Geology of the Dogskin Mountain Quadrangle, northern Walker Lane, Nevada

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Introduction

The Dogskin Mountain Quadrangle (DMQ) lies ~40 km north of the Reno-Sparks metropolitan area (Fig. 1). The DMQ encompasses most of Dogskin Mountain and the western part of the Virginia Mountains, two northwest-trending ranges that are separated by Winnemucca Valley. Dogskin Mountain reaches a maximum elevation of 2282 m (7487 ft), whereas maximum elevation of the Virginia Mountains is 2480 m (8140 ft) within the quadrangle and 2659 m (8724 ft) at Tule Peak immediately to the east. Elevations in Winnemucca Valley and Bedell Flat, the valley southwest of Dogskin Mountain, range from 1400 to 1500 m (4590 to 4920 ft).

Geologic mapping of the DMQ was undertaken for several applied and scientific reasons and is part of a broader investigation of the northern Walker Lane, a northwest-trending belt of active, right-lateral strike-slip faults (Fig. 2). Two major strands of the northern Walker Lane, the Warm Springs Valley and Honey Lake-Bedell Flat faults, pass through the DMQ. Western Nevada has experienced 13 earthquakes of magnitude 6 or greater since 1851 and 2 of magnitude 7 or more (dePolo et al., 1996). Geodetic data indicate the northern Walker Lane is undergoing ~10 mm/year of right-lateral motion, which represents 20-25% of Pacific-North American plate motion (Bennett et al., 1999, 2003; Thatcher et al., 1999). However, the earthquake hazard potential, as well as the Quaternary and late Tertiary structural-tectonic origin and evolution of the northern Walker Lane remain poorly understood. Important questions include which faults are taking up this motion, have all important faults been identified, what is the Pleistocene to Holocene displacement history, and what is the earthquake potential for these faults? Furthermore, the DMQ contains one of the region's most complete records of Oligocene to lower Miocene ash-flow tuffs. Our new mapping and other recent research show that these tuffs flowed in and are mostly preserved in generally west-striking paleovalleys cut into Mesozoic rocks (Davis et al., 2000; Henry et al., 2003). The paleovalleys are potential piercing points to measure strike-slip displacement. Much of the middle Miocene Pyramid sequence, a major mafic volcanic complex, lies within the quadrangle. Previous mapping of the DMQ consisted of a thesis map, which covered part of the northern Dogskin Mountain (Hutton, 1978), and 1:250,000-scale maps of Washoe County (Bonham and Papke, 1969) and the Reno 1°x2° sheet (Greene et al., 1991).

Major rock types in the DMQ are Mesozoic metamorphic and plutonic rocks, a complex sequence of Oligocene to lower Miocene ash-flow tuffs, a similarly complex sequence of middle Miocene mafic lavas and clastic sedimentary rocks (Pyramid sequence), and a wide array of Quaternary, mostly alluvial fan, deposits (Plate). Major structural elements of the quadrangle are northwest- and north-striking normal faults in Dogskin Mountain and the Virginia Mountains and northwest-striking, right-lateral strike-slip faults of the Warm Springs Valley and Honey Lake-Bedell Flat fault zones. General characteristics of the rocks are described on the map. This discussion focuses on regional geologic setting, especially how the rocks and structures of the DMQ fit into that setting.

Mesozoic Rocks

Mesozoic rocks consist of probably Jurassic metavolcanic (Jmv) and metasedimentary (Jms) rocks, and three distinct plutonic rocks, which are almost certainly Cretaceous (~90 Ma).

The metavolcanic rocks are metamorphosed, porphyritic andesite lavas, possible hypabyssal intrusions, and possible rhyolite ash-flow tuff. The metasedimentary rocks are metamorphosed, coarse volcanic conglomerate composed of andesite clasts and sandstone and shale (schist). The metamorphic rocks crop out adjacent to major plutons in the central part of Dogskin Mountain and in Black Canyon, as well as in deeper canyons in the western part of the quadrangle. This distribution suggests Tertiary rocks in the northern part of the quadrangle are mostly underlain by the metamorphic rocks. Similar metavolcanic rocks are widely distributed in western Nevada and are commonly assigned to the Peavine sequence (Fig. 2; Garside, 1998).

Parts of three major Cretaceous plutons crop out in the quadrangle. Quartz monzodiorite (Kqmd) makes up most of Dogskin Mountain and continues about 8 km south and southeast into the adjacent Bedell Flat (Garside, 1993) and Fraser Flat Quadrangles (Garside et al.,, 2003). Comparison of samples from the different quadrangles suggests a single pluton at least 15 km across. The quartz monzodiorite is cut by numerous, small bodies of aplite and pegmatite (Kf) and contains abundant bodies of fine-grained diorite (Kd), some of which appear to be dikes, whereas other bodies appear to be inclusions. A distinct paleoweathered zone (Kqw) is commonly developed along the contact with overlying tuffs. Granodiorite (Kgb) crops out in a small area (~0.5 km^2) in the footwall of a major normal fault in Black Canyon at the north end of the DMQ. The body is exposed for about another 2 km northward into the Spanish Flat Quadrangle. It is otherwise covered by Cenozoic rocks, and its overall distribution is unknown. A small area in the southwestern corner of the quadrangle is underlain by granite of Granite Peak (Kgg; equivalent to quartz monzonite of Granite Peak of Garside, 1987). Granite continues at least another 7 km to the southwest and makes up the Sand Hills, which lie mostly within the Granite Peak Quadrangle (Garside, 1987). Although the intrusions are not dated, they are probably all Cretaceous based upon their similarity to dated intrusions in the region.

Cenozoic Rocks

Oligocene-Lower Miocene Ash-flow Tuffs

The oldest Cenozoic rocks in the DMQ are a complex sequence of at least 16 distinct ash-flow tuffs, which are interbedded with conglomerate, sedimentary breccia**,** and other generally coarse clastic rocks (Plate). With the exception of the youngest tuff, all these erupted from sources well to the east in central Nevada. Most of the outcrop in the western part of the quadrangle consists of ash-flow tuff or interbedded sedimentary rocks. The tuffs were largely deposited in and are mostly preserved in a deep, west-southwest-trending paleovalley that had been eroded into the Mesozoic rocks across northern Dogskin Mountain. The tuffs in the DMQ fall into three distinct age groups (Tables 1 and 2): an oldest group deposited between 31.1 and 28.4 Ma; a second group erupted between 25.1 and 24.7 Ma; and a single, young tuff that is probably about 23.6 Ma.

The oldest group includes at least 11 mappable units that were formerly combined into the tuffs of Whisky Spring or Coyote Spring in regional studies (Garside and Bonham, 1992) or tuffs of McKisnick Spring in mapping within the DMQ (Hutton, 1978). Many of these tuffs are petrographically similar, with varying proportions of plagioclase, sanidine, and biotite phenocrysts and little quartz (Fig. 3). Their narrow age range and petrographic similarities suggest that they erupted from a related source area. A caldera complex in the Clan Alpine Mountains (Riehle et al., 1972) ~170 km to the east is probably one source. A caldera in the Desatoya Mountains (McKee and Conrad, 1987) about 200 km to the east was definitely the source of the 28.6-Ma tuff of Campbell Creek (Tcc).

The middle group consists of four tuffs ranging from 25.1 to 24.7 Ma. The distinctive petrographic character of the Nine Hill Tuff (Tnh) and tuff of Chimney Spring (Tcs) (Fig. 3) has made correlation relatively easy, and they are recognized widely in western Nevada and the eastern Sierra Nevada (e.g., Deino, 1985, 1989; Best et al., 1989; John, 1995; Brooks et al., 2003). The tuff of Chimney Spring and upper tuff of Painted Hills (Tpu) erupted from calderas in the Stillwater Range (John, 1995; Hudson et al., 2000), ~120 km to the east. The source of the extremely widespread Nine Hill Tuff (Deino, 1985, 1989) remains unknown.

The rhyodacite ash-flow tuff (Trt) is the youngest tuff and the only one with a possible local source. It is petrographically similar and probably related to a series of rhyolite to dacite intrusive domes that are concentrated in the southern parts of the Tule Peak and Sutcliffe quadrangles and northern parts of the Fraser Flat and Moses Rock Quadrangles (Figs. 1 and 2; Faulds et al., 2001; Garside et al., 2003). The domes are adjacent to and could be related to the hypothesized Perry Canyon caldera (Garside et al., 1999).

It is possible that still older ash-flow tuffs are present in deeper, unexposed parts of the paleovalley. The oldest currently recognized tuff, the tuff of Axehandle Canyon (Twb), has a steep depositional contact on Mesozoic metavolcanic rocks (Jmv) in Dry Valley Creek in the northwestern part of the quadrangle. This contact dives beneath alluvium in the creek, and the base of the tuff section is not exposed there.

