USGS-OFR-91-389

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE VIGO NW QUADRANGLE, LINCOLN COUNTY, NEVADA

By

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Open-File Report 91-389

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 except where noted. Radiometric ages of units are reported with 2 standard deviation errors]

Qal **Alluvium (late Holocene)**--Pale-yellowish-brown to grayish-orange sand, gravelly sand, and gravel; unconsolidated, poorly bedded, generally poorly sorted. Sand ranges from fine to very coarse and is chiefly coarse; massive to moderately well bedded, locally crossbedded. Clasts in gravel and gravelly sand are angular to rounded pebbles, cobbles, and boulders as much as 1.5 m across. Clasts consist of ash-flow tuff and lava; clasts of vesicular basalt are locally abundant. Unit forms large, low-gradient fans of sand and gravelly sand west of Kane Springs Wash; steeper fans of gravelly sand and gravel east of Kane Springs Wash; and channel deposits and low terrace deposits of interbedded sand, gravelly sand, and gravel along modern washes. Along the main channel of Kane Springs Wash, unit is chiefly sand but locally includes 1- to 2-m-thick beds of rounded cobble and boulder gravel containing clasts as much as 1.5 m in diameter. Surface of unit is generally smooth on fans and low terraces but in channel deposits, bar-and-swale topography is common. Soil on unit is limited to a thin sandy vesicular A horizon developed locally on some fans. Thickness 0 to more than 3 m

Qae **Alluvium (early Holocene and latest Pleistocene)**--Grayish-orange to yellowish-brown gravel, gravelly sand, and gravel; unconsolidated to weakly consolidated, poorly to moderately well bedded, generally poorly sorted. Clasts in gravel and gravelly sand are angular to subrounded pebbles, cobbles, and boulders generally less than 1 m across. Clasts consist of ash-flow tuff and lava. Sand is fine to coarse and poorly sorted. Unit forms remants of fans of gravel and gravelly sand along both sides of Kane Springs Valley and terrace deposits of sand and gravelly sand along and near Kane Springs Wash. Deposits of unit stand 1-2 m above active washes; surfaces are smooth and generaly undissected. Soil developed on unit consists of a thin sandy vesicular A horizon, a B horizon that shows no color difference from that of the parent material, and a 0.5-m-thick C horizon that has stage I carbonate development in the upper part. Thickness of unit 0 to more than 4 m

Qaj **Alluvium of Jumbo Wash (late Pleistocene)**--Unit named for deposits along and near Jumbo Wash (Scott and others, 1990a) in the Gregerson Basin quadrangle adjacent to the northwest. Pale-yellowish-brown to grayish-orange gravel and gravelly sand, weakly consolidated, moderately well to poorly bedded, and generally poorly sorted. Clasts in gravel and gravelly sand consist of angular to rounded pebbles, cobbles, and boulders, commonly less than 1 m in diameter, of ash-flow tuff and lava. Unit forms small poorly exposed, fan remnants, mostly along the west side of Kane Springs Valley. Surface of deposit is smooth to slightly dissected and commonly stands 2-4 m above active washes. A loosely to moderately packed stone pavement is locally developed; some surface clasts have a dull-brown rock varnish. Soil typically consists of a 2- to 4-cm-thick vesicular A horizon of silty sand, a 30- to 40-cm-thick, dark-yellowish-orange, cambic B horizon, and a 0.5-m-thick C horizon that has stage II carbonate development in the upper part.
Thickness 0 to more than 5 m

Qaw **Alluvium of Willow Spring (middle Pleistocene)**--Unit named for deposits about 3 km south of Willow Spring (Swadley and others, 1990) in the Delamar 3 SE quadrangle adjacent to the southwest. Pale-yellowish-brown to moderate-orange-pink interbedded gravel, gravelly sand, and sand; weakly to moderately well consolidated, poorly bedded, moderately well to poorly sorted; weakly cemented with secondary calcite along some bedding planes. Gravel and clasts in gravelly sand consist of angular to rounded pebbles, cobbles, and boulders of ash-flow tuff and lava as much as 1.5 m in diameter. Sand is fine to coarse and poorly sorted. Unit forms small remnants of steep fans of gravel and gravelly sand along the northwest flank of the Meadow Valley Mountains; large lower-gradient fans of gravel, gravelly sand, and sand along the west side of Kane Springs Valley; and interbedded terrace deposits of gravel, gravelly sand, and sand (not mapped separately from fan deposits) along Kane Springs Wash. Depositional surface of fans is largely intact but is moderately dissected by sharp, v-shaped washes. A tightly packed stone pavement is locally developed; some surface clasts have a dark-brown, dull to shiny rock varnish. Surface of unit commonly stands 2-5 m above active washes. Soil developed on unit typically has a 4- to 6-cm-thick clayey, silty sand vesicular A horizon, a cambic to slightly argillic B horizon that is sparsely preserved, and a 1- to 1.5-m-thick carbonate horizon that commonly has stage III carbonate development in the upper part. Thickness of unit 0 to more than 5 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 secondary 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 moderate-orange-pink gravel and gravelly sand; moderately well consolidated, poorly bedded, poorly sorted; weakly to moderately cemented with secondary calcite. Gravel consists of angular to subrounded pebbles, cobbles, and boulders of ash-flow tuff and lava; includes abundant boulders 0.6 to 1 m across and a few as much as 2 m across. Unit forms remnants of small fans adjacent to bedrock hills. Depositional surface of fans has been completely eroded; fan remnants are deeply dissected and have rounded interfluvial divides. Well exposed only in a few cutbanks; typical exposures have rubble-covered slopes littered with 1- to 2-m boulders and abundant chips of pedogenic carbonate. A tightly packed stone pavement is locally present on gently sloping surfaces. Surface clasts commonly have a dark-brown to black rock varnish. Soil developed on unit typically has a 4- to 6-cm-thick vesicular A horizon of clayey, silty sand overlying a 1- to 2-m-thick K horizon that has stage III carbonate development in the upper part. Soil commonly conforms to eroded surface of deposit and is probably approximately equivalent in age to the soil formed on unit Qaw. Unit is 0 to more than 25 m thick

QTes **Eolian silt (early Pleistocene? and Pliocene?)**--Very pale orange to very light gray and pinkish-gray carbonate-rich silt and minor sand; moderately well consolidated, massive, well sorted; moderately cemented with secondary calcite. Unit forms thin veneer on Tertiary alluvial fans (Ta). The veneer and underlying fans have been deeply dissected leaving only remnants of the veneer. Abundant pedogenic carbonate chips that litter the surface may represent a soil. Unit is 0 to more than 2 m thick

QTs **Landslide debris and gravity-slide block complex (Quaternary to late? Miocene)**--Complex mixture of unconsolidated debris and coherent blocks of igneous rocks. Crude stratigraphic order exists within slide debris. Debris is cemented locally by secondary carbonate. Surfaces are commonly littered with boulders as large as 2 m in diameter. Unit is at least 30 m thick locally. (Areas underlain by slide blocks and debris of a single bedrock unit are designated by that bedrock symbol; areas underlain by a mixture of lithologies are designated by QTS; in either case, unit is shown by coarse stipple pattern and, where appropriate, by fault trace with open teeth on the slide body)

