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PRELIMINARY GEOLOGIC MAP OF THE GREGERSON BASIN QUADRANGLE, LINCOLN COUNTY, NEVADA

By

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DESCRIPTION OF MAP UNITS

[Ages of surficial units have not been determined by absolute dating techniques; ages are estimates based on field observations of degree of soil development and local surface dissection. The stage of carbonate morphology reported for soils is a visual estimate using standards defined by Gile and others (1966). Unit colors are from the Rock-Color Chart (Rock-Color Chart Committee, 1951). Identification of volcanic units is based largely on megascopic identification and estimates of phenocryst abundances]

Qahl **Alluvium (late Holocene)**--Grayish-orange to pale-yellowish-brown sand, gravelly sand, and gravel; unconsolidated to weakly consolidated, moderately well to poorly sorted, poorly bedded to massive. Sand is chiefly medium to coarse; contains scattered clasts and minor interbeds of gravel and gravelly sand. Gravel consists of subangular to rounded clasts of ash-flow tuff, silicic lava, and dolomite; mostly pebble and small cobble size; near bedrock outcrops, unit includes clasts as much as 1 m in diameter as scattered boulders and in linear deposits. Unit forms large fans that are chiefly sand and minor gravelly sand in Gregerson Basin and Delamar Valley and channel deposits that are chiefly gravelly sand and gravel. Surfaces of unit are smooth on large fans and irregular in washes. No soil was observed. Thickness ranges from 0 to more than 3 m

Qahe **Alluvium (early Holocene and latest Pleistocene)**--Grayish-orange to yellowish-brown sand, gravelly sand, and gravel; unconsolidated to weakly consolidated, poorly to moderately sorted, poorly to moderately well bedded. Gravel consists of angular to subrounded clasts of ash-flow tuff, silicic lava, and dolomite commonly less than 1 m in diameter. Unit forms large fan remnants in Delamar Valley, small fan remnants flanking bedrock ridges, and small terrace deposits and inset fans along some washes. Deposits stand 1-2 m above active washes. Surfaces are commonly smooth. Soil development on unit consists of a thin sandy vesicular A horizon, a B horizon, and a 0.5-m-thick C horizon with stage I carbonate development. No color difference was observed in the B horizon. Thickness of unit 0 to more than 4 m

Qapl **Alluvium (late Pleistocene)**--Pale-yellowish-brown to grayish-orange gravelly sand and sandy gravel; weakly consolidated; poorly to moderately well sorted, poorly to well bedded. Gravel consists of angular to subrounded clasts of ash-flow tuff, silicic lava, and dolomite; mostly pebble and cobble size with some boulders as much as 1 m in diameter along large washes and near bedrock outcrops. Unit forms large fan remnants and small inset fans along most large washes. Deposits commonly stand 2-4 m above active washes. Surfaces are smooth to slightly dissected; a loosely packed stone pavement is locally developed. Soil consists of a 2- to 4-cm-thick silty sandy vesicular A horizon, a dark-yellowish-orange B horizon, and a 0.5-m-thick C horizon that typically has a stage II carbonate development in the upper part. Thickness 0 to more than 5 m

Qapm **Alluvium (middle Pleistocene)**--Pale-yellowish-brown to grayish-orange sandy gravel and gravelly sand; moderately well consolidated, moderately well sorted to poorly sorted, and poorly to well bedded. Gravel consists of angular to rounded clasts of ash-flow tuff, silicic lava, and dolomite commonly less than 1 m in diameter, except fans in the area of Jumbo Wash where boulders are commonly 1-2 m in diameter. Unit forms fan remnants and small inset fans. Depositional surfaces of fans largely intact but commonly exhibit moderate dissection; deposits typically stand 3-5 m above active washes, locally as much as 12 m. A tightly packed stone pavement is locally developed and clasts in the pavement commonly have a dull to shiny dark-brown rock varnish. Soil commonly consists of a 2- to 5-cm-thick clayey, silty, and sandy vesicular A horizon and a 1-m-thick K horizon that has a stage III carbonate development in the upper half. B horizon preserved at a few locations is light brown. Thickness 0 to more than 15 m

Qc **Colluvium (Quaternary)**--Unconsolidated to well consolidated talus; angular pebble- to boulder-size clasts and minor amounts of silt and sand. Colors are inherited from source rock. Unit is generally nonbedded and locally cemented by seconsdary calcite; occurs along base of steep slopes developed on Tertiary volcanic rocks and Paleozoic carbonate rocks. Unit thickness undetermined

QTa **Alluvium (early Pleistocene and Pliocene?)**--Grayish-brown to moderately well consolidated, poorly sorted, poorly bedded, and weakly to moderately well cemented with secondary carbonate. Gravel consists of angular to rounded clasts of ash-flow tuff, silicic lava, and dolomite commonly less than 2 m in diameter. Unit forms a few fan remnants in the northern part of map area. Deposits are extensively dissected and have rounded interfluves; original depositional surface of fans is not preserved. Poorly exposed, typical exposure has rubble-covered slopes littered with 1-2 m diameter boulders and common to abundant pedogenic carbonate chips. A tightly packed stone pavement is locally developed on gently sloping surfaces; some clasts in the pavement have a dark-brown to black shiny rock varnish. Soil developed on unit commonly has a 4- to 6-cm-thick clayey, silty, and sandy vesicular A horizon overlying a 1- to 1.5-m-thick K horizon that has a stage III and IV carbonate development in the upper half. Thickness is 0 to more than 20 m