All ash-flow tuffs are laterally discontinuous, because they were deposited almost exclusively in the deep paleovalley and commonly variably eroded before deposition of the next tuff. The oldest tuffs were deposited in and are largely restricted to the deeper parts of the paleovalley and crop out only in deep canyons, mostly in the western part of the DMQ (Plate). The southern edge of the paleovalley is readily apparent on the geologic map where the tuffs thin and pinch out southward against quartz monzodiorite (Kqmd). Younger tuffs, e.g., Nine Hill Tuff, rest directly on quartz monzodiorite outside the paleovalley, both in the range and along its southwest flank. A northern paleovalley margin is exposed in Black Canyon in the north central part of the quadrangle. In that area, the tuff of Cove Spring (Twc) rests on Mesozoic rocks and pinches out northward, where Pyramid sequence rocks rest directly on granodiorite (Kgb). Because this location is on the other side of the Warm Springs fault and amount of displacement on that fault zone is uncertain, the original position of this northern margin and whether it is the northern margin to the paleovalley exposed in Dogskin Mountain are uncertain.

Conglomerate, breccia, and some finer grained, clastic sedimentary rocks underlie and are interbedded with the tuffs. Clasts in the stratigraphically lowest conglomerate (Tsk), exposed only in Dry Valley Creek near the western edge of the DMQ, are exclusively meta-andesite and a few granitic rocks, which indicate deposition of the conglomerate before deposition of any of the tuffs. Coarse clasts of tuff are abundant in stratigraphically higher conglomerates. Although sedimentary deposits of some type are found locally between all tuffs, the coarsest, thickest, and most distinctive deposit developed during the long hiatus between the older and younger group of tuffs. This conglomerate and/or breccia (Tca) contains angular to moderately rounded clasts of tuff of Dogskin Mountain (Tdm) up to 12 m in diameter and of andesite up to 8 m in diameter. Andesite clasts include both Mesozoic meta-andesite (Jmv), distinguished by metamorphism of plagioclase and mafic phenocrysts, and probable Cenozoic andesite, characterized by unaltered mafic minerals. The clasts are commonly internally brecciated but not significantly disaggregated. The deposit generally underlies Nine Hill Tuff (Tnh) or tuff of Chimney Spring (Tcs) and overlies tuff of Campbell Creek (Tcc), but it locally underlies the tuff of Campbell Creek.

The complex interbedding of tuffs and sedimentary deposits is particularly well illustrated by a down-dip view of northeast-dipping rocks ~1 km southwest of Winnemucca Ranch (Plate). In that area, the tuff of Dogskin Mountain (Tmd) was deeply eroded before deposition of the tuff of Campbell Creek (Tcc). The tuff of Campbell Creek was itself deeply incised and the resulting valley filled with the coarse conglomerate/breccia (Tca). Unit Tsb was then eroded, and Nine Hill Tuff (Tnh) partly filled the valley. Finally, Nine Hill Tuff was eroded, and the tuff of Chimney Spring (Tcs) filled that valley. Each of these deposits shows considerable variation in thickness, to the point that each deposit pinches out to the southeast or northwest against older rocks.

Pre-Cenozoic outcrop within and along the southern edge of the paleovalley is mostly Mesozoic metamorphic rocks; no granitic rock is exposed within the paleovalley. This suggests that the paleovalley is largely eroded into the metamorphic rocks and that the contact between metamorphic rocks and quartz monzodiorite controlled the edge of the paleovalley. The northern margin in Black Canyon shows a similar pattern, but whether that was the northern margin of the Dogskin Mountain paleovalley is not certain. Present-day relief on the paleovalley is at least 500 m, from Dogskin Mountain at 2275 m to the top of metamorphic rocks at ~1775 m north of McKissick Canyon.

Minor Cenozoic Igneous Rocks

Distinctive dikes of hornblende andesite (Tih), having only sparse plagioclase phenocrysts, crop out in four locations in the west-central part of the quadrangle. The age and association of these dikes are unknown other than that they cut ash-flow tuff as young as tuff of Dogskin Mountain (Tdm). The dikes are unlike most other andesites in adjacent quadrangles, which have abundant, large plagioclase phenocrysts.

The presence of apparently Cenozoic andesite clasts up to 1 m in diameter in the sedimentary breccia (Tca) requires a nearby source at least 25.1 Ma old, the age of the overlying Nine Hill Tuff. Although we have found 28 Ma andesites near Carson City, the oldest dated andesites nearby are 22.5 Ma dikes in the Moses Rock Quadrangle.

Pyramid Sequence (Tp)

The informally named Pyramid sequence (Bonham and Papke, 1969), which constitutes the oldest, locally derived Cenozoic volcanic rocks in the quadrangle, crops out extensively in the northern part of the quadrangle and in one area along the west side of Dogskin Mountain. The Pyramid sequence consists of complexly interbedded basaltic to basaltic andesite and sparse andesite lavas, possibly one rhyolite lava(?), coarse to fine clastic rocks, and a dacitic ash-flow tuff. The lavas range, apparently gradationally, from aphyric to abundantly and coarsely porphyritic and are subdivided on the basis of phenocryst content (Fig. 4; Table 3) and known or inferred chemical composition (Table 4). Two end members are aphyric to very finely porphyritic basalt to basaltic andesite (Tpb) and coarsely porphyritic basaltic andesite (Tpp). The coarsely porphyritic rocks are characterized by prominent, tabular plagioclase phenocrysts up to 20 mm long and only a few millimeters wide. Other mappable units are sparsely porphyritic basaltic andesite (Tpb'), finely porphyritic basaltic andesite (Tpp'), bimodal porphyritic basaltic andesite (Tpp"), and rhyolite lava or breccia (Tpr). Lava types are distributed throughout the stratigraphic sequence. Figure 5 of a well-exposed section through the Pyramid sequence in the Virginia Mountains demonstrates the complex interbedding of different lavas and sedimentary rocks.

The dacitic tuff of Mullen Pass (Tpm) crops out discontinuously in the lower part of the Pyramid sequence. It correlates with the upper of two dacitic tuffs mapped to the east and southeast in the Tule Peak and Moses Rock Quadrangles (Garside et al., 2003; Faulds et al., 2001). The rhyolite at the northern edge of the DMQ occurs as boulders. Whether these boulders represent in-situ lava or are reworked is uncertain.

Conglomerate, breccia, sandstone, and other clastic rocks dominated by clasts of lava (Tpc) occur throughout the Pyramid sequence. Distal exposures of the Pyramid sequence, e.g., along the Warm Springs Valley fault zone in the east-central part of the quadrangle, are dominated by clastic rocks. Locally, the clastic rocks fill deep channels cut into lavas. Diatomite forms mostly thin, discontinuous lenses within the sedimentary rocks and was mapped locally where relatively thick or laterally continuous (Tpd). Where deeply weathered, the coarse deposits can be difficult to distinguish from late Pliocene – Quaternary alluvial deposits (QTa), and we may have misinterpreted some.

Both isotopic ages of lavas and leaf fossils in diatomite (Axelrod, 1956) demonstrate that the Pyramid sequence is middle Miocene. However, $^{40}Ar/^{39}Ar$ ages on different parts of the sequence are contradictory, with ages around 13.7 Ma in the lower part and ~15 Ma in the upper part (unpublished $^{40}Ar/^{39}Ar$ ages in the Tule Peak and Sutcliffe Quadrangles; J.E. Faulds and C.D. Henry). Hornblende from the tuff of Mullen Pass in the lower part of the Pyramid sequence gives an age of 13.77±0.15 Ma. Swisher (1992) reported an indistinguishable $^{40}Ar/^{39}Ar$ age of 13.84±0.15 Ma on plagioclase from the tuff. The matrix of a basaltic lava (Tpb) at the base of the sequence in the western part of the Tule Peak Quadrangle gives 13.62±0.12 Ma. However, lavas in the upper part of the sequence in the northern Tule Peak Quadrangle give ages around 15 Ma, and plagioclase from the rhyolite is 14.88±0.10 Ma. Dates on Pyramid sequence or similar rocks more regionally are mostly about 14 Ma but range from 13 to 18 Ma (Fig. 2).

The Pyramid sequence is widespread in western Nevada with a center of distribution approximately in the Virginia Mountains (Figs. 1 and 2). It extends to the northern end of the Virginia Mountains (Faulds and Henry, 2002), to the Pah Rah Range (Sutcliffe, Moses Rock, and Olinghouse Quadrangles) to the southeast (Faulds et al., 2002; Garside et al., 2003; Garside and Bell, in prep.), to the Lake and Nightingale Ranges to the east (Benham, 1982; Ressel, 1996), and to the Fort Sage Mountains, including slightly into California to the northwest (Grose, 1984; Grose et al., 1989, 1990). Correlation throughout this area is based on similar stratigraphic position and petrographic character, as well as on composition and age where available. For example, rocks in the Lake Range east of Pyramid Lake have similar compositions and K-Ar ages of 14.2±0.4 at the base and 14.1±0.4 Ma near the top (Fig. 2; Ressel, 1996). However, Ressel included silicic lavas at the base and top of what he mapped as Pyramid sequence, and the K-Ar dates are on these rocks. Our rhyolite lava or breccia could correlate with or be reworked from silicic lavas similar to these. An $^{40}Ar/^{39}Ar$ age of 13.02±0.04 Ma on a Pyramid sequence lava in the Olinghouse Quadrangle (Garside and Bell, in prep.) demonstrates that some mapped Pyramid sequence rocks in the area shown on Figure 2 are younger than those in the Virginia Mountains. Without detailed mapping and precise $^{40}Ar/^{39}Ar$ ages, correlation can be uncertain.

