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PRELIMINARY GEOLOGIC MAP OF THE DELAMAR 3 SW QUADRANGLE, LINCOLN COUNTY, NEVADA

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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 development reported for soils is a visual estimate using standards defined by Gile and others (1966). Surficial and bedrock unit colors are from the Rock-Color Chart (Rock-Color Chart Committee, 1951). Descriptions of volcanic units are based largely upon megascopic identification and estimates of phenocryst abundances, except where noted by reference]

Qahl **Alluvium (late Holocene)**--Pale-yellowish-brown to grayish-orange sand, gravelly sand, and gravel; unconsolidated to weakly consolidated, poorly sorted, and poorly bedded. Gravel is angular to well-rounded clasts of ash-flow tuff, lava, limestone, dolomite, and sandstone. Clasts are mostly cobble and pebble size; in the large wash that drains the east-central part of the quadrangle, rounded boulders 1-1.5 m in diameter are common. Unit forms channel and flood-plain deposits of active washes. Along Pahranagat and Kane Springs Washes, deposits are largely sand; in smaller washes, gravelly sand and gravel are more abundant. In the southern part of Pahranagat Wash, deposits locally include beds of silt. Surface of unit is commonly smooth in large washes and bar-and-swale topography common in smaller washes and in most active channels. No soil observed. Unit ranges from 0 to thicker than 3 m

Qd **Sand dunes (Holocene?)**--Pale-yellowish-brown sand; moderately well sorted, unconsolidated, nonbedded; chiefly medium sand and minor silt that form small vegetation-stabilized dunes near the southwest corner of the quadrangle. No soil observed. Unit ranges from 0 to 8 m thick

Qsh **Sheet sand deposits (Holocene)**--Pale-yellowish-brown sand, unconsolidated, moderately well sorted, nonbedded. Chiefly medium sand containing sparse cobbles and pebbles and minor amounts of silt. Wind-transported sand derived from channels of Pahranagat and Kane Springs Washes and containing gravel reworked from underlying alluvium by flooding and bioturbation. Unit forms discontinuous thin deposits on terraces and fans adjacent to Pahranagat and Kane Springs Washes. Where unit only partly covers underlying units, early Holocene alluvium (Qahe), younger middle Pleistocene terrace deposits (Qtmy), and older middle Pleistocene terrace deposits (Qtmo), the underlying units are identified by fractional symbols (Qsh/Qahe, Qsh/Qtmy, and Qsh/Qtmo), respectively. Surface smooth to hummocky. No soil observed. Unit ranges from 0 to 3 m thick

Qahe **Alluvium (early Holocene)**--Yellowish-brown to grayish-orange sand, gravelly sand, and gravel; poorly to well sorted, moderately well bedded to poorly bedded, weakly consolidated to unconsolidated. Gravel consists of angular to rounded clasts of ash-flow tuff, lava, limestone, dolomite, and sandstone. Unit forms steep bouldery fans in the northwest quarter of the quadrangle, sand and gravel inset fans and terrace deposits along small washes, sand and gravelly sand terrace deposits along small washes, as well as along Pahranagat and Kane Springs Washes. Deposits commonly stand 1 to 2 m above active washes. Surface of deposits are smooth on terraces and low-gradient inset fans; near heads of larger fans, bar-and-swale topography and patches and trains of 1- to 2-m-diameter boulders are common. A weakly developed stone pavement is locally present; a few surface clasts have poorly developed rock varnish. Soil development on unit consists of a thin sandy vesicular A horizon and a 0.5-m-thick C horizon with stage I carbonate. No color change was observed in the B horizon. Unit ranges from 0 to greater than 4 m thick

Qc **Colluvium (Holocene and Pleistocene)**--Unconsolidated to moderately consolidated debris consisting chiefly of talus; angular pebble- to boulder-sized clasts, and minor amounts of silt and sand. Colors are inherited from bedrock source. Unit is generally nonbedded and locally cemented by secondary carbonate; occurs along base of steep slopes developed on Tertiary volcanic rocks. No soil observed. Thickness unknown

Qfpl **Fan deposits (late Pleistocene)**--Pale-yellowish-brown to grayish-orange gravel and gravelly sand; weakly consolidated, poorly sorted to moderately well sorted, and poorly to moderately well bedded. Gravel is angular to subrounded clasts of limestone, dolomite, sandstone, ash-flow tuff, and lava commonly less than 0.5 m in diameter. Unit forms small inset fans and fan remnants. Surfaces of fan deposits are smooth and have a loosely packed stone pavement; a dull brown rock varnish occurs on some surface clasts. Soil consists of a 2- to 4-cm-thick silty sand vesicular A horizon, a weak cambic B horizon, and a 0.5-m-thick C horizon that typically has stage II carbonate development in the upper part. Unit commonly stands 2 to 4 m above active washes. Unit distinguished from younger middle Pleistocene fan deposits (Qfmy) chiefly on lower topographic position and weaker soil development. Unit thickness ranges from 0 to more than 4 m

Qtpl **Terrace deposits (late Pleistocene)**--Pale-yellowish-brown to yellowish-orange gravel, gravelly sand, and sand; weakly consolidated, moderately well sorted, and moderately well bedded. Gravel is subrounded to well-rounded clasts of limestone, dolomite, sandstone, ash-flow tuff, and lava commonly less than 0.5 m in diameter. Unit forms small terrace remnants along Pahranagat and Kane Springs Washes. Surfaces typically have a tightly packed stone pavement; some surface clasts have a dull brown rock varnish. Soil typically has a 2- to 4-cm-thick silty sand vesicular A horizon, a weak cambic B horizon, and a 0.5-m-thick C horizon that has stage II carbonate development in the upper part. Unit thickness ranges from 0 to more than 4 m

