## GEOLOGIC MAP OF THE CENTRAL MARYSVALE VOLCANIC FIELD, **SOUTHWESTERN UTAH**

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CORRELATION OF MAP UNITS Sedimentary rocks and silicic- to intermediate-composition volcanic rocks volcanic rocks Middle Jurassic Lower Permian MISSISSIPPIAN Upper Devonian Middle Devonian Lower Devonian

DESCRIPTION OF MAP UNITS

This map is intended to update the geologic map of the same area, but at 1:50,000 scale, but Cunningham and others (1983) as well as to provide digital coverage of the geology. The map is accompanied by the geophysical maps of the same area and at the same scale Campbell and others (1999). The geologic and geophysical maps will provide the geologic ramework of the heart of the Marysvale volcanic field, one of the largest volcanic fields in the Western United States and an area of significant mineral potential (Cunningham and others, 1997: Cunningham, Rowley, and others, 1999). Classifications of volcanic and plutonic rocks are those of the IUGS (Le Bas and others, 1986, and Streckeisen, 1976, respectively). Where necessary, isotopic dates given here have been recalculated using the IUGS decay constant (Steiger and Jäger, 1977). Age assignments for surficial deposits are estimated chiefly on the basis of their height above present streams, degree of post-depositional modification of original surface morphology, and degree of soil development—especially the morphology and thickness of calcium-carbonate-enriched horizons. Older deposits thus are typically higher the landscape, are more eroded, and contain more secondary calcium carbonate than younger deposits. We have not mapped man-made deposits.]

SURFICIAL DEPOSITS

Qac Alluvium and colluvium (Holocene and late Pleistocene)— Silt sand, and minor gravel deposited in modern channels and flood plains. Chiefly flood-plain and channel alluvium of the Sevier River as well as flood-plain and channel alluvium of perennia nd intermittent streams. Includes some local fan and sheetwash alluvium and hillslope colluvium. Maximum thickness about 10 m Young piedmont-slope alluvium (Holocene and late Pleistocene)—Poorly to moderately sorted deposits of sand gravel, and silt forming modern coalesced alluvial fans and pediments. Includes some alluvium of small streams and in some places colluvium, sheetwash alluvium, and talus. Thickness at Landslide deposits (Holocene and Pleistocene)—Mostly angula unsorted, and unstratified rock debris moved by gravity from nearby bedrock cliffs. Abundant in the mapped area, as is to be expected in such a tectonically active area, where basin-range

aulting is continuing (Rowley, Steven, and Mehnert, 1981). May include Pliocene landslide material. Includes minor talus and colluvium. Maximum thickness about 75 m Hot-spring deposits (Holocene and late Pleistocene)—Resistant, tan travertine and tufa mounds at the sites of active and former hot springs. Includes active mounds at Monroe Hot Springs and along the Dry Wash fault southeast of Joseph. Maximum thickness about 20 m Stream-terrace alluvium (late and middle Pleistocene)—Sand and pebbly to bouldery gravel that form dissected surfaces as much

as 15 m above the level of current streams. Unit mapped mostly near the town of Beaver, in the southwestern part of the napped area, where the unit partly includes glacial outwash deposits of the Pinedale glaciation, which is the most recen glacial episode and ended about 12,000-15,000 years ago; of the Bull Lake glaciation, which ended about 140,000 years ago: and of glaciations that preceded the Bull Lake and ended at about 250,000 years ago (Machette and others, 1984). Maximum thickness about 15 m Old piedmont-slope alluvium (late and middle Pleistocene)—Dissected, poorly to moderately sorted deposits

of sand, gravel, and silt forming coalesced alluvial fans and pediments that are not graded to present streams. Thickness at Glacial deposits (late and middle Pleistocene)—Mostly angular, unsorted, unstratified, sand and pebble- to boulder-grave deposited by glaciers of mostly Pinedale age, but may include deposits of Bull Lake or older age. Includes prominent latera moraines along streams below cirques on the western side of the northern Sevier Plateau and the southern and eastern sides of the high Tushar Mountains. Includes some ground moraine and

SEDIMENTARY ROCKS

**BIMODAL IGNEOUS SUITE AND SYNCHRONOUS** The bimodal suite is the product of the younger of two Cenozoic magmatic episodes in Marysvale volcanic field (Cunningham and others, 1983; Steven and others, 1990) Cunningham and others, 1997, 1999; Cunningham, Unruh, and others, 1998: Rowle

1998; Rowley and others, 1998). "Bimodal" refers to the two compositional types of volcani rocks (basalt and high-silica rhyolite) of the suite, present throughout the Western United States (Christiansen and Lipman, 1972)] Basalt lava flows (Pleistocene)—Resistant, dark-gray, black, and red, locally vesicular and amygdaloidal olivine basalt and basaltic andesite lava flows and cinder cones in the Cove Fort area (Clark, 1977; Steven and Morris, 1983). Includes basaltic scoria and ash deposits. K-Ar whole-rock age is 0.5 Ma (Best and

others, 1980). Maximum thickness about 100 m Sedimentary basin-fill deposits (lower Pleistocene to upp Miocene)—Soft to moderately indurated, mostly tan and gray sand and pebbly to bouldery gravel and sand. Consists general of laterally gradational fanglomerate deposits near current basir nargins, piedmont-slope deposits farther toward the center of the basins, and lacustrine deposits near the centers of the basin Includes minor white airfall tuff beds. Deposited in basins ormed by basin-range faults that largely control the presen opography and are generally synchronous with the deposits Deposits subhorizontal in most places. Includes deposits mapped and studied in detail in the Beaver basin, in the outhwestern part of the mapped area (Machette and othe 1984; Machette, 1985), where Evans and Steven (1982) dated rhyolites of about 9 Ma that are synchronous with and postdated the beginning of faulting that formed the basin. The main phase of basin-range faulting (Zoback and others, 1981, Anderson and others, 1983; Anderson, 1989) took place between 7.6 and 5.4 Ma in the Kingston Canyon area of the southern Sevier Plateau (Rowley, Steven, and Mehnert, 1981), about 5 km south of the napped area, where a conformable sequence of volcanic rocks as young as 7.6 Ma was offset vertically at least 2,000 m by basin-range faults to form the plateau. With subsequent ntegration of drainage that formed the present topograp Anderson, 1987; Rowley and others, 1988a,b), the deep antecedent Kingston Canyon was cut through the plateau, and -Ma rhyolite dome was emplaced in the bottom of the canyon. Only the upper part of the sedimentary basin-fill deposits is exposed, but the entire unit is inferred to be several hund

