young terrace deposits (Pleistocene to Holocene)

Unconsolidated sand, silt, and minor gravel form the lowest and youngest fill terrace along Dry Wash and Little Pinto Creek (Qat_1). Terrace deposits of this age are composed of orange sand and silt, identical to sediments composing the terrace deposits described above (Qat_2). Modern channels of Dry Wash and Little Pinto Creek are incised approximately 10 to 20 feet (3 to 6 m) into Qat_1 deposits.

Modern alluvium (Holocene)

This unit (Qal) consists of unconsolidated deposits of sand, silt, and gravel occurring in modern stream channels and flood plains.

Mine dump fill (Recent)

Mine dumps (Qfd) flank the northern pit of the Burke mine, located in the southeastern corner of the quadrangle. The southern boundary of the quadrangle passes through the center of the northern pit.

STRUCTURE

The Silver Peak quadrangle lies at or near the intersection of several regional features, including the Basin and Range-Colorado Plateau transition zone, "iron axis" (figure 1; Tobey, 1977), Timpahute lineament (Ekren and others, 1976), Delamar-Iron Springs mineral belt (Shawe and Stewart, 1976), eastern margin of the Sevier thrust belt (Armstrong, 1968), Intermountain seismic belt (Smith, 1978) and a crustal boundary described by Eaton (1975). Coincidence of these features suggests that the quadrangle straddles a long-lived volcano-tectonic boundary active since the Late Cretaceous and possibly earlier. Structural events that affected rocks in the quadrangle include Late Cretaceous thrusting during the

Sevier orogeny, Neogene extension, and deformation related to intrusion. The onset of extensional faulting corresponded to a shift from calc-alkaline to bimodal volcanism in the region (Rowley and others, 1979; Steven and Morris, 1984). Two ages of extensional faulting are distinguished by structural style and timing: middle to late Miocene extension, and late Miocene to Quaternary basin-range style extension.

Figure 4. Fault map of the Silver Peak quadrangle. Heavy lines represent major faults. Named faults are described in text. Stippled areas underlain by thick valley-fill deposits. Td, dacite of Bullion Canyon; Trs, rhyolite of Silver Peak.

LATE CRETACEOUS STRUCTURES

Thrust faulting and folding resulting from the Late Cretaceous Sevier orogeny produced a northeast-trending anticlinal structure, locally overthrust, which extends from the Bull Valley Mountains through the Iron Springs district. In the Iron Springs district this structure is expressed as the Iron Springs Gap thrust fault (Mackin, 1947) and the Calumet fault (Lewis, 1958) near the Iron Mountain pluton. Although not exposed in the Silver Peak quadrangle, the thrust is inferred to form a detachment surface at the base of the Carmel Formation with minimal stratigraphic offset. Mapping in the Bullion Canyon area of the quadrangle (McIntosh, 1987) revealed a gentle domal structure in the Iron Springs Formation. This structure may either be related to Sevier age deformation or may represent drag folding against the Bullion Canyon fault. Dramatic thinning of the inferred thickness of the Iron Springs Formation in the Bullion Canyon area (1050 feet as compared to over 3000 feet in surrounding areas) supports a Late Cretaceous age for the structure. Results from deep wells drilled to test the hydrocarbon potential of the Moenkopi Formation suggest the presence of thrust faults north and east of the quadrangle (Petroleum Information Corporation, UGMS files).

STRUCTURES RELATED TO INTRUSION

Several structures in the Silver Peak quadrangle appear to be related to the intrusion of the 20 Ma Iron Mountain pluton. The subsurface limit of the Iron Mountain pluton, as inferred from gravity, aeromagnetic, and field data, appears to coincide with an arcuate fault zone (Joel Spring Canyon fault zone, figure 4). Crude doming south and east of the Joel Spring fault zone is interpreted to be directly related to intrusion. High-angle normal faults bound the exposed portions of the pluton. Fault-bounded margins of plutons are common throughout the Iron Springs district (Rowley and Barker, 1978; Bullock, 1970).

