USGS-OF 91-124

DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE PANACA SUMMIT AND PROHIBITION FLAT QUADRANGLES, LINCOLN COUNTY, NEVADA, AND IRON COUNTY, UTAH

by

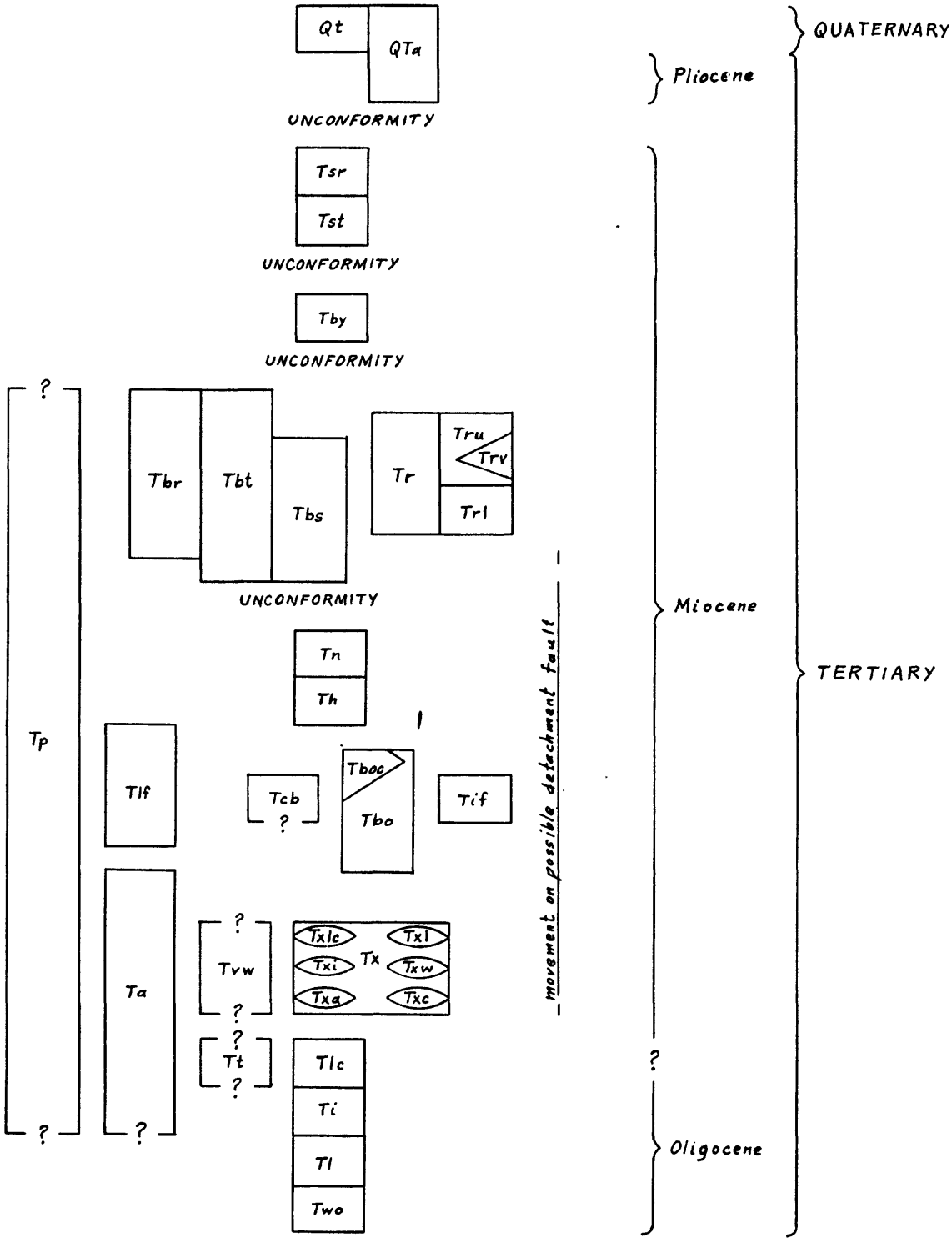
Myron G. Best, Douglas S. Miller, Lyle E. Radke,
and Bart J. Kowallis