meters thick, and in the Beaver basin it is probably much thicker Sevier River Formation (upper Miocene)—Mostly moderat indurated, gray, tan, yellow, white, pink, and light-green sandstone, pebbly to bouldery conglomerate, mudstone, an siltstone (Callaghan, 1938) of fluvial and locally lacustrine origin. Includes local white airfall tuff beds. Basalt clasts generally common. Probably deposited in basins that formed generally prior to the main episode of basin-range faulting (Rowley Steven, and Mehnert, 1981; Rowley and others, 1998; Rowley, 1998), and thus the distribution and coarseness of the deposits

are not necessarily related to the present topography. As

napped, includes deposits in the southern part of the Monroe

Peak caldera (Rowley, Williams, and others, 1981; Rowley and

others, 1986a) that may be older and better placed in ithologically similar upper moat sediments of Rowley and other 1986a). Airfall tuff beds within the formation near the town of Sevier have fission-track ages of 14 and 7 Ma (Steven and others, 1979); basalt flows (Tb) that intertongue within the ormation west of Sevier have K-Ar dates of 9 and 7 Ma (Best and others, 1980). The Sevier River Formation and the basalt are cut by many faults of the basin-range episode, including strike-slip faults (Anderson and Barnhard, 1992) that act as ransfer faults for extensional strain, as well as the dominant normal faults. A K-Ar date from an airfall tuff in the formation, collected about 11 km south-southeast of Marysvale, has a date of 13.6 Ma (Rowley and others, 1994). An airfall tuff within the unit east of Annabella has a K-Ar age of 5.6 Ma (Rowley and others, 1994). Exposed thickness at least 100 m, but total thickness may be as much as several hundred meters Basalt lava flows (Pliocene? and Miocene)—Resistant, dark-gray. plack, and red, locally vesicular and amygdaloidal olivine basalt and basaltic andesite lava flows, flow breccia, and cinder cones.

Includes basaltic scoria and ash deposits. East of Piute Reservoi

and 4 km south of the collection site of the underlying 13.6-Ma

tuff in the Sevier River Formation (Tse), the map unit has K-Ar

dates of 12.9 Ma (Damon, 1969) and 12.7 Ma (Best and others

1980). About 3 km west of Piute Reservoir, unit has a K-Ar

nterbedded at other places within the Sevier River Formation

gray, white, and black, flow-foliated, spherulitic, locally vesicular,

crystal-poor rhyolite lava flows and volcanic domes. Flows

locally contain black basal vitrophyre. Includes soft, poorly

exposed, white airfall and ash-flow tuff and locally derived

age of about 8 Ma (Rowley, Steven, and Mehnert, 1981).

Exposed in the southern Sevier Plateau (Rowley, 1979).

Rhyodacite of Dry Lake (Miocene)—Resistant, light-gray, pink, tan,

rich rhyodacite volcanic domes and lava flows. Flows locally

contain black basal vitrophyre. Exposed only in the Dry Lake

Rhyolite of Gillies Hill (Miocene)—Mostly resistant, white and light-

soft, white ash-flow tuff. Exposed on the western edge of the

Machette and others, 1984). K-Ar ages cluster at 9 Ma,

in the Beaver basin (Evans and Steven, 1982). Base not

Callaghan (1939) and mapped by Callaghan and Parker

derived from several caldera and volcano eruptive centers.

1961a,b; 1962a,b) and Willard and Callaghan (1962). Rocks

Stratigraphy revised by Cunningham and Steven (1979a) and

primarily uranium, molybdenum, and alunite (Steven and others,

mapped by Cunningham and others (1983) and Steven and

1981; Steven and Morris, 1987; Cunningham and others,

1994; Cunningham, Rasmussen, and others, 1998, 1999).

Isotopic dates 21-12 Ma (Cunningham, Unruh, and others,

to aphanitic rhyolite dikes, stocks, volcanic domes, and lava

flows from scattered vents. A series of glassy rhyolite dikes, too

has potential economic significance. These dikes contain

the uranium deposits of the Central mining area (Kerr and

small to be shown at map scale, cuts the Central intrusion (Tci),

fine-grained granite (Tmf), and Red Hills Tuff Member (Tmr) and

genetically related uranium- and molybdenum-bearing veins and

are interpreted to be derived from a hidden stock that formed

others, 1957; Cunningham and others, 1982; Cunningham,

section as well as cross section A-A' of Rowley and others

1988a). The apex of this stock may contain a porphyry-type

molybdenum deposit (Cunningham and Steven, 1979b). Local

heat supplied by hidden stocks of the map unit (Podwysocki and

Segal, 1983; Cunningham and others, 1984a). Includes the

dikes and small stocks (Tmd) and the rhyolite of Big Star (Tmbs)

of Cunningham and others (1983) and the dikes, lava flows, and

plugs of Mount Belknap Volcanics (Tmbd) of Rowley and others

(1988a.b). An unexposed 14-Ma stock, postulated to dome up

the Deer Trail Mountain-Alunite Ridge area, formed alunite and

gold and base-metal deposits (Cunningham and Steven, 1979c;

Steven, 1988). Most rocks of the map unit are younger than the

Red Hills Tuff Member (Tmr) and have isotopic ages that range

Cunningham and others, 1984a,b; Beaty and others, 1986;

from about 19-14 Ma (Rowley and others, 1988a,b; Rowley

volcanic dome as much as 100 m thick (Rowley and others,

Upper gray tuff member, Gray Hills Rhyolite Member, upper

red tuff member, and porphyritic lava flows-Four local unit

deposited in an east-trending paleocanyon that is east of, and

formerly drained, the Mount Belknap caldera. The youngest is

the upper gray tuff member (18 Ma; Steven and others, 1979), a

caldera. The underlying Gray Hills Rhyolite Member is a light-

basal thin, light-gray, crystal-poor, unwelded tuff confined to a

light-gray, partially welded, crystal-poor, rhyolite ash-flow tuff

unit at least 130 m thick derived from the Mount Belknap

gray, pink, and red, spherulitic, flow-foliated, crystal-poor

rhyolite that forms a volcanic dome, lava flows, dikes, and a

local vent east of the Mount Belknap caldera. Samples from

vitrophyres of flows have concordant K-Ar dates of 20.5, 20.5,

and 19.5 Ma (Bassett and others, 1963). At its dome source.

