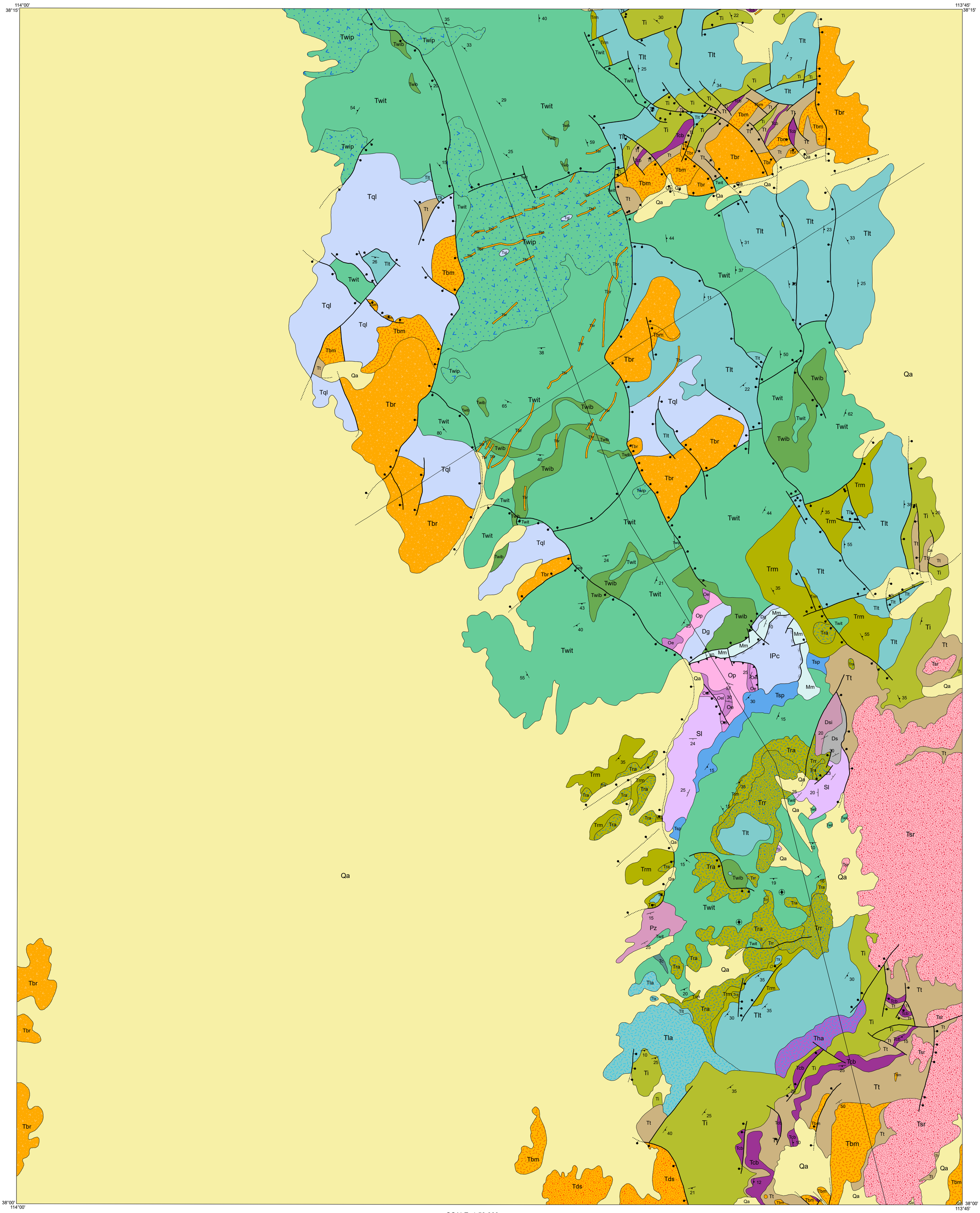


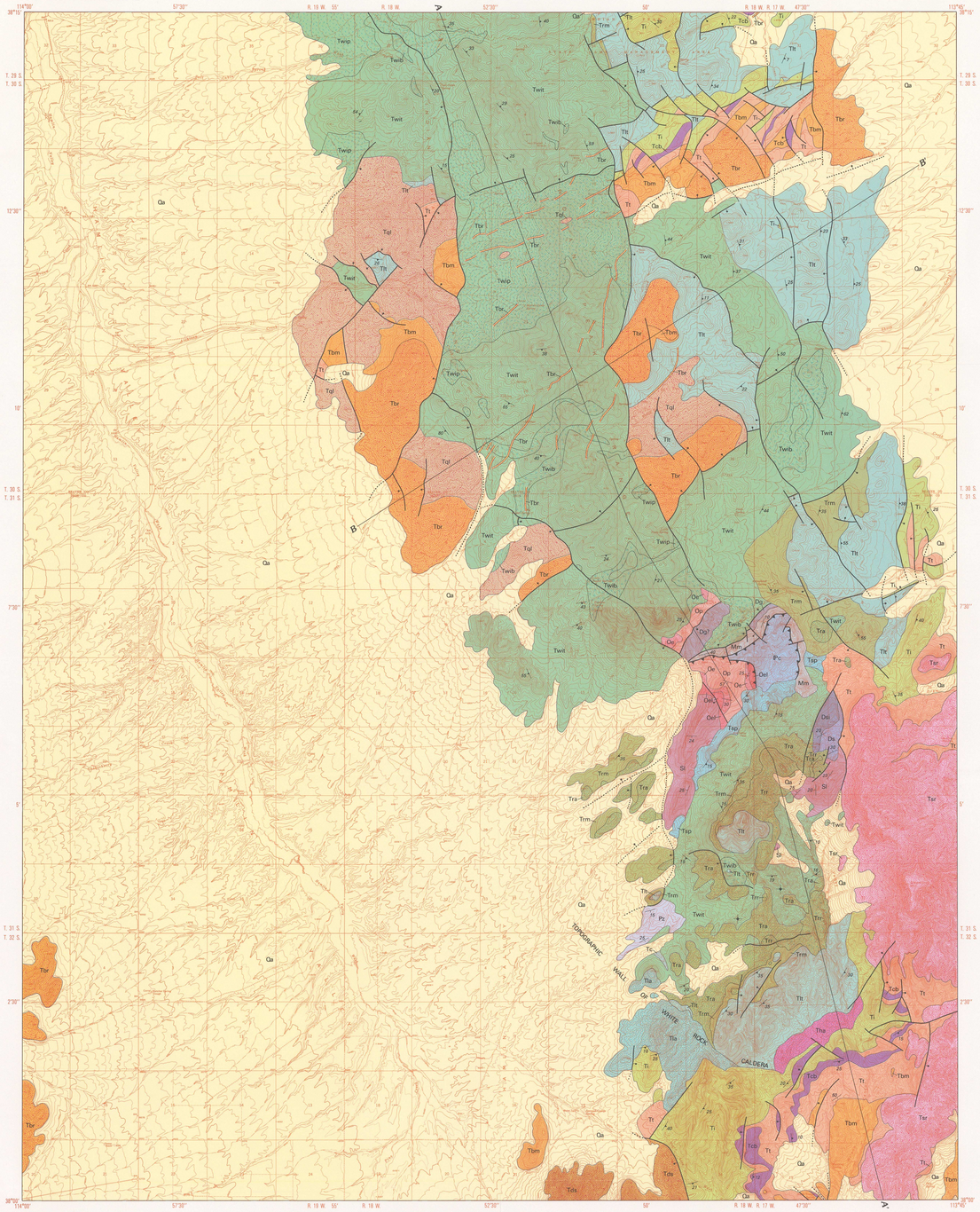
SCALE 1:50,000

1 0.5 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

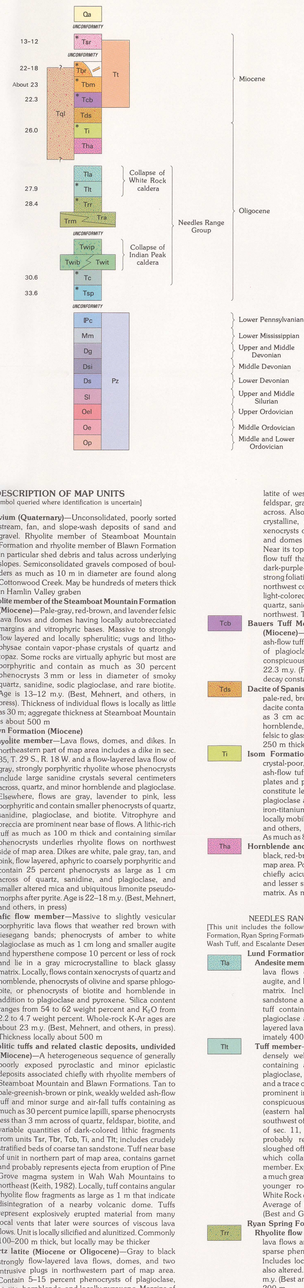
1 0.5 0 1 2 3 4 5 KILOMETERS

Utah Geological Survey Open-File Report 672DM
Geologic map of the Indian Peak (southern Needle) Range, Beaver and Iron Counties, Utah (GIS reproduction of USGS Map I-1795 [1987])
by
M.G. Best, S.K. Grant, L.F. Hintze, J.G. Cleary, A. Hutsinpiller and D.M. Saunders
2018



CORRELATION OF MAP UNITS

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



DESCRIPTION OF MAP UNITS

[Unit symbol queried where identification is uncertain]

Qa **Alluvium (Quaternary)**—Unconsolidated, poorly sorted stream, fan, and slope-wash deposits of sand and gravel. Rhyolite member of Steamboat Mountain Formation and rhyolite member of Blawn Formation in particular shed debris and talus across underlying slopes. Semiconsolidated gravels composed of boulders as much as 10 m in diameter are found along Cottonwood Creek. May be hundreds of meters thick in Hamlin Valley graben