Brigham Young University

OPEN-FILE REPORT 91-124

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

CORRELATION OF MAP UNITS



INTRODUCTION

The Panaca Summit-Prohibition Flat map area is underlain by uppermost Oligocene and lower Miocene stratigraphic units that are tilted eastward and repeated across west-dipping normal faults. Flat-lying middle Miocene rhyolite tuffs and lava flows of the Steamboat Mountain Formation locally cap these tilted older units. The same style of faulted and tilted units extends eastward to the Escalante Desert (Best, 1987) and westward through Condor Canyon in the adjacent 7 1/2-minute quadrangle to the west (G.J. Axen, Harvard University, written commun., 1989). These relations indicate that the map area and areas immediately to the east and west have been significantly extended, possibly as part of the hanging wall of a regionally west-dipping, low-angle normal, or detachment, fault. The subsurface position of this possible detachment is uncertain, but it may be no more than a few hundred meters below the structural chaos in the center of the map area.

Compared to the well-known sequence of regional outflow tuff deposits and the minor locally derived lavas exposed just to the west in Condor Canyon (e.g., Cook, 1965; Williams, 1967) , the Tertiary sequence in the map area contains additional thick ash-flow tuff, lava flow, landslide, and sedimentary deposits; moreover, the central part of the map area is underlain by a structural chaos of local lava flows and regional ash-flow tuffs. These additional volcanic, sedimentary, and chaos units indicate the existence during the early Miocene of a local topographic

basin, or basins, probably fault-bounded, in the hanging wall above the possible detachment that did not exist to the west or east.

Initial movement on the possible detachment may have occurred as early as about the time of deposition of the Swett Tuff Member of the Condor Canyon Formation--approximately 23 Ma--because that part of the volcanic section in the map area is occupied by a tuff resembling the Swett as well as by an anomalous sequence of thin lava flows and sandstones both older and younger than the Swett that are not found in adjoining areas. Major movement must have occurred about the time of deposition of the younger Bauers Tuff Member of the Condor Canyon Formation at 22.78 Ma because latitic lava flows (unit Tlf), with which the Bauers is intercalated, overlie widespread coarse landslide breccias composed of clasts of older volcanic units. Yet, locally, both tuff members of the Condor Canyon Formation are a major component of the landslide breccias. The Harmony Hills Tuff deposited after the Bauers Member but before 21.7, Ma is not a part of the breccia. Later movement on the possible detachment, apparently resulting in a basin in the hanging wall, occurred after deposition of the Harmony Hills, because it and overlying lava flows are covered by a thick sequence of sedimentary and volcanic debris-flow deposits and a local rhyolitic tuff. The Oligocene and lower Miocene stratigraphic section is tilted and cut by faults; however, the unconformably overlying middle Miocene Steamboat Mountain Formation deposited 12-10 Ma is

undeformed.

Early to middle Miocene detachment faulting has been documented in areas to the west and south. For example, the Highland detachment about 35 km west of the map area apparently was initiated after deposition of lowermost Miocene tuffs and was active at and after 15 Ma (Taylor and others, 1989).

High-angle, west-northwest-striking faults in the southwest corner of the map area may be tear faults associated with extensional motion in the possible detachment system. A major north-striking normal fault cuts these tear faults and is probably part of a younger system of faults that formed the eastern boundary of the Panaca basin into which the upper Miocene to Pliocene Panaca Formation was deposited (Rowley and Shroba, in press).

