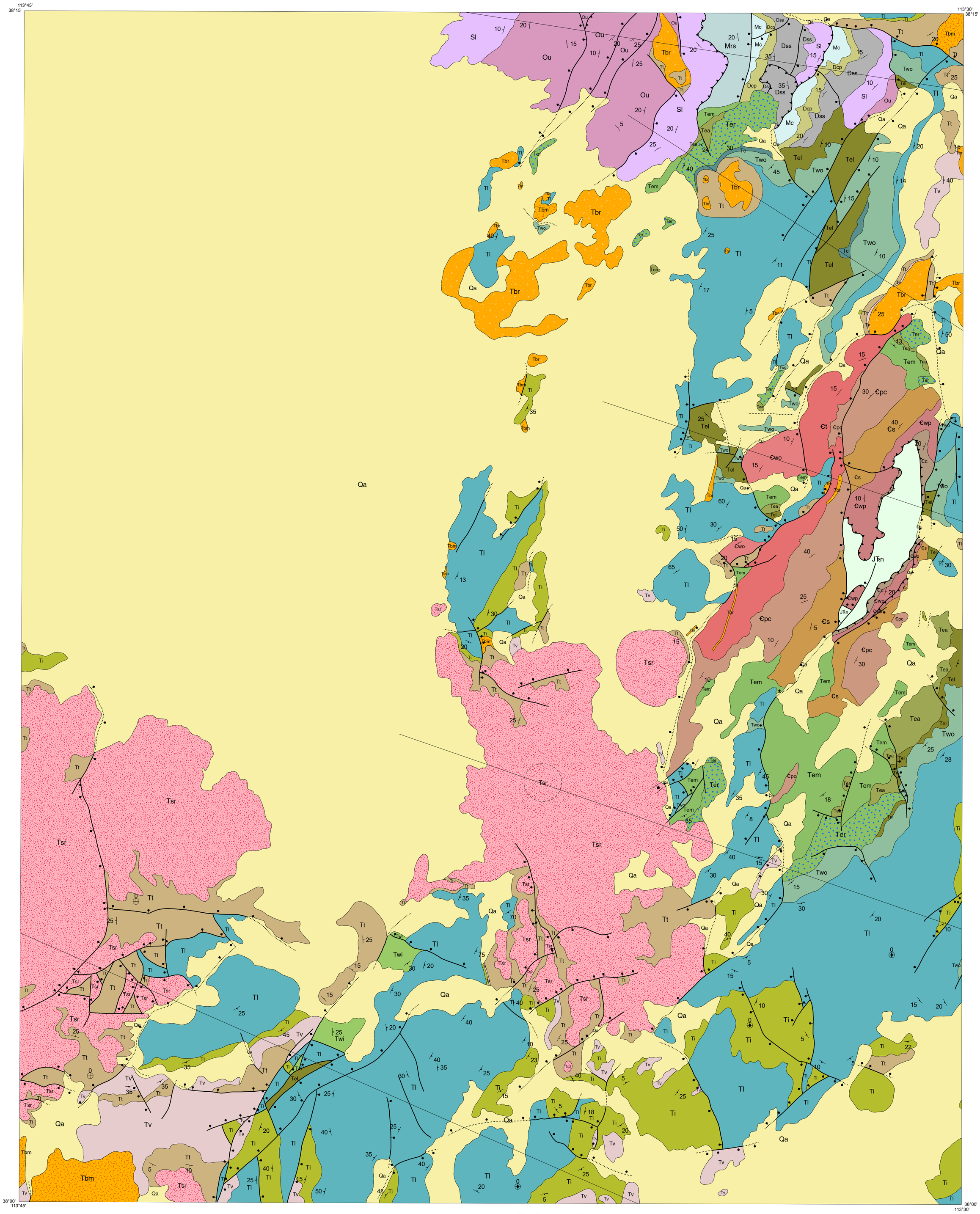


Utah Geological Survey Open-File Report 671DM

Geologic map of the southern Pine Valley area, Beaver and Iron Counties, Utah (GIS reproduction of USGS Map I-1794 [1987])

