

- Qca** Landslide deposits Slump masses of local volcanic and sedimentary rocks. Arrow indicates direction of movement.
- Qa** Alluvium Stream silt, sand, and gravel.
- Qoa** Older alluvium Alluvial fan and terrace deposits composed of silt, sand, and gravel. Locally may contain poorly consolidated lake deposits.
- Tys** Younger sedimentary rocks Sedimentary rocks, in part tuffaceous.
- Td** Biotite rhyodacite lavas* Flows and volcaniclastic rocks of fine-grained purple to red, blocky to platy, porphyritic rhyodacite. The lavas contain about 18% phenocrysts of plagioclase > biotite > clinopyroxene > Fe-Ti oxide, in addition to minor amphibole, orthopyroxene, and quartz set in a fine-grained groundmass of glass, plagioclase, and Fe-Ti oxides. More massive flows are frequently flow-folded and may be auto-brecciated. Where Td directly overlies Td₂, abundant angular clasts of Ta are present in the basal flow. Typical sections are about 300 feet thick; the thickest section is about 1,000 feet thick assuming no repetition by faulting. Top not exposed.
- Ta** Andesite lava* Fine-grained, crystal-poor, platy andesite lava flow. Grayish-green to black andesite containing app. 10% phenocrysts of plagioclase > clinopyroxene > orthopyroxene set in an extremely fine-grained pilotaxitic groundmass of plagioclase, pyroxene, and Fe-Ti oxides. Ta is particularly prone to erosion by and incorporation into, basal flows of Td, such that many mapped exposures of Ta are clast horizons within basal Td. Near Bradley Canyon in the northeast corner of the quadrangle, two poorly exposed north-west-striking vesiculated dikes of Ta are present. Thickness 0-15 feet.
- Td₂** Dactles** Flows and volcaniclastic rocks of fine-grained, platy gray porphyritic dacite. The lavas contain about 8% phenocrysts of plagioclase > biotite > clinopyroxene = Fe-Ti oxide > orthopyroxene = amphibole. Phenocrysts typically display well-developed treacherous alignment due to flowage. Most exposures are massive flows with well-developed platy jointing. Jointing occurs at a scale of less than 1 inch. Where the jointing is strongly developed this unit forms characteristic steep slopes covered by coarse, angular talus. Thickness 0-430 feet.
- Td₃** Glomeroporphyritic dactles** Lavas, vitric breccias, and block and ash flows of coarse-grained red to black dacite containing 20 to 34% phenocrysts of plagioclase > orthopyroxene > biotite > amphibole > Fe-Ti oxide > clinopyroxene > quartz. Glomerocrysts of orthopyroxene, plagioclase, plus Fe-Ti oxide are more common than those containing additional clinopyroxene or amphibole. Td₃ is primarily exposed as a 300-foot-thick dome complex in the northern region of the quadrangle. In outcrop Td₃ lavas are mainly blocky to platy with very contorted flow banding. A dark vitrophyre commonly marks the top of the unit. Td₃ can be distinguished in the field from other dactles by the greater abundance of phenocrysts and large (up to 1 inch across) plagioclase grains. Feeley (1989) reported a ⁴⁰Ar/³⁹Ar age of 35.1 Ma from an amphibole grain. Thickness 0-925 feet.
- Tv** Lava bearing magmatic inclusions Light-gray to red andesite to rhyodacite lavas; texture is seriate-glomeroporphyritic, minerals are in variable abundance and include plagioclase, clinopyroxene, orthopyroxene, quartz, amphibole, biotite, Fe-Ti oxide, and sandstone. Most sections range from 150 to 325 feet, but are as great as 1,700 feet. All lavas contain distinctive large, resorbed quartz grains that are typically in polycrystalline clusters, as well as fine-grained, vesiculated inclusions of basaltic andesite and andesite which range in size from microscopic to 6 inches across.
- Taf** Ash-flow tuff* Poorly welded to nonwelded, salmon to white, rhyodacite lapilli ash-flow tuff. Pumice contains phenocrysts of smoky quartz > plagioclase > sanidine > biotite > Fe-Ti oxide, plus trace amounts of amphibole, clinopyroxene, orthopyroxene, and accessory allanite, sphene, and zircon. The matrix contains 1% sandstone and carbonate lithic clasts and rounded inclusions that average 1.5-2.0 inches in diameter which appear to be composed of carbonaceous organic matter. Feeley (1989) reported a ⁴⁰Ar/³⁹Ar age of 35.8 ± 0.5 Ma. Thickness 0-15 feet.
- Tos** Older sedimentary rocks* Discontinuous, poorly exposed outcrops of oolite-bearing lacustrine limestones, tuffaceous sedimentary rocks, calcareous pebble conglomerates, and a volcaniclastic debris flow. Volcanic rock fragments within the debris flow are black quartz- and olivine-bearing two-pyroxene andesite, white biotite rhyolite and their vesiculated equivalents. Thickness 0-400 feet.