QTs **Landslide debris and gravity-slide block complex (Quaternary to late? Miocene)**--Complex mixture of unconsolidated debris and coherent blocks of igneous rocks. Slide unit generally shows an upward gradation from subrounded rubble at the base to larger and more coherent blocks at the top. Slide debris is cemented locally by secondary carbonate. Slide unit occurs near the base of steep slopes. As thick as 60 m. (Unit is shown by coarse stipple pattern and, where appropriate, by fault trace with open teeth on the slide body)

Ta **Alluvium (Pliocene)**--Yellowish-gray to yellowish-brown and moderate-reddish-pink gravel and sandy gravel, moderately well to well consolidated, poorly sorted, poorly bedded; locally cemented by secondary carbonate. Gravel consists of angular to rounded clasts of ash-flow tuff, silicic lava, and dolomite in a pebbly sand matrix. Clasts as much as 2 m in diameter are common; includes some boulders as much as 5 m in diameter. Unit forms deeply dissected fan remnants of a formerly more extensive basin-fill deposit north of Gregerson Basin where it appears to conformably overlie east-dipping volcanic units. Well exposed only in a few cutbank exposures along active washes. Typically expressed as steep, rubble-covered slopes littered with boulders; interfluves are generally rounded but sharply crested. Abundant rounded 1- to 5-cm pebbles of black obsidian (Apache tears) erode out of the basal 10-15 m of the unit; obsidian derived from intracaldera early rhyolite flows (Ter). A tightly packed stone pavement is locally developed on ridge crests; surface clasts of igneous origin locally have a thick, black, shiny rock varnish. Unit is distinguished from Quaternary and Tertiary alluvium (unit QTa) by greater degree of dissection and by topographic expression. Thickness of unit ranges from 0 to more than 90 m

Tab **Boulder bed (Pliocene)**--Brownish-gray and grayish-red-purple very coarse gravel, moderately to well consolidated, nonsorted, poorly bedded to non-bedded; locally cemented with secondary carbonate. Gravel consists of subrounded to rounded ash-flow tuff boulders as much as 8 m in diameter in an angular to subrounded pebble and cobble matrix. Unit forms one mapped lens-shaped bed and one more extensive bed within the lower part of unit Ta. Each deposit predominately consists of Kane Wash Tuff boulders. Poorly exposed, typically expressed as a discontinuous line or slightly resistant ledge of large rounded boulders. Unit ranges from 0 to more than 25 m thick

Tb **Basalt flow, extracaldera (Miocene)**--Medium-dark-gray and medium-gray aphyric basalt flow. Forms cap rock at two exposures at northwest end of Gregerson Basin. K-Ar age of basalt is 12.7 Ma (Novak, 1984). Thickness of map unit is about 40 m

Tbd **Basaltic dike**--Medium-dark-gray basalt dike containing plagioclase phenocrysts. Unit found only in float 3.3 km west of the east boundary and 5.8 km north of the south boundary of the quadrangle

Te **Tuff of Etna (Miocene)**--Light-brownish-gray devitrified moderately welded, informally named ash-flow tuff grading downward to a partially welded base without a vitrophyre. Pumice fragments are sparse. Unit contains about 20 percent phenocrysts that consist of 40 percent quartz, 50 percent sanidine, and 10 percent biotite with a trace of hornblende(?). Sanidine is sparcely adularescent. Unit contains few lithic fragments. The age of the tuff of Etna is bracketed by the K-Ar age of a sanidine in an overlying ash-fall tuff (13.8 ± 0.9 Ma; Snee and others, 1990) and the age of the underlying Gregerson Basin unit of the Kane Wash Tuff (Tkb)(14.1 Ma; Novak, 1984). Map unit exposed at northern end of Gregerson Basin and the east-central border of the quadrangle and is about 50 m thick

INTRACALDERA UNITS

Tbi **Basalt flow, intracaldera (Miocene)**--Medium-dark-gary tholeiitic plagioclase-olivine-phyric basalt lava containing as much as 5 percent plagioclase phenocrysts as long as 1 cm; locally contains as much as 40 percent vesicles partially filled with zeolites or calcite. Forms cap rock and prominent cliffs within caldera. K-Ar age of flow is 12.1 Ma (Best and others, 1980); map unit is late basalt of Novak (1984). Map unit is exposed along the southern boundary of the quadrangle and is about 75 m thick

Tlp **Late pyroclastic rhyolite (Miocene)**--Very light gray, light-gray, to pinkish-gray rhyolitic tuff including ash-fall tuff, nonwelded ash-flow tuff, and sparse reworked fluvial tuff. Phenocrysts of quartz, sanidine, and biotite form less than 5 percent of the rock. Unit contains locally abundant lithic fragments of basalt and trachyandesite (Tbta) that range from less than 1 mm to greater than 0.5 m in diameter. Map unit exposed along the southern boundary of the quadrangle and ranges from 0 to 135 m thick

Tbta **Basalt and trachyandesite flow (Miocene)**--Brownish-gray to brownish-black basalt and trachyandesite lava flows containing sparse plagioclase phenocrysts. Unit is generally massive with sparse scoriaceous zones. Although several flows are present, they are not individually mappable. K-Ar age of flows is 13.4 Ma (Novak, 1984). Unit forms prominent cliffs and ranges from 0 to 110 m thick

Ter **Early rhyolite flows (Miocene)**--Grayish-orange-pink, light-gray, pale-red, and grayish-red rhyolite lava flows ranging from aphyric to containing 10 percent phenocrysts that consist mostly of quartz with minor sanidine and sparse altered mafic minerals (ferroedenite?). Unit may be massive, flow banded, autobrecciated, lithophysal, or spherulitic; character is laterally and vertically discontinuous. Vapor-phase quartz and ferroedenite(?) are abundant in lithophysae. Rock is devitrified; vitrophyres are uncommon. Intercalated with early pyroclastic rhyolite (Tep). Cooling breaks that can be mapped are shown with dashed line. K-Ar age of flows is 13.8 Ma (Novak, 1984). Map unit forms steep rugged slopes and cliffs in south-central part of the quadrangle where it may exceed 300 m thick, but pinches out in the southeastern corner where unit laps on to syenite complex