Tsr **Rhyolite member of the Steamboat Mountain Formation (Miocene)**—Pale-gray, red-brown, and lavender felsic lava flows and domes having locally autobrecciated margins and vitrophyric bases. Massive to strongly flow layered and locally spherulitic; vugs and lithophysae contain vapor-phase crystals of quartz and topaz. Some rocks are virtually aphyric but most are porphyritic and contain as much as 30 percent phenocrysts 3 mm or less in diameter of smoky quartz, sanidine, sodic plagioclase, and rare biotite. Age is 13–12 m.y. (Best, Mehnert, and others, in press). Thickness of individual flows is locally as little as 30 m; aggregate thickness at Steamboat Mountain is about 500 m

Blawn Formation (Miocene)

Tbr **Rhyolite member**—Lava flows, domes, and dikes. In northeastern part of map area includes a dike in sec. 35, T. 29 S., R. 18 W. and a flow-layered lava flow of gray, strongly porphyritic rhyolite whose phenocrysts include large sanidine crystals several centimeters across, quartz, and minor hornblende and plagioclase. Elsewhere, flows are gray, lavender to pink, less porphyritic and contain smaller phenocrysts of quartz, sanidine, plagioclase, and biotite. Vitrophyre and breccia are prominent near base of flows. A lithic-rich tuff as much as 100 m thick and containing similar phenocrysts underlies rhyolite flows on northwest side of map area. Dikes are white, pale gray, tan, and pink, flow layered, aphyric to coarsely porphyritic and contain 25 percent phenocrysts as large as 1 cm across of quartz, sanidine, and plagioclase, and smaller altered mica and ubiquitous limonite pseudomorphs after pyrite. Age is 22–18 m.y. (Best, Mehnert, and others, in press)

Tbm **Mafic flow member**—Massive to slightly vesicular porphyritic lava flows that weather red brown with liesegang bands; phenocrysts of amber to white plagioclase as much as 1 cm long and smaller augite and hypersthene compose 10 percent or less of rock and lie in a gray microcrystalline to black glassy matrix. Locally, flows contain xenocrysts of quartz and hornblende, phenocrysts of olivine and sparse phlogopite, or phenocrysts of biotite and hornblende in addition to plagioclase and pyroxene. Silica content ranges from 54 to 62 weight percent and K_2O from 2.2 to 4.7 weight percent. Whole-rock K-Ar ages are about 23 m.y. (Best, Mehnert, and others, in press). Thickness locally about 500 m