Tc **Colluvium (Tertiary)**--Well consolidated talus; angular pebble- to boulder-size clasts and minor amounts of silt and sand. Colors of clasts are masked by very light gray, calcite cement. Unit is generally nonbedded; occurs along base of steep slopes developed on Tertiary basalt and rhyolitic ash-flow tuff. Unit thickness undetermined

Ta **Alluvium (Pliocene)**--Light-brownish-gray to medium-dark-gray gravel and sandy gravel; moderately to well consolidated, poorly sorted, poorly bedded; locally cemented by secondary carbonate. Gravel consists of angular to rounded clasts of basalt and minor silicic volcanic rocks in a pebbly sand matrix. Clasts as much as 2 m in diameter are common. Unit forms slightly to moderately dissected remnants of a fan on the east central side of the Meadow Valley Mountains. Well exposed in a few cutbanks exposures along active washes. Typically expressed as gentle to moderate, rubble-covered slopes littered with boulders and smaller clasts of the fan itself. Debris from overlying, calcite-cemented, eolian silt (QTes) obscures fan surface. Tertiary alluvium is distinguished from Quaternary and Tertiary alluvium (unit QTa) by greater degree of secondary carbonate cementation that is locally sparry. Unit ranges from 10 to as much as 40 m thick

Tfs **Fluvial sand (early Pliocene?)**--Pale-red and grayish-red to yellowish-gray very coarse sand and coarse gravel; moderately consolidated, poorly sorted, poorly bedded to non-bedded; locally cemented with secondary carbonate. Sand consists of subrounded grains of ash-flow tuff; gravel consists of subrounded to rounded boulders of ash-flow tuff as much as 1 m in diameter in a matrix of angular to subrounded pebbles and cobbles. Fluvial crossbeds are common. Only 2 m crop out at the sole exposure of the unit along a cut bank 0.8 km northwest of the southeastern corner of the quadrangle

Tmc **Muddy Creek Formation (?) early Pliocene? to late Miocene)**--Moderate-orange-pink to moderate-yellowish-brown silt and minor fine sand; poorly consolidated, moderately compacted, massive, well sorted. The Muddy Creek Formation is limited to two areas 0.4 km from the southeastern corner of the quadrangle along cutbanks where less than 4 m are exposed

POSTCOLLAPSE UNITS THAT FILL THE KANE SPRINGS WASH CALDERA IN THE DELAMAR MOUNTAINS

Try **Youngest rhyolite flows (Miocene)**--Medium-light-gray to light-gray, massive to flow-banded rhyolite containing 2-5 percent phenocrysts of quartz, sanidine, biotite, and ferroedenite (?). Most of unit is vitric; some zones contain devitrification spherulites 0.5-2 cm diameter. Unit consists of at least two flows separated by cooling breaks. The K-Ar sanidine date for the rhyolite is 13.3±0.4 Ma (Novak, 1984). Erosional remnants of flows form isolated caps on underlying basalt (Tbi); map unit is as thick as 60 m

Tbi **Basalt flows, intracaldera (Miocene)**--Medium-dark-gray to brownish-gray tholeiitic basalt flows containing less than 2 percent phenocrysts of plagioclase and olivine. Most of unit is massive but contains local scoriaceous zones; vesicles are partially filled with zeolites or calcite. Unit forms cap rock of small mesas and east-dipping cuestas and prominent cliffs within caldera. Because the K-Ar whole rock date for an intracaldera basalt in Kane Springs Wash caldera is 12.1±0.5 Ma (Best and others, 1980), this map unit must be a different, undated basalt, signifcantly older than the "young basalt lavas" of Novak (1984). Map unit is exposed in the northeastern part of the quadrangle and ranges from 10 to at least 65 m thick

Tlrbv **Late biotite rhyolite vent (Miocene)**--Pinkish-gray to pale-yellowish-brown, frothy, vitric rhyolite containing 5 percent phenocrysts consisting of quartz, sanidine, and biotite. Distinguished from late biotite rhyolite (Tlrb) by uniformly high-angle attitudes of flow-foliation, by a frothy, pumice-like matrix, and by a lense-shaped boundaries of the unit in the Elgin SW quadrangle to the north. Exposed at one locality along northern boundary of quadrangle where vent is as wide as 60m; the vent is nearly 400 m wide in the Elgin SW quadrangle

Tlrb **Late biotite rhyolite (Miocene)**--Light-brown to grayish-orange-pink, nonvesicular, devitrified, massive rhyolite containing 5 percent phenocrysts of quartz, sanidine, and biotite. Map unit fills a local topographic depression in northwestern part of the quadrangle; map unit as thick as 70 m in deepest part of the depression

Tlr **Late rhyolite flows (Miocene)**--Grayish-orange-pink, pinkish-gray, yellowish-gray, and light-brownish-gray, devitrified rhyolite flows ranging from flow-banded to lithophysal to massive. Vitrophyre is locally present at the base of flows. Rhyolite is aphyric in some flows but in other flows contains less than 8 percent phenocrysts of quartz, sanidine, and sparse biotite. Most flows have more quartz than sanidine phenocrysts. Vapor-phase quartz and amphibole are abundant in lithophysae; lithophysae are 0.5 to 2 cm in diameter. K-Ar sanidine dates for map unit are 13.3 ± 0.4 and 13.4 ± 0.6 Ma (Novak, 1984). Map unit is interlayered with late pyroclastic rhyolite (Tlp) in small cliffs and moderate to gentle slopes in the north-central part of the quadrangle. Map unit is as thick as 110 m and pinches out locally against the syenite complex toward the west

Tlp **Late pyroclastic (Miocene)**--Grayish-pink to very pale orange rhyolitic tuff including ash-fall tuff, nonwelded ash-flow tuff, and sparse reworked fluvial tuff. Ash-fall tuff locally has 0.2- to 5-cm-thick laminated and draped bedding. Phenocrysts of quartz, $\pm$sanidine, and $\pm$biotite form less than 5 percent of the rock. Unit contains sparse lithic fragments. Map unit exposed in the northwestern and north-central part of the quadrangle where it forms moderate slopes under the capping basalt (Tbi); map unit ranges from 0 to 50 m thick

Tbta **Basalt and trachyandesite flows (Miocene)**--Grayish red, devitrified, massive, plagioclase(?)-phyric basalt and trachyandesite flows containing sparse, silica-filled, pale-greenish-yellow amygdules 1-3 mm in diameter. Whole-rock K-Ar dates for map unit are 13.3 ± 0.6 and 13.5 ± 0.8 Ma (Novak, 1984). Map unit is highly weathered and is poorly exposed in moderate slopes of one wash in the northwest part of the quadrangle where it is 25 m thick

Tep **Early pyroclastic (Miocene)**--Very pale orange, pale-yellowish-orange, pale-red, and pinkish-gray bedded to massive, nonwelded to partially welded ash-flow tuffs, ash-fall tuffs, and sparse reworked tuffs. Rock contains 5 -20 percent phenocrysts of quartz, sanindine, and ferroedenite. In adjacent the Gregerson Basin quadrangle to the northwest (Scott and others, 1990a) and Delamar 3 NE quadrangle to the west (Scott and others, 1990b), map unit is intercalated with rhyolite flows that have K-Ar sanidine dates of 13.8$\pm$0.6 and 14.4$\pm$0.6 Ma (Novak, 1984). Map unit forms relatively gentle slopes or erosional benches, is laterally discontinuous where it pinches out against the syenite complex, and ranges between 0 and 50 m thick