M.G. Best, H.T. Morris, R.W. Kopf, and J.D Keith

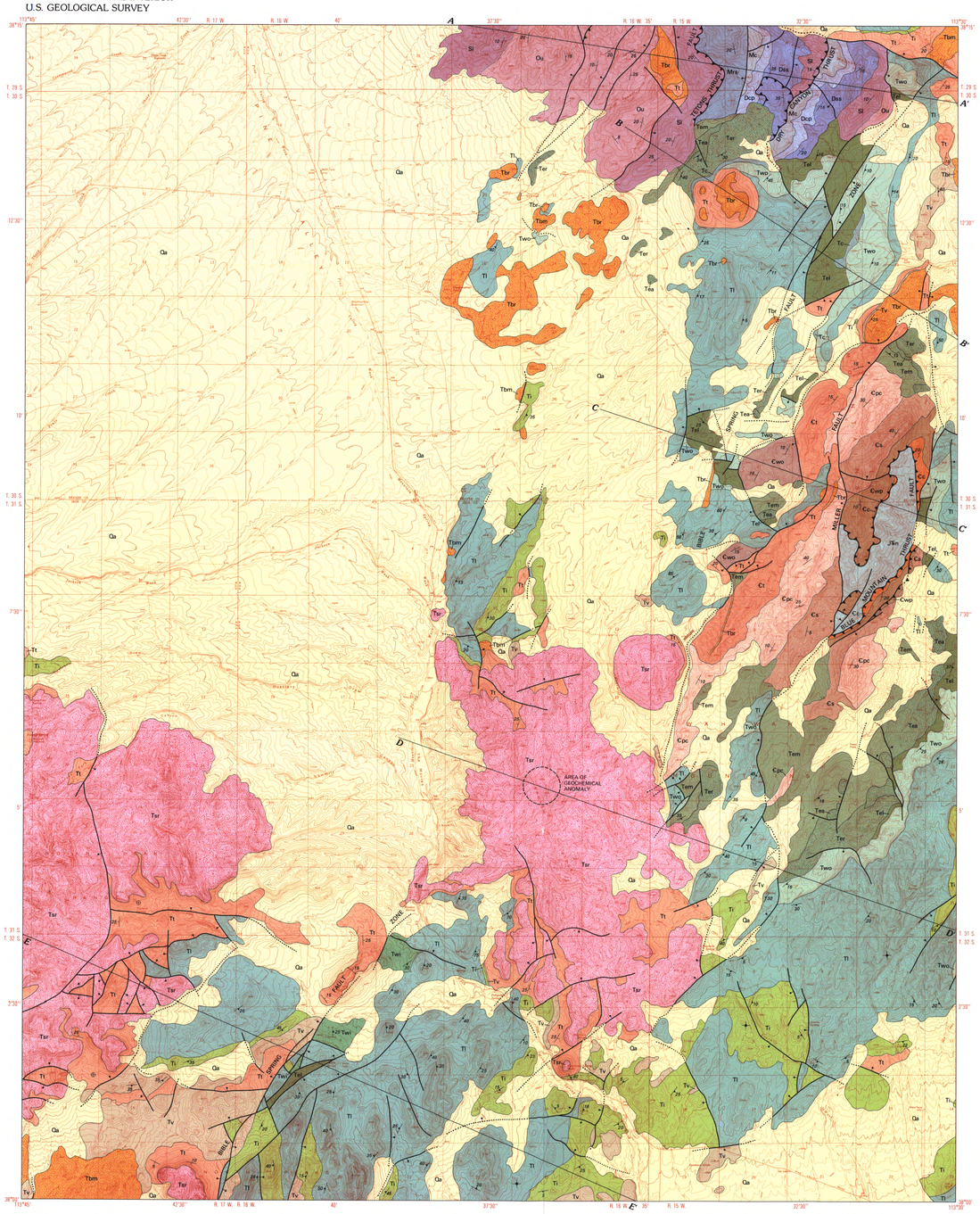
SCALE 1:50,000

1 0.5 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

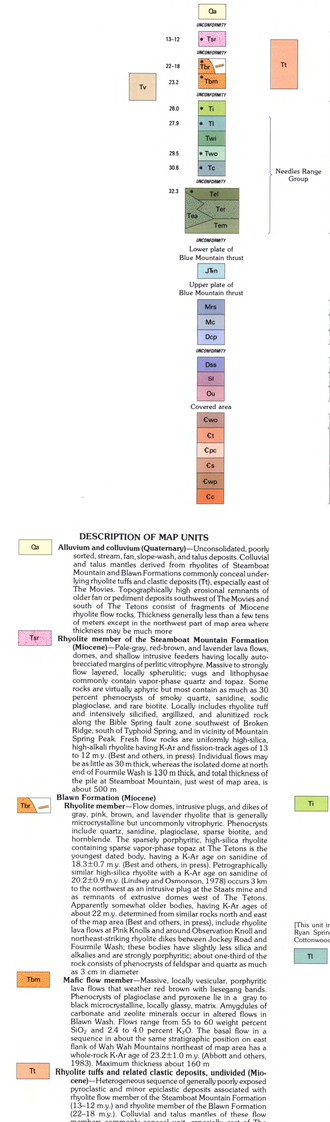
1 0.5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 50 METERS



CORRELATION OF MAP UNITS

[Asterisks indicate dated units and adjacent numbers indicate age in millions of years]



DESCRIPTION OF MAP UNITS

Qa **Alluvium and colluvium (Quaternary)**—Unconsolidated, poorly sorted, stream, fan, slope-wash, and talus deposits. Colluvial and talus deposits derived from rhyolites of Steamboat Mountain and Blawn Formations commonly conceal underlying rhyolite tuffs and clastic deposits (Ts), especially east of The Movies. Topographically high erosional remnants of older fan or pediment deposits southwest of The Movies and south of The Tetons consist of fragments of Miocene rhyolite flow rocks. Thickness generally less than a few tens of meters except in the northwest part of map area where thickness may be much more