Tt **Rhyolitic tuffs and related clastic deposits, undivided (Miocene)**—A heterogeneous sequence of generally poorly exposed pyroclastic and minor epiclastic deposits associated chiefly with rhyolite members of Steamboat Mountain and Blawn Formations. Tan to pale-greenish-brown or pink, weakly welded ash-flow tuff and minor surge and air-fall tuffs containing as much as 30 percent pumice lapilli, sparse phenocrysts less than 3 mm across of quartz, feldspar, biotite, and variable quantities of dark-colored lithic fragments from units Tsr, Tbr, Tcb, Ti, and Tlt; includes crudely stratified beds of coarse tan sandstone. Tuff near base of unit in northern part of map area, contains garnet and probably represents ejecta from eruption of Pine Grove magma system in Wah Wah Mountains to northwest (Keith, 1982). Locally, tuff contains angular rhyolite flow fragments as large as 1 m that indicate disintegration of a nearby volcanic dome. Tuffs represent explosively erupted material from many local vents that later were sources of viscous lava flows. Unit is locally silicified and alunitized. Commonly 100–200 m thick, but locally may be thicker

Tql **Quartz latite (Miocene or Oligocene)**—Gray to black strongly flow-layered lava flows, domes, and two intrusive plugs in northwestern part of map area. Contain 5–15 percent phenocrysts of plagioclase, biotite, hornblende, and locally pyroxene. Margins of eastern plug are brecciated and filled with light-greenish-gray quartz latite having larger and more abundant hornblende. Concentrated along its margin, latite of western plug contains fragments of quartz, feldspar, granite, and banded aplite as large as 2 m across. Also present in western plug is a holocrystalline, nearly aphanitic rhyodacite containing xenocrysts of quartz, and feldspar. Margins of flows and domes are of autobreccia or black vitrophyre. Near its top, unit includes purple-red to brown ash-flow tuff that resembles tuffs in Isom Formation. A dark-purple-red to brown, finer grained flow with strong foliation and sparse quartz xenocrysts occurs in northwest corner of sec. 17, R. 18 W., T. 30 S., and a light-colored ash-flow tuff containing 5–10 percent quartz, sanidine, and biotite lies about 3 km farther northwest. Thickness of entire unit is at least 500 m

Tcb **Bauers Tuff Member of Condor Canyon Formation (Miocene)**—Buff, pink, and lavender, densely welded ash-flow tuff containing about 10 percent phenocrysts of plagioclase, sanidine, and biotite and locally conspicuous light-colored pumice lapilli. K-Ar age is 22.3 m.y. (Fleck and others, 1975; adjusted to new decay constants). Thickness ranges from 20 to 120 m

Tds **Dacite of Spanish George Spring (Miocene)**—Variegated pale-red, brown, gray to purple, strongly porphyritic dacite containing phenocrysts of plagioclase as much as 3 cm across and minor smaller quartz, biotite, hornblende, sanidine, and augite in a microcrystalline felsic to glassy matrix; occurs as lava dome more than 250 m thick along south margin of map area

Ti **Isom Formation (Oligocene)**—Red-brown to purple, crystal-poor, densely welded but somewhat vuggy ash-flow tuffs and lava flows that weather to small plates and popcorn-like grus. Phenocrysts generally constitute less than 15 percent of rock and include plagioclase and minor, much smaller pyroxenes and iron-titanium oxides. Some or all lava flows may be locally mobilized ash-flow tuff. Age is 26.0 m.y. (Fleck and others, 1975; adjusted to new decay constants). As much as 800 m thick just north of Negro Liza Wash

Tha **Hornblende andesite lava flows (Oligocene)**—Gray to black, red-brown weathering flows in southern part of map area. Porphyritic; contain 25 percent phenocrysts, chiefly acicular hornblende and zoned plagioclase and lesser small pyroxene grains in locally vesicular matrix. As much as 250 m thick

NEEDLES RANGE GROUP (OLIGOCENE)

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

Lund Formation

Tla **Andesite member**—Gray, tan, or red-brown nonvesicular lava flows containing phenocrysts of plagioclase, augite, and hypersthene in microcrystalline to glassy matrix. Includes local lenses of tan, well-sorted sandstone and, locally near top, red-brown ash-flow tuff containing about 30 percent phenocrysts of plagioclase and augite and minor, red-brown, flow-layered lava of about the same composition. Approximately 400 m thick