DESCRIPTION OF MAP UNITS

Qt **Talus and colluvium (Quaternary)**--Chiefly fragments of rhyolite on hill slopes below rhyolite lava flows (units Tsr and Tbr). Locally conceals weakly consolidated, slope-forming rhyolite tuff (Tst and Tbt). Minor deposits not shown. Maximum thickness probably no more than a few meters

QTa **Alluvium (Quaternary and Pliocene)**--Unconsolidated and poorly consolidated alluvial-fan, fluvial, and minor colluvial deposits composed of silt, sand, and gravel. Probably includes some pediment deposits. In the eastern part of map area includes erosional remnants at least 60 m thick of Pliocene alluvial-fan deposits that formed adjacent to highlands to the east, north, and west underlain by rhyolite flow members of the Steamboat Mountain Formation (Tsr) and Blawn Formation (Tbr). In western part of map area locally includes minor talus deposits

Steamboat Mountain Formation (Miocene)--High-silica rhyolite tuff and lava flows that are associated with potassic mafic lava flows east and northeast of the map area and have isotopic ages of between 13 and 10 Ma (Best, 1987; Best, Morris, and others, 1987; Best, Mehnert, and others, 1987). Deposits are mostly flat-lying and unfaulted and unconformably overlie tilted older units

Tsr **Rhyolite flow member**--Pale-pinkish- to lavender-gray lava

flows and volcanic domes. Chiefly felsic, flow-layered, and aphyric to weakly porphyritic, locally spherulitic, vuggy, and lithophysal. Margins of flows and domes are auto-brecciated, vitrophyric, and pumiceous. Small sparse phenocrysts consist of quartz, sanidine, plagioclase, and rare biotite. Unit locally includes small amounts of poorly exposed tuff. Lower contact generally obscured by talus (Qt). Fission-track age on zircon from sample collected north of Prohibition Spring at 37° 50′ 49″ N. Lat. and 114° 5′ 5″ W. Long. is 11.7 ± 1.0 Ma. Thickness as much as 250 m

Tst **Rhyolite tuff member**--Sequence of generally poorly exposed, locally bedded, porous, pale-greenish- and yellow-gray, tan, and white volcaniclastic deposits. Contains the same sparse, small phenocrysts as in the rhyolite flow member (Tsr); pumice lapilli common in ash-flow deposits and dark volcanic lithic lapilli and blocks are widespread and locally abundant throughout unit. Locally includes beds of sandstone such as just north of Prohibition Spring where beds are about 30 m thick. Thickness of unit at least 120 m in places

Tby **Younger breccia (Miocene)**--Resistant volcanic mudflow breccia consisting of angular to subangular, cobble- to boulder-size clasts of tuffs of the Lund and Wah Wah Springs Formations, as well as pyroxene andesite (unit Ta), in a reddish-brown sandy matrix. Occurs as an

isolated outcrop capping a hill in the north-central part of map area. About 50 m thick

Tp **Porphyritic intrusions (Miocene)**--Small masses of porphyritic rocks apparently emplaced as shallow intrusions. Two bodies located just south of Rose Valley Reservoir on east side of map area and 1.5 km west of Panaca Summit contain phenocrysts of sanidine, as large as 3 cm, quartz, plagioclase, and subordinate biotite in an aphanitic matrix. These two bodies resemble the porphyry of Meadow Valley Wash exposed in several small intrusions north of Caliente, Nevada, about 30 km to southwest that are about 19.4 Ma (Rowley and others, in press; Rowley and Shroba, in press). Another mass 2.5 km northeast of Panaca Summit is petrographically similar to the latite lava flows (Tlf). An apparent dike that intruded along a fault located 2.5 km southeast of Panaca Summit along southern margin of map area contains phenocrysts of plagioclase and lesser amounts of biotite, hornblende, and pyroxene in a gray aphanitic matrix.

Blawn Formation (Miocene)--Sedimentary rocks and high-silica rhyolite tuff and lava flows that in areas to east and northeast of map area (Best, 1987; Best, Mehnert, and others, 1987) are associated with potassic mafic lava flows and have isotopic ages ranging between 24 and 18 Ma. Deposits in map area resemble those of the younger

Steamboat Mountain Formation but differ in being faulted and tilted. Age of rhyolite lava flows and tuffs in northwest corner of map area and shown as Blawn Formation is uncertain; they could be Steamboat Mountain Formation