- UNCONFORMITY**
- Pk** Kaibab Limestone Indistinctly bedded, light-gray to medium-gray moderately coarse- to very coarse-grained, massive crystalline limestone. Contains abundant light- to gray chert nodules. Maximum exposed thickness in quadrangle 280 feet; top eroded.
 - Pa** Arcturus Formation Yellowish- to reddish-gray fine-grained calcareous sandstone and siltstone interbedded with thin silty sandstone and dolomitic limestone in the upper part and massive limestone interbedded with thin sandstone and siltstone in the lower part. Maximum exposed thickness in quadrangle 390 feet; top and base not exposed together.
 - Pth** Rib Hill Sandstone Medium- to fine-grained yellowish-gray calcareous sandstone interbedded with thin beds of light-gray sandy to silty limestone. Forms gentle slopes. Maximum exposed thickness in quadrangle 190 feet; top and base not exposed together.
 - Pra** Riepe Spring Limestone Medium- to dark-gray moderately crystalline, massive, ledge-forming bioclastic limestone. Contains a thin, chert-pebble conglomerate at base. Maximum exposed thickness in quadrangle 100 feet; top and base not exposed together.
 - Pb** Ely Limestone Medium- to dark-gray organic detrital, coarse crystalline, ledge-forming limestone interbedded with medium-gray to yellowish-gray silty limestone. Contains several fossiliferous zones in the upper part. Maximum exposed thickness in quadrangle 170 feet; base not exposed.