Syenite complex (Miocene)--Complex of chemically related extrusive and intrusive units including, from uppermost to lowest, a trachytic ash-flow tuff (Ttaf), a trachytic lava flow (Ttf), and a subvolcanic xenolithic syenite (Txs). A minor trachyte ash-flow dike (Ttafd) intruded the trachyte ash-flow tuff (Ttaf). A syenite with a seriate texture intrudes the complex in the adjacent Delamar 3 NE quadrangle to the west (Scott and others, 1990b) and Gregerson Basin quadrangle (Scott and others, 1990a) to the northwest is not exposed in this quadrangle. K-Ar sanidine dates for syenite in the complex are 14.1$\pm$0.6 and 13.9$\pm$0.4 Ma (Novak, 1984). The trachyte ash-flow tuff (Ttaf) and underlying (but probably younger in part) trachyte flow (Ttf) appear to be the extrusive "skin" of the nearly coeval subextrusive xenolithic syenite (Txs)

Txs **Xenolithic syenite**--Grayish-pink, pinkish-gray, and light-brownish-gray porphyritic syenite containing xenoliths of pale-red trachyte. Xenoliths form a trace to 50 percent of the rock; locally xenoliths (0.5-25 cm 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. Map unit is gradational with the overlying trachyte flow (Ttf) over a few tens of meters in most places. Xenolithic syenite displays large-scale zonation in color (shown as dashed lines on map) with a wavelength greater than 100 m and an amplitude greater than 450 m; these features are probably related to flow foliation in the syenite body. Near the northwestern corner of the quadrangle, map unit forms moderate to steep slopes and is at least 350 m thick (base unexposed)

Ttf **Trachyte flow**--Light-brownish-gray to pale-red trachyte lava flow containing medium to coarse (0.2-10 mm long), 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 a discontinuous envelope above the xenolithic syenite (Txs) in most places. Foliation dips variably and unit is locally vesicular near the top. Upper part of flow is locally overlain by, and texturally gradational with, the trachytic ash-flow tuff (Ttaf). Map unit forms steep slopes in northwestern part of the quadrangle, is as thick as 240 m, and pinches out to the east

Ttaf **Trachytic ash-flow tuff (Miocene)**--Pale-red to grayish-red, devitrified, densely to partially welded, eutaxitic ash-flow tuff containing about 25 percent phenocrysts that consist largely of sanidine and small amounts of quartz, clinopyroxene, and opaque phases. Pumice fragments form less than 10 percent of the rock and, where highly flattened, are as great as 2 cm long. Lithic fragments consisting largely of fragments of the underlying trachytic flow (Ttf) form 20 percent of the rock and are 1-2 cm long. Map unit forms moderate to gentle slopes, is exposed in the northwestern part of the quadrangle, and is locally as thick as 60 m, but pinches out laterally over a distance less than 1 km

Ttafd **Trachytic ash-flow tuff dike (Miocene)**--Pale-red partially welded ash-flow tuff having nearly vertical foliation. A lense-shaped exposure bounded by nearly vertical contacts within the trachytic ash-flow tuff (Ttaf). Map unit is petrographically identical to trachytic ash-flow tuff (Ttaf). Map unit is exposed at one locality about 1.5 km east of the western boundary and 3 km south of the north boundary of the quadrangle

Tt **Trachyte flow, postcaldera (Miocene)**--Grayish-red, dusky-red and pale-red, devitrified, massive trachyte flow containing about 50 percent phenocrysts that consist principally of sanidine and minor clinopyroxene, opaque phases, and $\pm$quartz. Sanidine phenocrysts range from 0.2 to 1.5 cm long. The K-Ar sanidine date of the flow is 14.1$\pm$0.4 Ma (Novak, 1984). Exposures form low rounded hills and gentle to moderate slopes. In the two areas where map unit is exposed in the northwest part of the quadrangle, the unit is at least 40 m thick and its base is unexposed; younger covering units prevent determination of lateral extent

POSTCOLLAPSE UNITS THAT FILL THE KANE SPRINGS WASH CALDERA IN THE MEADOW VALLEY MOUNTAINS

Although this map and the report by Harding and others (1991) first described the Kane Spring Wash caldera wall and attributed the young volcanic rocks described below as caldera fill of the Kane Springs Wash caldera in the Meadow Valley Mountains, Pampeyan (1989) first suggested that the thick sequence of volcanic rocks north of the exposures of Kane Wash Tuff might be part of the volcanic fill within the Kane Springs Wash caldera.

Tbiu **Upper basalt flows, intracaldera (Miocene)**--Dark-gray and medium-dark-gray basalt flows, containing about 5 percent olivine phenocrysts and a trace of plagioclase phenocrysts; unit includes minor basaltic andesite. Map unit forms a volcanic center approximately at the 5386'-topographic high in the east-central part of the quadrangle. The flanks of the volcano consist exclusively of massive and vesicular dark-gray basalt flows. At the deeply eroded area northwest of the 5386'-topographic high, map unit is a heterogenous sequence including light-brownish-gray basaltic andesite flows, blackish-gray, dusky-red, and moderate-red, highly scoriaceous mounds of basaltic ejecta, and dark-gray basalt flows. This heterogenous sequence suggests close promximity to a volcanic vent that is also close to the boundary of the caldera. The map unit caps both caldera-filling rocks to the north and also caldera outflow facies consisting of the Kane Wash Tuff. K-Ar whole-rock ages of the basalt are 11.4 ± 0.4 and 11.6 ± 0.4 Ma (Novak, 1984). The map unit forms gentle hillsides on dip slopes and cliffs where flows have been deeply eroded; unit is about 950 m thick near the 5386'-topographic high

Tlir **Lithophysal rhyolite flow (Miocene)**--Light-brownish-gray, devitrified, massive, aphyric rhyolite flow containing about 10 percent lithophysal cavities about 1-2 cm in diameter. Lithophysae have concentric layers coated with fine-grained vapor phase crystals. Map unit is exposed only in one locality along the central-eastern boundary of the quadrangle where it has moderate to steep slopes and is about 50 m thick

Tbim **Middle basalt flow, intracaldera (Miocene)**--Dark-gray basalt flow containing about 5 percent olivine phenocrysts. Flow has scoriaceous upper and lower zones and a massive middle zone. Flow is exposed only along the northern part of the eastern boundary of the quadrangle where it has moderate to steep slopes and a thickness of about 15 m

Tbrd **Biotite-rhyolite dikes (Miocene)**--Very light gray to pale-red-purple, devitrified, massive, biotite-rhyolite dikes, locally including locally vitrophyres at the margins. Rock contains 15 percent phenocrysts of 50 percent quartz (<2 mm across), 40 percent sanidine (<4 mm long), and 10 percent biotite (<2.5 mm long). The K-Ar biotite date of 13.1$\pm$0.5 and sanidine date of 12.8$\pm$0.5 Ma are conformable (Harald Mehnert, written commun., U.S. Geological Survey, 1990). Dikes form small ridges and are typically 2-5 m wide but locally are 40 m wide