Tbr **Rhyolite flow member**--Unit resembles rhyolite flow member of Steamboat Mountain Formation (Tsr). Fission-track age on zircon from sample collected just north of Gleason Canyon Wash at 37° 50′ 43″ N. Lat. and 114° 8′ 43″ W. Long. is 16.5 ± 1.4 Ma. Thickness as much as 60 m

Tbt **Rhyolite tuff member**--Unit resembles rhyolite tuff member of Steamboat Mountain Formation (Tst). Hydrothermally altered north of Charcoal Kilns

Tbs **Sedimentary member**--Fluvial-lacustrine sequence of coarse volcanic debris flows and beds of conglomerate, sandstone, siltstone, chert, and limestone. Locally cross bedded. Debris-flow deposits poorly sorted, generally angular clasts of intermediate-composition volcanic rock. Debris-flow deposits (clasts as long as 0.5 m) occur in northern part of map area, where they are typically expressed as slopes covered by volcanic rubble. Sandstone and finer debris-flow deposits, locally hydrothermally altered, are common just north of Charcoal Kilns. Siltstone, limestone, and local chert are most common just north of Highway 25. On either side of the highway, directly overlying lava

flows of Ninemile Rocks (Tn), the unit consists of poorly sorted green sandstone containing hydrothermally altered clasts of the lava flows. Thickness as much as 600 m

Tr **Racer Canyon Tuff, undivided (Miocene)**--Multiple ash-flow cooling unit of rhyolite tuff that is about 19 Ma (Rowley and others, 1979; Siders and others, 1989). Relation to compositionally similar Hiko Tuff (Cook, 1965) of about the same age is problematic (Rowley and others, in press; Rowley and Shroba, in press) and will have to be resolved by means of precise age determinations and paleomagnetic data. Preliminary sampling by C.S. Gromme' (written commun., 1990) indicate that three of four cooling units within the unit mapped as Racer Canyon west of Panaca Summit have the same reverse polarity magnetic direction as the Hiko that is widespread farther west in Nevada. Tuff mapped as Racer Canyon undivided (Tr) at Devils Gap just south of the map area as well as part of the basal tuff (Trl) west of Panaca Summit both have normal polarities but their directions are not the same.

Tru **Upper member**--Tan, pale pinkish- to orangish-gray, and white, poorly to densely welded tuff. Pumice lapilli generally flattened, even in poorly welded tuff. Contains sparse lapilli of dark volcanic rock. Phenocrysts make up as much as 40 percent of rock and

consist of abundant quartz and sanidine, lesser plagioclase, and a percent or less of biotite; sphene is present in variable but trace quantities. Multiple cooling units are locally separated by beds of white to pink sandstone as much as 40 m thick. Black to dark-brown vitrophyre (not distinguished on map) locally exposed near base of unit. Thickness as much as 700 m

Trv **Vitrophyre member**--A conspicuous, thick (as much as 25 m), dark-gray to black, densely welded ash-flow tuff. Composition is similar to that of the upper member (Tru)

Trl **Lower member**--Pale-pinkish- to yellowish-gray, moderately welded ash-flow tuff containing sparse lapilli of carbonate rock. Phenocrysts are smaller (generally <2 mm) than in upper member (Tru), make up about 25 percent of rock, and consist of subequal proportions of quartz, sanidine, and plagioclase and lesser amounts of biotite and hornblende; several small grains of sphene are visible in any hand sample. As much as 20 m of thin-bedded white sandstone occurs locally within unit. Thickness less than 150 m

Tn **Lava flows of Ninemile Rocks (Miocene)**--Porphyritic, locally vesicular, greenish-gray (where slightly hydrothermally altered) to dark-gray lava flows. About 20 percent of rock consists of phenocrysts of aligned tabular plagioclase as much as 1 cm long that define a flow

foliation; other lesser phenocrysts include clinopyroxene, orthopyroxene, hornblende, biotite, and Fe-Ti oxides. Bulk chemical composition is transitional between latite and andesite in IUGS classification (Le Bas and others, 1986). Flows south-southeast of Marchell Spring at south edge of map area have same chemical composition and concentration of phenocrysts but phenocrysts are smaller and randomly oriented and biotite and hornblende are absent: rock weathers to rounded boulders and cobbles on hill slopes. Unit is 500 m thick near Marchell Spring but only 150-250 m in southwestern part of map area