Tsr **Rhyolite member of the Steamboat Mountain Formation (Miocene)**—Pale-gray, red-brown, and lavender lava flows, domes, and shallow intrusive feeders having locally autobrecciated margins of perlitic vitrophyre. Massive to strongly flow layered, locally spherulitic; vugs and lithophysae commonly contain vapor-phase quartz and topaz. Some rocks are virtually aphyric but most contain as much as 30 percent phenocrysts of smoky quartz, sanidine, sodic plagioclase, and rare biotite. Locally includes rhyolite tuff and intensively silicified, argillized, and alunitized rock along the Bible Spring fault zone southwest of Broken Ridge, south of Typhoid Spring, and in vicinity of Mountain Spring Peak. Fresh flow rocks are uniformly high-silica, high-alkali rhyolite having K-Ar and fission-track ages of 13 to 12 m.y. (Best and others, in press). Individual flows may be as little as 30 m thick, whereas the isolated dome at north end of Fourmile Wash is 130 m thick, and total thickness of the pile at Steamboat Mountain, just west of map area, is about 500 m

Blawn Formation (Miocene)

Tbm **Rhyolite member**—Flow domes, intrusive plugs, and dikes of gray, pink, brown, and lavender rhyolite that is generally microcrystalline but uncommonly vitrophyric. Phenocrysts include quartz, sanidine, plagioclase, sparse biotite, and hornblende. The sparsely porphyritic, high-silica rhyolite containing sparse vapor-phase topaz at The Tetons is the youngest dated body, having a K-Ar age on sanidine of 18.3±0.7 m.y. (Best and others, in press). Petrographically similar high-silica rhyolite with a K-Ar age on sanidine of 20.2±0.9 m.y. (Lindsey and Osmonson, 1978) occurs 3 km to the northeast as an intrusive plug at the Staats mine and as remnants of extrusive domes west of The Tetons. Apparently somewhat older bodies, having K-Ar ages of about 22 m.y. determined from similar rocks north and east of the map area (Best and others, in press), include rhyolite lava flows at Pink Knolls and around Observation Knoll and northeast-striking rhyolite dikes between Jockey Road and Fourmile Wash; these bodies have slightly less silica and alkalies and are strongly porphyritic, about one-third of the rock consists of phenocrysts of feldspar and quartz as much as 3 cm in diameter

Tt **Mafic flow member**—Massive, locally vesicular, porphyritic lava flows that weather red brown with lensoid banding. Phenocrysts of plagioclase and pyroxene lie in a gray to black microcrystalline, locally glassy, matrix. Amygdules of carbonate and zeolite minerals occur in altered flows in Blawn Wash. Flows range from 55 to 60 weight percent SiO_2 and 2.4 to 4.0 percent K_2O. The basal flow in a sequence in about the same stratigraphic position on east flank of Wah Wah Mountains northeast of map area has a whole-rock K-Ar age of 23.2±1.0 m.y. (Abbott and others, 1983). Maximum thickness about 160 m

Tt **Rhyolite tuffs and related clastic deposits, undivided (Miocene)**—Heterogeneous sequence of generally poorly exposed pyroclastic and minor epiclastic deposits associated with rhyolite flow member of the Steamboat Mountain Formation (13–12 m.y.) and rhyolite member of the Blawn Formation (22–18 m.y.). Colluvial and talus mantles of these flow members commonly conceal unit, especially east of The Movies. Tan to pale-green-brown or pink, weakly welded, lapilli ash-flow tuff is most common but minor air-fall and surge deposits also occur. Sparse phenocrysts less than 3 mm long of quartz, feldspar, and biotite and variable quantities of dark lithic fragments of Miocene rhyolite flow rocks and of older welded tuffs of the Bauers Tuff Member of the Condor Canyon Formation, Isom Formation, and Lund Formation. Locally, as at White Cliff and along west side of Broken Ridge, angular fragments of rhyolite flow rock as large as 1 m across compose as much as half of ash-flow tuff; these blocks were derived from nearby extrusive flow domes of rhyolite (Tsr) that were disintegrating concurrently with emplacement of these ash flows. Most tuffs represent material explosively erupted from many local vents from which viscous lavas were later extruded. Lower tuff beneath mafic flow (Tbm) in Blawn Wash contains dark-red garnet, indicating tuff's derivation from venting magma system centered in Pine Grove just north of map area (Abbott and others, 1983; Keith, 1983). Unit includes sparse, crudely stratified epiclastic beds of tan, coarse sandstone, locally containing cobbles of welded tuff (Lund Formation), and beds of red, poorly sorted, angular volcanic debris of sand to cobble size. Locally intensely silicified to form resistant masses of white to tan jasperoid; also argillized and alunitized. Thickness 100–200 m