Trd **Rhyolite dikes (Miocene)**--Grayish-pink, pale-red-purple, medium-light-gray, light-brownish-gray and very light gray phyric rhyolite dikes, including quartz-sanidine-mafic phase-phyric, quartz-phyric, quartz-sanidine-phyric, and sanidine-phyric dikes. Dikes are in part massive and in part flow-banded; vitrophyres are sparse. Rocks range in phenocryst content from < 1 percent to 25 percent. Rhyolite dikes are commonly exposed in the northeastern part of the quadrangle in the Meadow Valley Mountains but are absent in the Delamar Mountain part of the quadrangle. Dikes dip steeply to the west, have little or no topographic expression, and are commonly < 1 m to 10 m wide, but are locally 130 m wide

Tard **Aphyric-rhyolite dikes (Miocene)**--Very light gray to light-gray, massive or flow-banded, aphyric rhyolite dikes, locally having glassy margins. Distribution of dikes restricted to northeastern part of quadrangle in Meadow Valley Mountains. Dikes range from 1 to 90 m thick

Tvc **Volcanic center (Miocene)**--Rhyolitic volcanic center consisting of a capping lava flow, a lithic-rich tuff, and cross-cutting dikes. Rocks associated with the center intersect older shallowly dipping volcanic units at steeply dipping contacts. A devitrified, very light gray, rhyolitic lava flow, characterized by pale-reddish-purple streaks caps the sequence. Flow contains 7 percent phenocrysts that consists of 35 percent quartz (< 1 mm across), 65 percent sanidine (< 2 mm long), and a trace of ferromagnesian and Fe-Ti oxide phases. Below the lava flow to the north, a nonbedded and nonwelded, very light gray to pinkish-gray tuff contains rhyolitic lithic fragments, locally forming as much as 80 percent of the rock and resembling volcanic bombs which are as much as 1 m in diameter. A grayish-pink, devitrified, rhyolite dike (about 1.5 m wide), which cuts the tuff, contains 3 percent phenocrysts that consist of 75 percent quartz (<2 mm across) and 25 percent sanidine (<2 mm long). Below the tuff, a complex network of cross-cutting dikes are poorly exposed in talus slopes where no country rock is exposed; these dikes are partly devitrified, are partly vitric, and contain quartz and sanidine phenocrysts; one dike also contains biotite. Rocks in the volcanic center cannot be correlated with other map units. Volcanic center forms steep slopes, is 100 m thick, and is 250 m wide

Tfb **Flow-banded rhyolite flows (Miocene)**--Very light gray, light-brownish-gray, and pale-red, devitrified, aphyric, thinly flow-banded (1-2 mm), rhyolite flows. Map unit consists of two flows which exist both within the Kane Springs Wash caldera and extends south above the caldera boundary where they lie above the Kane Wash Tuff. The upper flow is the more widespread of the two. Both flows locally have 5-m-thick glassy bases but the upper has distinctive marekanites (Apache tears) that erode from its glassy base. The K-Ar whole-rock dates are 13.7 ± 0.5 and 12.9 ± 0.7 Ma, for devitrified and vitric parts of the rock, respectively; the vitric material probably lost Ar and therefore the older age is considered more representative (Harald Mehnert, written commun., U.S. Geological Survey, 1990). Map unit forms steep slopes, and is as thick as 110 m, and pinches out south of the caldera boundary

Tyt **Yellow ash-flow tuff, undivided (Miocene)**--Very pale orange, grayish-orange-pink, and grayish-yellow, devitrifed, nonwelded to partially welded, rhyolitic ash-flow tuff, including minor ash-fall tuff. The yellow ash-flow tuff is undivided close to the southern wall of the caldera, but toward the north, deposition of the map unit was interrupted by eruption two rhyolite lava flows. The younger lava flow is the biotite rhyolite flow (Tbr) and the older is the red lithic rhyolite flow (Trlr). The map unit overlies the bitotite rhyolite flow only in the Vigo NE quadrangle east of the boundary of this quadrangle. Although a tongue of the yellow ash-flow tuff separates the biotite rhyolite flow (Tbr) from the red lithic rhyolite (Trlr) in more southern exposures, toward the north the tongue pinches out where biotite rhyolite flow rests directly on red lithic rhyolite. North of the southernmost exposures of the red lithic rhyolite flow (Trlr), the yellow ash-flow tuff is subdivided into the upper yellow ash-flow tuff (Tytu) above the red lithic rhyolite and the lower yellow ash-flow tuff (Tytl) below the red lithic rhyolite. Unit forms gentle, rounded slopes and ranges from 0 to 230 m thick

Tytu **Upper yellow ash-flow tuff (Miocene)**--Very pale orange, grayish-orange-pink, and grayish-yellow, devitrifed, nonwelded to partially welded, ash-flow tuff, including crudely bedded ash-fall layers about 0.5 to 2 m thick. Rock contains 2-3 percent phenocrysts that consists of 31-44 percent quartz, 45-57 percent sanidine, and 2-11 percent plagioclase, 0-2 percent biotite, and 1-8 percent opaque (altered clinopyroxene? in part) (2 thin sections, 3930 and 4121 total point counts). Unit contains about 5-10 percent lithic fragments and abundant pumice fragments. Unit forms gentle to moderate, rounded slopes and ranges from 0 to 100 m thick

Tbr **Biotite-rhyolite flow (Miocene)**--Pinkish-gray to pale-red-purple, devitrified, massive, biotite-rhyolite flow, commonly including a grayish-black vitrophyric base about 20 cm thick. Rock contains 10-15 percent phenocrysts that consist of 30 percent quartz (about 1 mm across), 60 percent sanidine (< 3 mm long), and 10 percent biotite (< 1 mm long). Flow forms steep cliffs. Flow is as thick as 55 m but pinches out to the north along the eastern boundary of the quadrangle; upper part of unit is unexposed in this quadrangle but is exposed to the east in the Vigo NE quadrangle

Trlr **Red lithic rhyolite flow (Miocene)**--Pale-red to dusky-red, flow-banded, massive, and autobrecciated rhyolite flow containing grayish-red basaltic xenoliths. Rock contains 15 percent phenocrysts that consist of 75 percent quartz and 25 percent sanidine. Size, abundance, and distribution of basaltic xenoliths change greatly with locality; some are 15 cm long. Groundmass of xenoliths contains plagioclase and pyroxene. Unit forms gentle slopes to steep cliffs, is as thick as 85 m, and pinches out near the southern wall of the caldera

Tytl **Lower yellow ash-flow tuff (Miocene)**--Very pale orange, grayish-orange-pink, and grayish-yellow, devitrifed, nonwelded to partially welded ash-flow tuff, locally including moderate-red to grayish-red, tuffaceous sandstone or moderate-red, densely welded ash-flow tuff at its base. Also, a grayish-orange-pink densely welded and silicified ash-flow tuff locally is present just above the base. Unit also contains minor ash-fall tuff. Rock contains 6 percent phenocrysts that consist of 60 percent quartz, 10 percent sanidine, and 10 percent plagioclase, trace of biotite, and 10 percent opaque (altered clinopyroxene? in part) (one thin section, 3616 total point counts). Unit contains about 10 percent lithic fragments and abundant pumice fragments. Unit forms gentle, rounded slopes and ranges from 0 to 15 m thick