Qfmy **Fan deposits (younger middle Pleistocene)**--Pale-yellowish-brown to moderate-orange-pink gravel and gravelly sand; weakly to moderately well consolidated, poorly sorted to moderately well sorted, and poorly to moderately well bedded. Gravel consists of angular to subrounded clasts of limestone, dolomite, ash-flow tuff, lava, and sandstone, commonly less than 2 m in diameter. Near the heads of steep fans in the northwest quarter of the quadrangle, boulder trains containing 2- to 3-m-diameter boulders are common. Unit forms gravel and gravelly sand fans and inset fans flanking most bedrock ridges. Surfaces of deposits generally are smooth, a tightly packed stone pavement is typical; surface clasts have a dull to shiny dark-brown rock varnish. Depositional fan surfaces are largely intact; where fans are dissected, dissection is by sharp, v-shaped washes. Unit typically stands 2 to 6 m above active washes. At one exposure, unit includes at the base a white, fine-grained, vitric ash bed 0-1.1 m thick. Soil typically consists of 2- to 4-cm-thick clay, sand, and silt vesicular A horizon, a light-brown to dark-yellowish-orange B horizon, and 1-m-thick K horizon with stage III carbonate development. At many exposures the B horizon is not preserved. Unit ranges from 0 to thicker than 10 m

Qtmy **Terrace deposits (younger middle Pleistocene)**--Pale-yellowish-brown sandy gravel and gravelly sand; weakly to moderately well consolidated, poorly to well sorted ,and moderately well bedded. Gravel consists of subrounded to well-rounded clasts of limestone, dolomite, ash-flow tuff, lava, and sandstone. Unit forms terrace remnants along the valleys of Pahranagat and Kane Springs Washes. Surfaces of deposits generally are smooth and have a tightly packed stone pavement; surface clasts commonly have a dull to shiny dark-brown rock varnish. Soil consists of a sandy vesicular A horizon and a 1-m-thick K horizon that has stage III carbonate development. No B horizon was observed. Unit typically stands 3-5 m above active washes. A thin discontinuous layer of loose windblown sand is common on the terrace surface. Unit ranges from 0 to 5 m thick

Qfmo **Fan deposits (older middle Pleistocene)**----Pale-yellowish-brown to moderate-orange-pink gravel and gravelly sand; weakly to moderately well consolidated, poorly to moderately well sorted, and poorly to moderately well bedded. Gravel consists of angular to subrounded clasts of limestone, dolomite, ash-flow tuff, lava, and sandstone commonly less than 1.5 m in diameter. Unit forms two large fans in the southern part of the quadrangle. Along the southeast edge of the fan that occupies most of Coyote Spring Valley, older middle Pleistocene fan deposits (Qfmo) locally overlie an eroded Quaternary to Tertiary alluvium (QTa); Qfmo and QTa were not mapped separately in this area because of poor exposures. The Qfmo-QTa contact is marked by 1-2 m of bouldery lag gravel of reworked QTa where well exposed. In the large fan west of Pahranagat Wash, unit Qfmo in part overlies a pediment surface cut on the Muddy Creek Formation (Tmc). Surfaces of Qfmo are smooth and have some rounding at eroded edges; depositional surface of fans is largely intact but minor, shallow washes have developed within areas of Qfmo. A tightly packed stone pavement is typical; surface clasts have a dull to shiny dark-brown rock varnish. Unit typically stands 6-15 m above active washes. Soil typically consists of a 5- to 6-cm-thick clay, silt, and sand vesicular A horizon overlying a 1- to 1.5-m-thick K horizon that has stage III carbonate development. No B horizon was observed. Unit distinguished from younger middle Pleistocene fan deposits (Qfmy) by higher topographic position and increased amount of dissection. Unit ranges from 0 to more than 20 m thick

Qtmo **Terrace deposits (older middle Pleistocene)**--Pale-yellowish-brown gravel and gravelly sand; poorly to moderately well consolidated, moderately well sorted, and moderately well bedded. Gravel consists of subrounded to well-rounded clasts of limestone, dolomite, ash-flow tuff, lava, and sandstone commonly less than 0.6 m in diameter. Unit forms terrace remnants along the valleys of Pahranagat and Kane Springs Washes. Surfaces generally are smooth and have a tightly packed stone pavement; surface clasts commonly have a dull to shiny dark-brown rock varnish. Soil typically consists of a sandy vesicular A horizon overlying a 1-m-thick K horizon with stage III carbonate development. No B horizon was observed. Unit commonly stands 12-16 m above active washes and about 3 m above younger middle Pleistocene terrace deposits (Qtmy). A layer of loose windblown sand generally less than 1 m thick is common on the terrace surfaces. Deposits range from 0 to 20 m thick

QTa **Alluvium (early Pleistocene and Pliocene?)**--Grayish-brown to moderate-orange-pink gravel and sandy gravel; poorly sorted, moderately well consolidated, and poorly bedded. Gravel consists of angular to subrounded clasts of limestone, dolomite, ash-flow tuff, lava, and sandstone commonly less than 2 m in diameter. Unit forms fan remnants adjacent to bedrock ridges. Surfaces of fans are dissected and have rounded interfluvial divides. Typical exposure has rubble-covered slopes littered with 1- to 2-m-diameter boulders and abundant pedogenic carbonate chips and small plates. A tightly packed stone pavement is common on gently sloping surfaces; pavement conforms to eroded surfaces. Some clasts typically have a dark-brown to black shiny rock varnish. Soil commonly has a 4- to 6-cm-thick clay, silt, and sand vesicular A horizon overlying a 1- to 2-m-thick K horizon that has stage III to IV carbonate development in the upper part. Exposures in the east part of the quadrangle show a series of buried paleosols in unit. Unit is 0 to more than 20 m thick

Tfs **Fluvial sand (early Pliocene?)**--Moderate-reddish-orange sand, gravelly sand, and minor gravel; well consolidated, poorly to well sorted, moderately well bedded. Sand is chiefly coarse and contains scattered pebbles and lenses of pebbles and a few cobbles. Gravel is subangular to rounded, is poorly sorted, and largely consists of pebbles and cobbles and some boulders as much as 0.5 m in diameter; has sandy matrix. Unit is moderately well cemented by carbonate minerals, and stringers of carbonate are common along bedding planes and fractures. Unit well exposed in a few cutbanks along Kane Springs Wash. Many slopes are commonly covered by unmapped colluvium from overlying Quaternary alluvium. Large area of unit Tfs east of Kane Springs Wash is poorly exposed and forms rounded ridges covered with coarse colluvial gravel; pedogenic carbonate chips are common in the surface layer. Unit immediately overlies Muddy Creek Formation (Tmc) south of the quadrangle and may represent aggradation during stream gradient adjustments within the Muddy Creek depositional basin following breaching by Colorado River drainage (D.L. Schmidt, U.S. Geological Survey, oral commun., 1989). Unit is 0 to more than 50 m thick