Tep **Early pyroclastic rhyolite (Miocene)**--Very pale orange, pale-yellowish-orange, pale-red, and pale-reddish-brown bedded nonwelded to moderately welded ash-flow tuffs, ash-fall tuffs, and sparse reworked tuffs containing less than 10 percent phenocrysts of quartz, sanindine, and ferroedenite; some ash-flow tuffs contain biotite (annite?) in place of ferroedonite. Intercalated with early rhyolite flows (Ter). Map unit forms relatively gentle slopes or erosional benches, is laterally discontinuous, and ranges between 0 and 120 m thick

Syenite complex (Miocene)--Complex of chemically related extrusive and intrusive units including from top to bottom a trachytic lava flow (Ttf), a subvolcanic xenolithic syenite (Txs), and a seriate syenite (Tss). The xenolithic syenite is intruded by a trachytic dike (Ttd). K-Ar age of the complex is 14.1 to 13.9 Ma (Novak, 1984). Although the trachytic lava flow appears to be the skin of the nearly coeval subvolcanic xenolithic syenite, the seriate syenite appears to be a distinctively younger intrusive phase that has both ductilely and brittlely faulted the overlying parts of the syenite complex in different localities during intrusion

Tss **Seriate syenite**--Grayish-pink, pinkish-gray, and grayish-red massive syenite consisting of seriate alkali feldspar crystals between 0.25 and 7 mm in diameter. Rock contains a trace of interstitial quartz, 95 percent alkali feldspar, and 2-3 percent clinopyroxene. Unit forms exfoliation domes and intrudes and deforms the overlying xenolithic syenite (Txs) and trachytic flow (Ttf)

Ttd **Trachytic dike**--Grayish-pink trachytic dike consisting of phenocrysts of alkali feldspar between 0.1 and 2 cm in diameter in a matrix too fine-grained to identify. Margins of dike chilled against xenolithic syenite. Map unit observed only 2.4 km west of the eastern boundary and 1.6 km north of the southern boundary of the quadrangle

Txs **Xenolithic syenite**--Grayish-pink and pinkish-gray porphyritic syenite containing xenoliths of pale-red trachyte. Xenoliths form a trace to 40 percent of the rock; locally xenoliths (0.5 cm to 1 m long) or alkali feldspar laths form a crude foliation. Rock contains about 25 percent phenocrysts consisting of about 85 percent anorthoclase (with common sieve texture), and about 15 percent clinopyroxene; a groundmass of alkali feldspar and a trace of interstitial quartz make up 75 percent of the rock. Unit locally intrudes overlying trachytic lava flows (Ttf) but appears to be gradational with the overlying trachyte in most places

Ttf **Trachytic flow**--Light-brownish-gray to pale-red trachytic lava flow containing medium to coarse (0.1 to 8 mm in length) seived anorthoclase phenocrysts that form as much as 50 percent of the rock. Groundmass ranges from cryptocrystalline to very fine grained growths of alkali feldspar and minor amounts of clinopyroxene. Trachyte flow forms an envelope around the xenolithic syenite (Txs) in most places. Foliation dips variably and unit is locally vesicular near the top. Upper part of flows are overlain by early pyroclastic rhyolite (Tep) and early rhyolite flows (Ter). Map unit exposed in southeastern corner of the quadrangle and is as thick as 120 m

Twb **Caldera wall breccia (Miocene)**--Coarse, angular boulder breccia deposited as a wedge of debris along the Kane Wash caldera wall consisting mostly of clasts of Kane Wash Tuff from sand-sized to 2 m in diameter. Layers of breccia dip into the caldera near the angle of repose (30-35^{o}). Breccia is discontinuously exposed along the caldera wall in the southern part of the quadrangle. Wall breccia and caldera outflow facies of Kane Wash Tuff are locally hydrothermally altered close to southwest corner of quadrangle. Locally unit may be as thick as 85 m

EXTRACALDERA UNITS

Kane Wash Tuff (Miocene)--Peralkaline ash-flow tuff sequence including three informally named units. The upper two units, the Gregerson Basin (Tkb) and Grapevine Springs (Tkg) units were erupted from the Kane Springs Wash caldera; the lowest unit, the Delamar Lake unit was erupted from an older, unrecognized caldera