Tgt **Gray ash-flow tuff (Miocene)**--Very light gray to grayish-orange-pink partially welded to moderately welded, devitrified, rhyolitic, ash-flow tuff, including a less welded, very light gray upper part and more welded, grayish-orange-pink lower part. Rock contains 14-19 percent phenocrysts that consist of 10 to 22 percent quartz, 71-73 percent sanidine, <1-3 percent plagiclase, trace of biotite, and 3-19 percent opaque phases (2 thin sections, 2000 and 2065 total counts). Sanidine is adularescent. Pumice fragments are sparse; rock contains < 1 percent lithic fragments. Lower part contains the more abundant opaque phases, basaltic lithic fragments, and moderate-brown, altered, mafic clots. Map unit forms a ledge below a gentle slope and ranges from 5 to 25 m thick

Tbil **Lower basalt flow, intracaldera (Miocene)**--Grayish-black, generally massive, basalt flow containing sparse plagioclase phenocrysts less than 1 mm long. Unit is thin and discontinuous in most of the caldera but is locally as thick as 25 m in the northeast part of the quadrangle

Twb **Caldera-wall breccia (Miocene)**--Coarse, angular, boulder breccia deposited as a wedge of debris along the wall of the Kane Springs Wash caldera wall, consisting mostly of clasts of precaldera trachyte (Tpt) and the Grapevine Spring unit (Tkg) of the Kane Wash Tuff. Clasts range from 2 mm to 2 m long. One large clast (200 m long) is partly enveloped with a vitrophyre of the flow-lineated rhyolite (Tfl). The tuffaceous matrix is pale reddish brown, partially welded, devitrified, and contains phenocrysts of quartz and sanidine. Breccia is discontinuously exposed along the caldera wall. Locally, unit may be as thick as 40 m inflow facies units that fill the Kane Springs Wash Caldera in the Meadow valley Mountains

INFLOW FACIES THAT FILL THE KANE SPRINGS WASH CALDERA IN THE MEADOW VALLEY MOUNTAINS

Tfl **Flow-lineated ash-flow tuff (Miocene)**--Rhyolitic, flow-lineated ash-flow tuff consisting of partially welded top, densely welded middle, and layered basal zones. The flow-lineated ash-flow tuff is considered to be the inflow facies equivalent of the upper Gergerson Basin cooling unit of the Kane Wash Tuff (Tkbu). The top zone consists of pale-red, frothy, rhyolitic, ash-flow tuff containing grayish-red trachytic inclusions. Top zone contains 22-39 percent phenocrysts that consist of 27-29 percent quartz, 57-61 percent sanidine, <1-5 percent opaque phases, 9-11 percent mafic phases (clinopyroxene?) (2 thin sections, 2069 and 2707 total counts). Trachytic inclusions form <1 percent to 25 percent of the rock, contain alkali-feldspar phenocrysts, range from 1 cm to 2.5 m long, and are generally elongate parallel to the foliation of the ash-flow tuff matrix. At some localities, a yellowish-gray tuffaceous sandstone and light-brownish-gray, nonwelded tuff are included in the top zone. Top zone is about 40 m thick. The middle zone consists of a densely welded, devitrified, light-gray matrix that contains stringers of very light gray matrix aligned parallel to foliation. A strong flow lineation of ridges of matrix material generally occurs on the foliation in this zone. Middle zone contains 20 percent phenocrysts that consist of 30 percent quartz (most <2 mm in diameter), 60 percent sanidine (<5 mm, some adularescent), 10 percent mafic phases (altered grayish red, possibly pyroxene). Middle zone is about 70 m thick. The basal zone is densely welded, layered, and less than 3 m thick; from top to bottom: a pale-red, hackly fractured layer containing 20 percent phenocrysts; a pale-red and light-greenish gray (in a few places, dark-yellowish-brown) layer containing 10 percent phenocrysts including some white, altered sanidine; a grayish-red layer containing <5 percent phenocrysts; a pale-red layer containing 50 percent phenocrysts of quartz and sanidine; and in some places, a black vitrophyre. The K-Ar sanidine dates of

the map unit are 14.6±0.4 and 14.9±0.5 Ma (Harald Mehnert, written commun., U.S. Geological Survey, 1990) and the $^{40}Ar/^{39}Ar$ sanidine date of the map unit is 14.43±0.14 Ma (Lawrence Snee, written commun., U.S. Geological Survey, 1991). Basal and middle zones form steep slopes and cliffs and the top zone forms gentle slopes. Map unit is about 110 to 200 m thick

Tcj **Columnar-jointed ash-flow tuff (Miocene)**--Rhyolitic, flow-lineated, and columnar-jointed, ash-flow tuff consisting of partially welded top, densely welded middle, and layered basal zones. The columnar-jointed tuff is considered to be the inflow facies equivalent to part of the Gregerson Basin cooling unit of the Kane Wash Tuff (Tkb). The top zone consists of grayish-pink to pale-red-purple, rhyolitic, ash-flow tuff. Top zone contains 7 percent phenocrysts that consist of 27 percent quartz, 62 percent sanidine, 2 percent opaque phases, 8 percent mafic phases (clinopyroxene?) (1 thin section, 3483 total counts). Top zone is about 35 m thick. The middle zone consists of a densely welded, devitrified, light-gray to medium-light-gray, ash-flow tuff. Rock has a weak foliation. Middle zone contains 15 percent phenocrysts that consist of 30 percent quartz, 60 percent sanidine (some adularescent), and 10 percent mafic phases (possible pyroxene). Middle zone is about 90 m thick. The basal zone is densely welded and layered and is less than 5 m thick; but at some places, the entire basal zone is less that 30 cm thick. From top to bottom, the basal zone consists of: a light-bluish-gray layer containing 20 percent phenocrysts; a pale-red layer containing 20 percent phenocrysts; a black vitrophyric layer; and a greenish-gray altered vitrophyre at the basal contact. The K-Ar sanidine date of the columnar-jointed ash-flow tuff is 14.6 ± 0.5 Ma (Harald Mehnert, written commun., U.S. Geological Survey, 1990). Basal and middle zones form steep slopes and cliffs and the top zone forms gentle slopes. Map unit is about 130 m thick

Tlt **Lithic-rich ash-flow tuff (Miocene)**--Light-brownish-gray to grayish-red-purple, partially to moderately welded, devitrified, rhyolitic ash-flow tuff containing abundant lthic fragments. The lithic-rich tuff is considered to be the inflow faices equivalent of part of the Kane Wash Tuff. Only the upper 5 m of unit are exposed near range-front fault. Exposures are brecciated and partly covered with colluvial debris. Rock contains 20 percent phenocrysts that consist of 15 percent quartz, 80 percent sanidine, and 5 percent altered mafic phases. Sanidine is extensively altered, leaving 3-dimensional, lattice-like, remnant crystals. Rock contains about 30 percent pale-red to grayish-red trachytic xenoliths (?); one type of xenolith has 5-7-mm-long alkali-feldspar phenocrysts and a second type has <2-mm-long alkali-feldspar phenocrysts. Unit greater than 5 m thick