Tlt **Tuff member**—Pink-gray to red-brown, moderately to densely welded, crystal-rich, dacitic ash-flow tuff containing about 10 percent quartz, 25 percent plagioclase, 10 percent biotite, lesser hornblende, and a trace of sphene. Light-colored pumice lapilli are prominent in most outcrops but lithic fragments are conspicuous only locally. Propylitically altered on hill (eastern half sec. 25, T. 31 S., R. 18 W.) 2 km southwest of Bob Leroy Peaks. Thin lens in NE corner of sec. 11, T. 32 S., R. 18 W., is brecciated and probably represents remnant of landslide mass sloughed off topographic wall of White Rock caldera, which collapsed as a result of extrusion of tuff member. Exposed thickness is as much as 550 m, but a much greater thickness probably lies buried beneath younger rocks within topographic depression of White Rock caldera along southern edge of map area. Average of three K-Ar ages on biotite is 27.9 m.y. (Best and Grant, in press)

Ryan Spring Formation

Trr **Rhyolite flow member**—Variably altered flow-layered lava flows and intrusive-extrusive domes containing sparse phenocrysts of feldspar, biotite, and quartz. Includes local silicic volcaniclastic rocks, which are also altered. Fission-track age on zircon is 28.4±1.2 m.y. (Best and Grant, in press). Thickness as much as 200 m

Tra **Andesite flow member**—Gray to black, reddish-brown weathering, nonvesicular lava flows containing phenocrysts of plagioclase, augite, hypersthene, and locally hornblende. Well-sorted, olive-brown sandstone occurs locally west of Bob Leroy Spring. As much as 150 m thick

Trm **Mackleprang Tuff Member**—Variegated, light-gray, pink to lavender, moderately welded, rhyolitic ash-flow tuffs. Phenocrysts of plagioclase and minor biotite as much as 2 mm across constitute 20 percent or less of rock. Lapilli of dark-colored pumice and aphanitic volcanic rock are locally conspicuous. East of New Arrowhead mine, tuffs are possibly as much as 500 m thick and are overlain by sandstone comprised of grains of plagioclase and quartz and glassy rock fragments. Thins to as little as 50 m and locally pinches out entirely over block-faulted resurgent dome of Indian Peak caldera

Wah Wah Springs Formation—Only intracaldera member is exposed in map area. 29.5 m.y.-old (average of 16 K-Ar ages in Best and Grant, in press) outflow tuff member, which initiated caldera collapse, is not found within map area

Intracaldera member—Slightly to intensely altered, intrusive granodiorite porphyry (Twip), lithic dacite ash-flow tuff (Twit), breccia (Twib), and minor rhyolite and andesite lava flows (not distinguished and included in Twit). In northern part of map area member is propylitically altered to massive gray, green, or brown rock. Around Bob LeRoy Peaks and to south, tuff has been argillized and is purple, orange, brown, or white. Exposed thickness of entire member north of Arrowhead Pass is uncertain because of possible faults but is at least 2 km, whereas to south it ranges from 1 km to 30 m

Twit **Dacite ash-flow tuff**—Phenocrysts of plagioclase and lesser hornblende and biotite and minor quartz constitute about 40 percent of densely welded tuff. Lapilli and blocks of dark-colored pumice, volcanic rocks, and uncommon sedimentary rock constitute as much as 20 percent of tuff

Twib **Breccia**—Landslide and talus deposits sloughed off nearby unstable wall of caldera. Clast components change from north to south. In north, clasts of Cottonwood Wash Tuff are predominant. In central area, clasts include gray to pink, flow-foliated rhyolite containing 5–10 percent phenocrysts of plagioclase, biotite, and hornblende, slate-gray to dark-brown andesite, and dark-gray porphyry containing 30–40 percent phenocrysts of plagioclase and pyroxene. In south, clasts are chiefly of Sawtooth Peak Formation. Between Arrowhead Pass and New Arrowhead mine, a brecciated landslide mass of units Dg(?), Oe, and Op overlies intracaldera tuff. About 3 km south of Bob Leroy Peaks clasts include Precambrian metamorphic rocks

Twip **Porphyry**—Olive-gray granodiorite porphyry has phenocrysts that are somewhat less abundant, show better crystal outlines, and are larger (as much as 8 mm) than in compositionally similar associated tuff. Large central intrusive body exposed west of Cougar Spar mine has more, less well formed crystals than the peripheral bodies, in which the phenocrysts are nearly euhedral (Grant, 1979). Xenoliths of fine-grained granodiorite and much larger, but less abundant fragments of quartzite are distributed throughout porphyry