MIDDLE TO LATE MIOCENE EXTENSIONAL STRUCTURES

Deformation related to extensional tectonics is divided into two periods: an earlier period (21 to 19 Ma) consisting of dominantly north-northwest-striking normal faults and west-northwest-trending folds, and a later period (19 to 8.5 Ma) consisting dominantly of northwest-striking normal faults and west-northwest-striking dextral faults. The early period of deformation (21 to 19 Ma) is best expressed in the northeast corner of the quadrangle (plate 1). West-northwest-trending folds and north-northeast-striking normal faults developed in rocks as young as the 21 Ma Harmony Hills Tuff are unconformably overlain by the 19 Ma Racer Canyon Tuff. This closely brackets the age of the deformation between 21 and 19 Ma and represents the onset of extensional tectonism in the area. Intrusion of the Iron Mountain pluton was contemporaneous with this deformation. Folds plunge 10° to 35° to the west-northwest, have nearly vertical axial surfaces, have interlimb angles of approximately 50°, and are near-cylindrical. Fold and fault orientations are consistent with west-northwest-directed extension and concomitant north-northeast-directed compression.

Most faults mapped in the northwest part of the quadrangle belong to the later period (19 to 8.5 Ma) of extensional faulting. This deformation is characterized by closely-spaced northwest-striking normal faults, and west-northwest-striking dextral faults. Faults of this period cut rocks as young as the rhyolite of Silver Peak but don't appear to cut the dacite of Bullion Canyon. Thus, the age of this period of faulting is bracketed between 19 and 8.5 Ma. Prominent normal faults of this period include the Little Pinto and Upper Canyons faults (figure 4) for which respective stratigraphic separations of 2000 feet (610 m) and 2800 feet (850 m) were calculated. Both faults dip moderately to the southwest. Local stratal rotations of as much as 60° in rocks as young as the volcaniclastic rocks of Newcastle Reservoir suggest a listric-normal geometry for at least some of the normal faults. Prominent west-northwest-striking dextral faults of this period include the Chloride Canyon fault and the Bullion Canyon fault zone. A piercing point reconstruction for the eastern Chloride Canyon fault yielded a dextral displacement of 3200 feet (976 m) along a vector trending S 68° E and plunging 4°. Piercing point reconstructions show dextral displacements of 1700 feet (520 m) and 2200 feet (670 m) for other west-northwest-striking faults. Offset along north-northeast-striking sinistral faults is minimal.

LATE MIOCENE TO QUATERNARY STRUCTURE

Late Miocene to Quaternary deformation in the Silver Peak quadrangle formed the Antelope Range fault (figure 4). This fault, with a surface expression typical of basin-range faults, forms the boundary between the Antelope Range and Escalante Valley. Quaternary fault scarps delineate the fault and can be traced northeastward from the Silver Peak quadrangle to the center of the Antelope Peak quadrangle and southwestward to the south-central portion of the Newcastle quadrangle. Near Newcastle, the fault was found to exert a control on the Newcastle geothermal system (Clement, 1980). The Antelope Range fault truncates all structures within the range.

A prominent gravity low was discovered immediately west of the Antelope Range in a gravity survey of the Escalante Valley (Pe and Cook, 1980). The gravity low may represent a thickness of as much as 9800 feet (3 km) of alluvium. Pe and Cook named this feature the Newcastle graben. Displacement along the Antelope Range fault presumably formed the southeast side of the graben and indicates that offset along the fault may be in excess of 9800 feet (3 km). Uplift of the Antelope Range was rapid enough at some point to cause oversteepening of the range-front, and a gravity-slide block formed in the Bullion Canyon area. The presence of Quaternary scarps along the range front suggests that uplift is still active.

ECONOMIC GEOLOGY

Two mining districts, the Antelope Range and Pinto (Iron Springs extension) districts, overlap portions of the Silver Peak quadrangle. Most of the Antelope Range district, including all of the central part of the district, lies within the quadrangle. Shubat and McIntosh (1987) provide a more complete discussion of the mineral potential of the Antelope Range district. Iron deposits located in the southeast corner of the quadrangle are part of the Pinto district. Many authors have not distinguished between the Pinto and Iron Springs districts and consider all iron deposits in the area to be part of the Iron Springs district. Iron deposits adjacent to Granite Mountain and the Three Peaks plutons are included in the Iron Springs district. The Pinto district contains iron deposits surrounding the Iron Mountain pluton.

ANTELOPE RANGE DISTRICT

Mineralization

Known mineralization within the Antelope Range district occurs as veins enriched in base and precious metals. Commodities present in potentially economic concentrations include silver, gold, copper, lead, and zinc. Past exploration and limited development has been directed towards the precious-metal content of veins. Historically, the Antelope Range district has been known as a silver district.