NOTES ON TERTIARY STRATIGRAPHY

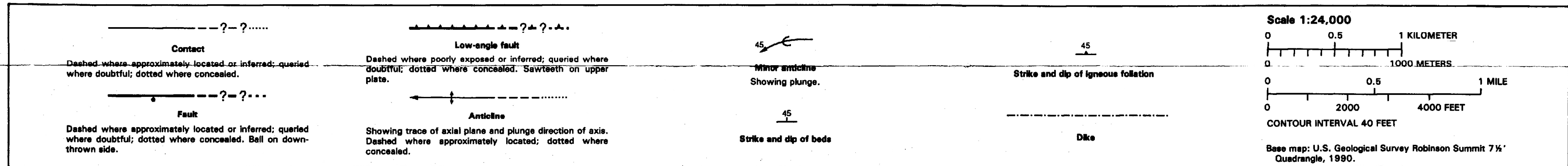
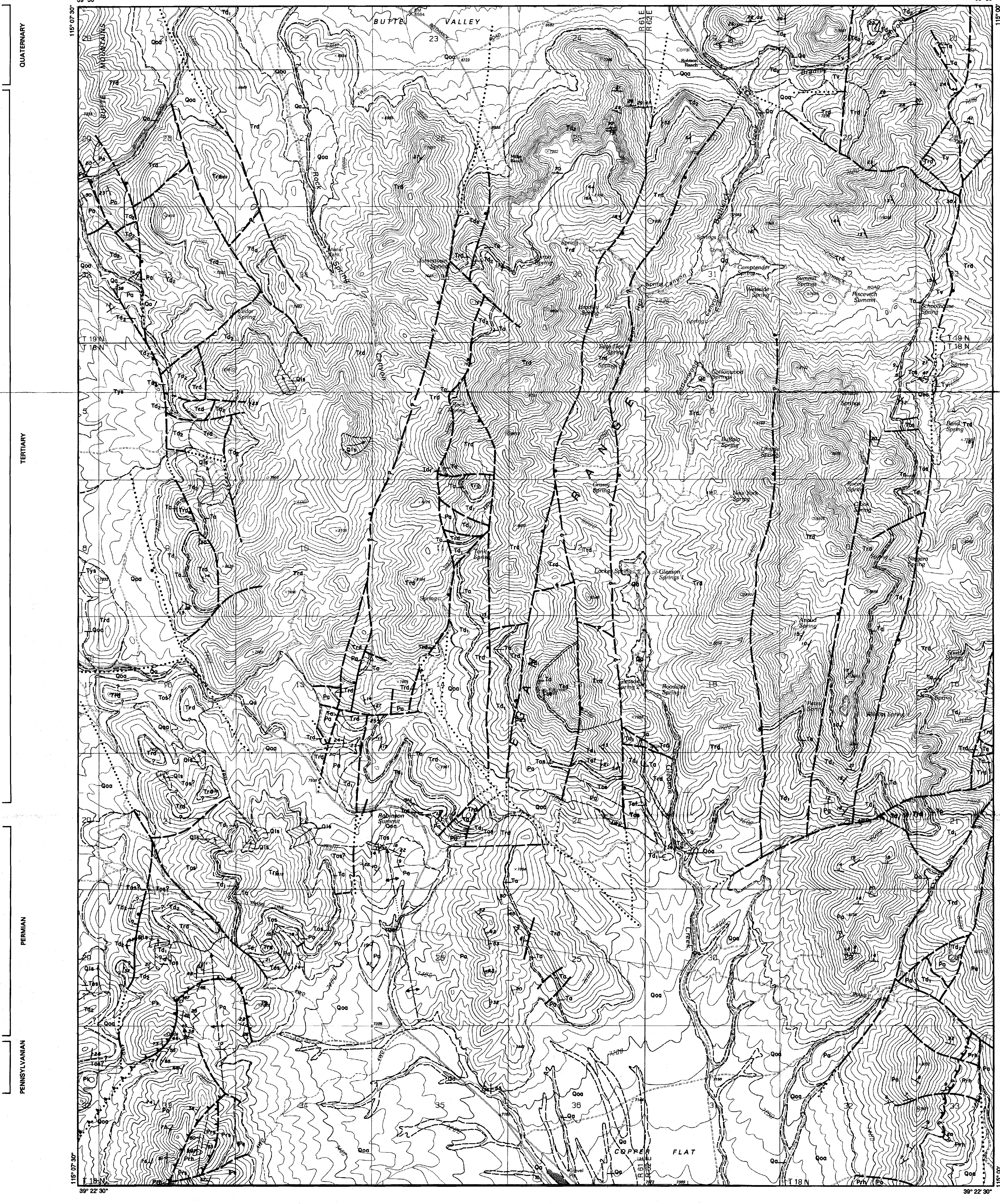
The volcanic rocks in the Robinson Summit Quadrangle correlate with widespread volcanic rocks in east-central Nevada described by Young (1960), Hise and Blake (1976), and Gans and others (1989). The petrography and geochemistry of the volcanic rocks exposed in the Egan Range, including those in the Robinson Summit Quadrangle, are described in detail by Feeley (1989) and Feeley and Grunder (1991). Feeley and Grunder divided the volcanic section in the Egan Range into three groups. In ascending stratigraphic order they are: (1) the early group which contains map units Tos, Taf, and Tv; (2) the middle group which contains map unit Td₂; and (3) the late group which contains map units Td₁, Ta, and Td.

*Paleozoic strata beneath the Tertiary unconformity are limited to Permian rocks and indicate that the Tertiary erosion surface could not have had more than about 3,300 feet of stratigraphic relief. This relationship holds true over a broad region throughout east-central Nevada (Armstrong, 1970; Gans and Miller, 1983).

**Young (1960) described discontinuous intervals of limestone conglomerate containing upper Paleozoic clasts overlain by lacustrine limestone and tuffaceous sedimentary rocks, collectively known as the Kinsey Canyon Formation, in the northern Sheep Creek Range. Rocks within map unit Tos are similar to the Kinsey Canyon Formation of Young (1960) and occur at a similar stratigraphic position and are considered correlative. Furthermore, Young (1960) correlated the Kinsey Canyon Formation with the Sheep Pass Formation in the southern Egan Range. Biostratigraphic studies have established the age of the Sheep Pass Formation as Eocene in the Grant Range, northern Nye County (Kleinhampl and Ziony, 1985). The age of the unconformity between the Tertiary and Paleozoic sections in the Robinson Summit Quadrangle is therefore most likely Eocene.

*Age determinations and the petrographic character of unit Taf suggest that it may be correlative with the Charcoal Ovens Tuff in the southern Egan Range (Hise and Blake, 1976). Taf yielded a ⁴⁰Ar/³⁹Ar age of 35.6 ± 0.5 Ma. A ⁴⁰Ar/³⁹Ar age agreement within weighted average ⁴⁰Ar/³⁹Ar age of 35.33 ± 0.06 Ma (Daino and Best, pers. comm., 1988) obtained from the Charcoal Ovens Tuff. In addition, both tuffs contain subhedral smoky quartz, sanidine, plagioclase, biotite, and rare sphene phenocrysts.