Th **Harmony Hills Tuff (Miocene)**--Gray, tan, pink, and orange crystal-rich, moderately welded, andesite ash-flow tuff (Williams, 1967). About one-half of rock consists of phenocrysts, mostly plagioclase and lesser amounts of biotite, hornblende, quartz, amd clinopyroxene. Corrected average of four K-Ar ages, determined by Armstrong (1970), is 21.2 Ma, but recently determined K-Ar ages (Rowley and others, 1989) on the Rencher Formation, which overlies the Harmony Hills in Utah, average 21.7 Ma. As much as 120 m thick

Tlf **Latite lava flows (Miocene)**--Sequence of generally red-brown lava flows and volcanic domes. Bases of flows commonly greenish-gray or black perlite that is locally autobreccia. Phenocrysts, forming a few percent to as

much as one-fourth of rock, consist of plagioclase, biotite, and clinopyroxene; biotite and clinopyroxene occur in widely varying proportions. To east of map area (Best, 1987), flows contain 60-65 weight percent SiO_2 and about 8 weight percent $Na_2O + K_2O$ and are latite and trachydacite according to IUGS classification (Le Bas and others, 1986). Isotopic ages of unit to the east are about 22 Ma (Best, 1987). In map area some flows underlie Bauers Tuff Member of Condor Canyon Formation deposited 22.78 Ma (Best and others, 1989). Unit locally hydrothermally altered in northeast corner of map area. As much as 1 km thick

Tbo **Older breccia (Miocene)**--Almost everywhere poorly exposed breccia that is manifested as red-brown angular rubble on hill slopes. Clasts, as much as 3 m across, are chiefly of Isom Formation (Ti), pyroxene-plagioclase phyric lava flows (Ta), and latite lava flows (Tlf); locally, 1 km south-southeast of Marchell Spring, some clasts of Leach Canyon Formation (Tlc). In few exposures southeast of Marchell Spring, unit is monolithologic and consists of tightly interlocking, randomly oriented clasts of Isom Formation with little or no matrix. Thin, unbrecciated intermediate-composition lava flows occur within unit 0.5 km west of Marchell Spring. Clasts are generally weakly hydrothermally altered, but 2 km east of Kiln Spring

unit is intensely silicified, and veins of milky quartz are pervasive. Unit was deposited unconformably on chaos unit (Tx) apparently as landslide deposits. At least 150 m thick

Tboc **Breccia of Condor Canyon Formation (Miocene)**--This unit resembles unit Tbo, but hillslope rubble and rare outcrops are entirely of Bauers and Swett Tuff Members of Condor Canyon Formation. As much as 150 m thick

Tif **Isom-like lava flow (Miocene)**--Red-brown, non-eutaxitic, flow-layered rock that petrographically resembles some cooling units of Isom Formation. Only exposed 1 km southeast of Marchell Spring where it is as much as 130 m thick

Condor Canyon Formation (Miocene)

Tcb **Bauers Tuff Member**--Generally resistant, densely welded rhyolitic ash-flow tuff (Williams, 1967). Upper part is pale gray to lilac gray and contains sparse, small (<2 mm) phenocrysts; lower part contains conspicuous white or pale-gray compacted lapilli and small blocks of pumice as well as larger (as much as 5 mm) and more abundant (about 20 percent) phenocrysts in a red to pinkish-, purplish-, or orangish-brown matrix. Phenocrysts are plagioclase, subordinate sanidine, minor biotite, and a trace of clinopyroxene and Fe-Ti oxides. Black vitrophyre about 2 m thick occurs near base of unit in southwestern corner of map area. Source

of member is the Clover Creek caldera (Rowley and Siders, 1988) just northeast of Caliente, Nevada in the Caliente caldera complex (Williams, 1967; Ekren and others, 1977) about 30 km southwest of map area. Age of the Bauers Member is 22.78 Ma (Best and others, 1989). Thickness as much as 200 m