Tkb **Gregerson Basin unit, undivided**--Comenditic to trachytic ash-flow tuff consisting of at least two, and perhaps locally as many as four cooling units with similar ranges in composition. Gregerson Basin unit includes units V2 and V3 of Novak, (1984). Cooling units are not mapped separately because lithologic similarities make them indistinguishable in most places in the field and cooling breaks are not traceable in all localities. Where cooling breaks are traceable, they are shown as dashed contacts within the undivided Gregerson Basin unit. Each cooling unit generally contains two intervals, each with a distinctive composition; an upper interval consists of a mafic trachytic cap above a lower interval containing comenditic upper, middle, and basal zones. The trachytic caps are mostly devitrified but partly vitric, partially welded to moderately welded, and pale yellowish brown. Trachytic caps contain as much as 15 percent cognate inclusions that are 1-20 cm long, are pale brown to grayish brown, contain about 50 percent alkali feldspar phenocrysts, and are slightly scoriaceous. Where trachytic caps are included in the undivided Gregerson Basin unit, they are generally less than 20 m thick. Of the commenditic interval, upper zones are devitrified, moderately to densely welded, and yellowish gray in most of the zone but are pale blue and light bluish gray in some stratigraphic intervals. Upper zones contain about 10 percent highly flattened pumice fragments that enhance parting parallel to the plane of compaction. Upper zones have 0-10 percent lithophysal cavities that contain vapor-phase crystals of amethyst and blocky mafic minerals (riebeckite and unidentified phases). Upper zones contain about 20 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenburgite, fayalite, and ilmenite; mafic phases are commonly altered. Upper zones range from 20 to 200 m thick. The middle zones are mostly devitrified, moderately to densely welded, commonly mottled pale blue and medium bluish gray where devitrified and dark gray to grayish black where vitrophyres are locally developed. Partings parallel to the plane of compaction follow boundaries between 1- to 10-cm-thick layers of tuff that differ greatly in phenocryst abundances (5 to 25 percent); these layers probably represent welded ash-fall tuff. Middle zones range from 1 to 5 m thick. The basal zones are commonly nonwelded to partially welded, moderate orange pink to pale yellowish orange, contain slightly fewer phenocrysts than middle zones, and are 1 to 4 m thick. Map unit characterized by conspicuous adularescent sanidine phenocrysts. The K-Ar age of the Gregerson Basin unit is 14.1 Ma (Novak, 1984). Cooling units form cliffs and rugged slopes; cooling breaks form slight erosional benches on dip slopes at some localities. Thickness of the Gregerson Basin unit is as great as 580 m. The Gregerson Basin unit is informally named for the exposures that border Gregerson Basin

Tkbm **Mafic trachytic interval**--Upper interval of cooling units within Gregerson Basin unit of the Kane Wash Tuff, consisting of ash-flow tuff. Two intervals of mafic trachytic rock are mapped. Unit described above in the Gregerson Basin unit, undivided. Map unit exposed in east-central part of the quadrangle where two 30-m-thick intervals are present in stratigraphic sequence, separated by a comenditic interval (Tkbc)

Tkbc **Comenditic interval**--Lower interval of cooling units within Gregerson Basin unit of the Kane Wash Tuff, consisting of ash-flow tuff. Two intervals of commenditic rock are mapped. Map unit described above in the Gregerson basin unit, undivided. Unit exposed on east-central part of the quadrangle where a 170-m-thick upper commenditic interval is separated from a 260-m-thick lower commenditic interval by a mafic trachytic interval

Tkg **Grapevine Spring unit**--Rhyolitic to trachytic ash-flow tuff, consisting of one compound cooling unit. Map unit is unit V1 of Novak (1984). Map unit grades downward through 4 zones that locally include a poorly developed trachytic cap above upper, middle, and lower rhyolitic zones. The cap rock contains sparse dark scoriaceous trachytic cognate inclusions in a matrix that is slightly darker brown than lower zones and is less than a few meters thick. The upper zone is devitrified, moderately to densely welded, and light brownish gray. Upper zone weathers to form smooth-textured surfaces; this smooth texture seems to be related to a relatively low abundance of phenocrysts (less than 10 percent). Upper zone contains few recognizable pumice fragments and lithophysal cavities. Upper zone contains about 10 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenburgite, fayalite, and ilmenite. Lithic fragments are sparse. Thickness of upper zone ranges from 75 to 145 m thick. The middle zone is devitrified, densely welded, and light brownish gray to yellowish gray to brownish gray. Middle zone weathers to form a rough-textured hackly surface; this hackly texture seems to be related to a relatively high abundance of phenocrysts (25-30 percent). Middle zone contains few recognizable pumice fragments and less than 10 percent lithophysal cavities, which have minor vapor-phase crystals of quartz and sparse garnet. Middle zone contains about 25 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenburgite, fayalite, and ilmenite. Middle zone contains less than 2 percent lithic fragments and ranges from about 65 to 130 m thick. The lower zone grades downward from moderate-brown, partly devitrified and partly vitric, densely welded, locally lithophysal tuff to pale-brown and dark-yellowish-brown nonwelded tuff. Where the vitrophyre is preserved, it is dark gray and contains grayish-red spherulitic devitrification centers. Lower zone ranges from 2 to 7 m thick. Map unit forms rugged slopes where dips are moderate and cliffs where dips are gentle. Only a small bench marks the cooling break with the overlying Gregerson Basin unit. Map unit characterized by moderate abundance of adularescent sanidine phenocrysts. The K-Ar age of the map unit is 14.1 Ma (Novak, 1984). The Grapevine Spring unit is about 145 m thick in the southwestern part of the quadrangle and about 280 m thick in the eastern part, and is informally named for exposures on the cliffs above Grapevine Spring in the Vigo NW quadrangle, east and south of the Gregerson Basin quadrangle

Tkd **Delamar Lake unit**--Informally named rhyolitic ash-flow tuff consisting of at least one cooling unit; base is unexposed. The Delamar Lake unit correlates with unit O of Novak (1984) and is the oldest unit of the Kane Wash Tuff; Novak considers that the Delamar Lake unit erupted from an unrecognized caldera related to the Kane Springs Wash volcanic center. The unit is devitrified, moderately welded, and grayish orange pink. Pinkish-gray flattened pumice fragments as large as 8 cm across in the plane of foliation form about 15 percent of the tuff. Rock contains about 25 percent phenocrysts that consist of 20 percent quartz, 75 percent sanidine, and 5 percent fayalite and other mafic minerals. Less than 4 percent of the rock consists of lithic fragments. The K-Ar age of the unit is 15.6 Ma (Novak, 1984). Exposures are limited to two small fault blocks southwest and northwest of Gregerson Basin. Sanidine phenocrysts are adularescent. Thicknesses less than a few meters are exposed at each locality. The Delamar Lake unit is named for the exposures in the vicinity of Delamar Lake in the Delamar Lake quadrangle west of the Gregerson Basin quadrangle (Scott and others, 1988) where the unit ranges from 15 to 190 m thick