EXTRACALDERA UNITS

Tb **Basalt flows, extracaldera (Miocene)**--Medium-dark-gray and dark-gray basalt flows containing less than 10 percent phenocrysts of olivine, plagioclase, and clinopyroxene. Flows have scoriaceous tops and bottoms and are massive in the middle. Unit forms low exposures under eolian silt (QTes) and Tertiary alluvium (Ta) in southeastern part of the quadrangle. Exposed upper part of unit is about 40 m thick

Tpr **Pumice-rich ash-flow tuff (Miocene)**--Pale-red, grayish-orange pink, and pale-reddish-brown, vitric, nonwelded to moderately welded, rhyolitic, ash-flow tuff containing conspicuous blackish-red to dark gray pumice fiamme in the more welded parts. Pumice fragments form as much as 85 percent of the rock, and nonwelded tuff contains white pumice fragments that range from 0.1 to 15 cm long. Rock contains about 7 percent phenocrysts that consist of 12 percent quartz, 25 percent sanidine, 42 percent plagioclase, 5 percent biotite, 3 percent hornblende, 4 percent clinopyroxene, and 9 percent opaque phases (one thin section, 2925 total point counts). Phenocrysts are generally less than 1 mm diameter. Lithic fragments of devitrified rhyolite form about 7.5 percent of the nonwelded tuff. Map unit is exposed in the central part of the quadrangle where it forms wedge-shaped layers between the less steeply dipping upper caldera-filling basalt (Tbiu) and the more steeply dipping underlying Kane Wash Tuff. Thin biotite-bearing tuffaceous sandstone included in the map unit occurs locally between the map unit and the overlying basalt. Map unit probably has a local source (Kane Springs Wash caldera?) because of its high abundance and large size of pumice fragments. Map unit forms gentle to moderate slopes and is as thick as 35 m

OUTFLOW FACIES FROM THE KANE SPRINGS WASH CALDERA

Kane Wash Tuff (Miocene)--Peralkaline ash-flow tuff sequence includes two newly defined members (Scott and others, in press), the Gregerson Basin Member (Tkb) and the Grapevine Springs (Tkg) Member of the Kane Wash Tuff that were erupted from the Kane Springs Wash caldera. Kane Wash Formation as used by Cook (1965), Kane Wash Tuff as redefined by Noble (1968), and informal V_3, V_2, V_1, W, and O members of the Kane Wash Tuff as used by Novak (1984) have been abandoned (Scott and others, in press). The names of the two oldest members of the Kane Wash Tuff, W member and O member of Novak (1984) have been replaced with new formation names, the Sunflower Mountain Tuff (Tsm) and the Delamar Lake Tuff (Tdl), respectively (Scott and others, in press); these chemically distinct and older tuffs were not derived from the Kane Springs Wash caldera. Both the Sunflower Mountain and Delamar Lake Tuffs are descibed below

Tkb **Gregerson Basin Member, undivided**--Comenditic to trachytic ash-flow tuff consisting of an upper and a lower cooling unit. Upper and lower units are indistinguishable where faulted out of stratigraphic sequence. See descriptions of upper cooling unit (Tkbu) and lower cooling unit (Tkbl) below for details of map unit descriptions

Tkbu **Upper cooling unit**--Comenditic to trachytic ash-flow tuff consisting of one cooling unit containing an upper interval consisting of a mafic trachytic cap and a lower interval consisting of comenditic upper and basal zones. Upper cooling unit of the Gregerson Basin Member is equivalent to V_3 member of Novak (1984). The trachytic cap is mostly devitrified but partly vitric, partially welded to moderately welded, and grayish orange pink. Trachytic cap contains as much as 15 percent cognate inclusions that are 1-20 cm long, are pale brown to grayish brown, contain about 50 percent phenocrysts of alkali feldspar, and are slightly scoriaceous; the trachytic cap is only locally exposed where protected from erosion. In the commenditic interval, the upper zone is devitrified, moderately to densely welded, and yellowish gray in most of the zone but is pale blue and light bluish gray in some strata. Upper zone contains about 10 percent highly flattened pumice fragments that enhance parting parallel to the plane of compaction. Upper zone has 0-10 percent lithophysal cavities that contain vapor-phase crystals of amethyst and blocky mafic minerals (riebeckite and unidentified phases). Upper zone contains about 20 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenbergite, fayalite, and ilmenite; mafic phases are commonly altered. Upper zone ranges from 0 to about 15 m thick. The lower zone is mostly devitrified, moderately to densely welded, commonly mottled pale blue and medium bluish gray where devitrified and medium dark gray where vitrophyre is 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. Lower zone ranges from 0 to 5 m thick. The $^{40}Ar/^{39}Ar$ sanidine date for the upper cooling unit is 14.39 ± 0.28 Ma (L.W. Snee, written commun., U.S. Geological Survey, 1991).

Cooling unit forms moderate slopes. Thickness of the upper cooling unit ranges from 0 to 20 m

Tkbl **Lower cooling unit**--Comenditic to trachytic cooling unit of ash-flow tuff consisting of an upper interval of mafic trachytic rock and a lower interval formed by comenditic upper, middle, and basal zones. The lower cooling unit of the Gregerson Basin Member is equivalent to the V_2 member of Novak (1984). The trachytic cap is mostly devitrified but partly vitric, partially welded to moderately welded, and pale yellowish brown. Trachytic cap contains as much as 20 percent cognate inclusions that are 1-30 cm long, are pale brown to grayish brown, contain about 50 percent phenocrysts of alkali feldspar, and are slightly to highly scoriaceous. In the commenditic interval, the upper zone is devitrified, moderately to densely welded, and pinkish gray to yellowish gray in most of the zone but is pale blue and light bluish gray in some strata. Upper zone contains about 20 percent highly flattened pumice fragments that enhance parting parallel to the plane of compaction. Upper zone has 0-5 percent lithophysal cavities that contain vapor-phase crystals of amethyst and blocky mafic minerals (riebeckite and unidentified phases). Upper zone contains about 20 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenbergite, fayalite, and ilmenite; mafic phases are commonly altered. Upper zone ranges from 5 to about 100 m thick. The middle zone is mostly devitrified, moderately to densely welded, commonly mottled pale blue and medium bluish gray. 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 zone ranges from 1 to 5 m thick. The basal zone is commonly nonwelded to partially welded, moderate orange pink to pale yellowish orange, contains slightly fewer phenocrysts than middle zone, and is 1 to 4 m thick. Map unit characterized by conspicuous, adularescent sanidine

phenocrysts. The K-Ar sanidine date for the lower cooling unit is 14.1±0.4 Ma (Novak, 1984), and the $^{40}Ar/^{39}Ar$ sanidine date is 14.55±0.14 Ma (L.W. Snee, written commun., U.S. Geological Survey, 1991). Cooling unit forms cliffs to moderate slopes. Thickness of the upper cooling unit ranges from 10 to 120 m