Tv **Volcanic rocks, undivided (Miocene)**—Heterogeneous group of rocks that includes: (1) pink to red-brown, monolithologic and heterolithologic breccias and megabreccias that apparently formed by slumping and fluvial transport of erosional debris into fault-controlled basins at south end of Bible Spring fault zone. In main area of exposure in sec. 13, unit forms hillslope rubble derived from rhyolite tuffs (Tt), Isom Formation, hornblende andesite, and Bauers Tuff Member of Condor Canyon Formation (see below); clasts range from sand size to shattered and pervasively silicken sided slab-like blocks tens of meters long. Elsewhere, this unit consists mostly of monolithologic breccias derived from Bauers Tuff Member of Condor Canyon Formation. Local sandstones and conglomeratic mudflows within the sequence of breccias contain clasts mainly of hornblende andesite. This breccia unit has been commonly affected by weak hydrothermal alteration and silicification. Thickness may be as much as several hundred meters. (2) Hornblende andesite lava flows; gray to black where fresh and brown where altered; porphyritic, with 25 percent of phenocrysts consist mainly of acicular hornblende and zoned plagioclase and sparse augite and hypersthene grains. Matrix is felted mass of feldspar and glass. Unit is thickest, 100 m, south of Mountain Spring Peak. (3) Bauers Tuff Member of the Condor Canyon Formation consists of gray, buff, pink, and lavender, densely welded ash-flow tuff containing about 10 percent phenocrysts of plagioclase, sanidine, and biotite and locally conspicuous, light-colored, collapsed pumice lapilli. Average of six K-Ar ages on biotite, plagioclase, and whole-rock samples is 22.3 m.y. (Fleck and others, 1975; adjusted for new decay constants). Maximum thickness ranges from 10 to 120 m. (4) Leach Canyon Formation consists of generally poorly exposed, weakly welded, crystal-poor rhyolitic ash-flow tuff. White pumice lapilli and sparse, darker colored lithic fragments are set in red matrix of welded ash. Thickness may be as much as 120 m

Tts **Isom Formation (Oligocene)**—Red brown to purple, crystal-poor ash-flow tuffs and lava flows that weather to small plates and grus. Phenocrysts generally constitute less than 15 percent of the rock and include plagioclase, and minor, smaller pyroxenes and Fe-Ti oxides. Tuffs are vuggy and densely welded and contain moderately compacted and locally elongated pumice fragments. Average K-Ar age on three plagioclase and whole-rock samples is 26.0 m.y. (Fleck and others, 1975; adjusted for new decay constants). Thickness ranges from 10 m to at least 150 m in southern part of map area

NEEDLES RANGE GROUP (OLIGOCENE)

[This unit includes the following formations in descending order: Lund Formation, Wah Wah Springs Formation (not found in map area), Wah Wah Springs Formation, Cottonwood Wash Tuff, and Escalante Desert Formation (Best and Grant, in press)]

Tl **Lund Formation**—Red-brown, moderately to densely welded, crystal-rich, dacitic ash-flow tuff with about 25 percent plagioclase, 10 percent biotite, lesser hornblende, and a trace of sphene. Flattened, light-colored pumice lapilli are prominent in most outcrops but lithic fragments are present only in the south. Black vitrophyre appears locally near base of unit. Average K-Ar age on two biotites is 27.9 m.y. (Best and Grant, in press). Unit in Blawn Wash includes 30–60 m of Three Creeks Tuff Member of Bullion Canyon Volcanics (Steven, 1981). This overlying tuff is gray, moderately welded, ash-flow tuff containing about 40 percent phenocrysts of (in descending order of abundance) euhedral white plagioclase as much as 6 mm long, hornblende, biotite, and trace amounts of quartz and sphene; white pumice lapilli are conspicuous. Thickness is somewhat uncertain because of faulting but is at least several hundred meters in places

Wah Wah Springs Formation—Crystal-rich, lapilli ash-flow tuffs of dacite composition. Crystals make up almost one-half of unit and include prominent plagioclase, lesser amounts of hornblende, biotite, quartz, Fe-Ti oxides, and a trace of pyroxene. Eruption caused collapse of Indian Peak caldera. Average K-Ar age on 16 biotites and hornblendes is 29.5 m.y. (Best and Grant, in press)

Twi **Intracaldera member**—Dacite tuff characterized by lithic fragments of dark volcanic rocks that constitute as much as 20 percent of rock; contains 3–4 percent quartz phenocrysts. Only exposed along Bible Spring fault zone where tuff is argillized and is purple, orange, brown, and white. Absent just south of map area. Exposed thickness is no more than a hundred meters

Two **Outflow member**—Similar to the intracaldera member with respect to phenocryst content but has only 1–2 percent quartz and no lithic fragments. Color where fresh is usually red brown. 100–250 m thick but pinches out just south of map area

Tc **Cottonwood Wash Tuff**—Densely welded, crystal-rich, dacite ash-flow tuff containing about 25 percent plagioclase, about 6 percent prominent euhedral biotite phenocrysts as much as 8 mm in diameter, 5 percent quartz phenocrysts as much as 4 mm in diameter, and 5 percent small hornblende phenocrysts that are inconspicuous in hand sample. Average K-Ar age on four biotites and a hornblende is 30.6 m.y. (Best and Grant, in press). Less than 20 m thick in northern part of map area and absent in south part

Escalante Desert Formation—Sequence of crystal-poor, lithic, rhyolite ash-flow tuffs, andesite and rhyolite lava flows, and sandstone