The tuff of Mullen Pass is recognized in the Tule Peak Quadrangle (Faulds et al., 2001.) and the southern Nigthingale Range (Benham, 1982). The appearance of the distinctive and precisely dated tuff in the Nightingale Range indicates that lavas there are the same age, at least in part, to lavas in Dogskin Mountain and Tule Peak Quadrangles. Evans et al. (1981) mapped a petrographically similar tuff in what they called the Pyramid sequence in the northern Lake Range, just north of the area depicted in Figure 2. However, they report K/Ar ages between 16.2±0.5 Ma and 17.8±0.7 Ma on the tuff, which is distinctly older than our $^{40}Ar/^{39}Ar$ date.

Source areas are spread throughout this region, although only a few dikes occur in the DMQ. Major source areas include a large volcanic complex that was centered on the north-central Virginia Mountains in the adjacent Tule Peak Quadrangle to the east (Faulds et al., 2001), several cinder cones and intrusions in the Pah Rah Range (Garside et al., 2003), several stocks and numerous dikes in the Lake Range (Ressel, 1996), and numerous subvolcanic intrusions in the Fort Sage Mountains (Grose, 1984; Grose et al., 1989, 1990). Most of the lavas in the northern part of the DMQ may have come from the volcanic center in the Tule Peak Quadrangle. The source of the tuff of Mullen Pass is unknown.

Late Pliocene – Quaternary alluvial deposits and fans

Variably deformed to undeformed, coarse to fine clastic rocks crop out extensively along the Warm Springs Valley fault zone. Two distinct types are clearly tilted and possibly folded and were mapped as late Pliocene to Quaternary(?). The stratigraphically older deposit (QTk) consists of pebble conglomerate and sandstone composed almost entirely of clasts of quartz monzodiorite (Kqmd). A tephra layer in this unit in the southern part of the Tule Peak Quadrangle yielded an age of 3.57±0.17 Ma (Faulds et al., 2001; Henry et al., 2002). At the dated sample location, beds dip 38° to the south. This relatively fine-grained deposit contrasts with Pleistocene to Holocene alluvial fans derived from Dogskin Mountain, which contain clasts of quartz monzodiorite up to 2 m in diameter all the way to the Warm Springs Valley fault zone. A possible interpretation is that unit QTk records erosion of a lower, "ancestral" Dogskin Mountain. If so, most of the uplift of Dogskin Mountain may have occurred after 3.57 Ma.

A second type (QTa) consists almost entirely of coarse clasts of Pyramid sequence lavas, presumably derived from erosion of the Virginia Mountains. Unit QTa forms uplifted ridges along the Warm Springs Valley fault, which distinguishes it as a map unit from the undeformed Pleistocene to Holocene alluvial fans, which have the same clast types and sizes. However, because faulting is ongoing, much of unit QTa may be toes of younger alluvial fans deformed along the Warm Springs Valley fault. Other parts may be only slightly younger than unit QTk, which it overlies wherever they occur together. Also, we may have mistakenly identified some of the coarse clastic rocks of the Pyramid sequence (Tpc) as these younger rocks.

Structure

Rocks in the DMQ are highly faulted and locally folded. Understanding of the overall structure is aided by dividing faults into normal and strike-slip faults and the quadrangle into four structural domains (Plate). These domains are (1) normal faults of Dogskin Mountain, (2) normal faults of the Virginia Mountains, (3) the Warm Springs Valley strike-slip fault zone, and (4) the Honey Lake-Bedell Flat strike-slip fault zone. The Sand Hills constitute a fifth domain that is mostly in the Bedell Flat Quadrangle.

Normal Faults

Dogskin Mountain

The southeastern part of Dogskin Mountain is a southwest-tilted fault block, bounded on the northeast by the major Dogskin Mountain normal fault. Displacement may be as much as 2.5 km, based on known and estimated elevations of quartz monzodiorite (Kqmd) on each side of the fault (Section C-C'). However, additional deformation along the Warm Springs Valley fault zone complicates this estimate. The Dogskin Mountain fault continues to the southeast, into the Tule Peak and Fraser Flat Quadrangles, where the fault forms the western boundary of Warm Springs Valley (Faulds et al, 2001; Garside et al., 2003). Although the southeastern flank of Dogskin Mountain is a steep topographic scarp, there is no evidence of very young, Pleistocene(?) displacement on it. A northwest-striking normal fault also bounds part of the southwestern side of Dogskin Mountain. However, southwest dips of ash-flow tuffs along the southwestern side and the asymmetric shape of the range, steeper on the northeast, indicate it is mostly southwest tilted.

The tuffs along the southwest side dip toward another major, northwest-striking normal fault in the southwestern corner of the quadrangle. This fault forms the range front of the Sand Hills, which is a west-tilted block that lies mostly in the Seven Lakes Mountain, Granite Peak (Garside, 1987), and Bedell Flat Quadrangles (Garside, 1993). Displacement on the Sand Hills fault is probably about 2 km, but estimation is again hampered by proximity to the Honey Lake-Bedell Flat strike-slip fault. The Sand Hills fault curves to a more north-northeasterly strike to the south (Fig. 2; Garside, 1993).

The Dogskin Mountain frontal fault dies out northwestward, and the northern part of the range is a gently north-plunging, faulted anticline (Section B-B'). Ash-flow tuffs dip southwest along the southwest flank and northeast along the northeast flank. The structural change is reflected in the shape of the range, from a steep face along the part bounded by the Dogskin Mountain fault to a much more gentle face along the anticlinal part (contrast Sections B-B' and C-C'). The anticline is cut by numerous, mostly moderate displacement normal faults that dip into the core of the anticline. Displacements range up to ~1 km, but most faults have only a few hundred meters of offset.

Fault surfaces are rarely exposed, but we were able to measure fault and striae orientations on 23 faults in the northern part of Dogskin Mountain (Fig. 6). The striae scatter widely but are consistent with approximately east to northeast extension. A few northwest-oriented striae may indicate reactivation during strike-slip faulting related to the Warm Springs Valley and Honey Lake-Bedell Flat fault zones.

Virginia Mountains

The Virginia Mountains in the DMQ are part of a broad, north-trending, faulted anticline whose main hinge line lies in the Tule Peak Quadrangle (Faulds and Henry, 2002; Faulds et al., 2001). Outcrop is mostly Pyramid sequence, which dips generally westward in the DMQ and eastward in the Tule Peak Quadrangle (Faulds et al., 2001). However, dips reverse across several minor folds, including one in the DMQ.

The Black Canyon fault is the westernmost and has the largest displacement of a series of north-striking, down to the east normal faults (Section A-A'). Granodiorite (Kgb) is exposed in the footwall of the fault in Black Canyon. Displacement on the Black Canyon fault in this quadrangle is about 1.5 km, and appears to increase northward off the quadrangle. Pyramid sequence lavas dip generally about 30° westward in both the footwall and hangingwall. To the east, west-dipping Pyramid sequence lavas are repeated by another major normal fault in the canyon of Dry Valley Creek and by several small displacement faults still farther east.

Along the eastern edge of the quadrangle, two faults with ~300 to 500 m displacement dip to the west, and Pyramid sequence rocks dip gently ($\leq 10°$) to the east. Pyramid sequence rocks in the keystone block between east- and west-dipping faults dip gently westward and are cut by several small-displacement faults. Rocks in the hangingwall of these faults dip less than rocks in the footwall, which suggests the faults steepen downward.

Fault surfaces are poorly exposed in the Virginia Mountains, and we were able to measure fault and striae orientations at only 8 locations (Fig. 6). Nevertheless, these data as well as the predominant northerly strike of faults may also indicate ~east to east-northeast extension as in the Dogskin Mountain domain. Reactivation during strike-slip faulting is again possible.

The northeast tilt of tuffs in the northern part of Dogskin Mountain and west tilt of rocks in the Virginia Mountains create a syncline between the two areas. The Warm Springs Valley fault zone passes through the core of this syncline. However, the relative location of the two areas before strike-slip faulting is uncertain. Nevertheless, tuffs dip southwest all along the southwestern flank of the Virginia Mountains (Faulds et al., 2001) and in the Pah Rah Mountains still farther southeast (Garside et al., 2003). So a syncline certainly lay between the two areas even before strike-slip displacement.