LOCAL PRECALDERA UNITS

Precaldera volcanic, sedimentary, and plutonic units (Miocene)--Ten volcanic rock units, a related sedimentary rock unit, and an intrusive porphyry occur close to the margin of the Kane Springs Wash caldera, the source of the Gregerson Basin and Grapevine Spring units of the Kane Wash Tuff. All these units (in descending order, tuffaceous sediment Tts through rhyolitic porphyritic stock Tp) underlie the Grapevine Spring unit of the Kane Wash Tuff and thus require that their minimum age be 14.1 Ma or older; however, their maximum age is uncertain. These units generally contain alkali feldspar and quartz phenocrysts, similar to the Kane Wash Tuff units. Both the pluton and volcanic units may be local precursors to the eruption of the Kane Springs Wash caldera because of their distribution close to the caldera; alternatively, they may be products of an older caldera that postdates the Delamar Lake unit (Tkd). These rocks are considered younger than the Delamar Lake unit of the Kane Wash Tuff (15.6 Ma; Novak, 1984), which was derived from an older unrecognized caldera. In the adjacent Delamar Lake quadrangle (Scott and others, 1988), the precaldera volcanic, sedimentary, plutonic units are not present, and an uninterruped sequence of the Kane Wash Tuff units are present. Novak (1984) has determined the K-Ar age of the youngest of these volcanic units, the precaldera trachyte, to be 14.1 Ma, an age indistinguishable from the ages of the overlying Grapevine Springs and Gregerson Basin units

Tts **Tuffaceous sediment**--Pale-red to grayish-pink, poorly sorted, consisting of moderately consolidated, silt-, sand-, and cobble-sized reworked tuff containing clasts of the underlying precaldera trachyte (Tpt). Map unit discontinuously exposed 3.0 km west of the eastern boundary and 7.5 km north of the southern boundary of the quadrangle. Unit erodes to form a distinct erosional bench and its maximum thickness is less than 25 m

Tpt **Precaldera trachyte**--Pale-red to grayish-red, devitrified, trachytic lava flow containing conspicuous alkali feldspar phenocrysts. Map unit is the precaldera trachyte of Novak (1984). Alkali felspar phenocrysts form about 25 percent of the rock, range from 0.25 to 1 cm in diameter, and have a sieved texture. Sparse altered mafic phenocrystic phase probably is clinopyroxene. No flow banding is present. A very dusky red basal vitrophyre is uncommon. The K-Ar age of map unit is 14.1 Ma (Novak, 1984). Unit forms rugged steep slopes and small cliffs. Exposures in east-central part of quadrangle reach 200 m in thickness but pinch out to the north, west, and southwest

Tt **Trachyte**--Pale-red to grayish-red, devitrified, trachytic lava flow containing relatively inconspicuous alkali feldspar phenocrysts compared to the percaldera trachyte (Tpt). Phenocrysts form 10 to as much as 25 percent of the rock; the more crystal-rich lithology is more common. Phenocrysts consist of 90 percent alkali feldspar and 10 percent altered mafic phases, probably clinopyroxene and Fe-Ti oxides. Alkali feldspars range from 0.1 to 0.3 cm in diameter and do not have a sieved texture. No flow banding is present. This trachytic flow probably is laterally equivalent to the precaldera trachyte (Tpt) or another flow of similar age; however, there is little constraint on its age as its isolated low-lying exposure is surrounded by an overlying Tertiary alluivial (Ta) north of Gregerson Basin. Map unit is less than 10 m thick

Tsp **Salt-and-pepper-textured ash-flow tuff (Miocene)**--Rhyolitic, light-gray to light-brownish-gray matrix of devitrified moderately to densely welded ash-flow tuff containing conspicuous dark-gray to black mafic phenocryst phases. Eutaxitic pumice fragments are 0.5 to 3.0 cm long parallel to the plane of folitation, are very light gray, and form about 20 percent of the rock. Unit contains 25-30 percent phenocrysts that consist of 40 percent quartz, 40 percent sanidine, and 20 percent unidentified mafic phases. Mafic phases form irregular spots where deuteric alteration has redistributed the original mafic phase into the surrounding groundmass. Lithic fragments are sparse. Unit is exposed along the east-central boundary of the quadrangle where it underlies the precaldera trachyte (Tpt). Forms steep, rugged slopes, and is at least 120 m thick; base is unexposed.

Tntu **Nonwelded tuff, upper**--Yellowish-gray to moderate-greenish-yellow and pale greenish-yellow ash-fall tuff including minor layers of reworked tuff. Unit exposed in northeast part of quadrangle where it forms a slight ersional bench and reaches a maxium thickness of about 10 m

Tpru **Pumice-rich tuff, upper**--Devitrified ash-flow tuff, pinkish-gray partially welded zone grading downward to a pale-red moderately welded zone and, still lower, to a pale-brown densely welded zone. At one locality, a basal dark-gray vitrophyre is present. Pumice fragments are conspicuous in the partially and moderately welded zones, range from 0.2 to 6 cm long parallel to the plane of foliation, and form about 25 percent of the rock. Rock contains about 25 percent phenocrysts that consist of 35 percent quartz, 60 percent sanidine, traces of plagioclase(?) and biotite (?), and Fe-Ti oxides. Lithic fragments are sparse. Unit forms moderately steep slopes and reaches a maximum thickness of about 230 m in the east-central part of the quadrangle but pinches out and becomes discontinuous toward the northeast