Tel **Beers Spring and Lamerdorf Tuff Members, undivided**—The younger Beers Spring Member is an olive-brown, well-sorted sandstone containing grains of pyroxene, plagioclase, and quartz. Ranges in thickness from a meter or so to as much as 400 m south of Jockey Road. The underlying Lamerdorf Tuff Member is variegated orange-brown to lavender, densely welded rhyolitic ash-flow tuff containing about 10 percent phenocrysts of chalky white plagioclase, lesser biotite, dark lithic fragments, and conspicuous light-colored pumice lapilli. A K-Ar age on biotite is 32.3±1.1 m.y. (Best and Grant, in press)

Ter **Rhyolite flow member**—Variegated lavender, brown, and red to pink, flow-layered lava flows containing less than 20 percent phenocrysts of chalky plagioclase, minor biotite, and hornblende. Weathers to pitted plates and chips in which angular pits once were occupied by plagioclase. Includes a gray dacite sill that consists of strongly porphyritic rock, containing phenocrysts of andesine, biotite, hornblende, and quartz in a aphanitic matrix, and that intrudes andesite flow member (Tea) 2 km south of Herd Pass. As much as 250 m thick south of Herd Pass and north of The Tetons

Tea **Andesite flow member**—Black, massive, generally nonvesicular, lava flows containing phenocrysts of plagioclase and augite in a felty to glassy matrix. Weathers into brown blocks. Maximum thickness is 360 m

Tem **Marsden Tuff Member and associated tuff and conglomerate**—White, gray, orange, or pale-green crystal-poor and locally lithic-rich rhyolitic ash-flow tuff; phenocrysts of quartz, feldspar, and biotite are less than 1 mm across and make up only a few percent of rock; lithic fragments include pink and gray felsite and, near base of unit, pink quartzite, probably derived from earliest Cambrian and latest Precambrian quartzite units that occur in southwestern Utah. Unit includes at its base: tuff containing abundant plagioclase and biotite phenocrysts in exposures 3 km southwest of Herd Pass; conglomerate of well-rounded pebbles and cobbles of limestone and some quartzite in gray- to tan-weathering, sandy mudstone that is locally more than a hundred meters thick in secs. 16, 17, 18, 20, 21, and 29, T. 31 S., R. 15 W. In Indian Peak and Mountain Home Ranges to west, Marsden Tuff Member is underlain by tuff of Sawtooth Peak Formation, which has a K-Ar age on biotite of 33.5±1.2 m.y. and a fission-track age on zircon of 33.6±1.8 m.y. (Best and others, in press). Thickness 300 m

JŦkn **Navajo Sandstone (Jurassic and Triassic?)**—Tan or yellowish-gray to white, medium- to fine-grained, eolian crossbedded sandstone. About 650 m thick

Mrs **Formation of Rose Spring Canyon (Upper Mississippian)**—Sequence of somewhat heterogeneous strata. Similar in age but differs in lithology from Woodman Formation in Gold Hill district, Utah, and Humbug Formation in Tintic and Ophir districts, Utah. Also similar in many respects to Upper Mississippian Battleship Wash Formation of Bird Spring Group of Langenheim and Langenheim (1965), which is exposed in the Arrow Canyon Range of southeastern Nevada. In Wah Wah Mountains, upper part of the formation of Rose Spring Canyon is interbedded blue-gray, medium-bedded, cherty, fossiliferous limestone, and buff to greenish-brown, medium-grained sandstone, and some minor beds of fine-grained argillaceous dolomite. Commonly contains large and small masses of gray hydrothermal jasperoid. Top is concealed, but total thickness of upper part is estimated to be about 300 m. Lower part is mostly buff to reddish-tan, medium-bedded, medium- to fine-grained sandstone and some similar-colored siltstone, and a conspicuous zone of gray, thin- to medium-bedded, sparsely cherty, argillaceous dolomite in the middle. Lower part is possibly correlative with Scotty Wash Quartzite of southeastern Nevada (Westgate and Knopf, 1932). Base is cut out by a fault in Wah Wah Mountains; thickness of lower part is estimated to be about 225 m. Entire unit ranges from 500 to 525 m thick

Mc **Monte Cristo Limestone (Lower Mississippian)**—Medium- to bluish-gray, medium- to thick-bedded, medium- to fine-grained, fossiliferous limestone. Upper two-thirds is free of sand and silt and is characterized by moderate to abundant nodules, stringers, and lenses of dark-brown to black chert. Lower one-third is somewhat thinner bedded than middle and upper parts and locally contains small to moderate quantities of dispersed sand and silt. Like the Monte Cristo Limestone in its type area in the Spring Mountains of southwestern Nevada (Hewett, 1931, p. 18–21), the Monte Cristo of the Wah Wah Mountains is believed to be of Early and Late Mississippian age. Top of unit or Upper Mississippian part is absent because of faulting, but the complete formation is estimated to be about 200 m thick. Sandberg and Poole (1977) and Sandberg and Gutschick (1984) included these rocks in the Gardison Limestone, Fitchville Formation, and upper member of the Pinyon Peak Limestone