Tc **Cottonwood Wash Tuff**—Red-brown, densely welded lapilli ash-flow tuff. Abundant phenocrysts of plagioclase and biotite (as much as 6 mm in diameter) and lesser quartz, inconspicuous hornblende, and augite. Only a few meters thick. K-Ar age is 30.6 m.y. (Best and Grant, in press)

Tsp **Sawtooth Peak Formation (Oligocene)**—Gray to pale-lavender, moderately welded, lapilli ash-flow tuff. Phenocrysts are as much as 5 mm in diameter and are chiefly quartz (20 percent) and lesser plagioclase, biotite, and hornblende. As much as 200 m thick. Average age is 33.6 m.y. (Best and Grant, in press)

ꟾc **Callville Limestone (Lower Pennsylvanian)**—An incomplete section exposed south of Skougard mine between Jackson Wash and Bob Leroy Peaks consists of about 270 m of tan to red-brown, fine-grained sandstone and calcareous sandstone interbedded with layers of medium-gray, fine-grained, medium-bedded, cherty limestone. Section is bounded on both upper and lower contacts by subhorizontal faults. Sandberg and Poole (1977) and Sandberg and Gutschick (1984) included these rocks in their Needle Siltstone Member of the Chainman Shale

Mm **Monte Cristo Limestone (Lower Mississippian)**—As much as 170 m of lower part of section is exposed in and below subhorizontal fault south of Skougard mine. Upper 2–30 m are chert-rich dolomite; dark-gray to black chert ribbons several centimeters thick constitute as much as 80 percent of rock. Chert-rich zone has been brecciated and silicified along subhorizontal fault, which is contact with overlying Callville Limestone. Below chert is about 60 m of medium- to dark-gray, medium-grained, fossiliferous dolomite; upper part is coarse-grained and black and white striped (zebra textured). Base of unit is gray limestone containing horn corals and abundant crinoid stems. Sandberg and Poole (1977) and Sandberg and Gutschick (1984) included these rocks in their Joana Limestone

Dg **Guilmette Formation (Upper and Middle Devonian)**—About 100 m of Devonian rocks are exposed southwest of Skougard mine and conformably underlie Mississippian section. Upper 10 m is light-gray, thick-bedded, fine-grained, unfossiliferous dolomite underlain by a tan quartzite bed less than 1 m thick. Base is dark-gray, coarse-grained dolomite containing corals and stromatoporoids. North of Arrowhead Pass, unfossiliferous sequence of brecciated and bleached dolomite and interbedded limestone in intracaldera landslide mass is tentatively correlated with Guilmette Formation

Dsi **Simonson Dolomite (Middle Devonian)**—Alternating dark- and medium-gray, laminated, coarse-grained dolomite containing local abundant *Amphipora*. 50 m thick

Ds **Sevy Dolomite (Lower Devonian)**—Light-gray, fine-grained, medium-bedded dolomite. 110 m thick

Sl **Laketown Dolomite (Upper and Middle Silurian)**—Fine- to medium-grained, ledge- and cliff-forming dolomite, somewhat brecciated and light gray in lower half of unit and light gray with darker gray interbeds in upper half. Contains sparse chert nodules and stringers. At least 200 m thick

Oel **Ely Springs Dolomite (Upper Ordovician)**—Brecciated, medium-grained, brown-gray dolomite. More poorly exposed than overlying Laketown Dolomite. Upper part is somewhat fossiliferous and cherty. About 150 m thick

Oe **Eureka Quartzite (Middle Ordovician)**—Thick beds of tan to light-gray, medium- to fine-grained orthoquartzite that weathers orange brown to white. Commonly pock marked by weathering and limonite stained. Maximum thickness is about 30 m, although northwest of Arrowhead Pass quartzite is over 200 m due to folding. Southeast of Arrowhead Pass, includes about 50 m of medium- to dark-gray, medium-grained Crystal Peak Dolomite at base