Tmc **Muddy Creek Formation (early Pliocene? to late Miocene)**--Silt and minor sand, limestone, and mudstone. Silt is grayish yellow to white, poorly to moderately well consolidated, locally well compacted, thin bedded to massive; thin beds of irregular calcareous concretions are locally present. Near the southwest corner of the quadrangle locally includes thin beds of brownish-gray carbonaceous silt. Grayish-yellow sand is fine to coarse, thin bedded to massive, locally pebbly, and weakly to moderately well cemented and occurs as thin interbeds and lenses in silt. Light-gray to pinkish-gray limestone is hard and vuggy, weathers to very rough surfaces, and forms lenses as much as 1 m thick that crop out as resistant ledges. Pale-olive mudstone occurs as thin interbeds in silt. Two occurrences of ash beds are indicated by the outcrop symbol (x). In the southern occurrence, the bed is fine-grained white vitric ash as thick as 0.6 m. Exposures of Muddy Creek Formation adjacent to Pahranagat Wash are commonly covered with a thin, irregular layer of stream-worn gravel that exhibits a dark-brown to black varnish; this gravel is a lag from either the younger or older middle Pleistocene terrace deposits (Qtmy or Qtmo) and is not mapped where less than 1 m thick. Maximum thickness exposed within the quadrangle is greater than 20 m

QTs **Blocks and debris of gravity-slide complex (Pleistocene? to late Miocene)**--Mixture of coherent blocks and chaotic debris including landslide material; unit generally consists of blocks and debris of Tertiary rocks. Debris is unconsolidated to moderately consolidated. Most parent rocks of blocks and debris are Tertiary volcanic rocks but in several cases they consist of Paleozoic rocks. Generally unit grades downward from larger and more coherent blocks at the top through faulted and rotated blocks, to subrounded chaotic debris at the base; although the top of the unit locally contains relatively undisturbed blocks with stratal attitudes that are nearly consistent with those of areas surrounding unit QTs, attitudes of unit are commonly bounded laterally by more chaotic parts of the unit. Chaotic parts are commonly cemented by secondary carbonate. Unit occurs near the base of steep slopes on the flanks of the high parts of the range. Thicknesses are as great as 90 m. (Where parent rocks in slide complex are mappable, they are identified with parent rock symbols and the symbol QTs is not used; where parent rocks are not mappable, the unit is designated by the symbol QTs. In both cases slide unit is shown with stippled pattern.)

Kane Wash Tuff (Miocene)--Peralkaline ash-flow tuff sequence divided into four informally named units

Tkb **Gregerson Basin unit**--Informally named, comenditic to trachytic ash-flow tuff consisting of at least two nearly identical cooling units. Map unit includes units V2 and V3 of Novak (1984). Individual cooling units are not mapped separately because lithologic similarities make them indistinguishable, and the cooling break between them is not traceable at all localities. Variations in degree of welding indicate that the lower cooling unit is a compound cooling unit; where the cooling break is traceable, it is shown as dashed contact within the Gregerson Basin unit. Each cooling unit generally contains a trachytic cap above upper, middle, and basal comenditic zones. Trachytic caps are partly vitric, partially welded, and pale brown; they commonly contain abundant cognate inclusions of scoriaceous trachyte in matrices that are noticeably darker and browner than the lower zones of the cooling units. Trachytic caps range from 0 to 5 m thick and are commonly absent. Upper zone are devitrified, moderately to densely welded, and yellowish gray to light brownish gray in most places. The upper zones contain few pumice fragments and have 0-20 percent lithophysal cavities that contain abundant vapor-phase crystals of amethyst and blocky mafic minerals (riebeckite and unidentified phases). The upper zones contain as much as 25 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenbergite, fayalite, and ilmenite (Novak, 1984). Upper zones range from 1 to 30 m thick. Middle zones are partly devitrified, densely welded, commonly mottled pale blue, medium bluish gray, grayish green, and pale yellowish brown. The middle zones commoly have partings between layers of different degrees of devitification, range from 5 to 25 percent phenocrysts, and are generally 1-2 m thick. Basal zones are most commonly nonwelded to partially welded, are moderate orange pink to pale yellowish orange, contain less than 5 percent phenocrysts, and are about 1 m thick. The cooling units form cliffs, and the cooling break between them has little or no geomorphic expression. The K-Ar age of the Gregerson Basin unit is 14.1 Ma (Novak, 1984). The Gregerson Basin unit thins from about 40 m thick in the northeast part of the quadrangle to about 35 m thick in the north-central part

Tkg **Grapevine Spring unit**--Informally named, rhyolitic to trachytic ash-flow tuff consisting of one compound cooling unit. Grapevine Spring unit is unit V1 of Novak (1984). Map unit grades downward through four zones that include a poorly and locally developed trachytic cap rock above upper, middle, and lower rhyolitic zones. Cap rock contains sparse dark scoriaceous trachytic cognate inclusions in a matrix that is sightly darker brown than lower zones. The cap rock is generally less than a few meters thick. Upper zone is devitrified, moderately to densely welded, and yellowish gray to light brownish gray in most areas. The upper zone contains few recognizable pumice fragments and contains 0-10 percent lithophysal cavities, which have minor vapor-phase crystals of quartz and sparse garnet. The upper zone contains as much as 30 percent phenocrysts that consist of 25 percent quartz, 60 percent sanidine, and 15 percent hedenbergite, fayalite, titano-magnetite, and ilmenite (Novak, 1984). The upper zone contains less than 1 percent lithic fragments of volcanic rocks and ranges from less than 5 to about 70 m thick. Middle zone is densely welded, grayish brown, brownish gray, to moderate brown. Locally developed, highly lenticular lithophysae are 2 to 4 cm in diameter in the plane of foliation. The middle zone contains less than 5 percent phenocrysts and is about 1 m thick. Basal zone is nonwelded to partially welded, is pale brown to dark yellowish brown, contains less than 2 percent phenocrysts, and is less than 1 m thick. The map unit forms cliffs, and the break between it and the Gregerson Basin unit (Tkb) forms a slight notch or bench in the cliffs. The K-Ar age of the unit is 14.1 Ma (Novak, 1984). Thickness of Grapevine Spring unit ranges from about 75 m along the east border of the quadrangle to about 5 m in the north-central part