the unit is about 500 m thick. The lowest part of the unit

consists of the upper red tuff member, derived from the Mount

Belknap caldera and consisting of a red, densely welded, crystal-

poor rhyolite ash-flow tuff, about 20 m thick, characterized by

plack fiamme: and of coeval porphyritic lava flows, as much as

75 m thick, consisting of dark-gray, red, and pink, poorly to

moderately crystal-rich rhyodacite lava flows interbedded with

Intracaldera intrusive rocks—Moderately resistant, mostly gray,

Crystal-rich tuff member—Dark-reddish-brown, red, gray, and

pink, resistant, moderately to densely welded, crystal-rich

rhyolite ash-flow tuff. Fills paleochannels that radiate outward

small, crystal-poor rhyolite to dacite stocks within the Mount

some ash-flow tuff

and others, 1994). The rhyolite of Big Star is a 16- to 12-Ma

vein natroalunite of 18-13 Ma appears to have resulted from

Rasmussen, and others, 1998). The stock is shown on the cross

Late rhyolite dikes, stocks, and volcanic domes—Moderately

others (1990). Source of considerable mineral potential,

Mount Belknap Volcanics (Miocene)—Originally defined by

gray, flow-foliated, locally vesicular, aphanitic to crystal-rich

rhyolite lava flows and volcanic domes. Includes interlayered

mapped area and areas to the west (Evans and Steven, 1982;

probably synchronous with the initiation of basin-range faulting

area of the southern Sevier Plateau, in the southeastern part of

the mapped area (Rowley, 1979). Maximum thickness 230 m

and black, flow-foliated, locally spherulitic, moderately crystal-

sandstone and conglomerate at the base of the unit. Has K-Ar

Tse) have K-Ar dates of 9.2 and 7.4 Ma (Best and others,

Rhyolite of Forshea Mountain (Miocene)—Mostly resistant, light-

1980). Maximum thickness about 130 m

Maximum thickness 300 m

exposed; thickness at least 350 m

date of 10.9 Ma (Rowley and others, 1994). Basalt flows

intracaldera intrusions, airfall tuff, and fluvial and lacustrine sedimentary rocks that were deposited in the Monroe Peak and sedimentary units (Rowley and others, 1988a,b). This the Cove Fort transverse zone (see index map). This and the Blue Ribbon transverse zone (which passes just south of the mapped area) are east-striking shear zones that have accommodated extensional deformation in the Marysvale

998: Rowley, 1998; Rowley and others, 1998). "Calc-alkaline" refers to the composition of

volcanic field (Rowley, 1998) Sedimentary rocks—Mostly soft, tan, gray, yellow, brown, pink, and green, thin- to medium-bedded, mostly planar-bedded, fineto coarse-grained tuffaceous sandstone and airfall tuff, and minor intertongued crystal-poor and crystal-rich lava flows, siltstone, and conglomerate. Primarily fluvial but locally lacustrine in origin. Commonly hydrothermally altered and silicified. Maximum thickness about 60 m

Lava flows of Indian Flat—Resistant, compositionally heterogeneous sequence of lava flows exposed in the eastern part of the Monroe Peak caldera. In the map area, they consist of purplish-gray and light-gray, crystal-poor, rhyodacitic lava flows that are about 50 m thick and were formerly called rhyodacite of Burnt Flat (Rowley and others, 1981b). East of the mapped area, they thicken to 200 m against the caldera wall and include andesite and dacite flows (Rowley and others, Lava flows of Monroe Peak-Mostly resistant, gray, pink, khaki, and dark-green, vesicular and amygdaloidal, generally crystal-rich rhyodacitic lava flows and minor crystal-poor lava flows, flow breccia, volcanic mudflow breccia, fluvial sandstone, and airfall tuff. K-Ar age is 21.3 Ma (Rowley and others, 1988b). Maximum exposed thickness 150 m. Includes the dacite of Big

Flat, a lithologically similar volcanic dome as much as 130 m thick that was mapped in the southern part of the Monroe Peak caldera (Rowley, Williams, and others, 1981). An area 2 km east-northeast of Manning Meadow includes a local lens of soft conglomerate about 100 m thick (base not exposed) that was formerly interpreted to represent pre-caldera rocks (Rowley, Williams, and others, 1981; Cunningham and others, 1983) but Volcanic rocks of Sage Flat-Mostly resistant, reddish-brown medium- to dark-gray, pink, black, and purplish-brown, locally amugdaloidal and vesicular, mostly crystal-poor andesitic lava lows and minor volcanic mudflow breccia, flow breccia, and fluvial sandstone and conglomerate. In the mapped area exposed only in the northern part of the Monroe Peak caldera where these rocks are about 60 m thick (Rowley, Cunningham, and Kaplan, 1981); east of the map area they thicken to at least

300 m against the eastern wall of the caldera (Rowley and Lava flows of Monkey Flat Ridge—Moderately resistant, reddish brown, gray, khaki, and green, vesicular and amygdaloidal, crystal-poor dacitic to rhyodacitic lava flows, and minor fluvial sandstone, fluvial conglomerate, and crystal-rich lava flows. Includes lava flows of Greenwich Creek, a lithologically similar unit that was mapped separately at larger scale by Rowley and others (1986a,b). Maximum exposed thickness 150 m Lava flows of Bagley Meadows—Local sequence of resistant ight- to medium-gray and pink, vesicular and amygdaloidal, locally flow-foliated, crystal-rich dacitic lava flows or a volcanic dome. Confined to the northern margin of the Monroe Peak caldera (Rowley, Cunningham, and Kaplan, 1981). Maximum

Intracaldera intrusions, undivided—Resistant, tan, light-gray, and light-green, locally flow-foliated monzonite porphyry and quartz monzonite porphyry intrusive masses that were the source for and are intruded into, late intracaldera deposits of the Monroe Peak caldera (Tmpu) and the Osiris Tuff (To, Toi). In some caldera complexes (for example, Smith and Bailey, 1968; Lipman, 1997), such intrusions are referred to as resurgent plutons because they dome up the cover (intracaldera) tuffs above them in the caldera, but the Monroe Peak caldera exhibits no such structural dome (Steven, Rowley, and Cunningham, 1984 b). At their margins, the intrusions are finer grained and locally resemble intracaldera Osiris Tuff, into which they intrud Older phases of the same intrusive complex at depth were the source of the Osiris Tuff. Isotopic dates suggest an age of about 22-21 Ma (Rowley and others, 1988a,b). These intrusions make up the eastern end of the east-trending Pioche-Marysvale igneous belt (Rowley, 1998) Central intrusion—Resistant, gray and green, porphyritic to locally equigranular, quartz monzonite and monzonite stock that exhibits a fine-grained chilled margin as wide as 60 m. Distinctive enough so is mapped separately from other intracaldera intrusions of the Monroe Peak caldera. Unit is a possible source for some lava flows in the late intracaldera

deposits of the Monroe Peak caldera (Tmpu). Isotopic age is about 22 Ma (Rowley and others, 1988a,b). The pluton was eroded and unroofed by about 19 Ma, when it was unconformably overlain by the Red Hills Tuff Member (Tmr) of the Mount Belknap Volcanics Volcanics of Lousy Jim (Miocene)—Resistant, light- to dark-gray.

flow-foliated, crystal-rich trachydacite porphyry lava flows and flow breccia forming a volcanic dome that is about 8 km in diameter in the southwestern part of the mapped area (Sigmund 1979). K-Ar age is 22.6 Ma (Fleck and others, 1975).