Strike-slip Faults

Warm Springs Valley Fault Zone

The Warm Springs Valley fault zone (WSF) is a northwest-striking, right-lateral fault system that extends southward ~60 km from the Honey Lake basin in California to near the east-northeast-striking, left-lateral Olinghouse fault (Fig. **2**). The DMQ contains an approximately 14-km-long segment of the fault zone.

In this quadrangle, the WSF consists of as many as four strands over a width of about 1.5 km. The fault zone over most of its length cuts bedrock consisting of Pyramid sequence or Oligocene ash-flow tuffs. In a zone about 4 km long through the southeastern part of the quadrangle, the fault zone cuts Quaternary fans and late Pliocene-Quaternary(?) deposits. Linear hills are well developed along much of the WSF in the DMQ and for about another 5 km into the Tule Peak Quadrangle (Henry et al., 2002; Faulds et al., 2001).

Movement along faults of the WSF has significantly deformed both bedrock and surficial units. In bedrock, this deformation has greatly accentuated the syncline developed between the northeast dips of Dogskin Mountain and west dips of the Virginia Mountains. The northeastern limb of the syncline is overturned, whereas dips developed only from extension are generally about 30° and never more than about 50°.

The WSF is marked by a series of linear ridges cored by Quaternary fans and late Pliocene-Quaternary deposits in both the DMQ and Tule Peak Quadrangle. Unit QTk is tilted 38° where it contains the 3.57±0.17 Ma tephra in the Tule Peak Quadrangle about 2.5 km east of the DMQ; correlative deposits just 0.5 km east of the DMQ are vertical. These units are probably similarly deformed in the DMQ, but poor exposure of the unconsolidated deposits makes measuring attitudes difficult. By analogy to the bedrock deformation, these units may also be folded.

The most obvious fault scarps show vertical rather than horizontal displacement. Although this may mostly reflect the difficulty in preserving and recognizing lateral scarps, the faults certainly have a vertical component. Vertical scarps are developed along the borders of older, deformed fan deposits (Qdao) approximately 2 and 4 km southeast of Winnemucca Ranch. Possible fault scarps are developed in probable mid to late Holocene alluvial fan deposits (Qfy1) and lacustrine deposits (Qlo) along the same fault strand about 3 and 5 km southeast of Winnemucca Ranch.

Distal fan deposits that are deformed along the WSF are not measurably displaced from their undeformed proximal fans. This limits total Pleistocene displacement along some individual strands to much less than 1 km. Clast compositions and sizes in older/deformed fan deposits (Qdao) indicate that they are the deformed toes of adjacent Quaternary fans and that some fault strands have negligible lateral displacement since deposition of these units. For example, unit Qdao approximately 2 km southeast of Winnemucca Ranch is bordered on the southwest by a distinct fault scarp, down on the southwest. Unit Qdao there appears to be the uplifted toe of alluvial fans (Qfdy2 and Qfdi) adjacent to the southwest. Clasts in Qdao are of ash-flow tuff at its northwestern end. Southeastward along Qdao outcrop, clasts of metavolcanic rocks (Jmv) and then of quartz monzodiorite (Kqmd) appear. This distribution matches clast-type distribution in the adjacent alluvial fans (Qfdy2 and Qfdi), which reflects bedrock distribution in the source areas of the fans, and implies that Qdao has not been displaced laterally relative to Qfdy2 and Qfdi. Unit Qdao, adjacent Quaternary fans, their clast types, and bedrock distribution about 4 km southeast of Winnemucca Ranch show a similar pattern.

Displacement along one major strand of the WSF apparently blocked southwest-flowing drainage across the large alluvial fan complex at the eastern edge of the quadrangle. This displacement, which could have been either lateral or vertical, created a closed basin(s?) where lacustrine deposits (Qlo) accumulated upfan from the linear ridges. Fan drainage subsequently cut back through the ridges in two locations, and the lacustrine deposits are being dissected. Dating of the lacustrine deposits should indicate at least one time of major displacement along the WSF.

A poorly understood, east-striking fault is developed along an approximately 4-km-long segment of Dry Valley Creek where the WSF crosses. Oligocene tuffs and Pyramid sequence do not match across the fault. How this zone relates to the WSF is unclear.

Tuff-filled paleovalleys may be the best potential piercing points to determine total displacement across the WSF. Allowing for several assumptions about the precise locations and orientations of these valleys, we estimate between 6 and 10 km right-lateral displacement on the WSF.

Honey Lake-Bedell Flat Fault zone

The Honey Lake-Bedell Flat fault zone (HLBF) is another northwest-striking right-lateral fault zone that extends ~80 km from Honey Lake (Grose et al., 1990; Wills and Borchardt, 1993) at least to Warm Springs Valley (Figs. 1 and 2; Garside et al., 2003). Just a short, 2.5 km-long segment crosses the southwestern corner of the DMQ, entirely in alluvial fan deposits. However, the zone in this area displays several similarities to the WSF, including parallelism to an adjacent, major normal fault, wide zone of faulting, development of linear ridges, and obvious vertical displacements along some fault strands. The HLBF parallels part of the Sand Hills fault to the southwest. Young fault scarps are developed over a width of nearly 2 km across the HLBF.

Uplift along the HLBF is indicated by a series of discontinuous low hills along the fault zone that become higher toward the northwest. The southeasternmost line of hills are about 100 m wide and 500 m long, rise about 2 m above adjacent alluvial fans on the downstream side, but blend imperceptibly into fans on the upstream side. “Outcrop” consists of powdery caliche, which shows white on aerial photographs. Boulders of quartz monzodiorite (Kqmd) to 50 cm and tuff to 30 cm lie along the flanks of the caliche hills. We interpret these to be the uplifted, calichified horizon (Qfdic) of adjacent fans. A faint photolinear along the southwest flank of the caliche hills may be a fault scarp.

The next line of hills (Qfdo) to the northwest are almost 1 km long, continuing into the Seven Lakes Mountain Quadrangle, and up to 250 m across. These hills rise as much as 10 m above adjacent alluvial fans, higher to the northwest. Abundant boulders, mostly of felsite (Kf) up to 80 cm in diameter, along with some tuff (Tcs, Tnh, and Tmd) up to 50 cm, and a few quartz monzodiorite up to 1 m, coat the hills, mostly along their steeper southwest flanks. These boulders contrast with clasts on adjacent, undeformed alluvial fans, where the coarsest grains are pebbles up to about 5 mm in diameter. A faint linear break along the southwest side of the hills may be another fault scarp. We interpret these hills also to be uplifted fans but eroded into coarse, lower parts of the fans. Hills farther northwest into the Seven Lakes Mountain Quadrangle are still higher and expose ash-flow tuff bedrock.

Numerous faults cut the alluvial fans. The most obvious displacements are vertical, both down-to-the-northeast and down-to-the-southwest. The largest scarp, about 20 m, separates deeply incised older fans (Qfdo) on the northeast from less dissected younger fans (Qfdy2) on the southwest. Three drainages show apparent right-lateral displacement of about 20 to 40 m, which constitutes the strongest evidence for relatively young strike-slip displacement along the HLBF. Too little of the HLBF has been mapped at this time to evaluate total displacement along it.

Lack of Strike-slip Displacement in the Ranges

Several features indicate little if any strike-slip displacement has occurred within Dogskin Mountain or the Virginia Mountains within the DMQ. The southern edge of the paleovalley in Dogskin Mountain forms a continuous wall striking west-southwest across the central part of the range. Coarse conglomerate/breccia (Tca) forms a discontinuous series of outcrops paralleling and within about 1 km of Mesozoic outcrop and the southern edge of the paleovalley. In the Virginia Mountains, the northern pinch out of the distinctive bimodal porphyritic basaltic andesite lava (Tpp”), probably the margin of the flow, makes an east-west line across several of the fault zones.

The relative timing of, and genetic relation between, the normal and strike-slip faults is uncertain. My favored interpretation is that the normal faults, including the Dogskin Mountain and Sand Hills range front faults and normal faults within the ranges, formed and were active dominantly during possibly two episodes of approximately east to east-northeast extension that preceded strike-slip faulting. Strike-slip faulting may have begun only in the last 3 Ma. The range front faults may have undergone minor displacement contemporaneous with strike-slip faulting, but they are now mostly inactive. Alternatively, the normal and strike-slip faults could be kinematically related, and both active contemporaneously (Faulds et al., 2003). This alternative recognizes that the normal faults curve to a more northeasterly strike southwest of the WSF. Normal displacement on the north-northeast-striking faults would allow relative northwest-southeast displacement, as would the strike-slip faults.

References Cited

Axelrod, D.I., 1956, Mio-Pliocene floras from west-central Nevada: University of California Publications, Geological Sciences, v. 33, p. 1-322.