Sunflower Mountain unit--Informally named, rhyolitic ash-flow tuff consisting of a compound cooling unit divided into an upper and a lower mappable zone. The Sunflower Mountain unit correlates with unit W of Novak (1984). The K-Ar age of the unit is 14.7 Ma (Novak, 1984). The combined thickness of the two zone varies between about 140 m in the northeast corner of the quadrangle and 70 m in the north-central part

Tksu **Upper zone**--More welded part of the Sunflower Mountain unit grading downward from partially welded, through moderately welded, to moderately to densely welded tuff. Upper zone is devitrified, pale red and mottled. Mottling consists of distinctive moderate-orange to very pale orange altered blotches in a pale-red matrix. The upper zone contains as much as 15 percent pumice fiamme as large as 10 cm in diameter in the plane of foliation and has indistinct lithophysae. Contains as much as 25 percent phenocrysts that consist of subequal amounts of quartz and sanidine and sparse hedenbergite and fayalite (Novak, 1984). Lenticular pumice fragments are common, and lithic fragments of volcanic rocks form less than 1 percent of the rock. Map unit forms bold cliffs; a small notch or bench in the cliff above the map unit marks the base of the Grapevine Spring unit (Tkg) in most areas. The zone ranges in thickness from about 10 m in the northeast to about 50 m in the north-central part of the quadrangle

Tksl **Lower zone**--Less welded part of the Sunflower Mountain unit grading downward from partially welded, through a slightly more welded to a nonwelded tuff. The lower zone is devitrified and very pale orange to grayish orange. Pumice fragments form about 15 percent of the rock and range from 0.2 to 1.5 cm in diameter. The lower zone contains as much as 15 percent phenocrysts that consist of subequal amounts of quartz and sanidine and sparse altered mafic minerals (Novak, 1984). Volcanic lithic fragments are commonly as large as 0.3 to 0.75 cm in diameter and locally form as much as 7 percent of the rock. Lower zone forms distinct slopes. Map unit is as thick as 120 m in the northeast part of the quadrangle but thins to about 15 m along the north-central part

Tkd **Delamar Lake unit**--Informally named, rhyolitic ash-flow tuff consisting of an upper and a lower simple cooling unit. The Delamar Lake unit correlates with unit O of Novak (1984). The upper cooling unit is devitrified, nonwelded to moderately welded, and is grayish pink to pale red. Pumice fragments as large as 3 cm in diameter in the plane of foliation forms as much as 25 percent of tuff. Rock contains as much as 20 percent phenocrysts that consists of 20 percent quartz, 75 percent sanidine, and 5 percent fayalite and other mafic minerals (Novak, 1984). The tuff contains less than 2 percent volcanic lithic fragments. The lower cooling unit is devitrified, nonwelded to moderately welded, and is grayish orange pink to pale red to light brownish gray. Pumice fiamme as large as 4 cm in diameter in the plane of the foliation forms as much as 30 percent of the tuff. The lower cooling unit contains about 15 percent phenocrysts that consist of 35 percent quartz, 60 percent sanidine, and 5 percent fayalite and other mafic minerals (Novak, 1984). The tuff contains less than 3 percent volcanic lithic fragments. The two cooling units form slopes in their less welded zones and low cliffs where the degree of welding is greater. The K-Ar age of the Delamar Lake unit is 15.6 Ma (Novak, 1984). Map unit is about 20 m thick in the northeast part of the quadrangle but pinches out toward the south and west.

Th **Hiko Tuff (Miocene)**--Rhyodacitic ash-flow tuff consisting of one cooling unit grading downward from a devitrified zone, through a locally developed vitrophyre, to a nonwelded base. The devitrified zone is eutaxitic, moderately welded, and mottled very light gray to light gray; pumice fiamme are lighter in color. Pumice fiamme as large as 5 cm in diameter in the plane of foliation form 10 percent of the rock, and lithophysae are commonly 4 cm in diameter parallel to foliation. Rock contains 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. The tuff contains less than 2 percent lithic fragments consisting largely of argillite. The vitrophyre is partly glassy and partly devitrified, eutaxitic, moderately to densely welded, and mottled medium gray to grayish black; pumice fiamme are darker in color. The basal zone is nonwelded to partially welded and very light gray; pumice fragments are white. The tuff forms crumbly but rugged cliffs and weathers to distinctive rounded knobby exfoliated surface in the devitrified zone; these knobs vary between 1 and 4 m wide and 1 and 3 m high. The $^{40}Ar/^{39}Ar$ age of the Hiko Tuff is 18.6 Ma (Taylor and others, 1989). The tuff ranges from 8 to 60 m thick in the northeast part of the quadrangle and from 10 to 25 m thick in the north-central part

Thh **Harmony Hills Tuff (Miocene)**--Andesitic ash-flow tuff consisting of one cooling unit grading downward from a partially welded upper zone, through a densely welded central zone, to a nonwelded basal zone. The map unit is phenocryst rich, devitrified, and massive with crudely developed foliation. The moderately to densely welded zones of the tuff range from pale red where more weathered to light olive gray to pinkish gray where fresher. Pumice fragments are sparse. The rock contains 50 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. The unit forms cliffs, the lower part of which are commonly covered with colluvial debris from the Hiko Tuff (Th) and the Harmony Hills Tuff. A small bench above the Harmony Hills Tuff marks the base of the Hiko Tuff. 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 may provide a better age constraint (Rowley and others, 1989). Although the Harmony Hills Tuff, Bauers Member of the Condor Canyon Formation (Tcb), and the Leach Canyon Tuff (Tlc) 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 all these ash-flow tuffs have not been determined. The Harmony Hills Tuff ranges from about 60 m to 125 m thick in the northeast part of the quadrangle and from about 50 m to 85 m in the north-central part