Dcp **Crystal Pass Member of Sultan Limestone and Cove Fort Quartzite, undivided (Upper Devonian)**—Crystal Pass Member is medium- to dark-bluish-gray, medium- to thin-bedded, locally sand-streaked, somewhat silty limestone, or lapilli. Average of six K-Ar ages on biotite, plagioclase, and whole-rock samples is 22.3 m.y. (Fleck and others, 1975; adjusted for new decay constants). Maximum thickness ranges from 10 to 120 m. (4) Leach Canyon Formation consists of generally poorly exposed, weakly welded, crystal-poor rhyolitic ash-flow tuff. White pumice lapilli and sparse, darker colored lithic fragments are set in red matrix of welded ash. Thickness may be as much as 120 m

Ti **Isom Formation (Oligocene)**—Red brown to purple, crystal-poor ash-flow tuffs and lava flows that weather to small plates and grus. Phenocrysts generally constitute less than 15 percent of the rock and include plagioclase, and minor, smaller pyroxenes and Fe-Ti oxides. Tuffs are vuggy and densely welded and contain moderately compacted and locally elongated pumice fragments. Average K-Ar age on three plagioclase and whole-rock samples is 26.0 m.y. (Fleck and others, 1975; adjusted for new decay constants). Thickness ranges from 10 m to at least 150 m in southern part of map area

Dss **Lower part of Simonson Dolomite and Sevy Dolomite, undivided (Middle and Lower Devonian)**—Simonson Dolomite is medium to dark brownish-gray, medium to thick bedded, medium to coarse grained; locally contains a few beds of light-gray dolomite. Fossils are sparse but many so-called "spaghetti beds" contain masses of *Amphipora*. Regional studies indicate that upper part of Simonson Dolomite, and Guilmette Formation that overlies it elsewhere, were removed by erosion prior to deposition of overlying Cove Fort Quartzite or Crystal Pass Member of Sultan Limestone. Thickness of the partial section of Simonson in map area is about 150 m. The Sevy Dolomite is medium to light gray, medium bedded to massive, faintly laminated, dense. Commonly weathers chalky white, but on fresh fractures is light olive to pinkish gray. In some areas the upper one-third of Sevy is medium to coarse grained and has sandy texture. Fossils are rare to absent throughout formation. Thickness of Sevy is 100–250 m

Sl **Laketown Dolomite (Upper and Middle Silurian)**—Medium- to light-gray, medium- to thick-bedded, medium-to coarse-grained dolomite. Fossils are rare, but large radial colonies of *Favosites* and sparse gastropods help identify formation in some areas. Locally, near Staats pluton, areas of bleached and weakly contact metasomatized Laketown Dolomite superficially resemble Sevy and Simonson Dolomites. Thickness ranges to as much as 400 m

Ou **Ordovician sedimentary rocks, undivided**—Unit includes Fish Haven Dolomite, Eureka Quartzite, and Juab Limestone. Upper Ordovician Fish Haven Dolomite is medium and dark gray to black, medium bedded, medium to coarse grained. In some areas middle one-third of formation is predominantly composed of medium- to light-gray dolomite, but these zones may be the result of hydrothermal alteration that has bleached and modified large parts of formation near plutons and faults. Some of these bleached areas superficially resemble Sevy and Simonson Dolomites. In comparison to Laketown Dolomite, which it generally resembles, the unaltered Fish Haven is somewhat darker toned and contains many more fossils. In upper plate of The Tetons thrust, Fish Haven is about 250 m thick and is uncommonly fossiliferous, containing large specimens of *Catenipora* sp., *Favosites* sp., *Deiracorallium* sp., and *Grewingkia* sp., all identified by W. A. Oliver, Jr. (written commun., 1981), as well as large, high-spired gastropods. In lower plate of the thrust, Fish Haven is only about 110 m thick, or less, and is only sparsely fossiliferous, except for some beds that contain small horn coral *Bighornia* and halysitid coral *Catenularia*, which are particularly abundant in upper one-third of formation. Generally upper contact of Fish Haven is placed at uppermost dusky-gray to black dolomite bed containing *Bighornia*. Middle Ordovician Eureka Quartzite is white, buff, or pinkish-gray, medium-bedded, fine to very fine grained orthoquartzite. Locally it weathers yellow, tan, or reddish brown. In upper plate of The Tetons thrust, only incomplete sections a few tens of meters thick of Eureka are exposed, and it rests directly on Middle Ordovician Juab Limestone, a medium-blue-gray, thin- to medium-bedded, medium-grained silty limestone containing scattered lenses of brownish-green shale and limestone, and flat-pebble conglomerate. Base of Juab is concealed. Kanosh Shale and Lehman Formation lie between the Eureka and Juab in nearby areas of Utah (Hintze, 1973) but are absent in map area