Benham, J.A., 1982, Geology and uranium content of middle Tertiary ash-flow tuffs in the southern Nigthingale Mountains and northern Truckee Range, Washoe County, Nevada: M.S. thesis, University of Nevada, Reno, 112 p.

Bennett, R.A., Davis, J.L., and Wernicke, B.P., 1999, Present-day pattern of Cordilleran deformation in the western United States: Geology, v. 27, p. 371-374.

Bennett, R.A., Wernicke, B.P., Niemi, N.A., Friedrich, A.M., and Davis, J.L., 2003, Contemporary strain rates in the northern Basin and Range province from GPS data: Tectonics, v. 22, no. 2, 1008, doi:10.1029/2001TC001355.

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

Bonham, H.F., and Papke, K.G., 1969, Geology and mineral deposits of Washoe and Storey Counties, Nevada: Nevada Bureau of Mines and Geology Bulletin 70, 139 p.

Brooks, E.R., Wood, M.M., Boehme, D.R., Potter, K.L., and Marcus, B.I., 2003, Geologic map of the Haskell Peak area, Sierra County, California: California Geological Survey Map Sheet 55.

Davis, D.A., Henry, C.D., Garside, L.J., Faulds, J.E., and Goldstrand, P.M., 2000, Eocene-Oligocene paleovalleys cross the Sierra Nevada – Basin and Range boundary, western Nevada and eastern California: Geological Society of America Abstracts with Programs, v. 32, no. 7, p. A-167.

Deino, A.L., 1985, Stratigraphy, chemistry, K-Ar dating, and paleomagnetism of the Nine Hill Tuff, California-Nevada [Ph.D. dissertation]: University of California, Berkeley, 457 p.

Deino, A.L., 1989, Single crystal $^{40}Ar/^{39}Ar$ dating as an aide in correlation of ash flows: Examples from the Chimney Springs/New Pass Tuffs and the Nine Hill/Bates Mountain Tuffs of California and Nevada: New Mexico Bureau of Mines and Mineral Resources, Continental Magmatism Abstracts Bulletin 131, p. 70.

Deino, A., and Potts, R., 1990, Single-Crystal $^{40}Ar^{39}Ar$ dating of the Olorgesailie Formation, Southern Kenya Rift: Journal of Geophysical Research, v. 95, p. 8453-8470.

dePolo, C.M., Rigby, J.G., Johnson, G.L., Jacobson, S.L., Anderson, J.G., and Wythes, T.J., 1996, Planning scenario for a major earthquake in western Nevada: Nevada Bureau of Mines and Geology Special Publication 20, 128 p.

Evans, S.H., Moore, J.N., and Adams, M.C., 1981, K/Ar ages of the Pyramid sequence in the vicinity of the San Emidio geothermal area, Washoe County, Nevada: Isochron/West, no. 31, p. 19-21.

Faulds, J.E., dePolo, C.M., and Henry, C.D., 2002, Geologic map of the Sutcliffe Quadrangle: Nevada Bureau of Mines and Geology DELIVERABLE, 1:24,000.

Faulds, J.E., and Henry, C.D., 2002, Tertiary stratigraphy and structure of the Virginia Mountains, western Nevada: Implications for development of the northern Walker Lane: Geological Society of America Abstracts with Programs, v. 34, no. 5, p. A84.

Faulds, J.E., Henry, C.D., and dePolo, C.M., 2001, Preliminary geologic map of the Tule Peak Quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology DELIVERABLE, 1:24,000.

Faulds, J.E., Henry, C.D., and Hinz, N.H., 2003, Kinematics and cumulative displacement across the northern Walker Lane, an incipient transform fault, northwest Nevada and northeast California: Geological Society of America Abstracts with Programs, v. 35, no. 7, p.

Garside, L.J., 1987, Reconnaissance geologic map of the Granite Peak Quadrangle, Nevada: Nevada Bureau of Mines and Geology Open File Report 87-8, scale 1:24,000.

Garside, L.J., 1993, Geologic map of the Bedell Flat Quadrangle, Nevada: Nevada Bureau of Mines and Geology Field Studies Map FS-3, 1:24,000.

Garside, L.J., 1998, Mesozoic metavolcanic and metasedimentary rocks of the Reno-Carson City area, Nevada and adjacent California: Nevada Bureau of Mines and Geology Report 49, 30 p.

Garside, L.J., and Bonham, H.F., Jr., 1992, Olinghouse Mining District, Washoe County, Nevada, *in* Craig, S.D., ed., Structure, tectonics, and mineralization of the Walker Lane: Geological Society of Nevada, Walker Lane Symposium, Proceedings Volume, p. 227-238).

Garside, L.J., Castor, S.B., dePolo, C.M., and Davis, D.A., 2003, Geologic Map of the Fraser Flat Quadrangle and western half of the Moses Rock Quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 146, 1:24,000.

Garside, L.J., Castor, S.B., Henry, C.D., and Faulds, J.E., 2000, Structure, volcanic stratigraphy, and ore deposits of the Pah Rah Range, Washoe County, Nevada: Geological Society of Nevada Symposium 2000 Field Trip Guidebook No. 2, 132 p.

Greene, R. C., Stewart, J. H., John, D. A., Hardyman, R. F., Silberling, N. J., and Sorensen, M. L., 1991, Geologic map of the Reno 1° by 2° quadrangle, Nevada and California: U. S. Geological Survey Miscellaneous Field Studies Map MF-2154-A, scale 1:250,000.

Grose, T.L.T., 1984, Geologic map of the Stateline Peak Quadrangle, Nevada-California: Nevada Bureau of Mines and Geology Map 82, scale 1:24,000.

Grose, T.L.T., Saucedo, G.J., and Wagner, D.L., 1990, Geologic map of the Susanville Quadrangle, Lassen and Plumas Counties, California: California Division of Mines and Geology Open-File Report 91-1, scale 1:100,000.

Grose, T.L.T., Wagner, D.L., Saucedo, G.J., and.Medrano, M.D., 1989, Geologic map of the Doyle 15-minute Quadrangle, Lassen and Plumas Counties, California: California Division of Mines and Geology Open-File Report 89-31, scale 1:62,500.

Henry, C.D., Faulds, J.E., and dePolo, C.M., 2002, Structure and evolution of the Warm Springs Valley fault (WSF), northern Walker Lane, Nevada: Post-3-Ma initiation(?): Geological Society of America Abstracts with Programs, v. 34, no. 5, p. A84.

Hudson, M.R., John, D.A., Conrad, J.E., and McKee, E.H., 2000, Style and age of late Oligocene-early Miocene deformation in the southern Stillwater Range, west central Nevada: Paleomagnetism, geochronology, and field relations: Journal of Geophysical Research, v. 105, p. 929-954.

Hutton, R.A., 1978, Geology and uranium content of middle Tertiary ash-flow tuffs in the northern part of Dogskin Mountain, Nevada: M.S. thesis, University of Nevada, Reno, 94 p.

John, D.A., 1995, Tilted middle Tertiary ash-flow calderas and subjacent granitic plutons, southern Stillwater Range, Nevada: Cross sections of an Oligocene igneous center: Geological Society of America Bulletin, v. 107, p. 180-200.

McKee, E.H., and Conrad, J.E., 1987, Geologic map of the Desatoya Mountains Wilderness Study Area, Churchill and Lander counties, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1944.

Ressel, MW., 1996, A transitional basaltic center in west-central Nevada: Petrochemistry and constraints on regional middle Miocene magmatism and tectonics: M.S. thesis, University of Nevada, Reno, 197 p.

Riehle, J.R., McKee, E.H., and Speed, R.C., 1972, Tertiary volcanic center, west-central Nevada: Geological Society of America Bulletin, v. 81, p. 1383-1396.

Swisher, C.C., III, $^{40}Ar/^{39}Ar$ dating and its application to the calibration of the North American land mammal ages: University California, Berkeley, Ph.D. dissertation, 239 p.

Thatcher, W., Foulger, G.R., Julian, B.R., Svarc, J., Quilty, E., and Bawden, G.W., 1999, Present-day deformation across the Basin and Range Province, western United States: Science, v. 283, p. 1714-1718.

Wills, C.J., and Borchardt, G., 1993, Holocene slip rate and earthquake recurrence on the Honey Lake fault zone, northeastern California: Geology, v. 21, p. 853-856.