Tuff of Lion Flat (Miocene)—Soft, light-gray to pink, crystal-poor, nonwelded rhyolitic ash-flow tuff exposed in the southwestern part of the mapped area (Wickstrom, 1982; Lanigan, 1987) Was suggested to be the product of a small caldera (Steven, Rowley, and Cunningham, 1984) but more likely represents tuff-ring deposits preceding and during initial eruption of the overlying volcanics of Lousy Jim (Tli) because the tuff contains clasts of the volcanics of Lousy Jim believed to be derived from their common magma chamber (C.G. Cunningham, unpub. data, 1993; Rowley and others, 1994). Thickness about 100 m Osiris Tuff (Miocene)—Petrologically similar sequences of mostly ash-flow tuff derived from the largest caldera in the Marysvale volcanic field, the Monroe Peak caldera (Steven, Rowley, and Cunningham, 1984; Rowley and others, 1986a,b, 1988a,b).

This unit is the main product of the Monroe Peak caldera, leading to caldera subsidence. K-Ar age is about 23 Ma (Fleck and others, 1975) Intracaldera facies—Soft to resistant, orange and tan, densely welded ash-flow tuff and lava flows(?) that are petrologically similar to the Osiris Tuff outflow facies (To) but are generally altered to clay. Confined to the source Monroe Peak caldera. Includes intracaldera-collapse breccia derived from landslides from the caldera walls into the caldera. The alteration grade is in most places argillic and is due to emplacement of the intracaldera intrusions, undivided (Tmpi), and the central

caused by secondary flowage of rock fused in the last few tens of

meters of movement. Maximum thickness about 60 m

moderately resistant, tan, gray, pink, light-green, and light-

purple volcanic mudflow breccia and sparse flow breccia, lava

flows, ash-flow tuff, and fluvial conglomerate and sandstone.

its calc-alkaline phase (Anderson and Rowley, 1975). The

a near-source vent facies and a more distal alluvial facies,

following the concepts of Parsons (1965, 1969) and Smedes

stratovolcanoes or the erosion of stratovolcanoes that dominated

the southern part of the Marysvale volcanic field during most of

formation is the most voluminous unit in the volcanic field, and it

has been traditionally divided (Anderson and Rowley, 1975) into

and Prostka (1973). In detailed mapping, most rocks are shown

to belong to the alluvial facies, although in the southwestern part

and alluvial-facies rocks are combined in this map unit. Many of

the source stratovolcanoes formed an east-west string along the

Rowley, 1975; Rowley, Steven, and others, 1979; Blackman,

1990a.b). The string of stratovolcano vents is aligned along the

east-striking Blue Ribbon transverse zone, whose axis is just

south of the mapped area (Rowley, 1998; Rowley and others,

1998). This transverse zone extends westward across the entire

Great Basin (Rowley and others, 1978, 1998; Rowley, 1998).

lithologic type. Slight variations represent different source

volcanoes. Most rocks consist of crystal-poor to aphanitic

conglomerate, and sandstone, as well as lava flows, are the same

andesite or less commonly dacite. The crystal-poor aspect of the

rocks, and a general absence of exposed source plutons for the

unit in the Marysvale volcanic field, indicate that the intrusive

sources of the rocks were deep. K-Ar dates, corrected for new

units indicate a long episode of magmatism, from 30 to 21 Ma

within the Mount Dutton Formation (Td), mostly in the Sevier

black basal vitrophyre as much as 3 m thick. Source has not

been found but may underlie Sevier Valley in the vicinity of the

towns of Sevier or Joseph (Rowley and others, 1988b). Vents

for such densely welded, high-temperature ash-flow tuffs have

rarely been described in the literature because they are rarely

exposed. This is probably because their magma chambers were

deep in the crust and vent areas were never expressed by typical

collapse calderas (Ekren and others, 1984). K-Ar age is 25 Ma

(Rowley and others, 1994). Maximum thickness 15 m

Kingston Canyon Tuff Member (Oligocene)—Resistant, mostly

purple, densely welded, crystal-poor trachytic ash-flow tuff

intertongued within the Mount Dutton Formation (Td) mostly in

the Sevier Plateau (Anderson and Rowley, 1975). Generally

derived from the same source as the Antimony Tuff Member

includes a black basal vitrophyre as much as 1 m thick. Probably

(Tda). Exposed south of the Monroe Peak caldera and in the

southern Sevier Plateau, especially south of the mapped area.

K-Ar age is 26 Ma (Fleck and others, 1975). Maximum

Mount Dutton Formation, and tuff of Albinus Canyon,

lava flows that make up a relatively thin sequence in the

locally vesicular and amygdaloidal, crystal-poor, basaltic andesite

southeastern Pavant Range. Intertongued with the Antimony

Tuff Member of the Mount Dutton Formation (Tda) and tuff of

Albinus Canyon (Tal). Probably represent flows of one or more

shield volcanoes, which may underlie valley-fill deposits in Sevier

Valley or occur in the northern Sevier Plateau; if so, they may

correlate with the volcanic rocks of Signal Peak (Tsp).

Tuff of Albinus Canyon (Oligocene)—Resistant, light-purplish-

gray, pink, tan, reddish-brown, red, and gray, vesicular, crystal-

poor, densely welded trachytic ash-flow tuff. Several thin cooling

units, locally separated by thin beds of volcanic mudflow breccia,

overlies it, and the Kingston Canyon Tuff Member, which in part

seated source, perhaps buried beneath the Sevier Valley basin in

conglomerate, and sandstone, are exposed in the southern

Lithologically similar to the Antimony Tuff Member, which

underlies it. Probably all were derived from the same deep-

the Joseph area. Has a K-Ar age of 25.3 Ma (Rowley and

Bullion Canyon Volcanics (Miocene and Oligocene)—Moderately

and fluvial conglomerate and sandstone. Unit originally

resistant, tan, gray, brown, pink, light-green, and light-purple

volcanic mudflow breccia, lava flows, flow breccia, ash-flow tuf

proposed by Callaghan (1939) and mapped by Callaghan and

Parker (1961a,b; 1962a,b) and Willard and Callaghan (1962).