Op **Pogonip Group, undivided (Middle and Lower Ordovician)**—North of Arrowhead Pass, unit is in intracaldera landslide mass and includes Lehman Formation and Kanosh Shale. Lehman Formation (Middle Ordovician) is light-gray, very fine grained limestone about 25 m thick. Kanosh Shale (Middle Ordovician) is thin-bedded, fossiliferous, silty limestone interbedded with phyllitic, dark-brown to olive shale and dark-weathering, gray quartzites. Section is faulted and folded, and thickness varies from 80 to 200 m. South of Arrowhead Pass, unit is made up of Fillmore Formation (Lower Ordovician), thin interbeds of gray, fossiliferous limestone and poorly exposed, slope-forming, yellow-gray shale. Limestone contains layers of intraformational conglomerate of flat pebbles of sandy limestone in finer, sandy, calcareous matrix. Only upper 300 m is exposed

Pz **Paleozoic rocks, undivided**—Mostly intensely silicified; only minor unaltered and unfossiliferous gray limestone

Contact—Dashed where approximately located or inferred on cross sections

High-angle fault—Dotted where concealed. Ball and bar on downthrown side

Low-angle fault—Sawteeth on upper plate

Strike and dip of beds
67 **Inclined**
26 **Overturned**

Strike and dip of compaction foliation in tuffs
62 **Inclined**
Horizontal

GEOLOGY

Rocks exposed in the Indian Peak Range include an incomplete and complexly deformed section of Ordovician through Pennsylvanian sedimentary rocks together with more extensive Oligocene and Miocene volcanic rocks.

Paleozoic rocks can be divided into three distinct stratigraphic and structural assemblages. (1) East of Bob Leroy Spring, Devonian and Silurian dolomites dip uniformly to the northwest. (2) West of Bob Leroy Spring and southeast of Jackson Wash, Paleozoic rocks dip moderately to the south and are complexly faulted and folded. Near the Skougard mine, an arcuate-shaped breccia zone defines a low-angle alteration fault that has juxtaposed Pennsylvanian strata over Lower Mississippian and Devonian carbonates. Farther to the south, a low-angle thrust fault has placed overturned Silurian and Ordovician beds upon Pennsylvanian and Mississippian rocks. (3) Northwest of Jackson Wash, a folded and faulted section of Middle and Lower Ordovician and Devonian(?) rocks forms an intracaldera landslide mass that is underlain by the intracaldera member of the Wah Wah Springs Formation.

Folding and low-angle faulting in the Paleozoic rocks are likely related to the Cretaceous Sevier orogeny.

Following a long period of erosion after this episode of deformation, intermediate composition calc-alkalic volcanism began about 33.6 m.y. ago as ash-flow tuff of the Sawtooth Peak Formation was erupted. During the next 6 m.y. ash-flow tuffs and local lava flows of two compositional cycles comprising the Needles Range Group were deposited over an area of about 20,000 km^2 in southwestern Utah and adjacent Nevada (Best and Grant, in press). The sources of these tuffs that altogether comprise a volume of at least 7,000 km^3 lay partly within the map area (fig. 1). Each cycle began with eruption of relatively crystal-poor, lithic-rich, rhyolite tuffs and was succeeded by eruption of more voluminous crystal-rich dacite tuffs. Pyroxene-andesite lava flows were extruded more or less concurrently with the rhyolites of both cycles. The oldest rhyolite tuff in the Needles Range Group is not exposed in the map area.

Dacite tuff of the 30.6-m.y.-old Cottonwood Wash Tuff is exposed only locally in the southern part of the map area at the distal end of the sheet whose source apparently lay some 40 km to the northwest. Eruption 29.5 m.y. ago of about 2,000 km^3 of dacite tuff of the Wah Wah Springs Formation caused collapse of the Indian Peak caldera, which apparently completely encompasses the map area. None of this early outflow tuff member is exposed in the map area but the somewhat younger intracaldera member made up of intercalated lithic tuff and landslide breccia together with an intrusive granodiorite porphyry of the same composition as the tuff is as much as 2 km thick in places. Brecciated Paleozoic rocks immediately north of Arrowhead Pass constitute a landslide wedge that fell into the caldera during its subsidence and extrusion of the intracaldera tuff. Paleozoic rocks and precaldera tuff of the Sawtooth Peak Formation south of Arrowhead Pass are the basement rocks of the caldera; the basement has been exposed by significant post-collapse uplift, probably in part during resurgence and in part during local magmatic activity about 28.4 m.y. ago that produced the extrusions of rhyolite and andesite lavas in the Ryan Spring Formation. Rhyolite tuff of this formation, as well as dacite tuff of the 27.9-m.y.-old Lund Formation, vary significantly in thickness in the map area because of deposition on the block-faulted resurgent floor of the Indian Peak caldera.