Tntm **Nonwelded tuff, middle**--Very pale orange to grayish-orange nonwelded ash-fall tuff containing about 5-10 percent lithic clasts of the underlying rhyolitic porphyritic stock (Tp). Minor partially welded ash-flow tuff of similar lithologic character is also present in map unit. Pumice fragments form about 10 percent of the rock and are 0.1-0.5 cm in diameter. Rock contains about 15 percent phenocrysts that consist of subequal amounts of quartz and sanidine and a trace of altered mafic phases. Unit forms a slight bench where it is draped over the rugged exposures of the rhyolitic prophyritic stock (Tp) and is less than 10 m thick along discontinuous exposures on the east side of the Tp stock

Tlr **Lithic-rich tuff**--Light-brownish-gary, light-olive-gray, and brownish-gray ash-flow tuff containing a conspicuously high abundance of lithic fragments; a greenish-black basal vitrophyre is locally present. Pumice fragments form as much as 25 percent of the rock, locally form a eutaxitic texture with dark-gray fiamme, and are 0.5 to 4 cm long parallel to the plane of compaction. Rock contains about 20 percent phenocrysts that consist of 50 percent quartz, 40 percent sanidine, and 10 percent unidentified altered mafic phases. Volcanic lithic fragments are 0.1 to 4 cm across and form about 15-20 percent of the rock. The rock has a "cluttered" appearance, crowded with pumice and lithic fragments; these components tend to obscure the welded and eutaxitic texture that characterize most ash-flow tuffs and make recognition of the plane of foliation difficult. Map unit forms a shield-shaped accumulation in the northeast part of the quadrangle where it reaches a maximum thickness of about 170 m; unit thins and pinches out to the south and west

Tprl **Pumice-rich tuff, lower**--Pale-red to moderate-red, devitrified, moderately welded ash-flow tuff containing conspicuously lineated pumice fragments. Pumice fragments form about 25 percent of the rock and are 1-2 cm long parallel to the plane of flattening and direction of lineation. Pumice fragments are grayish orange pink and form a eutaxitic texture. Rock is nearly aphyric containing only a trace of sanidine and quartz(?) and unidentifed altered mafic phases. Lithic fragments are sparse. Unit exposed only in two small low-relief areas about 1 km northeast of the rhyolitic porphyritic stock (Tp); less than 35 m of map unit exposed

Tntl **Nonwelded tuff, lower**--Yellowish-gray to pale-olive nonwelded devitrified ash-flow tuff and minor ash-fall tuff containing volcanic lithic fragments. Pumice fragments are pale yellowish green, are about 0.2-0.5 cm in diameter, are not flattened, and form about to 20 percent of the rock. Sparse quartz phenocrysts are present. Lithic fragments are 0.2-1.5 cm in diameter and form about 10 percent of the rock. Unit restricted to one exposure 2.6 km south of the northern boundary and 3.6 km west of the eastern boundary of the quadrangle; map unit is less than 15 m thick

Trf **Rhyolite flow**--Typically a massive, devitrified, pinkish-gray to very light gray series of rhyolite lava flows including vitrophyres within the lava flow series, minor moderately welded ash-flow tuffs, and sparse ash-fall tuffs. Vitrophyres are commonly a waxy light moderate brown and some lava flows are grayish yellow green. Altered lava flows are commonly mottled pale red and medium light gray. Lava flows are nearly aphyric, but ash-flow tuffs contain 10 percent quartz phenocrysts, sparse mafic phases, and 20 percent flattened pumice fragments. Exposures of map unit are in the northeast part of the quadrangle, and locally unit thickness is as great as 95 m

Tp **Rhyolitic porphyritic stock (Miocene)**--Rhyolitic porphyritic stock containing a central facies and a chilled border facies. Central facies consists of pale-red porphyritic rhyolite containing conspicuous porphyritic grayish-pink alkali feldspar. Rock contains about 60 percent phenocrysts that consist of about 10 percent quartz (1 mm diameter), about 80 percent orthoclase (2-5 mm diameter), and about 10 percent altered mafic phases. The groundmass consists of feldspar, altered mafic phases, and quartz. Most large alkali feldspar phenocrysts have a sieved texture and contain about 25 percent exsolved plagioclase lamellae. Chilled border facies of the stock is 10 to 50 m thick and has a greenish-gray to light-gray matrix; phenocryst content varies between 15 and 60 percent of the rock, and alkali feldspar phenocrysts are significantly smaller in diameter (1-2mm) than those in the central facies. Informally called stock of Jumbo Spring

UNITS UNRELATED TO KANE SPRINGS WASH VOLCANIC CENTER

Th **Hiko Tuff (Miocene)**--Rhyolitic ash-flow tuff consisting of one cooling unit. Rock is devitrified, moderately to densely welded and light brownish gray. Pumice fragments form 10-25 percent of the rock, are pale pink, and as long as 3 cm in the plane of foliation. Rock contains about 35 percent phenocrysts that consist of 25 percent very pale purple quartz, 25 percent sanidine, 35 percent plagioclase, 10 percent biotite, and less than 5 percent horblende and pyroxene. Locally some zones in the tuff contain as much as 25 percent lithic fragments but most of the tuff contains about 10 percent. A thick basal zone of the Hiko Tuff is exposed in the southwest corner of the quadrangle; the basal zone is nonwelded to partially welded and very light gray. In the northeast part of the quadrangle the tuff is moderately to densely welded, steeply dipping, poorly exposed in low-relief hills and in gullies, and commonly deformed by multiple shear planes. The $^{40}Ar/^{39}Ar$ age of the Hiko Tuff is 18.6 Ma (Taylor and others, 1989). In the southwest part of the quadrangle the map unit is about 320 m thick, and in the northeast part the unit is at least 900 m thick if it has not been repeated by faulting