Stratigraphy revised by Steven and others (1979), discussed by

Rowley, Steven, and others (1979) and Cunningham and other

(1984c), and mapped by Cunningham and others (1983) and

Steven and others (1990). Most of these deposits, which make

up the second most voluminous unit in the Marysvale volcanic

field, are the products of clustered stratovolcanoes or the erosion

of stratovolcanoes (Steven and others, 1979). Unit consists of

undivided vent-facies and alluvial-facies rocks. Clasts in mudflow

breccia, conglomerate, and sandstone are lithologically the same

as lava flows in the unit. These flow rocks are of several similar

local accumulations of fine-grained, crystal-poor, black andesitic

rock. The crystal-rich, more highly evolved aspect of the rocks,

and a general abundance of exposed source plutons for the unit

of the rocks were shallow at the time of magmatism. Isotopic

dates and stratigraphic relationships indicate an age of at least

30-22 Ma (Steven and others, 1979; Kowallis and Best, 1990;

altered areas indicate that the mineral potential is high for these

rocks and their associated intrusive sources (Steven and Morris,

1987; Cunningham, Unruh, and others, 1998). Thickness at

monzonite. These plutons are the solidified magma sources of

some of the younger deposits of the Bullion Canyon Volcanics.

Plutons represent cupolas of a large composite batholith that

Steven, Rowley, and Cunningham, 1984; Steven and Morris,

1987). K-Ar ages cluster at about 23 Ma (Steven and others,

field (Campbell and others, 1984; Cook and others, 1984;

979: Cunningham and others, 1984a)

underlies the central and northern part of the Marysvale volcanic

Intermediate-composition intrusive rock—Moderately resistant

gray, tan, and brown, crystal-rich monzonite and quartz

least 1,500 m in the mapped area

Rowley and others, 1994). Former metal production of the

chalcophile elements, shallow intrusive sources, and abundant

in the Marysvale volcanic field, indicate that the intrusive sources

rock types, commonly representing different source volcanoes

that consist mostly of crystal-rich dacitic rock, but also include

others, 1994). Maximum thickness about 100 m

Pavant Range, Antelope Range, and Annabella area.

mum thickness about 150 m

undivided (Miocene and Oligocene)

Plateau (Anderson and Rowley, 1975). Generally includes a

(Fleck and others, 1975; Rowley and others, 1994). Many

other rock units intertongue with the formation. Thickness

Antimony Tuff Member (Oligocene)—Resistant, mostly red,

about 1,500 m in, and south of, the mapped area

south side, and south of, the mapped area (Anderson and

1985: Rowley and others, 1987: Anderson and others,

Within the formation, clasts in the mudflow breccia,

of the mapped area, vent and alluvial facies intertonque. Vent-

Most of these deposits are the products of clustered

Td Mount Dutton Formation (Miocene and Oligocene)—Soft to

about 19 Ma (Steven and others, 1979). Maximum exposed Mount Baldy Rhyolite Member-Resistant, light-gray, flowintrusion (Tci). A local volcano within the caldera (called "volcanic rocks of Upper Box Creek Reservoir" in Rowley and foliated, crystal-poor intracaldera rhyolite lava flows and dikes derived from, and deposited mostly within, the Mount Belknap others. 1986a,b) occurs near the top of the unit in the southeastern part of the caldera, where it forms a lens of caldera. Maximum exposed thickness about 800 m Volcaniclastic rocks—Soft to moderately resistant, light-gray and moderately resistant, red to brown andesitic lava flows and volcanic mudflow breccia as much as 150 m. Thickness of white intracaldera volcanic mudflow breccia that is slightly older than, and derived from, lava flows of the Mount Baldy Rhyolite intracaldera facies at least 350 m; base not exposed Member (Tmb). Derived from and deposited within the Mount Outflow facies—Resistant, brown (lower part) and light-gray Belknap caldera. Clasts lithologically similar to the Mount Baldy (upper vapor phase zone), densely welded, moderately crystal-Rhyolite Member. Includes landslide debris and fluvial sandstone rich, rhyodacitic ash-flow tuff (Williams and Hackman, 1971). and conglomerate. Maximum thickness about 240 m Forms one or two cooling units that commonly contain black basal vitrophyres. Contains drawn-out pumiceous lenticules. Middle tuff member—Soft, light-gray and tan, poorly welded crystal-poor intracaldera rhyolite ash-flow tuff. Lithologically Upper part locally contains steeply dipping flow-foliated rock

similar to, and locally continuous across the margin of, the Mount Belknap caldera into the upper part of the Joe Lott Tuff Member (Tmj). Thickness about 500 m Blue Lake Rhyolite Member and lower tuff member—Lower earts of the intracaldera fill of the Mount Belknap caldera (Cunningham and others, 1983). The Blue Lake Rhyolite Member consists of moderately resistant, gray, flow-foliated, crystal-poor lava flows about 340 m thick. The underlying lower uff member, lithologically similar to the middle tuff member (Tmm) and the Joe Lott Tuff Member (Tmj), is about 460 m thick (base not exposed) in the lowest exposed parts of the caldera, so is likely to be much thicker Lower heterogeneous member—Mostly soft, gray rhyolite volcanic domes, lava flows, and subordinate ash-flow tuff and uvial sandstone. Derived from a volcanic source northwest of Marysvale. Thickness about 70 m Fine-grained granite—Resistant, gray and greenish-gray. fine ined granite and granodiorite stock that cuts the Central

from its source in the Mount Belknap caldera (Cunningham and

Steven, 1979a). Locally includes a black basal vitrophyre and

about 19 Ma (Steven and others, 1979). Thickness about 60 m

Red Hills Tuff Member—Reddish-brown, reddish-tan, and light-

ash-flow tuff derived from the Red Hills caldera north of

black basal vitrophyre. Location of caldera is beneath this

subhorizontal tuff based on steep flow foliation suggestive of

post-eruptive flow of the tuff back into its source vent.

hickness about 180 m

hickness about 120 m

abundant lithic clasts. Exposed west of Marysvale. K-Ar age is

gray, moderately resistant, crystal-poor, densely welded rhyolite

Marysvale (Cunningham and Steven, 1979a). Locally contains a

Unconformably overlies the Central intrusion (Tci). About 19

1982) and on ages of overlying and underlying units. Maximum

Ma, based on a K-Ar date of 18.9 Ma (Cunningham and others

Joe Lott Tuff Member-Light-gray, tan, reddish-brown, and light-

reen, moderately resistant, partially welded, crystal-poor

thyolite ash-flow tuff (Budding and others, 1987). Contains

abundant lithic clasts of darker, flow-foliated cogenetic rhyolite

flow rock. Locally contains brown and black basal vitrophyre.