*Rocks within units Td₁, Td₂, Ta, and Td are those that, on the basis of field relations, Td₁ and Td₂ are age equivalents. Several lines of evidence, however, suggest that Td₁ lavas are products of a



1989). Gans and others (1989) divided the Kalamazoo volcanic rocks into the Kalamazoo Tuff, the hornblende dacite lavas, and the tuff of North Creek and related lavas. Hornblende from a biotite-hornblende-bearing dacite vitrophyre near the base of Td₂ yielded a ⁴⁰Ar/³⁹Ar age determination of 35.1 Ma. This age determination signifies that Td₂ lavas are more similar to Td₁ and Ta lavas in that they have elevated K₂O, Rb, and Zr relative to the older lavas. Dactles of Td₁ are therefore stratigraphically equivalent to Td₂ dactles but are considered to be part of a younger cycle of magmatism here (tuff of North Creek of Gans and others, 1989).

NOTES ON GEOLOGICAL STRUCTURE

Recognition and mapping of faults in the quadrangle was in part dependent on exposure and the distinctiveness of the stratigraphy. Thick, monotonous sequences of flow-folded to massive biotite rhyodacite (map unit Td) in the central part of the quadrangle greatly limit the recognition of faults and determination of attitudes. High-angle normal faults are abundant in the Robinson Summit Quadrangle. Although Gans (1982) has identified many down-to-the-east, shallow-dipping normal faults that cut mid-Tertiary volcanic units in the Hunter district 10 miles north of this study area, no evidence for shallow-dipping faults cutting the volcanic units was seen in the Robinson Summit Quadrangle. One shallow-dipping, nearly bedding planar fault juxtaposes Permian Kaibab Limestone over Permian Arcturus Formation in the southwest corner. This fault was folded along with Paleozoic strata which are now unconformably overlain by unfolded Tertiary strata. The fault is therefore older than the mid-Tertiary low-angle faults in the Hunter district (Gans, 1982). A few other shallow-dipping faults which juxtapose upper Paleozoic units are present in the southwest and southeast corners of the quadrangle.

Angular discordance across the Tertiary unconformity in the quadrangle is quite variable. Along the western edge of the quadrangle there is a buttress unconformity between west-dipping Paleozoic strata and east-dipping Tertiary strata, as evidenced by attitudes on basal Tertiary sedimentary rocks and regional attitudes of lavas. This relationship is well exposed in a stream cut along Bothwick road in the northwest corner of the quadrangle. Much of the angular discordance across the unconformity in the western region is not a result of Tertiary deformation. Rather, it is associated with northwest-trending folds formed during development of the Butte Mountains synclinorium during the Mesozoic (Douglas, 1980). Two northwest-trending anticlines probably formed during the Mesozoic folding event are exposed in the southwest part of the quadrangle. Elsewhere, the Arcturus Formation appears to be overlain with little to no angular discordance by the volcanic rocks. These relationships and the small degree of stratigraphic relief developed across the Tertiary unconformity suggest that the amount of pre-Tertiary deformation in the quadrangle was limited to local gentle warping of the Paleozoic strata prior to deposition or eruption of the Tertiary units.

The major high-angle faults in the quadrangle are responsible for the present topography typical of the Basin and Range. Although none of the mapped faults are exposed, their inferred map patterns suggest they are high-angle normal faults. Displacements are up to 500 feet along some of the larger faults, based upon offset of unit Ta which forms a distinctive stratigraphic marker unit. Most if not all of this normal faulting episode postdates eruption of the Tertiary volcanic rocks because the faults cut all the volcanic units. This relationship does not preclude active faulting during eruption; however, the monotonous, massive nature of the lavas makes demonstration of angular unconformities developed within the volcanic section difficult. A few small-displacement, high-angle faults cut the basal Tertiary sedimentary rocks and are depositionally overlapped by the youngest volcanic units suggesting local deformation during deposition of the Tertiary strata.

The present structure of the quadrangle is a series of approximately north-striking horsts and grabens. The largest graben is topographically expressed as Cottonwood Canyon in the north and Glasson Creek valley in the south. This region is characterized by numerous springs which issue along the graben-

bounding faults that appear to have served as the conduits. In the western region, the northwest trend of the faults parallels folds in the Butte Mountains suggesting local control of fault geometry by pre-existing structures.

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