Veins in the Antelope Range district occur as fillings within structures, often referred to as "fissure veins." Veins typically show open-space-filling textures such as banding, cockscomb texture, and encrustation. Individual veins range in strike length from less than 100 feet (30 m) to as much as 4500 feet (1370 m). Longer veins tend to occur along major structures and smaller veins along fractures. Widths of veins are also highly variable. The maximum vein width observed is 45 feet (14 m). In many places veins were observed to "horsetail" along strike, changing from a discrete vein to a series of closely spaced veinlets (stockwork zone). Veins also pass laterally (along strike) and vertically into breccia fillings.

Prominent veins mapped in the district are shown on plate 1. The dominant vein trend subparallels the dominant fault trend (produced by middle to late Miocene faulting), with an average strike of approximately N 30° W. Several areas of high vein density (vein systems) have been identified. One of the longest, the Little Pinto, consists of a single chalcedonic vein lying along the Little Pinto fault and has a strike length of over 7000 feet (2130 m). The largest vein system contains about 40 individually mapped veins and extends over a strike length of approximately 10,000 feet (3050 m). Other vein systems have lengths ranging from 2000 to 5000 feet (610 to 1520 m) and widths of 700 to 1200 feet (210 to 370 m).

Because mineralization within the veins was not uniform and hand sample identification of mineralized samples is tenuous, a geochemical approach to the identification of mineralized areas was employed in the district study (Shubat and McIntosh, 1987). A few hand sample generalizations, however, can be made. Base metals-enriched veins show sparse original sulfides (galena and chalcopyrite), and typically contain supergene minerals such as cerussite, malachite, chrysocolla, and brochantite. Silver-rich veins are quartz dominated, vuggy, show some base metals enrichment, and contain abundant barite and rose-colored to amethyst quartz. Gold-enriched veins tend to be more chalcedony-rich and may contain disseminated pyrite.

Ore minerals present in the mineralized veins of the Antelope Range district are typically fine grained. Primary (hypogene) sulfides include galena (PbS), chalcopyrite ($CuFeS_2$), and sphalerite (ZnS). Silver is present in several hypogene sulfosalt minerals, namely pearceite ($Ag_{16}As_2S_{11}$+Cu), tennantite ($(Cu, Fe)_{12}As_4S_{13}$+Zn, Ag, Co), stromeyerite ($CuAgS$), and proustite (Ag_3AsS_3). Supergene ore minerals include tenorite (CuO), cuprite (Cu_2O), covellite (CuS), digenite (Cu_9S_5), malachite ($Cu_2CO_3(OH)_2$), brochantite ($Cu_4(OH)_6SO_4$), chrysocolla ($Cu_2H_2(Si_2O_5)(OH)_4$), cerussite ($PbCO_3$) and smithsonite ($ZnCO_3$). Primary gangue minerals in veins include quartz, calcite, chalcedony, barite, pyrite, and psilomelane. Vein quartz crystals are clear with milky zones and are locally amethystine. Calcite ranges in color from white to brown to black. X-ray diffraction analysis shows the presence of manganocalcite, and a complex manganese mineral similar to psilomelane or manganite. Barite typically occurs in blades, as much as an inch long, intergrown with quartz and calcite. Secondary gangue minerals include hematite, goethite, and braunite.

McIntosh (1987) examined polished sections of sulfide-bearing vein material from the Bullion Canyon area and determined a two-stage hypogene mineral paragenesis. Stage I mineralization is dominated by base-metal sulfides, which are partially replaced by silver sulfosalts in stage II. In stage I mineralization, galena, chalcopyrite, and sphalerite coprecipitated with quartz, calcite, intermittent barite, and pyrite. Boiling textures are intimately associated with stage I mineralization. During stage II, silver minerals precipitated with quartz, amethyst, and psilomelane. By the end of stage II, sulfide deposition ceased and stage III gangue minerals including quartz, calcite, barite, and chalcedony precipitated. Oxidation effects are common and comprise the supergene stage of McIntosh (1987).

Hydrothermal Alteration

Two genetic types of alteration occur in the district: (1) structurally controlled alteration, and (2) pervasive alteration. As the name implies, structurally controlled alteration formed as hydrothermal solutions passed through open faults and fractures, penetrating into and altering the wall rock to varying degrees. Pervasive alteration, however, was controlled primarily by lithology.