This is the main outflow unit derived from the Mount Belknap

position relative to isotopically dated units indicates an age of

caldera (Cunningham and Steven, 1979a). Stratigraphic

intrusion (Tci) in the Central Mining Area and hosts some of the uranium-bearing veins of the district. Exposed northeast of the Red Hills caldera and shown on the cross section. Includes associated dikes as wide as 8 m. Isotopic dates cluster at 21–20 Ma (Cunningham and others, 1982; Rowley and others, 1988a,b). Emplaced within the Monroe Peak caldera and possibly a late intrusive phase of this caldera, but included within the Mount Belknap Volcanics on the basis of its similarity in Crystal-rich volcanic domes and plugs—Resistant, tan, pink, and gray, flow-foliated, crystal-rich rhyolite volcanic domes and intrusive feeders for domes since eroded away. Unit crops out

northeast of Marysvale. Age about 21 Ma (Steven and others, 1979; Cunningham and others, 1982). Maximum thickness of domes about 250 m Potassium-rich mafic volcanic rocks (Miocene)—Resistant, black and dark-gray, locally vesicular and amygdaloidal, crystal-poor lava flows and scoria. Rock resembles basalt, but chemical analyses show the rocks to be high in K2O and thus they may be classified as absarokite (Wender and Nash, 1979) or shoshonite (Best and others, 1980). Referred to as "older basalt" by Anderson and Rowley (1975). We retain the name "potassium rich mafic volcanic rocks" (Cunningham and others, 1983) lows of Birch Creek Mountain, Tbi; mafic gravels of Gunsight Flat, Tgf) in the southwestern part of the mapped area. Matto: and Walker (1989, 1990), Walker and Mattox (1989), and Mattox (1991a, 1992) considered the rocks to represent the termination of volcanism of the Mount Dutton Formation (Td) but we considered them to be the oldest product of bimodal volcanism (Cunningham, Unruh, and others, 1998). K-Ar ages are 25–21 Ma (Rowley and others, 1994). Maximum thickness

dark-gray, vesicular and amygdaloidal, crystal-poor, potassiumrich mafic lava flows (Anderson and Rowley, 1975; Wickstrom, 1982; Anderson and others, 1990a,b). Isotopic dates are 23-22 Ma (Rowley and others, 1994). Mapped only in one place in the southwestern part of the mapped area, where it is about 15 m thick, but south of the mapped area unit is as much Mafic gravels of Gunsight Flat—Moderately resistant, black and dark-gray fluvial conglomerate made up of clasts of potassiumrich mafic lava flows (Anderson and others, 1990b). Locally intercalated with the mafic lava flows of Birch Creek Mountain

Mafic lava flows of Birch Creek Mountain—Resistant, black and

Taa Basaltic andesite lava flows, Antimony Tuff Member of the (Tbi). Interpreted to represent fanglomerates shed northward from Miocene fault scarps (Anderson and others, 1990b). Maximum thickness about 300 m

Basaltic andesite lava flows-Resistant, dark-gray and black, CALC-ALKALINE IGNEOUS SUITE AND SYNCHRONOUS SEDIMENTARY ROCKS The calc-alkaline suite is the product of the older of two Cenozoic magmatic episodes in the Maryvale volcanic field, and it makes up 95 percent of the total volume of igneous rocks in the Marysvale field (Cunningham and others, 1983; Steven and others, 1990; Cunningham and others, 1997; Cunningham, Rowley, and others, 1999; Cunningham, Unruh, and others

the volcanic rocks, which ranges from andesite to low-silica rhyolite, as occurs throughout the Western United States (Lipman and others, 1972).] Late intracaldera deposits of the Monroe Peak caldera, undivided (Miocene)—Lava flows of varied compositions. caldera after subsidence. The lava flows represent the effusive products of intracaldera intrusions (commonly called "resurgent intrusions" in other calderas; Smith and Bailey, 1968) that were emplaced into the caldera and that altered and deformed the intracaldera Osiris Tuff. Although most of these rocks are fresh. huge masses of white bull quartz locally formed as hot-spring sinter and as replacement masses during wallrock alteration by intracaldera intrusions that were emplaced within the volcanic lumped rock unit (Tmpu) is mapped only in the northwestern and central part of the caldera, where rocks are so intensely hydrothermally altered that mapping individual lithologic units is not possible. The Monroe Peak caldera was initially formed during the eruption of the Osiris Tuff (To, Toi). The northern part of the caldera, like the southern margin of the Three Creeks caldera and other features (Rowley, 1998; Rowley and others, 1998; Campbell and others, 1999), seems to be controlled by

Delano Peak Tuff Member (Miocene)—Resistant, dark-reddish brown, densely welded, crystal-rich dacitic ash-flow tuff. Source is the Big John caldera in the central Tushar Mountains (Cunningham and others, 1984c; Steven, Cunningham, and others, 1984; Steven, Rowley, and Cunningham, 1984). K-Ar age is about 23 Ma (Steven and others, 1979). Earlier interpretations suggesting that the unit is younger than the Osiris Tuff (Cunningham and others, 1983) have been revised, and the unit now is interpreted to be older than the Osiris (Rowley and others, 1994). Maximum thickness about 200 m Three Creeks Tuff Member (Oligocene)—Resistant, light-gray and tan, moderately welded, crystal-rich, dacitic ash-flow tuff. Source is the poorly defined, relatively small Three Creeks caldera in the southern Pavant Range (Steven, 1981). The caldera is likely controlled by the Cove Fort transverse zone, which also bounds the northern side of the calderas, volcanoes and batholith complex of the central Marysvale field (Rowley, 1998; Rowley and others, 1998). K-Ar age is 27 Ma (Steven

and others, 1979). Probably the most voluminous ash-flow tufin the Marysvale field. Unit formerly was included in the Needles Range Group, which is derived from the Indian Peak caldera complex on the Utah-Nevada border (Best and others, 1973; Best and Grant, 1987; Best and others, 1989). Maximum thickness about 220 m Volcanic rocks of Little Table (Miocene and Oligocene)-Mostly resistant, tan, brown, gray, brownish-red, green, and pink, amygdaloidal, crystal-poor, andesite lava flows and flow brecci and intertongued volcanic mudflow breccia containing clasts of the same lithologic type. Vent-facies and alluvial-facies rocks (Anderson and Rowley, 1975) were separated during more detailed mapping (Cunningham and others, 1983). Probably represents a shield volcano complex that intertongues with the Mount Dutton Formation (Td) and its members as well as lower parts of the volcanic rocks of Langdon Mountain (TIm) in the