Cwo **Big Horse Limestone Member of Orr Formation and Wah Wah Summit Formation, undivided (Upper Cambrian)**—Big Horse Limestone Member is medium-gray to brownish-gray, mottled and striped, dolomitized limestone containing a zone of fossiliferous oolite about 15 m thick at base. According to L. F. Hintze (written commun., 1980) this oolite contains *Meteorospis* and other representatives of the *Crepicephalus* trilobite zone, diagnostic of early Late Cambrian time. Only about 75 m of Big Horse Limestone Member are exposed. The Wah Wah Summit Formation of Hintze and Robison (1975) is mostly medium- to brownish-gray, medium-bedded, somewhat granular dolomitic limestone containing some relatively thin beds and zones of dusky-gray dolomite and medium- to light-gray dolomite. Top of formation is faulted out but remaining part of section is about 325 m thick

Ct **Trippe Limestone (Middle Cambrian)**—Alternating light-gray to creamy-white laminated dolomite, commonly termed *boundstone*, and dark-gray mottled dolomite in bands 1–10 m thick. Boundstone zone about 20 m thick marks base, and other highly conspicuous zones of boundstone make up about 30 to 40 percent of overlying beds. Thickness about 200 m

Cpc **Pierson Cove Formation (Middle Cambrian)**—Thick sequence of dark-gray, thick-bedded, silty to argillaceous limestone and dolomite and minor shale lenses. Most of formation consists of dull, limy mudstone mottled with light-olive to brownish-gray dolomitic mudstone. Next in abundance is massive, finely crystalline, medium-gray limestone or dolomite commonly studded with small, white dolomite rods or blebs. Least in abundance, but highly conspicuous, is faintly yellowish-gray laminated dolomite boundstone that forms light-colored zones throughout the formation. About 500 m thick

Cs **Swasey Limestone (Middle Cambrian)**—Medium- to light-gray, thick-bedded to massive limestone or dolomite. Some beds in lower part are oolitic or pisolitic, and rod-shaped dolomite blebs are common throughout. Upper part of unit is mostly light-gray, thick-bedded to massive micrite. Thickness about 300–370 m

Cwp **Whirlwind Formation, Dome Limestone, and Pensley Limestone, undivided (Middle Cambrian)**—Whirlwind Formation is mostly brown-weathering, olive-green, fissile shale containing sparse, thin lenses of sandy or silty limestone and limestone, and flat-pebble conglomerate. Some thin beds in upper part are almost completely composed of fossilized fragments of disarticulated trilobites of the genus *Ehmaniella*. Whirlwind is about 40 m thick. Dome and Pensley Limestones are chiefly medium- to light-gray, thick-bedded to massive, locally dolomitic limestone, commonly containing small blebs and rods of white calcite or dolomite. Lower one-third of combined Dome and Pensley unit is blue gray and contains zones of fairly abundant oolites and pisolites. Thickness of these two limestone units is about 250 m. Basal beds grade downward into underlying Chisholm Shale

Cc **Chisholm Shale (Middle Cambrian)**—Throughout all of its exposures in map area and in adjacent Blue Mountain quadrangle (Weaver, 1980), unit has acted as slip plane of Blue Mountain thrust plate, and consequently is highly sheared and deformed. Generally micaceous, olive-green shale containing thin interbeds of oolitic or pisolitic, blue-gray to dark-gray, silty or sandy limestone. Regionally, averages about 30 m in thickness, but in map area exposures range from a meter or so to about 50 m. Unit includes an undivided, displaced slab of stratigraphically older Howell Limestone. Slab lying along Blue Mountain thrust fault is about 30 m thick

Contact

High-angle fault—Dotted where concealed; bar and ball on downthrown side where displacement is certain

Thrust fault—Sawteeth on upper plate; dotted where concealed

Strike and dip of beds
Inclined
Horizontal

Strike and dip of compaction foliation
Inclined
Horizontal

GEOLOGY

Bedrock in the southern Pine Valley area comprises Oligocene and Miocene volcanic rocks overlying Paleozoic and Mesozoic sedimentary rocks that were folded and cut by three thrust faults during the Cretaceous Sevier orogeny. Chief among these faults is the regionally extensive Blue Mountain thrust, which brought Cambrian carbonate rocks over Jurassic and Triassic(?) Navajo Sandstone. Following the orogeny, extensive erosion reduced the landscape to low rolling hills before the inception of volcanism about 34 m.y. ago.

Basal Oligocene volcanic rocks belong to the Needles Range Group (Best and Grant, in press), which, in the map area, are from the base upwards rhyolite ash-flow tuffs and lava flows of The Escalante Desert Formation and crystal-rich, dacite ash-flow tuffs of the Cottonwood Wash Tuff, Wah Wah Springs Formation, and Lund Formation. The source of the Escalante Desert tuffs was the Pine Valley caldera, which encompasses the map area. Since the Oligocene, the source calderas (see fig. 1) of the Needles Range tuffs have experienced an estimated 40 percent east-west extension accompanying development of the Basin and Range tectonic province; this has caused their perimeters to be elongated. The Cottonwood Wash Tuff pinches out in the central part of the map area but is several hundred meters thick to the north and northwest in Nevada where its source is located.