Figures

Tables

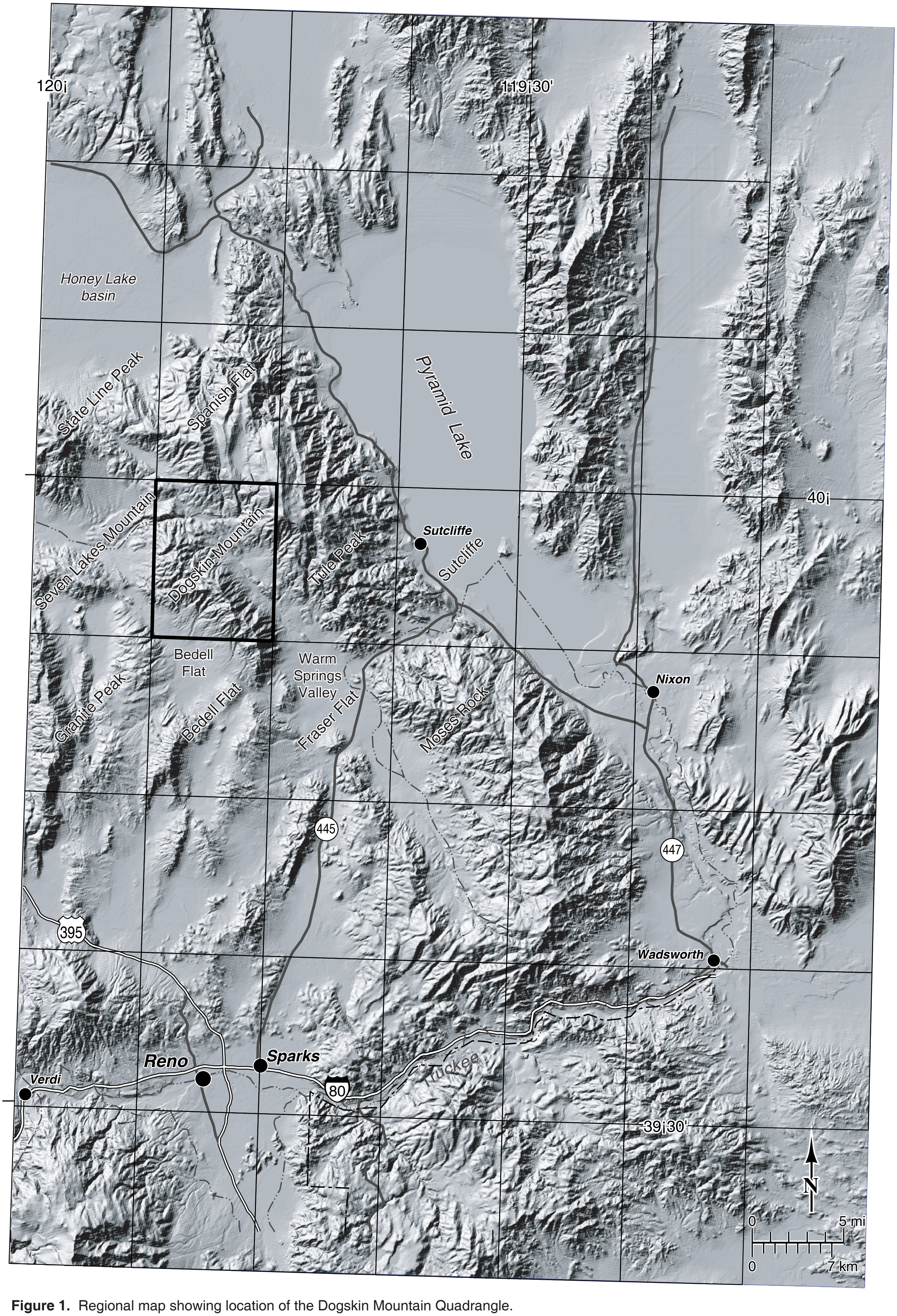
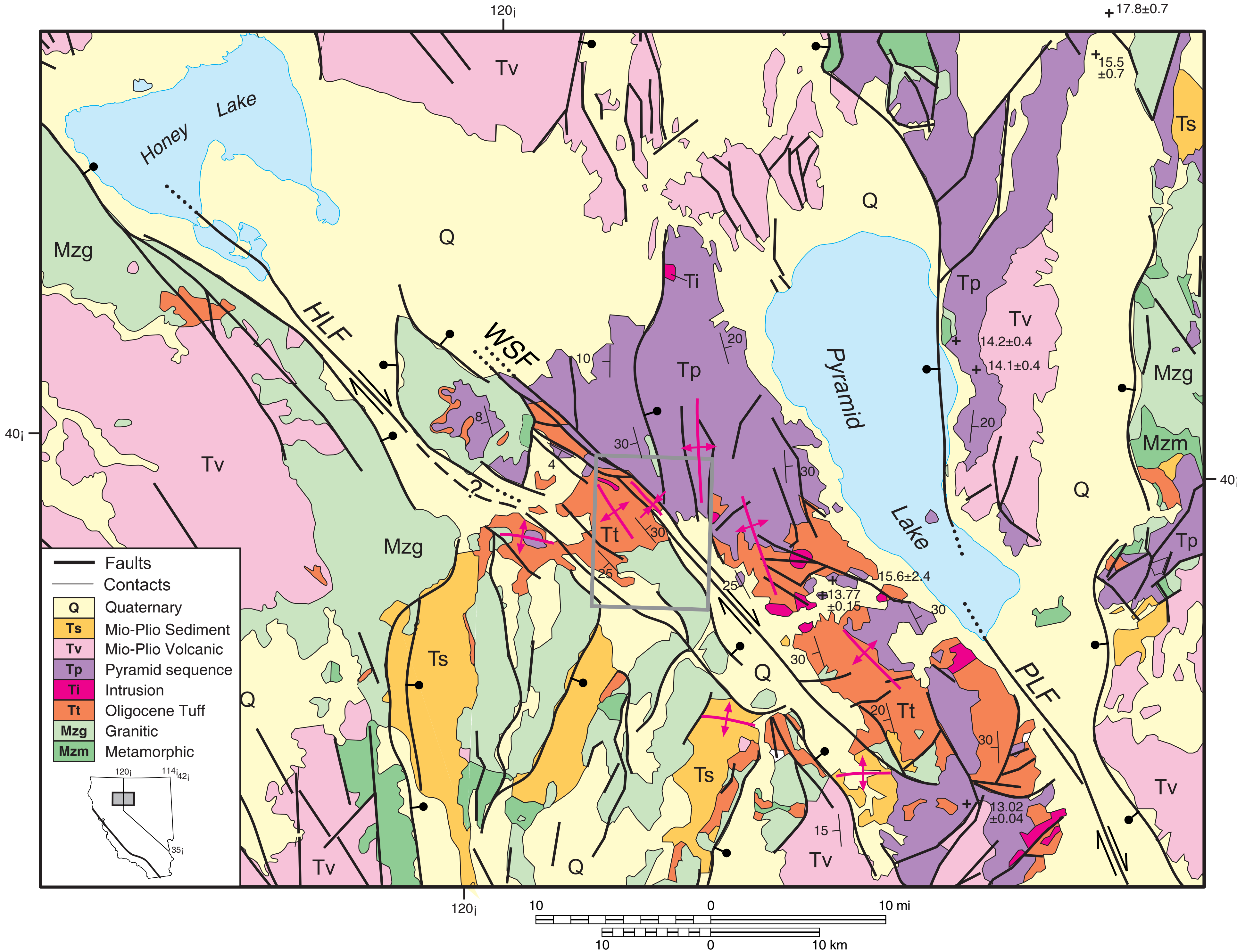
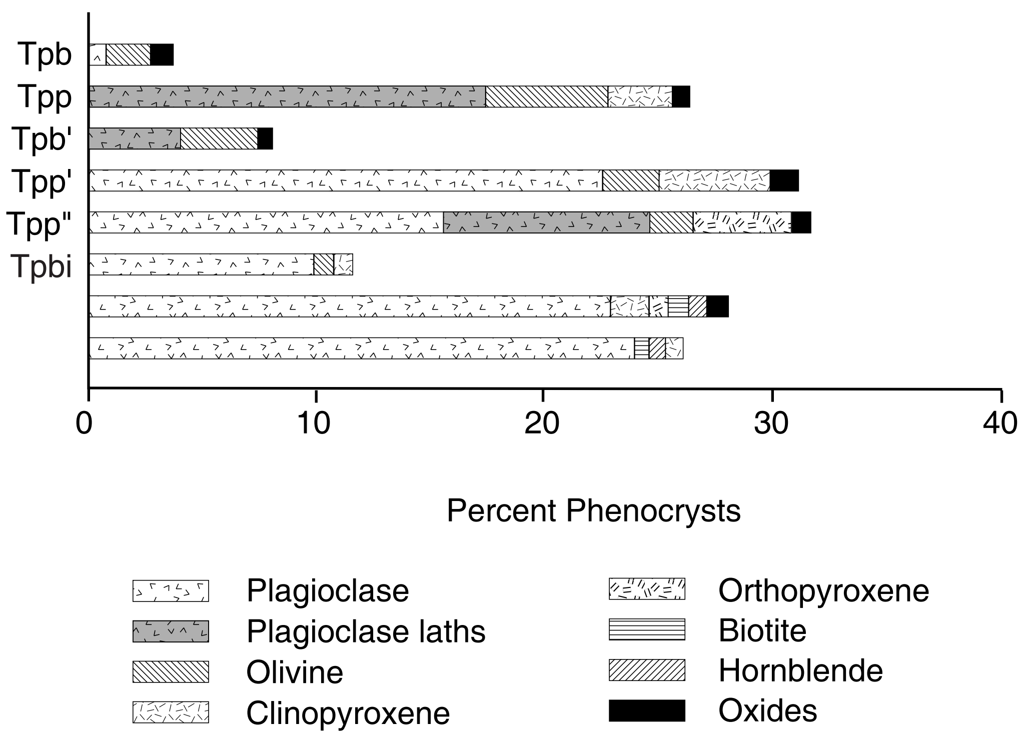
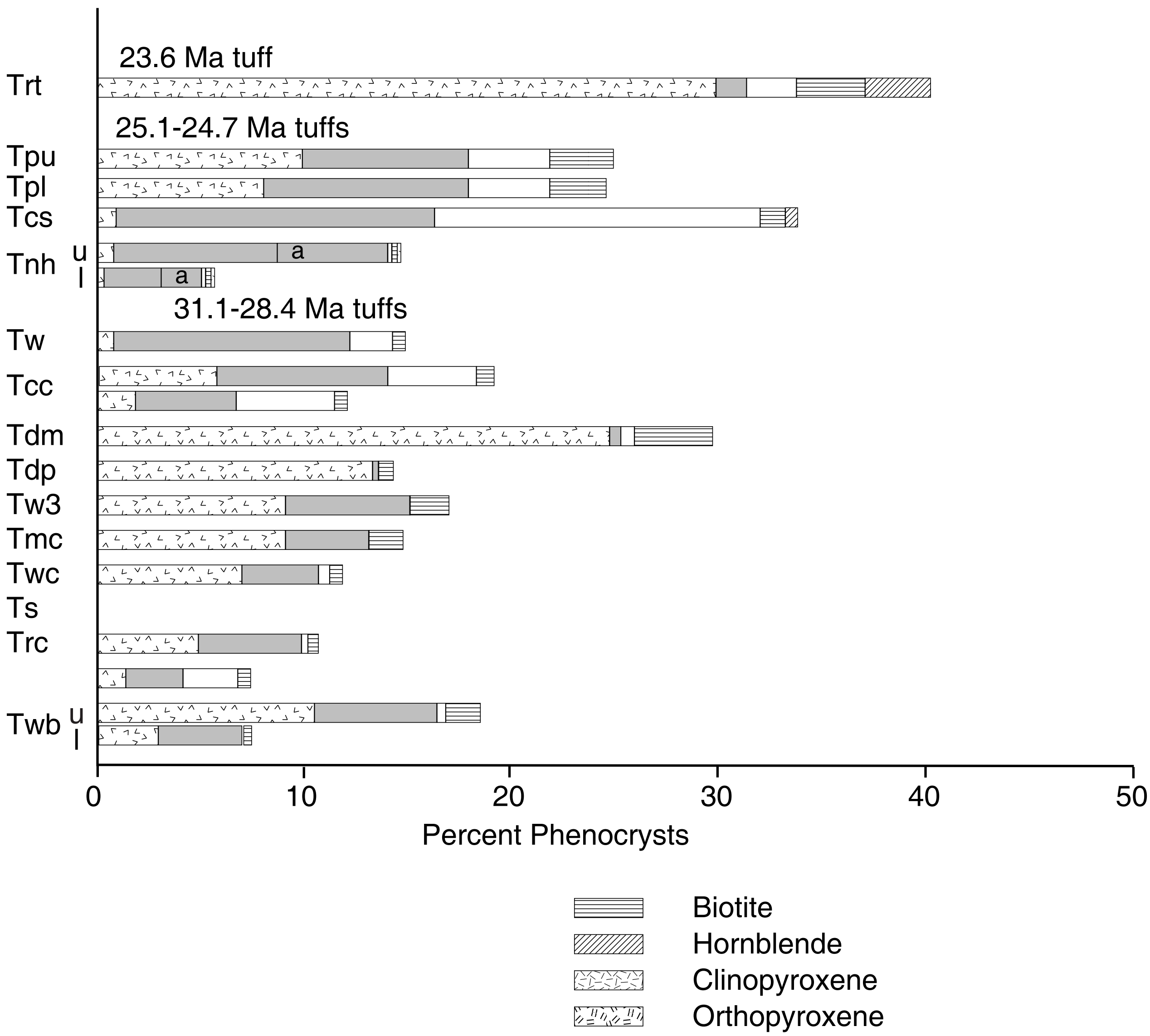