central Sevier Plateau. Maximum thickness about 750 m Volcanic rocks of Langdon Mountain (Miocene and Oligocene?)— Soft to resistant, pink, tan, light-gray, red, and purplish-gray, locally amygdaloidal, moderately crystal-rich dacitic lava flows, flow breccia, and volcanic mudflow breccia, and minor fluvial conglomerate and sandstone. Vent-facies and alluvial-facies rocks were separated during more detailed mapping (Cunningham and others, 1983). Probably represents eruptions of clustered stratovolcanoes in the central Sevier Plateau. Deposits extend into the Awapa Plateau to the east (Williams and Hackman, 1971; Mattox, 1991b). An unusual nepheline syenite breccia pipe, located just east of the mapped area and dated at about 24.4 Ma, was emplaced into both the volcanic rocks of Little Table (TIt) and Langdon Mountains (Agrell and others, 1986, 1999; Rowley and others, 1994). Alluvial facies about 400 m thick and vent facies about 150 m thick in the Sevier Plateau Volcanic rocks of Signal Peak (Miocene and Oligocene)—Mostly

resistant, gray, black, brown, reddish-brown, and red, locally

flows and flow breccia and subordinate volcanic mudflow breccia,

densely welded ash-flow tuff, and conglomerate. Primarily vent-

facies rocks of a clustered, long lived (middle Oligocene to early

Miocene) shield volcano complex in the northern Sevier Plateau.

Vent-facies and alluvial-facies rocks were separated during more

detailed mapping (Cunningham and others, 1983; Rowley and

others, 1986b). Thickness as much as 650 m

vesicular and amugdaloidal, mostly crystal-poor, andesitic lava

Zeolitic tuff (Miocene)—Soft, white, partially welded, crystal-poor rhyolitic ash-flow tuff containing about 10 percent lithic clasts Cunningham and others, 1983). Matrix converted to the zeolite clinoptilolite. May correlate with the 24-Ma Leach Canyon Formation a widespread ash-flow sheet in the eastern Great Basin (Anderson and Rowley, 1975). Exposed only in the Cove Volcanics (Tbc). Thickness about 120 m

Fort area, where it is intertongued with the Bullion Canyon Volcanic rocks of Willow Spring (Miocene and Oligocene)—Soft to moderately resistant, reddish-brown, light-gray, and black, crystal-poor dacitic volcanic mudflow breccia and subordinate lava flows, flow breccia, and fluvial conglomerate and sandstone. The product of primarily alluvial-facies rocks of a stratovolcano in the central Sevier Plateau. Maximum exposed thickness about Tgl Quartz latite volcanic dome (Oligocene)—Resistant, gray, crystal-

rich quartz latite lava flows of a large volcanic dome in the southern Pavant Range. Includes a resistant, dark-gray, crystalpoor rhyodacitic lava flow that overlies the dome. Maximum thickness about 200 m Volcanic rocks of Wales Canyon and volcanic rocks of Dog Valley, undivided (Oligocene)—Originally described by Caskey and Shuey (1975) and mapped by Cunningham and others

Volcanic rocks of Wales Canyon—Moderately resistant, red, moderately crystal-rich, intermediate-composition lava flows and densely welded ash-flow tuff exposed in the northwestern part of the mapped area. Locally intertongued within the Three Creeks Tuff Member (Tbct) of the Bullion Canyon Volcanics. Thickness Volcanic rocks of Dog Valley—Soft to moderately resistant, gray, heterogeneous assemblage of intermediate-composition, crystalpoor lava flows, flow breccia, and volcanic mudflow breccia, and

minor moderately welded ash-flow tuff. Exposed in the southern Payant Range, Maximum thickness about 370 m Wah Wah Springs Formation of the Needles Range Group (Oligocene)—Mostly resistant, gray, tan, and pink, moderately welded, crystal-rich dacite ash-flow tuff. Exposed in scattered places near the base of the volcanic section in the mapped area. One of the world's largest known ash-flow sheets, derived from the Indian Peak caldera complex on the Utah-Nevada border (Best and others, 1973; Best and Grant, 1987; Best and others, 1989). Isotopic age about 30 Ma (Best and Williams, 1997).

Maximum thickness in the mapped area about 70 m

SEDIMENTARY ROCKS THAT PREDATE ROCKS OF THE MARYSVALE VOLCANIC FIELD

Conglomerate (Oligocene, Eocene, or Paleocene)-Soft, lightgray and tan, fluvial, pebble conglomerate containing rounded clasts of sandstone and limestone derived from Mesozoic and Paleozoic rocks. Locally includes tuffaceous sandstone, which suggests affinity to nearby Oligocene volcanic rocks. Mapped only in the central Tushar Mountains. Thickness as much as 10 Formation of Aurora of Willis (1988) (Eocene)—Mostly soft, white and light-gray, lacustrine and fluvial mudstone, shale, siltstone, sandstone, and minor limestone. In the upper and middle parts, contains upwardly increasing amounts of fine-grained rhyolitic northern part of the mapped area. Informally named by Willis

volcanic ash and reworked volcanic detritus. Exposed only in the (1988) to generally replace the Bald Knoll Formation of Spieker (1949) and Gilliland (1949, 1951), which Willis abandoned. Biotite in the ash from the upper part yielded a K-Ar date of 40.5 Ma, and pumice near the top of the formation yielded K-Ar dates of 39.6 and 38.4 Ma (Willis, 1985). Thickness about 85 Flagstaff Limestone (Paleocene)—Mostly moderately resistant, white, tan, reddish-brown, and gray, locally fossiliferous, slightly vuggy lacustrine limestone. Includes minor soft red and gray shale and siltstone in upper part and soft gray shale and limy siltstone near the base. Exposed only at the northern edge of

the mapped area. Full thickness not known but probably more than 600 m in and near the mapped area decay constants, and stratigraphic relationships with other dated Price River Formation (Upper Cretaceous)—Moderately resistant massive, reddish-gray conglomerate and local interlayered beds of sandstone and siltstone. Derived during rapid fluvial deposition from erosion of Sevier thrust sheets, some of which are exposed in the northern part of the mapped area. Exposed only in the northern part of the mapped area. Unconformably overlies the Arapien Formation (Ja). Thickness change abruptly within short distances and ranges from a few meters to more than 800 m in the western Pavant Range Arapien Formation (Middle Jurassic)—Soft to resistant, multicolored but generally light-gray marine siltstone, shale, mudstone, limestone, sandstone, and minor conglomerate. Evaporite beds are abundant outside the mapped area. Exposed