Structurally controlled alteration encompasses all vein systems within the Antelope Range district. Seven separate zones of structurally controlled alteration are present and include stockwork and structurally controlled silicification, phyllic, potassic, propylitic, and argillic alteration (Shubat and McIntosh, 1987). In general, silicification is strongest adjacent to veins, being nearly pervasive in areas of high vein density. Argillization resulted in widespread areas of kaolinitic alteration of plagioclase. Propylitic alteration is volumetrically insignificant in comparison to other epithermal districts. Potassic alteration is defined by sparse occurrences of adularia in highly silicified vein margins. Phyllic alteration is defined by the presence of sericite and pyrite in silicified rocks adjacent to veins. Both potassic assemblages are rare.

Pervasive alteration is restricted to the west-central part of the quadrangle, southwest of the Little Pinto fault. Three alteration assemblages are present: argillic, extreme silicification, and kaolinitic alteration. Argillic alteration is dominant and is hosted by the relatively porous Racer Canyon Tuff. Extreme silicification, restricted to a sedimentary interbed within the Racer Canyon Tuff (Tri), consists of complete replacement of the interbed by chalcedonic silica. Kaolinitic alteration, representing the effects of extreme acid leach, consists of a fine-grained mixture of kaolinite and chalcedonic quartz with variable calcite (secondary?) and minor stringers of opaline silica.

IRON DEPOSITS

Several iron ore deposits of the Pinto district lie within the Silver Peak quadrangle. Geologic and geophysical investigations concerning these deposits include those by Mackin (1968), Lewis (1958), Bullock (1970), Rowley and Barker (1978), Blank and Mackin (1967), Cook and Hardman (1967), and Ratté (1963). Production of iron ore from the district dates back to the early pioneers. Major production began in 1924 and continued until the early 1980s. Production was greatly increased during World War II and the Korean War, with a steady decline in production occurring after 1962 (Bullock, 1970). Mining in the district has been nearly abandoned because of the recent decline in steel prices. Cumulative production from the district, from 1923 to 1971, was 84 million tons (Bullock, 1970; Rowley and Barker, 1978), at grades averaging between 50 to 55 percent iron. Reserves of iron ore in the Pinto and Iron Springs districts are in excess of 300 million tons.

Three iron ore bodies lie within the Silver Peak quadrangle. The Rex ore body, owned by U.S. Steel Corp., is one of the largest undeveloped iron deposits in the State of Utah. It is located in SW ¼ sec. 26, SE ¼ sec. 27, NE ¼ sec. 34, and NW ¼ sec. 35, T. 36 S., R. 14 W. (Bullock, 1970), in the southeastern portion of the quadrangle. A small outcrop of iron mineralization, which caps Milner Hill, is the only surface expression of the deposit. Bullock (1970) described the deposits as follows:

> "The Rex ore body is situated on the nonderoofed westward extension of the Iron Mountain intrusion. Extensive brecciation is associated with Homestake Limestone, overlying Entrada Sandstone and the Iron Springs Formation. The main Rex ore body is a metasomatic hydrothermal replacement of Homestake Limestone, but mineralization is also strong in overlying brecciated formations. Significant breccia filling as veinlets occurs in the Entrada Sandstone and the Iron Springs Formation where they overlie the main Rex ore body. Iron mineralization was encountered in the lower Iron Springs Formation at a depth of about 500 feet, continuing through the Entrada Sandstone and into typical replacement ore in underlying Homestake Limestone. A mineralized zone more than 750 feet thick occurs at this deposit. The property is owned by U.S. Steel Corporation. The estimated ore potential of this ore body exceeds 100 million tons of ore."

Two other ore bodies, the McCahill and Burke ore bodies, straddle the southern boundary of the Silver Peak quadrangle. The McCahill ore body lies in W ½ sec. 34, T. 36 S., R. 14 W. and has no surface expression (Bullock, 1970).

> "The McCahill ore body does not crop out and lies 500 to 800 feet beneath the surface, a tabular replacement ore body that dips to the west. Ore is traceable for about 1200 feet down-dip; in places the full thickness of the Homestake Limestone is replaced. The ore body apparently is cut by a fault which thins the ore body, a mixture of hematite and magnetite, fairly high in sulfur from the presence of pyrite."