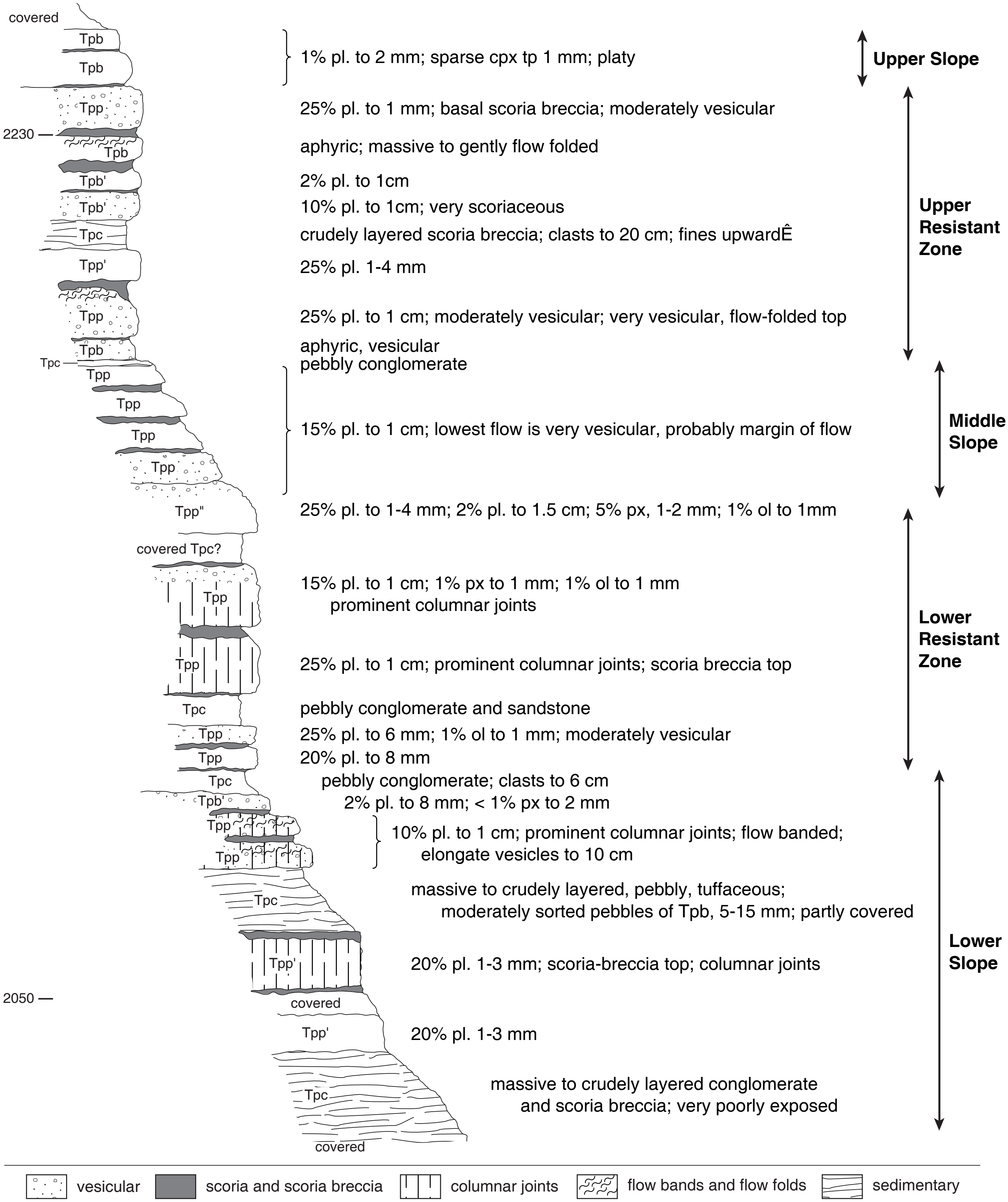
Figure 1. Regional map showing location of the Dogskin Mountain Quadrangle.