Tpl **Tuff of Pahranagat Lake (Miocene)**--Rhyolitic ash-flow tuff consisting of one simple cooling unit grading downward from nonwelded, through partially welded, to nonwelded. This informally named tuff is the Pahranagat Lake tuff of Williams (1967). The tuff is devitrified and ranges from grayish pink, to very light gray, and to grayish orange pink. Pumice fragments as large as 5 cm in diameter form as much as 20 percent of tuff. Rock contains 15 percent phenocrysts that consist of 45 percent quartz, 25 percent sanidine, 25 percent plagioclase, and less than 5 percent biotite. Less than 1 percent lithic fragments occur in the tuff. The tuff forms gentle slopes commonly covered by talus from the Harmony Hills Tuff (Thh). The $^{40}Ar/^{39}Ar$ age of the tuff is 22.65 Ma (Deino and Best, 1988); The map unit is as thick as 35 m in the northeast part of the quadrangle but pinches out over local Miocene topographic highs

Tcb **Bauers Tuff Member of the Condor Canyon Formation (Miocene)**--Rhyolitic ash-flow tuff consisting of one simple cooling unit grading downward from a light-brownish-gray to pale-red, moderately to densely welded devitrified zone, through a brownish-gray, moderately welded vitropyre, to a grayish-pink, partially to nonwelded basal zone. Pumice fiamme are generally less than 0.5 cm in diameter in the plane of foliation and make up less than 5 percent of the rock. Lithophysal cavities are 2 to 4 cm in diameter and form as much as 20 percent of the member. Rock contains 10 percent phenocrysts that consist of 35 percent sanidine, 65 percent plagioclase, 5 percent biotite, and a trace of hornblende. Volcanic lithic fragments are generally less than 1 cm in diameter and form about 2 percent of the rock. Unit forms a resistant ledge. The $^{40}Ar/^{39}Ar$ age of the tuff is 22.8 Ma (Best and others, 1989). The Bauers Tuff Member is locally absent over Miocene topographic highs and is a thick as 25 m in topographic lows in the east-central part of the quadrangle

Tl **Limestone (middle Tertiary)**--Lacustrine limestone containing disrupted algal plates. Limestone is very light gray to pinkish gray, medium grained, and recrystallized. Beds range from 0.1 to 2.5 m thick. Limestone occurs locally in northeast part of the quadrangle where it is as thick as 7 m.

Tlc **Leach Canyon Formation (Oligocene)**--Rhyolitic ash-flow tuff conisting of one compound cooling unit grading downward from grayish-pink partially welded tuff, through grayish-orange-pink moderately welded devitrified tuff, to pinkish-gray nonwelded to partially welded tuff at the base. Pumice fragments form less than 5 percent of the rock and are less than 0.5 cm in diameter. Map unit 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 and poorly developed cliffs. The average K-Ar age of the Leach Canyon Formation is about 24.7 Ma (Armstrong, 1970). Map unit pinches out over local Oligocene topographic highs and is as thick as 50 m in topographic lows

Tspl **Shingle Pass Tuff, lower member (Oligocene)**--Rhyodacitic ash-flow tuff consisting of a simple cooling unit grading downward from a moderate-orange-pink, moderately welded tuff, through a nearly ubiquitous very dark red, brownish-black, to grayish-red vitrophyre, to a pinkish-gray, nonwelded to partially welded tuff at the base. Pumice fiamme as large as 4 cm in diameter in the plane of foliation form about 5 percent of the rock. The rock contains about 15 percent phenocrysts that consist of 5 percent quartz, 55 percent sanidine, 40 percent plagioclase, and a trace of hornblende. Lithic fragments as large as 2 cm in diameter form less than 5 percent of the rock. Flattened lithophysal cavities as great as 6 cm in diameter form about 10 percent of the rock. Flow lineations are common where member is draped on buried topography. Unit forms a sharp cliffy ledge above the gentle slopes of the Monotony Tuff (Tm). The $^{40}Ar/^{39}Ar$ age of the lower member is 26.7 Ma (Best and others, 1989, table 2). Map unit pinches out over local Oligocene topographic highs and is as thick as 45 m in topographic lows

Tm **Monotony Tuff (Oligocene)**--Rhyodacitic ash-flow tuff consisting of a simple cooling unit; nonwelded to partially welded, very light gray to pinkish-gray tuff. Layers of bedded ash-fall tuff overlie ash-flow tuff. Pumice fragments are sparse. Rock contains about 15 percent phenocrysts that consist of 15 percent quartz, 10 percent sanidine, 50 percent plagioclase, 10 percent biotite, 5 percent hornblende, and 5 percent pyroxene. Lithic fragments are sparse, and unit forms gentle slopes. The $^{40}Ar/^{39}Ar$ age is 27.3 Ma (Best and others, 1989, table 2). Map unit is absent over most of the quadrangle but is preserved at two localities in the west-central part where it is as thick as 18 m

Tc **Conglomerate (early Tertiary ?)**--Conglomerate and subordinate limestone, derived from Paleozoic limestone, dolomite, sandstone, quartzite, and chert. Pale-red color of the conglomerate is imparted by the calcareous, slightly ferruginous cement. Unit found above angular unconformity on Paleozoic rocks. Conglomerate is locally present in Tertiary topographic lows where it is as thick as 75 m

