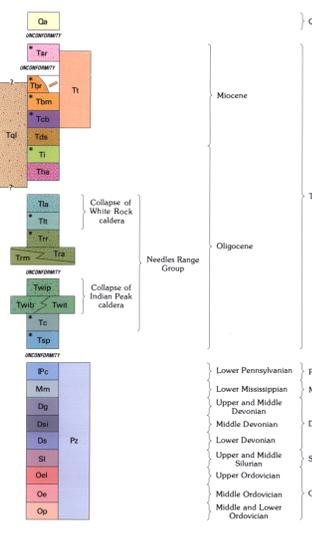


CORRELATION OF MAP UNITS

(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. Rhylite member of Steamboat Mountain Formation and rhyolite member of Blawn Formation in particular debris and talus under underlying slope-emplaced breccia 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.
- Trm Rhyolite member of the Steamboat Mountain Formation (Miocene)**—Pale gray, red-brown, and lavender felsic lava flows and domes having locally auto-brecciated margins and vitrophytic bases. Massive to strongly flow layered and locally spherulitic, vugs and lithophyses contain vapor-phase crystals of quartz and topaz. Some rocks are virtually aphyre 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 3 m; aggregate thickness of Steamboat Mountain is about 500 m.
- Twf Blawn Formation (Miocene)**
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 low-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. Vitrophytic 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 northwestern side of map area. Dikes are white, pale gray, tan, and pink, flow layered, aphyre 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).
- Tbn Mafic flow member**—Massive to slightly vesicular porphyritic lava flows that weather red brown with leucogran 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 plagioclase, or phenocrysts of biotite and hornblende in addition to plagioclase and pyroxene. Silica content ranges from 54 to 62 weight percent and K₂O 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 Tr, Tcb, Tt, and Tw. 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 northeast (Keith, 1982). Locally, tuff contains angular rhyolite flow fragments as large as 1 m that indicate distintegration 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 aluminated. 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.

NEEDLES RANGE GROUP (OLIGOCENE)

- 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 minor plagioclase, biotite, and hornblende. As much as 200 m thick. Average age is 33.6 m.y. (Best and Grant, in press).
- Pc Callville Limestone (Lower Pennsylvanian)**—An incomplete section of Devonian rocks consisting of 270 m of tan to red-brown, fine-grained, medium-bedded, cherty limestone. Section is bounded on both upper and lower contacts by subhorizontal sandstone, Sandberg and Poole (1977) and Sandberg and Gutcheck (1984) included these rocks in their Needles Range Member of the Chinle Sandstone.
- Mn Monte Cristo Limestone (Lower Mississippian)**—As much as 17 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 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 Gutcheck (1984) included these rocks in their Joana Limestone.
- Dy Gulmette 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 Gulmette Formation.
- Dlr Simmon Dolomite (Middle Devonian)**—Alternating dark and medium-gray, laminated, coarse-grained dolomite containing local abundant Amphipora. 50 m thick.
- Dh 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 quartzite that weathers orange brown to white. Commonly rock marked by weathering and limonite staining. Maximum thickness is about 30 m, includes northwest of Arrowhead Pass quartzite over 200 m due to folding. Southeast of Arrowhead Pass, about 50 m of medium- to dark-gray, medium-grained Crystal Peak Dolomite at base.
- Op Pogojo Group, undivided (Middle and Lower Ordovician)**—North of Arrowhead Pass, unit is intracaldera landslide mass and includes Lehman Formation and

locally well-sorted, olive-brown sandstone occurs locally west of Bob Leroy Springs. As much as 150 m thick.

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 aphyre 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. This is 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 (Twi), breccia (Twb), and minor rhyolite and andesite lava flows (not distinguished and included in Twf). In northern part of map area member is progressively altered to massive gray, green, or brown rock. Around Bob Leroy Peaks and to south, tuff has been agglutinated and 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.

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.

Breccia—Landslide and talus deposits sloughed off nearby unstable wall of caldera. Glast components change from north to south. In north, clasts of Cottonwood Wash Tuff are predominant. In central area, clasts include gray to pink flows of Sawtooth Peak Formation, and in south, clasts of Cottonwood Wash Tuff, 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.

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 peripheral bodies, in which the phenocrysts are nearly subhedral (Grant, 1979). Xenoliths of fine-grained granodiorite and much larger, but less abundant fragments of quartzite are distributed throughout porphyry.

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- 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**—Sawtooth on upper plate.
- Strike and dip of beds**
- Overturned**
- Strike and dip of compaction foliation in tuffs**
- 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 divided into three distinct stratigraphic and structural assemblages. (1) East of Bob Leroy Springs, Devonian and Silurian dolomites dip uniformly to the northwest. (2) West of Bob Leroy Springs and southeast of Jackson Wash, Paleozoic rocks dip moderately to the south and are completely faulted and folded. Near the Skougard mine, an arcuate-shaped breccia zone defines a low-angle attenuation fault that has juxtaposed Pennsylvanian strata over Lower Mississippian and Devonian carbonates. Farther to the south, a low-angle 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 km² 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 km³ 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 rhyolite 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 km³ 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 its 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 development by significant post-collapse uplift, probably in part during reemergence 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.

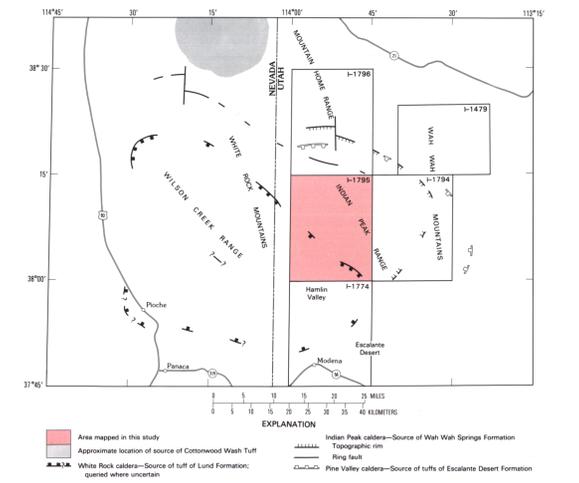


Figure 1.—Map showing location of caldera complexes and recently published geologic maps, Utah and Nevada.

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

By
M. G. Best, S. K. Grant, L. F. Hintze, J. G. Cleary, A. Hutsinpillar,
and D. M. Saunders
1987