Thh **Harmony Hills Tuff (Miocene)**--Andesitic ash-flow tuff consisting of one cooling unit grading downward from a nonwelded and partially welded upper zone to a moderately to densely welded central zone; lower zones are not exposed. Map unit is devitrified, phenocryst-rich, and massive with crudely developed foliation. Tuff is pale red where less welded and grayish purple to pale red purple where more highly welded. Pumice fragments are sparse. The rock contains 45-55 percent phenocrysts that consist of 5 percent quartz, 65 percent plagioclase, 15 percent biotite, 10 percent hornblende, and less than 5 percent clinopyroxene. Lithic fragments are sparse. Five K-Ar ages by Armstrong (1970) and one by Noble and McKee (1972) average 21.6 Ma for the map unit; however, isotopic ages of 22.5-22 Ma for plutons and an ash-flow tuff that postdate the Harmonly Hills Tuff in the Iron Springs District of southwestern Utah may provide a better minimum age constraint (Rowley and others, 1989). Although the Harmony Hills Tuff and the Bauers Member of the Condor Canyon Formation (Tcb) were included in the Quichapa Group (Cook, 1957; Williams, 1967; Anderson and Rowley, 1975), the group name will not be used here because the source(s?) of two ash-flow tuffs have not been recognized. Only the moderately to densely welded tuff is exposed in the northeastern part of the quadrangle where the tuff is steeply dipping to overturned; rock is commonly deformed by multiple shear planes. The apparent thickness of the map unit in the northeast part of the quadrangle ranges from 50 m to at least 115 m. In the southeast part of the quadrangle exposures of the map unit are limited to low-relief gentle hills where only about 35 m of the upper part of the unit is exposed

Tcb **Bauers Tuff Member of the Condor Canyon Formation (Miocene)**--Rhyolitic ash-flow tuff consisting of one simple cooling unit. Only moderately to densely welded, devitrified, pale-red-purple to pale-purple tuff is exposed. Highly flattened pumice fragments(?) occur as elongate (1-5cm-long) lenticules that form about 10-15 percent of the rock. Rock contains about 10 percent phenocrysts that consist of 30 percent sanidine, 65 percent plagioclase, and 5 percent biotite and a trace of hornblende. About 5 percent of the rock consists of volcanic lithic fragments that are less than 1 cm in diameter. Exposures are limited to low-relief gentle hills and gullies. The $^{40}Ar/^{39}Ar$ age of the Bauers Tuff member is 22.8 Ma (Best and others, 1989). Although the steeply dipping map unit exposed in two areas north of the stock of Jumbo Spring probably has been internally faulted to an unknown degree, the unit is about 500 m thick based upon the geometry of these areas

Tba **Basaltic andesite lava flow (Miocene)**--Dark-greenish-gray to medium-dark-gray massive basaltic andesite. Rock contains 20-35 percent phenocrysts that consist of 50-90 percent plagioclase and 50-10 percent clinopyroxene. Exposures are limited to gullies and areas of low relief northwest of the rhyolitic porphyritic stock (Tp); thickness is about 120 m

Tcbl **Lower cooling unit of the Bauers Tuff Member of the Condor Canyon Formation (?) (Miocene)**--Grayish-red-purple, devitrified, moderately to densely welded tuff exhibiting a eutaxitic texture. Pumice fragments are highly flattened parallel to the plane of compaction and form about 10 percent of the rock. Rock contains about 15-20 percent altered phenocrysts that consist of sanidine(?), plagioclase, and biotite(?); plagioclase forms most of the phenocrysts. At most localities the tuff has been silicified and partly altered to celadonite. Map unit has not been correlated with any specific unit but is lithologically most similar to the Bauers Tuff Member of the Condor Canyon Formation; unit may be a lower cooling unit of the Bauers Tuff Member. Exposures are limited to gullies and areas of low relief north and northwest of the rhyolitic porphyritic stock (Tp); thickness is about 100 m

Tl **Limestone (Miocene?)**--Pale-red, massive, fine-grained limestone containing recrystallized pale-pink algal(?) plates. Upper part of limestone contains sand-sized erosional debris from tuffs including sanidine and quartz phenocrysts. Exposure of unit is limited to one gully 5.1 km west of the eastern boundary and 5.3 km south of the northern boundary of the quadrangle. Strata dip steeply to the southwest away from the rhyolitic porphyritic stock (Tp). Map unit underlies the Gregerson Basin unit (Tkb) and overlies a rhyolitic ash-flow tuff (Tf); the upper contact may be a fault. All three units are roughly parallel and dip 67-90^{o}. Unit thickness about 50 m

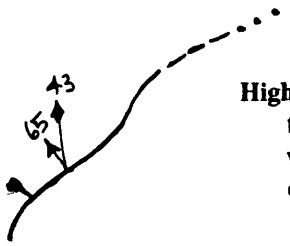
Tf **Ash-flow tuff (Miocene?)**--Grayish-orange to pale-red ash-flow tuff exhibiting exutaxitic texture of pumice fragments. Pumice fragments are 1-2 cm long parallel to the plane of flattening and form about 15 percent of the rock. Rock contains about 10-15 percent altered phenocrysts that consist largely of feldspar and smaller quantities of mafic phases. Base of map unit includes a layer of carbonate cobbles in a pale-reddish-brown soil(?) matrix above the Cambrian Highland Peak Formation (Chp). Unit has an uncertain age and has a thickness of about 25 m

Tc **Conglomerate (early Tertiary?)**--Grayish-pink to light-gray conglomerate consisting of Paleozoic clasts. Poorly sorted, well consolidated and cemented, and poorly bedded; contains boulders as much as 0.5 m in diameter near the base of the unit. About 70 percent of the rock consists of carbonate and quartzite pebbles. About 30 percent of the rock consists of a sand-sized matrix of similar lithologies. Unit is exposed on the northwestern edge of the exposures of the Highland Peak Formation (Chp) northwest of the rhyolitic prophyritic stock (Tp). Map unit thickness locally is about 110 m