Half of the northern pit of the Burke mine is located in the southeastern corner of the quadrangle. An outline of the pit, locations of mine dumps, and geologic relations in the pit are shown on plate 1. Bullock (1970) described the Burke deposit:

"Ore originally was exposed continuously over a north-south strike for about 1600 feet with a maximum surface width of exposure of 350 feet. The deposit was a typical contact metasomatic replacement of Homestake Limestone. It was an ore body of average size whose form was tabular and homoclinal, dipping toward the west. Drilling operations by the U.S. Steel Corporation and the U.S. Bureau of Mines showed that the deposit was composed of two ore bodies at depth. The north section was known as Burke No. 2 and the south section as Burke No. 3. The Burke ore body has been mined out. In the vicinity of the Burke ore deposit the Homestake Limestone strikes north-south and dips 20° to 40° west. Quartz monzonite porphyry is in intrusive contact with Homestake Limestone and lies immediately east of the iron deposit. A small porphyry cupola west of the Burke No. 3 ore body delimited its westward extension at depth. The Burke No. 2 ore body was considerably larger, and the ore extended to a depth of about 1000 feet down-dip. The ore was variable in thickness but averaged about 150 feet and consisted principally of hard dense mixtures of magnetite and hematite. The property is owned by U.S. Steel Corporation. The Burke ore deposit produced about 165 million tons of ore and is now depleted."

Many genetic models have been proposed to explain the origin of the iron deposits, two of which are the most widely accepted: Mackin's deuteric release hypothesis (Mackin, 1947) and a combined contact metasomatic-hydrothermal origin advanced by Ratté (1963) and Bullock (1970). In his deuteric release hypothesis, Mackin proposed that iron forming the deposits was leached from ferromagnesian minerals of the intrusive rock by deuteric volatiles during the final stages of crystallization of the plutons. These iron-rich fluids then migrated outwards into the surrounding country rock and precipitated iron ore in the Homestake Limestone Member by replacement reactions. In the alterantive hypothesis advanced by Bullock (1970) and Ratté (1963), iron-rich fluids are thought to have originated as late magmatic fluids expelled from the plutons with the iron not being derived by deuteric alteration.

OTHER RESOURCES

Non-metallic resources in the Silver Peak quadrangle include alluvial sands and gravels. Although the alkali reactivity and low mechanical strength of most weathered felsic volcanic rocks makes them less desirable than limestone or sandstone for use in concrete products, the material may be useful as borrow or to provide road metal for local roads.

A known geothermal resource area (KGRA) occurs just a few miles to the west in the Newcastle quadrangle (Clement, 1980). The major range-boundary fault of the Antelope Range, which is believed to partially control this geothermal activity, occurs in the northwestern corner of the quadrangle. Geothermal resources localized by this structure may occur in the Silver Peak quadrangle; however, no surface expression of geothermal activity exists.

Several wildcat oil and gas wells have been drilled north and east of the Silver Peak quadrangle, the closest of which are the Table Butte (Hunt Oil) and Three Peaks (ARCO) wells. These wells were presumably drilled to test the hydrocarbon potential of the Moenkopi Formation beneath the frontal thrust of the Sevier thrust belt. No significant hydrocarbons were reported.

WATER RESOURCES

No major perennial streams flow through the Silver Peak quadrangle, although several springs produce a limited flow along the bottoms of several stream channels. The springs shown on the USGS topographic sheet include Hidden Spring, Joel Spring, Sand Spring, and two unnamed springs. Several other springs were encountered during mapping, but these produce only a limited amount of flow. Spring snowmelt may create temporary flow through the usually dry channels. A permanent pond exists at the bottom of the mined-out Burke pit, adjacent to Iron Mountain. This water is accessible with difficulty and may benefit wildlife, although the quality of the water is unknown. The land within the map area is utilized mainly as rangeland and some small dams have been constructed to form water catchment basins for livestock. Some gravelly, unconsolidated sediments beneath the Escalante Desert are known to be good aquifers in the Newcastle area and thus may have some ground-water potential in the Silver Peak quadrangle. Bedrock units generally lack sufficient porosity to be considered suitable aquifers.

GEOLOGIC HAZARDS

No landslide masses or scarps were found in the Silver Peak quadrangle, although steep slopes occur throughout the area. The relatively high slope stability of the various hard-rock units is partly related to the degree of induration. The unconsolidated Quaternary deposits and incompetent shales and mudstones in some of the sedimentary units may be more susceptible to slumping or sliding on steep slopes than would the lava flows and welded tuffs. Rockfall may occur more commonly, as boulders and blocks of volcanic rocks weather and loosen. Debris flows would also be possible, given enough water to induce movement. An upper Tertiary/Pleistocene? debris flow, containing automobile-sized boulders of Harmony Hills Tuff, was mapped in the northeastern corner of the quadrangle. However, this debris flow probably formed during a time when climatic conditions were wetter than those of the present. The possibility of property damage or personal injury is low to moderate.