Tkg **Grapevine Spring Member**--Rhyolitic to trachytic ash-flow tuff consisting of one compound cooling unit. Map unit is unit V_1 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 to brownish gray. Upper zone weathers to form smooth-textured surfaces; this smooth texture may be related to a relatively low abundance of phenocrysts (< 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 hedenbergite, fayalite, and ilmenite. Lithic fragments are sparse. Upper zone ranges from about 20 m to 40 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 may 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 35 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenbergite, fayalite, and ilmenite. Middle zone contains less than 2 percent lithic fragments and ranges from about 80 to 160 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 5 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 below the overlying Gregerson Basin unit. At this stratigraphic level in several localites, the groundmass of a partially welded tuff has been replaced by light-gray calcium carbonate, leaving adularescent sanidine phenocrysts unaltered. Map unit characterized by moderate abundance of adularescent sanidine phenocrysts. The K-Ar sanidine dates for the map unit are 14.0 ± 0.4 and 14.2 ± 0.4 Ma (Novak, 1984), and the $^{40}Ar/^{39}Ar$ sanidine date is 14.67 ± 0.22 Ma (L.W. Snee, written commun., U.S. Geological Survey, 1991). The Grapevine Spring Member is about 210 m thick near the caldera margin in the Meadow Valley Mountains and thins to 85 m thick in the south part of the quadrangle

MAP UNITS UNRELATED TO KANE SPRINGS WASH CALDERA

Tpt **Precaldera trachyte (Miocene)**--Pale-red to grayish-red, devitrified, trachytic lava flow containing conspicuous alkali feldspar phenocrysts. Map unit is the precaldera trachyte of Novak (1984). In one locality, two cooling breaks occur, indicating at least three flows. Alkali feldspar 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 phenocrysts are probably clinopyroxene. Trachyte flow is massive and has no flow banding. A very dusky red to black basal vitrophyre occurs in some places. The K-Ar sanidine ages of map unit are 13.6$\pm$0.4 and 14.2$\pm$0.4 Ma (Novak, 1984). Unit forms rugged, steep slopes and small cliffs. In the east-central part of quadrangle map unit reaches 180 m thick close to the caldera wall but pinch out to the south

Tot **Older comenditic ash-flow tuffs (Miocene)**--Pale-red-purple, devitrified, densely welded, rhyolitic ash-flow tuff containing 5-7 percent phenocrysts that consist of 25 percent quartz, 75 percent sanidine, and a trace of mafic phases. Map unit limited to three small exposures near center of quadrangle, east of the Kane Springs Valley fault. Maximum age is uncertain because older rocks are not exposed below the map unit. Unit forms a small bench; only 2 m of the unit are exposed

Tsm **Sunflower Mountain Tuff, undivided (Miocene)**--Pinkish-gray to grayish-pink, devitrified, nonwelded to moderately welded ash-flow tuff consisting of a compound cooling unit. An upper and a lower zone of the compound cooling unit, (Tsmu and Tsml, respectively) are described separately below. The Sunflower Mountain Tuff is a newly defined formation (Scott and others, in press), replacing the informal name W member of Novak (1984) of the Kane Wash Tuff. Pumice fragments form about 20 percent of the rock. Rock contains 5-20 percent phenocrysts that consist of subequal amounts of quartz and sanidine and sparse, altered, mafic minerals. Volcanic lithic fragments form 1-20 percent of the rock. The K-Ar sanidine date for the map unit is 14.7$\pm$0.4 Ma (Novak, 1984). Unit is about 220 m thick

Tsmu **Upper zone**--Pinkish-gray to pale-red and mottled, devitrified, partially welded to moderately welded ash-flow tuff consisting of the upper, more welded zone of the Sunflower Mountain Tuff. Mottling consists of distinctive moderate-orange to very pale orange altered blotches in a pale-red matrix. Pumice fragments form about 20 percent of the rock and are as long as 15 cm in the plane of foliation. Rock contains 20 percent phenocrysts that consist of subequal amounts of quartz and sanidine and sparse hedenbergite and fayalite. Volcanic lithic fragments form about 1 percent of the rock. Map unit forms moderate slopes to bold cliffs and has a thickness of 60-140 m

Tsml **Lower zone**--Pale-orange to grayish-orange, devitrified, nonwelded to partially welded ash-flow tuff consisting of the lower, less welded zone of the Sunflower Mountain Tuff. Pumice fragments form about 20 percent of the rock and are 0.5 to 3 cm long. Rock contains about 10 percent phenocrysts that consist of subequal amounts of quartz and sanidine and sparse altered mafic minerals. Volcanic lithic fragments form about 20 percent of the rock. Map unit forms gentle to moderate slopes and has a thickness of 140-210 m

Tdl **Delamar Lake Tuff (Miocene)**--Grayish-pink to pale-red, devitrified, moderately to densely welded ash-flow tuff consisting of two cooling units. The Delamar Lake Tuff is a newly defined formation (Scott and others, in press), replacing the informal name O member of Novak (1984) of the Kane Wash Tuff. Pinkish-gray, flattened, pumice fragments as large as 4 cm across in the plane of foliation form about 10 percent of the tuff. Rock contains about 20 percent phenocrysts that consist of 25 percent quartz, 70 percent sanidine, and 5 percent fayalite and other mafic minerals. Less than 2 percent of the rock consists of lithic fragments. Map unit is slightly but pervasively hydrothermally altered from the southern edge of the Kane Springs Wash caldera margin to 3 km south in the Meadow Valley Mountains. Unaltered younger Sunflower Mountain unit (Tsm) restricts age of alteration. Altered rocks display Liesegang rings of yellowish-gray to light-red iron oxides in some places; other colors in altered rocks are pale pink, pale red purple, pale yellowish orange, and moderate reddish orange. The K-Ar sanidine dates for the unit are 15.5 ± 0.4 and 15.8 ± 0.4 Ma (Novak, 1984). Map unit ranges from about 60 to 120 m thick

Th **Hiko Tuff (Miocene)**--Rhyolitic ash-flow tuff consisting of one cooling unit. Rock is devitrified, moderately to densely welded, and light brownish gray. Tuff is slightly but pervasively hydrothermally altered from the southern edge of the Kane Springs Wash caldera margin to 3 km south in the Meadow Valley Mountains. Unaltered younger Sunflower Mountain unit (Tsm) restricts age of alteration. Altered rock is grayish orange to dark yellowish orange. 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 hornblende 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 $^{40}Ar/^{39}Ar$ biotite date for the Hiko Tuff is reported as 18.5 ± 0.4 Ma, but the best estimate may be 18.6 Ma based on other data (see Taylor and others, 1989). Unit thickness is about 80 m

Tpw **Partially welded ash-flow tuff (Miocene)**--Grayish-pink to moderate pink, devitrified, partially welded ash-flow tuff containing about 5 percent phenocrysts of quartz, sanidine, plagioclase, and biotite. Rock contains sparse pumice and lithic fragments. Unit forms gentle to moderate slopes where exposed south of a fault that predates the Hiko Tuff. Thickness of map unit is about 60 m

Tss **Tuffaceous sandstone (Miocene)**--Grayish-orange-pink to moderate-orange-pink, poorly sorted, poorly bedded, poorly to moderately cemented, tuffaceous sandstone containing angular clasts of pumice fragments and reworked phenocrysts. Matrix consists of reworked ash shards. Unit forms gentle to moderate slopes and is about 70 m thick where exposed south of a fault that predates the Hiko Tuff