Ta **Pyroxene-bearing andesitic lava flows (Miocene and Oligocene?)**--Red-brown to black, aphyric to porphyritic lava flows containing phenocrysts of plagioclase and pyroxene. Petrographically similar flows of similar age elsewhere in the southeastern Great Basin (Best and others, 1989; Best, Mehnert and others, 1987) are latite and shoshonite. As much as 200 m thick

Tvw **Volcanic rocks of White Wash (Miocene)**--Sequence of ash-flow tuff, lava flows, and minor sandstone exposed in and near White Wash in southwest corner of map area. Tuff deposits are of two types: 1, purplish- and reddish-brown tuff containing abundant lapilli and small blocks of gray compacted pumice and dark volcanic lithic fragments and about 25 percent phenocrysts of plagioclase and minor biotite; sanidine and quartz also occur in some pumice clasts. 2, gray, green, and orangish-brown altered tuff containing about 20 percent phenocrysts of plagioclase and minor clinopyroxene, biotite, and Fe-Ti oxides. Lava flows are of two types: 1, red-brown, slightly altered rock that contains

phenocrysts of plagioclase, pyroxene, and hornblende. 2, mostly a pink flow-layered rock, but locally a black vitrophyre, containing sparse phenocrysts of plagioclase and biotite. Poorly exposed sandstone in the unit is tan, gray, or pale green. The purplish- and reddish-brown tuff within the Tvw unit petrographically resembles the Swett Tuff Member of the Condor Canyon Formation exposed in Condor Canyon 6 km to west of map area (Williams, 1967) as well as in areas to the east of the map area (e.g., Siders and others, 1989). However, in these places the Bauers Tuff Member of the Condor Canyon Formation directly overlies the Swett and none of the deposits that make up the Tvw unit occur. Additional work is necessary to confirm the correlation of the Swett with the purplish- and reddish-brown tuff of the unit. Thickness at least 200 m

Tx Chaos (Miocene)--Mosaic of tightly packed, internally coherent, random blocks of weakly hydrothermally altered Oligocene and Miocene rocks. Poorly exposed. Most blocks are larger than a typical outcrop of several meters across. Original stratigraphic order of depositional units is more or less preserved through the chaos even though there are striking angular discordances in attitude between adjacent blocks, as well as local out-of-place depositional units. Includes mappable bodies bounded by faults that are mostly of

one stratigraphic unit recognized elsewhere in map area: Leach Canyon Formation (Txlc), pyroxene andesite (Txa), Isom Formation (Txi), Lund Formation (Txl), and Wah Wah Springs Formation (Txw). Widely scattered outcrops of Ryan Spring(?) Formation are included in units Txl and Txw. Two bodies of conglomerate (Txc) near the center of the map area and a small, unmapped body 3 km south of Kiln Spring consist of poorly sorted, moderately well-rounded clasts as much as 2 m in diameter of gray carbonate rock, white quartzite, and less commonly tuffs of the Lund and Wah Wah Springs Formations and andesitic rock, all in a sandy matrix. The conglomerate, which may be as much as 50 m thick, probably formed as an alluvial fan deposit derived from a former highland underlain by Paleozoic and Tertiary rocks; the nearest Paleozoic exposures are about 15 km north and west of the map area. Unit resembles the Amargosa chaos in Death Valley described by Noble (1941) and interpreted by Wright and Troxel (1969; 1973) to be the highly extended allochthonous hanging wall over a low-angle normal (i.e., detachment) fault. Southern boundary of chaos unit east of Panaca Summit is approximately where the upper Oligocene volcanic units appear less disrupted and crop out as more continuous ledges than to north. Thickness of unit at least a few hundred meters

Tt **Latitic ash-flow tuff (Miocene or Oligocene?)**--Brownish-black ash-flow tuff that contains about 25 percent phenocrysts of plagioclase and subordinate pyroxene, hornblende, and biotite. Locally densely welded and non-eutaxitic so that unit appears lava-like. Thickness about 150 m