Catastrophic eruption of about 2,000 km^3 of dacite magma 29.5 m.y. ago formed the outflow tuff member of the Wah Wah Springs Formation which covers an area of about 20,000 km^2 in western Utah and eastern Nevada. This eruption caused the collapse of the Indian Peak caldera. The eastern perimeter of the associated topographic depression probably lies within the map area (see fig. 1), but its exact location has been obscured by subsequent events and deposits. Roughly an equivalent volume of more lithic-rich tuffs of the intracaldera member of the Wah Wah Springs Formation partly filled the caldera to a depth of at least 2 km in the northern Indian Peak Range. However, only a hundred meters or so of the intracaldera member is exposed in the map area.

Several hundred meters of the crystal-rich dacitic tuff of the Lund Formation accumulated within the eastern part of the Indian Peak caldera after resurgent uplift had occurred. The source of this 27.9-m.y.-old tuff is the White Rock caldera, which lies west of the map area.

Ash-flow tuffs of the regionally extensive, 26.0-m.y.-old Oligocene Isom Formation cap the older Needles Range Group.

Earliest Miocene volcanic rocks include local hornblende andesite lava flows and a 22.3-m.y.-old regional ash-flow tuff, the Bauers Tuff Member of the Condor Canyon Formation. Subsequent volcanism at many local centers produced two more or less bimodal silicic-mafic associations (Best and others, in press). The older of these, the 23- to 18-m.y.-old Blawn Formation, comprises rhyolite lava flows, shallow intrusions, tuffs, and potassium-rich mafic lava flows of trachyandesite composition. The younger bimodal association, the 13- to 12-m.y.-old Steamboat Mountain Formation, in the map area consists of high-silica, high-alkali, topaz-bearing rhyolite lava flows and tuffs; however, contemporaneous basalt flows are exposed widely northeast and southwest of the map area.

Following emplacement of older units in the Blawn Formation the whole rock section was cut by high-angle faults having a predominant northeast strike. Chief among these faults are those in the Bible Spring fault zone, which extends from near the southwest corner of the map area to almost the northeast corner where the zone terminates against a major northwest-striking fault of about the same age. The latter fault runs from the west end of Blawn Mountain (Abbott and others, 1983) eastward into the Blue Mountain area (Weaver, 1980). Hydrothermally altered rocks are associated with these fault systems. Younger rhyolite tuffs and lava flows of the Blawn Formation, having an age of 18 m.y., unconformably overlie faulted and tilted older rocks at The Tetons. Rhyolite tuffs and an overlying thick pile of topaz rhyolite flows of the Steamboat Mountain Formation rest unconformably on tilted horsts and grabens of Oligocene volcanic rocks at Broken Ridge in the central segment of the Bible Spring fault zone. A geochemical anomaly (molybdenum, tin, bismuth, beryllium, niobium) in the rhyolites at Broken Ridge lies over the buried Bible Spring fault zone (Tucker and others, 1981). Highly silicified, alunitized, and faulted rhyolite tuffs and flows south of Typhoid Spring and north of Mountain Spring Peak probably overlie shallow intrusions of Steamboat Mountain age.

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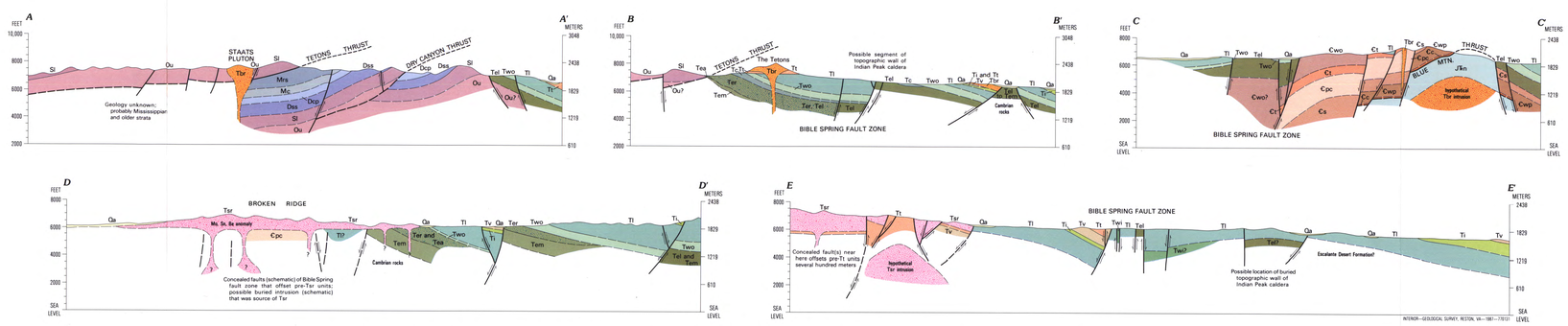
Figure 1.—Map showing location of caldera complexes and recently published geologic maps, Utah and Nevada.



GEOLOGIC MAP OF THE SOUTHERN PINE VALLEY AREA, BEAVER AND IRON COUNTIES, UTAH

By
M. G. Best, H. T. Morris, R. W. Kopf, and J. D. Keith

1987

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