> Navajo Sandstone (Lower Jurassic)—Resistant, tan, yellowish-gray, and white, medium- to fine-grained, crossbedded eolian sandstone. Locally altered to resistant quartzite. Unconformably overlies the Petrified Forest Member of the Chinle Formation (Rc). Thins southwestward from more than 600 m to about Chinle Formation (Upper Triassic)—Fluvial and lacustrine rocks consisting of part of the Petrified Forest Member and the underlying Shinarump Member. The Petrified Forest Member is moderately resistant, red, maroon, chocolate, tan, and white mudstone overlying a basal bed of purple, coarse-grained sandstone; the member is 1–100 m thick. The Shinarump Member is moderately resistant, red to brownish-red, fine- to medium-grained conglomerate; the member is a few meters to

> > surface. Thickness 150-250 m

in the central Tushar Mountains. More than 350 m thick, the

130 m thick. Unconformably overlies the Moenkopi Formation Moenkopi Formation (Middle? and Lower Triassic)—Mostly soft to moderately resistant, dark-red to chocolate-brown siltstone and shale. Contains two prominent light-bluish-gray limestone beds. Deposited in alternating marine and continental environments. Thickness is 300-700 m Kaibab Limestone and Toroweap Formation, undivided (Lower Permian)—Kaibab Limestone is mostly a resistant, mediumgray, thick-bedded, locally cherty marine limestone. Underlying

resistant, bluish-gray to gray, fine- to medium-grained, thin-

marine limestone and dolomite. The upper third of this

bedded to massive, commonly cherty, moderately fossiliferous

sequence is commonly dolomitic, includes sparse sandstone and

quartzite beds, contains fossils of Permian age, and is believed to

represent the Pakoon Limestone of McNair (1951). The lower

dolomite typical of the Callville Limestone, some beds of which

have yielded conodonts of Pennsylvanian age (Wardlaw, 1980).

interbedded tan and brown, fine- to coarse-grained quartzite and

sandstone, resembling parts of the Oquirrh Group of generally

equivalent age, as mapped farther north in Utah. The Pakoon

and Callville are as much as 1,500 m thick in and north of the

fossiliferous, marine limestone containing sparse beds of tan

sandstone in the upper part. Exposed only in the northwestern

Cove Fort Quartzite (Upper Devonian)—Defined by Crosby (1959)

for a moderately resistant, white to light-gray, somewhat vuggy

quartzite and subordinate beds of conglomerate made up of flat

pebbles of limestone. Unit apparently overlies an extensive

unconformity cut on the Simonson Dolomite (Dsi). Exposed

Simonson Dolomite (Middle Devonian)—Resistant, medium- to

the mapped area. Thickness 25-175 m

Ds Sevy Dolomite (Lower Devonian)—Moderately resistant, light- to

part of the mapped area. Thickness 150-200 m

Laketown (Silurian) and Ely Springs (Upper Ordovician)

only in the northwestern part of the mapped area. Average

dark-brownish-gray, medium- to thick-bedded, medium- to

medium-gray, medium- to thick-bedded, dense to faintly

laminated, marine dolomite. Exposed only in the northwestern

Dolomites, undivided —Laketown Dolomite is a moderately

medium- to coarse-grained, sparsely cherty marine dolomite that

is 300-400 m thick. The underlying Ely Springs Dolomite is a

moderately resistant, mostly black but locally light- to medium-

gray, medium-bedded to massive, sparsely fossiliferous, medium-

to coarse-grained marine dolomite that is 50-150 m thick.

Exposed only in the northwestern part of the mapped area

Ordovician)—Marine deposits that are mapped together. The

Eureka Quartzite, at the top, is resistant, white, tan, and pinkish

gray, fine- to very-fine-grained, medium-bedded orthoguartzite

that is 25–125 m thick. The Juab Limestone is a moderately

fossiliferous, silty limestone or limy siltstone about 50 m thick

The Wah Wah Limestone is a moderately resistant, medium-

gray, thin-bedded, abundantly fossiliferous, silty limestone about

80 m thick The Fillmore Formation is a moderately resistant

medium-gray, thin-bedded silty limestone, much of which is

intraformational conglomerate. The Fillmore contains minor

m thick. The House Limestone is a moderately resistant,

these faults are shown with a bar and ball symbol on the

downthrown side. Those in which strike slip predominates are

shown with arrows indicating relative strike-slip movement.

Dashed where approximately located, dotted where concealed

approximately located, dotted where concealed. Of the Sevier

where concealed. In most places it is the topographic boundary

deformational event (Late Cretaceous to early Cenozoic)

of the caldera, as this term was used by Lipman (1997)

Axial trace of fold—Dashed where approximately located, dotted

the northwestern part of the mapped area

High-angle fault—Normal slip predominates on most faults, and

\_\_\_\_ Thrust fault—Sawteeth on upper plate. Dashed where

where concealed

Strike and dip of beds

Syncline

Horizontal

\_\_\_\_\_Caldera margin—Dashed where approximately located, dotted

medium-bluish-gray, medium-bedded, sparsely cherty, finely

crystalline silty limestone about 150 m thick. Exposed only in

interbeds of yellowish-gray shale in its upper part; it is 500-600

Eureka Quartzite, Juab and Wah Wah Limestones, Fillmore

resistant, medium-gray, thin- to thick-bedded, sparsely

Formation, and House Limestone, undivided

resistant, light- to medium-gray, medium- to thick-bedded,

coarse-grained marine dolomite that locally contains minor beds

of light-gray dolomite. Exposed only in the northwestern part of

Redwall Limestone (Upper and Lower Mississippian)—Resistant,

dark-gray, medium-bedded to massive, locally cherty,

part of the mapped area. Thickness 400-500 m

two-thirds of the sequence consists mostly of limestone and

This lower two-thirds also contains moderate amounts of

Toroweap Formation is mostly a resistant, medium-gray marine tah: Mineralium Deposita, v. 33, p. 477-494. limestone that is interlayered with medium-gray dolomite, tan sandy and silty limestone, and minor shale. It also contains minor beds of gypsum that typically were leached away at the Talisman Quartzite and Pakoon Limestone (Lower Permian) and America Abstracts with Programs, v. 29, no. 6, p. A-305. Callville Limestone (Pennsylvanian), undivided—Marine deposits that are mapped together. Talisman Quartzite, at the top of the map unit, is a resistant, light-tan, well-sorted, crossbedded orthoguartzite about 50–250 m thick. Some prefer the designation Queantoweap Sandstone for the Talisman. Underlying this is a sequence made up mostly of moderately

B. scale 1:100.000.

Geological Survey Professional Paper 1299-A, 22 p. Map I-1430-A, scale 1:50,000

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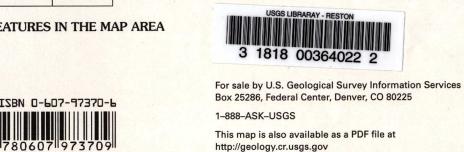
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