Tlc **Leach Canyon Formation (Oligocene)**--Slightly hydrothermally altered, tan, densely welded, rhyolitic ash-flow tuff (Williams, 1967). As much as 5 m of speckled dark-gray vitrophyre locally near base. Contains abundant lapilli of light-colored, intensely flattened pumice and dark-colored volcanic fragments. Phenocrysts make up about 20 percent of rock and consist of plagioclase, quartz, sanidine, biotite, and hornblende. Fission-track age on zircon from sample at type locality of unit is 24.2 ± 2.0 Ma (Kowallis and Best, 1990). About 200 m thick

Ti **Isom Formation (Oligocene)**--At least two densely welded trachytic ash-flow tuff cooling units (Best and others, 1989; Anderson and Rowley, 1975). Less than 15 percent phenocrysts of plagioclase and minor pyroxene and Fe-Ti oxides in a red, brown, or lilac matrix of devitrified glass shards. Contains gray compacted pumice clasts as much as 0.4 m across. An unpublished $^{40}Ar/^{39}Ar$ age, determined by laser fusion of single grains of plagioclase from a sample of the upper Bald Hills Member of the Isom at Hole-in-the-Wall, southwestern

Utah, by A.L. Deino is 26.96 ± 0.16 Ma. Thickness as much as 200 m

Tl **Lund Formation (Oligocene)**--Densely welded, crystal-rich dacite ash-flow tuff. Abundant (about 25 percent of rock) chalky plagioclase phenocrysts in a red matrix of devitrified glass shards; lesser phenocrysts are quartz and altered biotite and hornblende. Source is White Rock caldera just north of map area. Average K-Ar age is 27.9 Ma (Best, Christiansen, and Blank, 1989). Basal part of unit includes as much as 10 m of tuff of the Ryan Spring Formation overlying 4 m of sandstone. Thickness about 150 m

Two **Wah Wah Springs Formation (Oligocene)**--Petrographically identical to the Lund Formation except unit contains no quartz, and hornblende is more abundant than biotite. Source is Indian Peak caldera northeast of map area. Average K-Ar age is 29.5 Ma (Best, Christiansen, and Blank, 1989). Thickness exceeds 50 m

REFERENCES CITED

Anderson, J.J. and Rowley, P.D., 1975, Cenozoic stratigraphy of southwestern High Plateaus of Utah: Geological Society of America Special Paper 160, p. 1-52.

Armstrong, R.L., 1970, Geochronology of Tertiary igneous rocks, eastern Basin and Range province, western Utah, eastern Nevada, and vicinity, U.S.A.: Geochimica et Cosmochimica Acta, v. 34, p. 203-232.

Best, M.G., 1987, Geologic map and sections of the area between Hamlin Valley and Escalante Desert, Iron County, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1774, scale 1:50,000.

Best, M.G., Christiansen, E.H., and Blank, H.R., Jr., 1989, Oligocene caldera complex and calc-alkaline tuffs and lavas of the Indian Peak volcanic field, Nevada and Utah: Geological Society of America Bulletin, v. 101, p. 1076-1090.

Best, M.G., Christiansen, E.H., Deino, A.L., Gromme', C.S., McKee, E.H., and Noble, D.C., 1989, Eocene through Miocene volcanism in the Great Basin of the western United States: New Mexico Bureau of Mines and Mineral Resources Memoir 47, p. 91-133.

Best, M.G., Mehnert, H.H., Keith, J.D., and Naeser, C.W., 1987, Miocene magmatism and tectonism in and near the southern Wah Wah Mountains, southwestern Utah: U.S. Geological Survey Professional Paper 1433-B, p. 29-47.

Best, M.G., Morris, H.T., Kopf, R.W., and Keith, J.D., 1987, Geologic map of the southern Pine Valley area, Beaver and Iron Counties,

Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1794, scale 1:50,000.

Cook, E.F., 1965, Stratigraphy of Tertiary volcanic rocks in eastern Nevada: Nevada Bureau of Mines Report 11, 61 p.