Dg **Guilmette Formation (Upper and Middle Devonian)**--Limestone, dolomite, and minor interbedded quartzite. The Guilmette Formation can be divided into four informal members, an upper limestone, a middle dolomite, a lower limestone, and a basal dolomite. Upper limestone member is predominantly limestone and subordinate dolomite and quartzite. Limestone is medium gray (fresh), light olive gray (weathered), aphanic to finely crystalline, and thin bedded; unit contains several 0.5- to 1.0-m-thick stromatoporoid biostromes. Dolomite is medium dark gray, arenaceous, aphanic to finely crystalline, and thin bedded; has planar bedding-parallel laminations. Some 1-m-thick beds of yellowish-gray, vuggy coarse recrystallized dolomite are present. Quartzite is dolomitic, medium gray (fresh), light brown, moderate brown, and dusky yellowish brown (weathered), fine to medium grained, subrounded, and well sorted. Quartzite interbeds range from 0.1- to 1.0-m-thick and are generally trough crossbedded. Stromatoporoid biostromes, *Amphipora*, gastropods, brachiopods, and corals are present in upper limestone member. Middle dolomite member is characteristically a medium-dark-gray-weathering stromatoporoid biostromal dolomite. Dolomite is finely crystalline and thin to thick bedded; has planar bedding-parallel laminations. Several zones of finely crystalline intraclastic-dolomite occur in the middle dolomite member; clasts are dark gray in contrast to a lighter gray matrix, range from 0.5-3.0 cm, subangular, and are faintly imbricated. Stromatoporoids are commonly recrystallized to coarse, yellowish-gray dolomite; *Amphipora* and brachiopods also common. Lower limestone member is medium-gray limestone and subordinate dolomite. Limestone is predominantly aphanic, laminated to thick bedded, and fetid. Dolomite is medium dark gray, aphanic to finely crystalline, thin bedded, and commonly bioturbated. Stromatoporoids are common in lower part. Basal dolomite member includes a 13-m-thick, argillaceous, aphanic, medium-gray (fresh) and grayish-yellow (weathered) dolomite, known as the "yellow bed" (Tschanz and Pampeyan, 1970). Guilmette Formation forms step-like cliffs and is approximately 420 m thick; top of formation not exposed.

Dsi **Simonson Dolomite (Middle Devonian)**--Dolomite, consisting of four informal members, upper alternating, brown cliff-forming, lower alternating, and basal coarse members of Osmond (1954). The upper alternating member consists of an upper part (25 m thick) and a lower part (16 m thick). Upper part is dominantly dolomite that weathers to alternating light and dark shades of gray; rock is aphanic to medium crystalline, thin to thick bedded, and has planar bedding-parallel laminations and sparse recrystallized stromatoporoids. The lower part forms massive cliffs of olive-black-weathering, highly fossiliferous, finely crystalline dolomite. Several 0.3- to 0.6-m-thick *Stringocephalus* biostromes are present 3 m from the top of the lower part; other fauna include *Thamnopora*, *Amphipora*, stromatoporoids, and brachiopods. Brown cliff-forming member is medium gray (fresh) and light olive gray (weathered), medium crystalline, vuggy, and thin to thick bedded with internal wavy laminations. Member also contains abundant discontinuous beds of aphanic to finely crystalline dolomite, which is dark gray (fresh) and dusky yellowish brown to moderate brown (weathered). Forms massive cliffs. Lower alternating member consists of alternating dark- and light-gray dolomite that weathers olive black to light olive gray, respectively. Light-gray dolomite is aphanic to finely crystalline; dark-gray dolomite is finely crystalline. Both are thin bedded and have distinctive planar bedding-parallel laminations. Sparse recrystallized stromatoporoids, corals, and brachiopoods are present. Forms ledgy slopes. Basal coarse member consists of arenaceous dolomite and interbedded dolomitic quartzite; these lithologies are locally gradational. Dolomite is medium light gray (fresh) and mottled light olive gray and yellowish gray (weathered), medium to coarsely crystalline, sugary, vuggy, mottled, and thin bedded with both wavy and planar bedding-parallel laminations. Dolomitic quartzite is medium gray (fresh) and moderate brown, light brown, and dusky yellowish brown (weathered), fine to medium grained, subrounded, and moderately sorted and thin bedded with planar bedding-parallel laminations and small-scale trough crossbeds. Stromatoporoids are poorly preserved. Basal coarse member forms massive cliffs. Simonson Dolomite is about 230 m thick

Sevy Dolomite (Lower Devonian)--Dolomite, quartzite, and siltstone; divided into upper and lower informal members. Sevy Dolomite is about 248 m thick

Dseu **Upper member**--Quartzite, dolomite, and siltstone. Upper part of member is dolomitic quartzite, dark-gray to olive-gray (fresh) and dusky-yellowish-brown to moderate-yellowish-brown (weathered), fine grained, sugary, subangular to subrounded, moderately sorted, and thin- to thick-bedded; trough crossbed sets average 0.2 m thick. Upper part of member forms a 13-m-thick cliff and is correlative with upper sandy member of Osmond (1962). Lower part of member is olive-gray (fresh) and moderate-yellowish-brown (weathered) argillaceous dolomite that is aphanic, silty, very thin to thin bedded with planar bedding-parallel laminations and conchoidal fracturing; also includes common discontinuous beds and nodules of olive-gray to light-gray smoky chert and local interbeds of very thin, wavy laminated, olive-gray (fresh) and moderate-yellowish-brown to dusky-red (weathered) dolomitic siltstone. Lower part of member forms slope and is about 15 m thick; correlative with cherty argillaceous member of Osmond (1962). Combined thickness of member is 28 m

Dsel **Lower member**--Correlative with dolomite member of Osmond (1962). Dolomite, medium-light-gray (fresh) and light-gray and light-olive-gray (weathered), mostly aphanic, homogenous, dense, and thin to thick bedded with planar bedding-parallel laminations; rock fractures conchoidally, sparse stylolites. Quartzite interbeds are common in the upper part of member. Quartzite is light olive gray to medium gray (fresh) and moderate brown to dusky yellowish brown (weathered), dolomitic, fine grained, well rounded, and moderately well sorted. Beds range from 0.1 to 1 m thick and exhibit trough crossbedding. Forms ledgy cliffs and is about 220 m thick

Laketown Dolomite (Upper and Middle Silurian)--Dolomite, divided into an upper dark-gray member, a middle light-gray member, and a lower dark-gray member. Laketown Dolomite is about 245 m thick