Ꞓhp **Highland Peak Formation (Late and Middle Cambrian)**--Upper dolomite and lower limestone members observed but not separately mapped. Upper member dolomite, medium-dark-gray (fresh), medium-light-gray to medium-dark-gray (weathered); mottled to light gray and dark gray, finely to medium crystalline, thin bedded; contains brachiopods and oncolites. Rock is recrystallized to marble and dolomitic marble by contact metamorphism adjacent to intrusion; contact metamorphosed rock is white to pinkish gray (fresh) and very light gray (weathered), and has a sugary texture. Wollastonite crystals occur on some rock surfaces; diopside, actinolite, and grossularite occur in a few localities; and sparse hydrothermal sulfide minerals occur at one locality. Lower limestone member consists of limestone and chert; limestone is medium dark gray (fresh) and light gray, medium gray, pale red, and moderate brown (weathered), locally arenaceous, aphanic to medium crystalline; abundant stringers of chert are dark gray (fresh) and moderate brown (weathered). Dolomite in the northern part of quadrangle is mottled medium light gray and medium dark gray and contains distinctive continuous to discontinuous alternating light-gray and medium-dark-gray laminae; common streaks and vugs aligned subparallel to bedding are filled with coarse recrystallized dolomite. As much as 300 m of the map unit is exposed in the northeastern part of the quadrangle

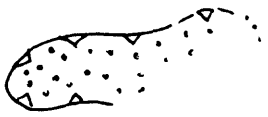
Contact

Cooling break between ash-flow tuffs or lava flows

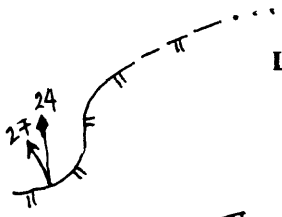


High-angle normal or reverse fault--showing dip (barbed arrow) and trend and plunge of lineation (diamond-shaped arrow). Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side

Strike- or oblique-slip fault--Arrows show relative direction of lateral offset. Dashed where approximately located; dotted where concealed. Faults cut the stock of Jumbo Spring, postdate Kane Wash tuff units, and may postdate the Kane Springs Wash intracaldera units



Low-angle fault beneath slide block--Open sawteeth on upper plate of slide block. Dashed where approxiamtely located; dotted where concealed. Coarse stipple pattern on upper plate



Low-angle normal fault beneath upper plate--Hachures on upper plate. Dashed where approximately located; dotted where concealed. Dip shown by barbed arrow and trend and plunge of lineation shown by diamond-shaped arrow

Fault scarp along which younger unit has been deposited--Hachures on side of postfault deposit

Strike and dip of sedimentary beds and of compaction foliation of ash-flow tuffs

Inclined

Overturned

Horizontal

Vertical

Strike and dip of flow foliation in lava flow

Inclined

Vertical

Hydrothermally altered area

Contact metamorphic rock

× Prospect pit

REFERENCES CITED

Anderson, J.J., and Rowley, P.D., 1975, Cenozoic stratigraphy of the southwestern High Plateaus of Utah, in Anderson, J.J., Rowley, P.D., Fleck, R.J., and Narin, A.E.M., Cenozoic geology 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., McKee, E.H., and Damon, P.E., 1980, Space-time-composition patterns of late Cenozoic mafic volcanism, southwestern Utah and adjoining areas: American Journal of Science, v. 280, p. 1035-1050.

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 Western United States. Excursion 3A: New Mexico Bureau of Mines and Mineral Resources Memior 47, p. 91-133.

Cook, E.F., 1957, Geology of Pine Valley Mountains, Utah: Utah Geological and Mineralogical Survey Bulletin 58, 111 p.

Gile, L.H., Peterson, F.F., and Grossman, R.B., 1966, Morphological and genetic sequences of carbonate accumulations in desert soils: Soil Science, v. 101, p. 347-360.

Noble, D.C., and McKee, E.H., 1972, Description and K-Ar ages of volcanic units of the Caliente volcanic field, Lincoln County, Nevada, and Washington County, Utah: Isochron/West, no. 5, p. 17-24.

Novak, S.W., 1984, Eruptive history of the rhyolitic Kane Springs Wash volcanic center, Nevada: Journal of Geophysical Research, v. 89, p. 8603-8615.

Rock-Color Chart Committee, 1951, Rock-color chart: Boulder, CO, Geological Society of America.

Rowley, P.D., McKee, E.H., and Blank, H.R., 1989, Miocene gravity slides resulting from emplacement of the Iron Mountain pluton, southern Iron Springs District: EOS, Transactions of the American Geophysical Union, v. 70, p.1309.

Scott, R.B., Swadley, W C, Novak, S.W., 1988, Preliminary geologic map of the Delamar Lake quadrangle, Lincoln County, Nevada: U.S. Geological Survey Open-File Report 88-576, scale 1:24,000, 11 p.

Snee, L.W., Mehnert H.H., Rowley, P.D., Anderson, R.E., and Scott, R.B., 1990, New isotopic ages demonstrate extensional faulting of 19-12 Ma in the western Caliente caldera complex and vicinity, Lincoln County, Nevada: EOS, Transactions of the American Geophysical Union, v. 71, in press.

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: Journal of Geophysical Research, v. 94, 7757-7774.

Williams, P.L., 1967, Stratigraphy and petrography of the Quichapah Group, southwestern Utah and southeastern Nevada: Seattle, University of Washington, Ph.D. dissertation, 139 p.

Correlation of Map Units

Gregerson Basin