Ekren, E.B., Orkild, P.P., Sargent, K.A., and Dixon, G.L., 1977, Geologic map of Tertiary rocks, Lincoln County, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I-1041, scale 1:250,000.

Kowallis, B.J. and Best, M.G., 1990, Fission track ages from volcanic rocks in southwestern Utah and southeastern Nevada: Isochron/West, no. 55, p. 24.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., and Zenettin, B., 1986, A chemical classification of volcanic rocks based on the total alkalies-silica diagram: Journal of Petrology, v. 27, p. 745-750.

Noble, L.F., 1941, Structural features of the Virgin Spring area, Death Valley, California: Geological Society of America Bulletin, v. 52, p. 941-1000.

Rowley, P.D., McKee, E.H., and Blank, H.R., Jr., 1989, Miocene gravity slides resulting from emplacement of the Iron Mountain pluton, southern Iron Springs mining district, Iron County, Utah (abs.): EOS, Transactions of the American Geophysical Union, v. 70, no. 43, p. 1309.

Rowley, P.D. and Shroba, R.R., in press, Geologic map of the Indian Cove quadrangle, Lincoln County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ-1701, scale 1:24,000.

Rowley, P.D., Shroba, R.R., Simonds, F.W., Burke, K.J., and Axen, G.J., in press, Geologic map of the Chief Mountain quadrangle, Lincoln County, Nevada: U.S. Geological Survey Geologic Quadrangle Map, 1:24,000.

Rowley, P.D. and Siders, M.A., 1988, Miocene calderas of the Caliente caldera complex, Nevada-Utah (abs.): EOS, Transactions of the American Geophysical Union, v. 69, no. 44, p. 1508.

Rowley, P.D., Steven, T.A., Anderson, J.J., and Cunningham, C.G., 1979, Cenozoic stratigraphic and structural framework of southwestern Utah: U.S. Geological Survey Professional Paper 1149, 22 p.

Siders, M.A., Rowley, P.D., Shubat, M.A., Christenson, G.E., and Galyardt, G.L., 1989, Geologic map of the Newcastle quadrangle, Iron County, Utah: U.S. Geological Survey Open-File Report 89-449, scale 1:24,000.

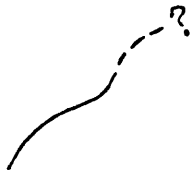
Taylor, W.J., Bartley, J.M., Lux, D.R., and Axen, G.J., 1989, Timing of Tertiary extension in the Railroad Valley-Pioche transect, Nevada: constraints from $^{40}Ar/^{39}Ar$ ages of volcanic rocks: Journal of Geophysical Research, v. 94, p. 7757-7774.

Williams, P.L., 1967, Stratigraphy and petrography of the Quichapa Group, southwestern Utah and southeastern Nevada: Seattle, University of Washington, Ph.D. dissertation, 182 p.

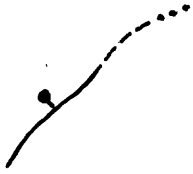
Wright, L.A. and Troxel, B.W., 1969, Chaos structure and Basin and

Range normal faults: Evidence for a genetic relationship (abs.): Geological Society of America Abstracts with Programs for 1969, part 7, p. 242.

Wright, L.A. and Troxel, B.W., 1973, Shallow fault interpretation of Basin and Range structure, southwestern Great Basin, in de Jong, K.A. and Scholten, R., eds.: Gravity and Tectonics, John Wiley and Sons, New York, p. 397-407.



Contact--Dashed where approximately located on cross sections and queried where inferred



High-angle fault--Ball and bar on downthrown side where relative movement known. Dashed where approximately located or inferred; dotted where concealed

Low-angle normal fault--Teeth on upper plate

High-angle strike-slip fault--Arrows indicate relative movement

Strike and dip of beds

Inclined

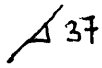
Horizontal

Strike and dip of compaction foliation in welded tuff--Locally enhanced by rheomorphic flow after deposition in Isom Formation

Inclined

Horizontal

Trace in cross section



Strike and dip of flow layering in lava flow