Slu **Upper dark-gray member**--Dolomite, medium-dark-gray to dark-gray (fresh) and light-olive-gray to grayish-orange (weathered), finely crystalline to slightly aphanic, and has highly abundant discontinuous layers and nodules of black (fresh) and moderate-brown to dusky-yellowish-brown (weathered) chert. Upper member contains *Favosites*, silicified corals, pelmatozoan stems, and brachiopods. Upper dark-gray member forms cliffs and is about 15 m thick

Slm **Middle light-gray member**--Dolomite, light-gray to yellowish-gray, finely crystalline, sugary, and vuggy; some zones of aphanic dolomite occur near top. *Favosites*, *Halysites*, corals, and brachiopods are present. Forms cliffs and is about 115 m thick

Sll **Lower dark-gray dolomite**--Dolomite, medium-gray to medium-dark-gray, fetid, finely to medium crystalline, thin- to thick-bedded with planar bedding-parallel laminations. Lower member is more fossilierous than the upper and middle members; contains *Favosites*, *Halysites*, solitary corals, pelmatozoan stems, and brachiopods. Basal 10 m is medium-dark-gray, vuggy dolomite that forms a massive cliff. Member forms cliffs and is about 115 m thick

Oes **Ely Springs Dolomite (Upper Ordovician)**--Dolomite, medium-dark-gray, finely crystalline, generally thin- to thick-bedded with planar bedding-parallel laminations. Upper 24 m is distinctive light-olive-gray-weathering aphanic dolomite that contrasts sharply with adjacent darker dolomite units. Middle part commonly contains zones of discontinuous layers and nodules of dark-brown-weathering chert, and vugs and streaks lined with coarse recrystallized white dolomite. Lower part is arenaceous. Fossils include *Favosites*, *Halysites*, large horn corals, pelmatozoan stems, and brachiopods. Forms massive cliffs, has a dark color and craggy texture from a distance, and is about 135 m thick

Oe **Eureka Quartzite (Middle Ordovician)**--Quartzite and friable sandstone, white (fresh), moderate-brown, moderate-reddish-brown, dark-yellowish-orange, and dusky-yellowish-brown (weathered), fine- to medium-grained, subrounded, and moderately well sorted; upper part is thin to thick bedded and lower part is very thin to thin bedded. Abundant 0.1- to 0.2-m-thick sets of tabular-planar crossbeds and less common small-scale trough crossbeds occur. Trace fossils (burrows and trails) occur locally on tops of beds. Forms cliffs and is as thick as 40 m

Op **Pogonip Group (Middle and Lower Ordovician)**--Limestone and subordinate dolomite, shale, and siltstone. Five parts are recognized but not mapped; these consist of an uppermost dolomite, an upper limestone, a middle limestone, a lower limestone, and a basal dolomite. Uppermost dolomite part consists of dolomite, light-gray to medium-dark-gray and grayish-yellow, mottled, aphanic to finely crystalline, arenaceous, and laminated to thin bedded; abundant pale-red shale partings. Brachiopods, corals, gastropods, and sponges are present. Uppermost dolomite part forms ledgy slopes and is about 30 m thick. Upper limestone part is medium-light-gray to medium-dark-gray (fresh), light-olive-gray to yellowish-gray (weathered), mottled, mostly aphanic, and laminated to thin bedded limestone. Most beds consist of 5- to 15-mm-thick alternating layers of micritic and fossiliferous intraclastic limestone. Abundant pale-red shale and shaly limestone partings, and less abundant interbeds of yellowish-gray and pale-red (weathered) laminated siltstone. Brachiopods, *Maclurites* and other gastropods, corals, pelmatozoan stems, and oncolites are present; *Receptaculites* and sponges are common near base. Upper limestone part forms cliffs and is about 190 m thick. Middle limestone part consists of limestone, medium-gray (fresh), yellowish-gray (weathered), aphanic to coarsely crystalline, characteristically very thin bedded, and intensely bioturbated. Beds consist of 2- to 10-mm-thick alternating layers of micritic and fossiliferous intraclastic limestone. Abundant grayish-red siltstone and pale-red shale partings. Burrows and trails on bedding planes, trilobites, brachiopods, and pelmatozoan stems are common to abundant. Middle limestone part forms ledgy slopes and is about 140 m thick. Lower limestone part consists of limestone, subordinate dolomite, shale, siltstone, and abundant nodules and discontinuous layers of dusky-yellowish-brown (weathered) chert. Limestone is medium gray to medium dark gray (fresh) and light gray to grayish orange (weathered), mottled, aphanic to coarsely crystalline, and thin bedded. Beds consist of 2- to 15-mm-thick alternating layers of micritic and fossiliferous intraclastic limestone. Shaly limestone and fissile shale partings are common and as thick as 1 m; shaly limestone and shale are medium dark gray (fresh) and pale yellowish brown (weathered). Ripple marks occur on some bedding planes. Lower limestone part forms cliffs and is about 200 m thick. Basal dolomite part consists of dolomite, olive-gray (fresh), yellowish-gray (weathered), mottled, aphanic, thin bedded, arenaceous, and bioturbated. Basal dolomite part contains brachiopods, trilobites, and oncolites, forms ledgy cliffs, and is about 10 m thick. Pogonip Group is about 570 m thick

Desert Valley Formation (Upper Cambrian)--Dolomite, divided into six informal members by Heckel and Reso based on a measured section in this quadrangle (P.H. Heckel, written commun., 1987). In descending order these members are the orange dolomite, light dolomite, variegated limy, upper dark dolomite, white band, and lower dark dolomite members. The orange dolomite member is included in the overlying Pogonip Group. The Desert Valley Formation forms massive cliffs and is about 555 m thick