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 to a nonwelded base. Tuff is devitrified, phenocryst-rich, and massive, displaying 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 dates of the Harmony Hills Tuff 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 is not used here because the source(s?) of two of the ash-flow tuffs within the group have not been recognized. Unit forms gentle to steep slopes. Thickness of map unit is about 160 m

Tad **Andesitic dike (Miocene?)**--Grayish-red, devitrified, massive andesitic dike containing 25 percent phenocrysts consisting of about 60 percent plagioclase and 40 percent clinopyroxene. Unit is exposed at one short dike that intruded the Bauers Tuff Member of the Condor Canyon Formation (Tcb) about 2.2 km north of the southern boundary of the quadrangle. Dike is about 2 m wide

Tcb **Bauers Tuff Member of the Condor Canyon Formation (Miocene)**--Rhyolitic ash-flow tuff consisting of one simple cooling unit. Tuff is moderately to densely welded, devitrified, pale red purple, pale purple, and moderate yellowish brown. Highly flattened pumice fragments occur as elongate (1-25 cm 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, 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. Unit forms indistinct ledge. The $^{40}Ar/^{39}Ar$ date for the Bauers Tuff member is 22.8 ± 0.03 Ma (Best and others, 1989). Map unit is about 20 m thick

Tlc **Leach Canyon Formation (Oligocene)**--Rhyolitic ash-flow tuff consisting of one compound cooling unit, grading downward from grayish-pink, partially welded, devitrified tuff, through grayish-orange-pink moderately welded devitrified tuff, to pinkish-gray nonwelded to partially welded devitrified tuff at the base. Pumice fragments less than 0.5 cm in diameter and form less than 5 percent of the rock. Rock contains about 15 percent phenocrysts that consist of 35 percent quartz, 25 percent sanidine, 35 percent plagioclase, 5 percent biotite, and a trace of hornblende. Lithic fragments are sparse. Unit forms gentle, undulating slopes. Average K-Ar age of Leach Canyon Formation is about 24.7 Ma (Armstrong, 1970). Unit is about 180 m thick

Tl **Limestone (Oligocene?)**--Lacustrine limestone containing disrupted algal plates. Limestone is very light gray to pinkish gray, medium grained, and recrystallized. Beds range from 0.2 to 2 m thick. Unit is as thick as 55 m

PPb **Bird Spring Formation (Permian and Pennsylvaian)**--Medium-gray, light-brown, and pale-red-purple limestone. Limestone is aphanitic to finely crystalline and arenaceous; discontinuous beds and nodules of chert are common. Beds range in thickness from 0.1-2.5 m. Rock has abundant beds of pale-red and grayish-orange chert; also contains shaley limestone and shale that weather as recessive layers between more resistant limestone beds. Less common are interbeds of light-gray silty dolomite, light-brown sandstone, and siltstone. Locally highly fossiliferous (corals, pelmatazoan stems, brachiopods, fusulinids, and gastropods). Unit forms ledgey slopes. Although upper part of Bird Spring Formation has been eroded, at least 85 m of the lower part of the map unit are exposed

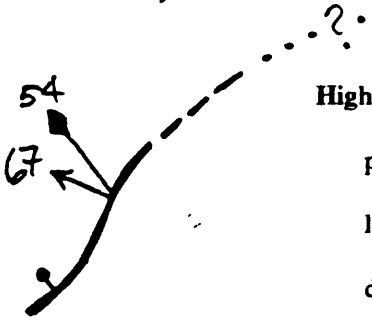
Msw **Scotty Wash Formation (Mississippian)**--Limestone and subordinate siltstone and fine-grained sandstone. Limestone is medium gray (fresh) and dark yellowish orange to light brown (weathered), arenaceous, medium to coarsely crystalline, and thin bedded. Limestone contains very thin beds of grayish-red siltstone and fine-grained sandstone. Brachiopods, solitary corals, and pelmatozoan stems are common at several intervals where coarse fossil hash forms cross-bedded sandstone layers. Unit forms ledgy slopes and is about 40 m thick

Mc **Chainman Shale (Mississippian)**--Clastic and carbonate sedimentary rocks consisting of two members. Upper member consists of micaceous, dark-yellowish-brown, olive-gray, and blackish-red, fissile shale containing beds of grayish-brown siltite and yellowish-gray limestone near top. Black fissile shale includes minor phosphorite and phosphatic black shale. Upper member is well exposed only in washes and is estimated to be 215 m thick (Duley, 1975). Lower member consists of a laminated to thinly laminated, grayish-red-purple (fresh) and moderate-yellowish-brown (weathered) siltstone. Contains subordinate interbedded medium-gray to light-olive-gray, arenaceous, finely to coarsely crystalline, and thin-bedded crinoidal limestone; bedding-parallel laminations are common. Lower member erodes to ledgy slopes and is estimated to be about 70 m thick

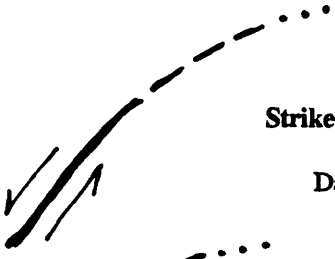
Contact

Dip of contact

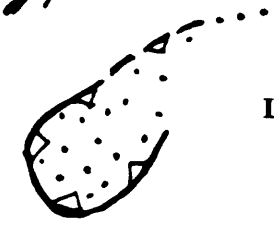
Cooling break between ash-flow tuffs or lava flows



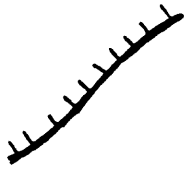
High-angle normal or reverse fault--showing dip (barbed arrow) and trend and plunge of lineation (diamond-shaped arrow). Dashed where approximately located; dotted where concealed; queried where uncertain. Bar and ball on downthrown side



Strike- or oblique-slip fault--Arrows show relative direction of lateral offset. Dashed where approximately located; dotted where concealed

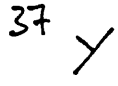


Low-angle fault beneath slide block--Open sawteeth on upper plate of slide block. Dashed where approxiamtely located; dotted where concealed. Coarse stipple pattern on upper plate



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



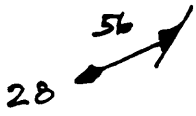
Inclined

Horizontal

Trend and plunge of flow lineation on compaction foliation

Strike and dip of flow foliation in lava flow

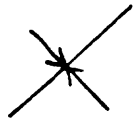
Inclined



Flow lineation on flow foliation

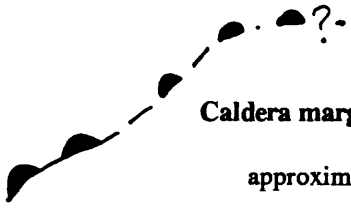
Flow lineation

Anticline



Syncline

Hydrothermally altered area--fine stipple pattern



Caldera margin--Half-circles on down-dropped caldera interior. Dashed where approximately located; dotted where concealed; queried where uncertain

Prospect

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Correlation of Map Units

Vigo NW quad, NV
Scott and others