A segment of the topographic wall of the White Rock caldera, which was the source of the Lund Formation, the youngest unit in the Needles Range Group, is marked in the southern part of the map area by an unusually thick section of the 26-m.y.-old Isom Formation that butts along strike against older rocks.

The source of ash-flow tuffs in the Isom Formation must be nearby, to the south of the map area, due to the unusually large size of the pumice blocks in the tuff and its lava-like aspect in many places (see Rowley and others, 1979).

As much as 2.5 km of earliest Miocene intermediate composition lava flows accumulated to the southwest of the map area (Best and Mehnert, in press), but only the oldest of this sequence, the dacite of Spanish George Spring, is found along the south margin of the map area. South of the map area, this unit rests directly on Isom Formation.

During the Miocene the style of magmatism shifted to more or less bimodal mafic-silicic associations without caldera formation. The oldest of these associations is the early Miocene Blawn Formation which comprises 23- to 18-m.y.-old rhyolite tuffs, lava flows, domes, and swarms of northeast-striking feeder dikes together with mafic lava flows. Northeast-striking normal faulting during Blawn time produced southeastward tilted horsts and grabens in the southern part of the map area. This early Miocene deformation is clearer in the Southern Pine Valley map area to the east (Best, Morris, and others, in press).

After a hiatus of about 5 m.y., bimodal magmatism resumed and produced the 13- to 12-m.y.-old mid-Miocene Steamboat Mountain Formation. This bimodal association includes high-silica, high-alkali, topaz-bearing rhyolite flows and minor tuffs, which unconformably overlie older rocks tilted and faulted during early Miocene block faulting. Contemporaneous basaltic lava flows are not exposed in the map area, but extensive sequences occur on the east flank of the Wah Wah Mountains 50 km to the northeast (Abbott and others, 1983).

The northern half of the map area is cut by many north-northwest striking normal faults, including a major but concealed fault bounding the east side of the Hamlin Valley graben. This system of faults created a central horst block within the range in which are exposed early Miocene rhyolite dike swarms; dotting the flanking grabens are contemporaneous extrusive rhyolite flow domes that must have been fed from the same dike system.

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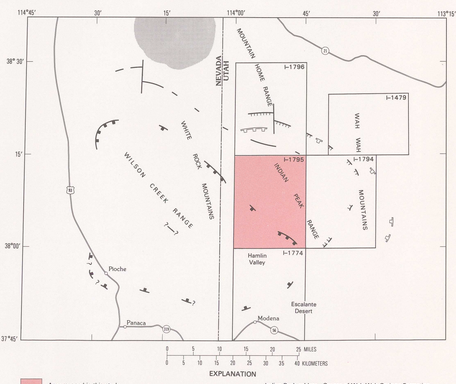
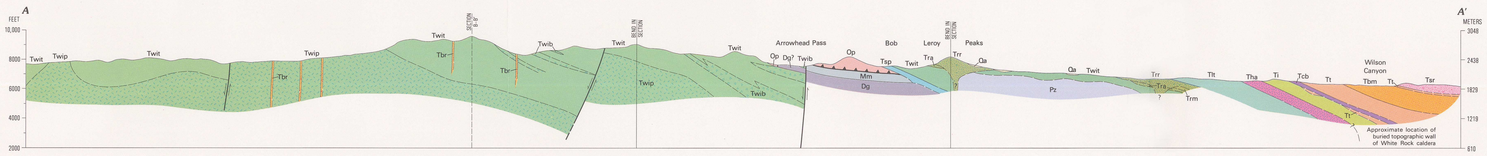
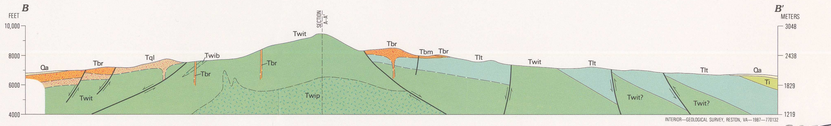


Figure 1.—Map showing location of caldera complexes and recently published geologic maps, Utah and Nevada.





GEOLOGIC MAP OF THE INDIAN PEAK (SOUTHERN NEEDLE) RANGE, BEAVER AND IRON COUNTIES, UTAH

By
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