-Cdv5 **Light dolomite member**--Dolomite, medium-gray (fresh), light-olive-gray (weathered) medium crystalline, sugary, thin- to thick-bedded and has wavy internal laminations and local small-scale trough crossbedding. Abundant discontinuous layers, stringers, and nodules of bluish-gray to medium-gray (fresh) and moderate-brown to dusky-yellowish-brown (weathered) chert. Vugs lined with coarsely recrystallized white dolomite are common. About 125 m above base is a 15-m-thick zone of dusky-yellow (weathered), aphanic, intraclastic dolomite, which is trough crossbedded, mottled, and cherty. Rip-up clasts are micritic and angular. Member contains sparse stromatolitic zones, and some brachiopods. Forms massive cliffs, and is about 260 m thick

-Cdv4 **Variegated limy member**--Limestone, fossiliferous, dark-yellowish-orange to light-olive-gray (weathered), and mostly aphanic. Beds contains wavy and planar bedding-parallel laminations and are mottled and bioturbated. Beds of fossiliferous intraclastic limestone are 1- to 3-cm-thick and abundant; rip-up clasts are micritic, subangular, and as much as 3 cm long. Oolitic, trough-crossbedded limestone is very abundant in upper part. Discontinuous stringers and nodules of moderate-brown to dark-brown (weathered) chert are abundant throughout the member. Trilobite fragments, brachiopods, oncolites, and trace fossils (burrows) are common. Member weathers to a less resistant ledgy slope and is about 15 m thick

-Cdv3 **Upper dark dolomite member**--Dolomite, medium-dark-gray, finely to medium crystalline, and thin- to thick-bedded with planar bedding-parallel laminations. Streaks of coarsely recrystallized white dolomite are abundant, moderate-brown to dusky-yellowish-brown (weathered) chert nodules occur locally, and several zones of oncolites and brachiopods are present. Member forms ledgy cliffs and is about 105 m thick

-Cdv2 **White band member**--Dolomite, light-gray, medium crystalline, sugary, thin- to thick-bedded; common vugs and streaks lined with coarsely recrystallized white dolomite. Member forms massive cliffs and is about 20 m thick

-Cdv1 **Lower dark dolomite member**--Dolomite, medium-gray (fresh), light-olive-gray (weathered), mottled, finely to medium crystalline, laminated to thick bedded with planar bedding-parallel and wavy laminations, and sparse trough crossbeds. Discontinuous stringers and nodules of dark-brown-weathering chert and streaks and vugs lined with coarse recrystallized white dolomite are common. Abundant oncolites, less common stromatolites, brachiopods, and pelmatozoan stems. Member forms massive cliffs and is about 155 m thick

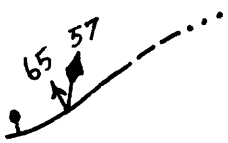
-Cd **Dunderberg Shale (Upper Cambrian)**--Limestone and subordinate interbedded shale and siltstone. Limestone is medium dark gray to olive gray (fresh) and moderate brown to dusky yellowish-brown (weathered). In the upper part of the unit, limestone is aphanic, mottled, and bioturbated; contains interbeds of light-brown, calcareous shale. Small black, linguloid brachiopods are common in upper part. In the lower part of the unit, limestone is medium to coarse crystalline, very thin bedded, and characteristically flaggy; locally it contains interbeds of very thin bedded to laminated pale-red to medium-gray siltstone. Trilobite fragments are abundant throughout. Formation forms slopes and is 70-80 m thick

Highland Peak Formation (Upper and Middle Cambrian)--Dolomite and limestone, divided into an upper and a lower informal member. The Highland Peak Formation forms cliffs and is approximately 460 m thick; base is not exposed

-Ehpu **Upper member**--Dolomite, characterized by alternating medium-gray and light-olive-gray (weathered) layers that appear "banded" from a distance. Dolomite is mostly medium crystalline, sugary, but becomes aphanic toward the base. Beds range from 0.1- to 1.0-m-thick and contain planar bedding-parallel laminations. Stylolites are abundant. A distinctive 18-m-thick zone of bluish dolomite occurs about 8 m above the base. Contains small streaks of coarse recrystallized white dolomite, and dark-brown-weathering blebs which may be poorly preserved fossils. Member forms massive cliffs and is about 300 m thick

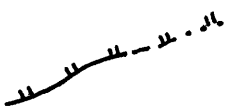
-Ehpl **Lower member**--Limestone, medium-gray to medium-dark-gray (fresh), and medium-gray (weathered), partially mottled with "leopard-spotted" or "tiger-striped" patterns. Mottled parts of rock are dolomitized and are light olive gray, light brown, pale yellowish orange, and dark yellowish orange (weathered). Limestone is aphanic to finely crystalline, and beds average 0.2 m in thickness. Upper part contains less resistant 0.2-1.0-m-thick interbeds of light-gray- to white-weathering aphanic and very fine laminated dolomite. Discontinuous stringers, layers, and nodules of dusky-yellowish-brown-weathering chert are common throughout. Silicified stromatolites are abundant in lower part. Member forms step-like ledges and is about 160 m thick

Contact--Direction and amount of dip shown by bar

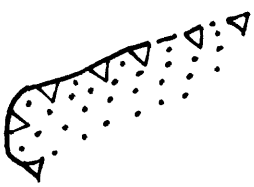


High-angle normal--Amount of dip (barbed arrow) and trend and plunge of lineation (diamond-shaped arrow). Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side.

Normal fault superimposed on preexisting thrust fault--Bar and ball on downthrown side of normal fault; sawteeth on upper plate of thrust. Dotted where concealed.



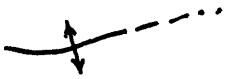
Low-angle normal fault beneath upper plate--Hachures on upper plate. Dashed where approximatly located; dotted where concealed



Low-angle normal fault beneath landslide and gravity-slide block--Sawteeth on upper plate. Dashed where approximately located; dotted where concealed. Stippled pattern on upper plate

Fault scarp--Hachures on downthrown side where scarp is partially covered by younger surficial unit

Height of eroded fault scarp in meters--Triangle on upthrown side of scarp



Anticline--Dashed where approximately located; dotted where concealed

Strike and dip of sedimentary bed and of compaction foliation of ash-flow tuff

Inclined

Overturned

⊕ Horizontal

X Outcrop of ash bed

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Correlation of Map Units