Heavy summer cloudbursts can produce arroyo flash floods throughout the quadrangle. Debris flows might be generated during such floods. The Quaternary deposits in the southwestern portion of the area are deeply incised (10-20 feet) by stream channels. The young age and degree of erosion testifies to the regular occurrence of heavy runoff.

The Utah Seismic Safety Advisory Council places the general area within the U-2 zone (U-4 is the highest hazard) and the Uniform Building code places it in seismic zone 2, indicating a moderate earthquake hazard. The fault along the west side of the Antelope Range in the northwest corner of the quadrangle is an active fault and may rupture the surface in a large earthquake. Because of probable lack of shallow ground water, the liquefaction hazard is low.

RECREATION

The rugged hills of the Antelope Range have long been the object of prospecting for mineral resources. The Silver Peak quadrangle is adjacent to the historic Iron Springs mining district and is also a district of its own right (Shubat and McIntosh, 1987). The rockhound or mineral buff can expect to find abundant boulders of magnetite, as well as outcrops of magnetite near Iron Mountain. Euhedral crystals of magnetite and some lodestone can be found. Different forms of quartz occur in the high hills north of Highway 56.

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Table 1. Silver Peak Petrography.

*Form	Matrix	Plag	Qtz	San	Fe-Ti	Biot	Hb	Cpx	Liths	Sph
Tccb	82.6	8.7	0.1	2.8	0.5	1.7		1.3	2.4	
	76.3	13.4		6.8	0.5	1.4		0.5	0.9	
	85.5	10.2		1.8	1.2	1.1		0.1		
	88.5	5.8		3.6	0.8	1.3				
	83.3	6.9		8.2	0.2	1.4				
	77.4	13.3	0.1	6.9	0.2	1.8			0.2	
AVG	82.3	9.7	0.1	5.0	0.6	1.5		0.6	1.2	
**N = 6										
Tccs	91.9	6.2			0.1	1.5	0.0	0.0	0.3	
	87.7	9.2			0.5	2.3		0.0	0.4	
	89.2	8.1			0.5	2.3				
	90.0	7.0			0.2	2.0			0.7	
AVG	89.7	7.6			0.4	2.0	0.0	0.0	0.5	
**N = 4										
Td	56.5	25.5	5.0	6.3	0.5	6.2	0.0			0.0
AVG	56.5	25.5	5.0	6.3	0.5	6.2	0.0			0.0
**N = 1										
Ti	85.1	12.5	0.1		1.0			0.9	0.4	
	88.7	8.3			1.2			1.5	0.2	
AVG	86.9	10.4	0.1		1.1			1.2	0.3	
**N = 2										
Tl	71.7	7.9	11.4	6.3	0.0	2.4	0.3			0.0
	72.8	9.0	9.6	6.9	0.5	1.0	0.1			
	77.5	4.4	9.3	5.4	0.7	2.1			0.6	
	73.6	9.2	7.4	7.4	0.2	1.4	0.5		0.3	0.2
AVG	73.9	7.6	9.4	6.5	0.3	1.7	0.3		0.4	0.1
**N = 4										
Tr	60.2	11.9	11.9	6.5	0.0	3.4	0.5		5.4	0.0
	56.5	12.2	9.5	3.6	0.3	3.1	0.3		14.5	0.0
	67.4	10.0	5.0	3.5	0.8	2.1	0.0	1.2	10.1	0.0
	65.5	11.4	8.6	6.0	0.6	3.5	0.4		3.8	0.1
	63.9	11.7	10.6	6.5	0.9	2.5			3.9	
	65.8	15.3	7.1	5.4	0.6	2.9	0.2		2.5	0.1
AVG	63.2	12.1	8.8	5.2	0.5	2.9	0.3	1.2	6.7	0.1
**N = 6										
Trs	81.0		8.5	9.1	0.6	0.8				
AVG	81.0		8.5	9.1	0.6	0.8				
**N = 1										

*Form = formation, symbols keyed to figure 2.
**N = number of samples examined.