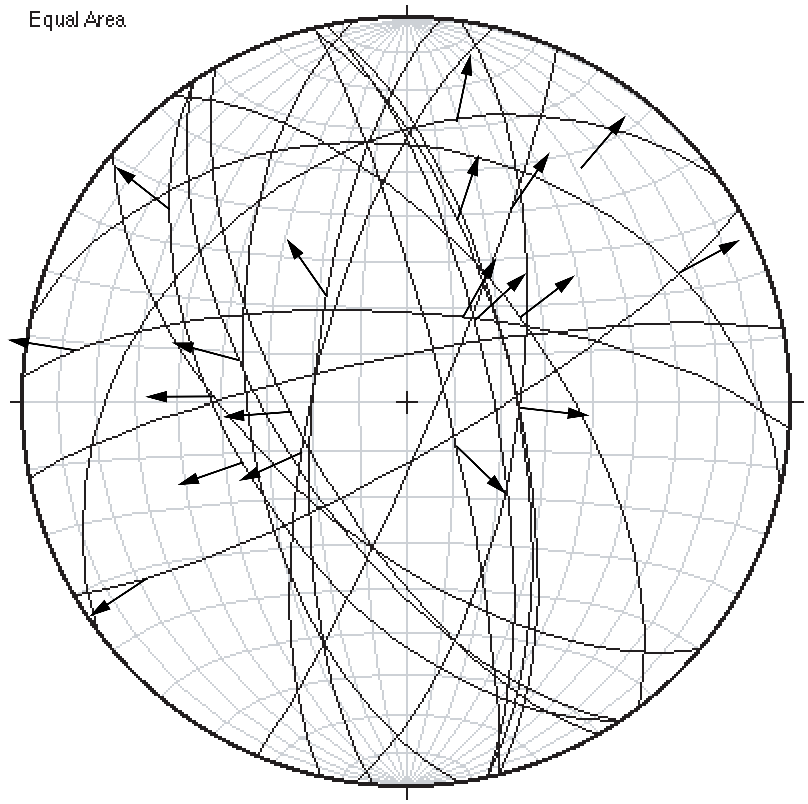

120¡
+17.8±0.7
+15.5
±0.7
Honey Lake
Tv
Ts
Q
Q
Mzg
Ti
Tp
Tv
14.2±0.4
14.1±0.4
HLF
WSF
10
20
Tp
Pyramid
Lake
Mzg
8
30
20
Mzm
40¡
40¡
Tv
4
30
Q
Tt
30
Tp
Mzg
25
25
15.6±2.4
13.77
±0.15
30
Ts
30
Q
PLF
Q
20
Tt
30
Ts
13.02
±0.04
15
Tv
Tv
Tv
Q
120¡
10
0
10 mi
10
0
10 km
Faults
Contacts
Q Quaternary
Ts Mio-Plio Sediment
Tv Mio-Plio Volcanic
Tp Pyramid sequence
Ti Intrusion
Tt Oligocene Tuff
Mzg Granitic
Mzm Metamorphic
120¡
114¡
42¡
35¡


Tpb
Tpp
Tpb'
Tpp'
Tpp"
Tpbi
0
10
20
30
40
Percent Phenocrysts
Plagioclase
Plagioclase laths
Olivine
Clinopyroxene
Orthopyroxene
Biotite
Hornblende
Oxides

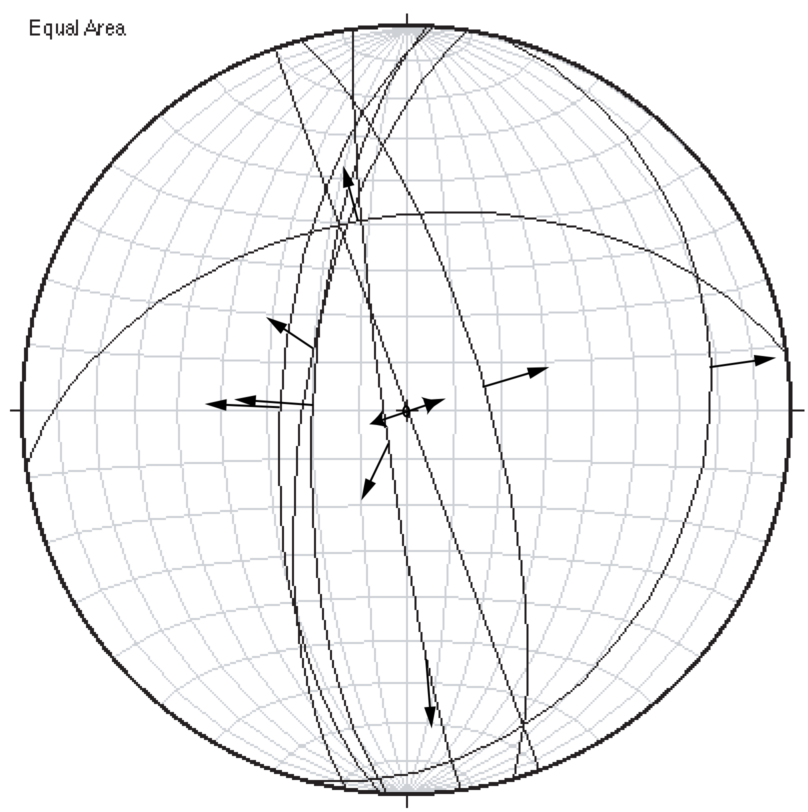


23.6 Ma tuff
Trt
25.1-24.7 Ma tuffs
Tpu
Tpl
Tcs
Tnh
u
l
a
a
31.1-28.4 Ma tuffs
Tw
Tcc
Tdm
Tdp
Tw3
Tmc
Twc
Ts
Trc
Twb
u
l
0
10
20
30
40
50
Percent Phenocrysts
Biotite
Hornblende
Clinopyroxene
Orthopyroxene


covered
Tpb
Tpb
1% pl. to 2 mm; sparse cpx tp 1 mm; platy
Upper Slope
Tpp
25% pl. to 1 mm; basal scoria breccia; moderately vesicular
2230
Tpb
aphyric; massive to gently flow folded
Tpb'
2% pl. to 1cm
Tpb'
10% pl. to 1cm; very scoriaceous
Tpc
crudely layered scoria breccia; clasts to 20 cm; fines upwardÊ
Upper
Resistant
Zone
Tpp'
25% pl. 1-4 mm
Tpp
25% pl. to 1 cm; moderately vesicular; very vesicular, flow-folded top
Tpb
aphyric, vesicular
Tpc
pebbly conglomerate
Tpp
Tpp
Tpp
Tpp
15% pl. to 1 cm; lowest flow is very vesicular, probably margin of flow
Middle
Slope
Tpp"
25% pl. to 1-4 mm; 2% pl. to 1.5 cm; 5% px, 1-2 mm; 1% ol to 1mm
covered Tpc?
Tpp
15% pl. to 1 cm; 1% px to 1 mm; 1% ol to 1 mm
prominent columnar joints
Lower
Resistant
Zone
Tpp
25% pl. to 1 cm; prominent columnar joints; scoria breccia top
Tpc
pebbly conglomerate and sandstone
Tpp
25% pl. to 6 mm; 1% ol to 1 mm; moderately vesicular
Tpp
20% pl. to 8 mm
Tpc
pebbly conglomerate; clasts to 6 cm
Tpb'
2% pl. to 8 mm; < 1% px to 2 mm
Tpp
Tpp
10% pl. to 1 cm; prominent columnar joints; flow banded;
elongate vesicles to 10 cm
Tpc
massive to crudely layered, pebbly, tuffaceous;
moderately sorted pebbles of Tpb, 5-15 mm; partly covered
Tpp'
20% pl. 1-3 mm; scoria-breccia top; columnar joints
Lower
Slope
2050
covered
Tpp'
20% pl. 1-3 mm
Tpc
massive to crudely layered conglomerate
and scoria breccia; very poorly exposed
covered
vesicular
scoria and scoria breccia
columnar joints
flow bands and flow folds
sedimentary



Dogskin Mountain (n=24)



Virginia Mountains (n=9)

Figure 6.

Table 1. Data on Ash-Flow Tuffs of the Dogskin Mountain Quadrangle.

Tuff	symbols	maximum thickness (	Age*	± 1σ	mineral	sample	source	Phenocrysts total %	plagioclase		quartz		sanidine		biotite		hornblende		other
									%	size	%	size	%	size	%	size	%	size	
rhyodacite tuff	Trt	50	23.59		sanidine		rhyolite domes, Tule Peak Quadrangle	35-45	25-35	<1-4	2, 4	1, 4	0, 4	5, 15	4, 5	<1-3	1, 4	<1-5	
upper tuff of Painted Hills	Tpu	25	24.73		sanidine		caldera, Stillwater Range	20-25	10	.5-2	3, 4	1, 3	8	1, 3	2, 3	1, 2			
lower tuff of Painted Hills	Tpl	50	~24.8				caldera, Stillwater Range	20-25	8	<1-3	3, 5	1, 5	10	≤2	1, 3	1, 2			
tuff of Chimney Spring	Tcs	50	24.92		sanidine		caldera, Stillwater Range	25-40	0-3	<1-2	10, 20	1, 3	10, 20	1, 3	<1-2	≤1	<1	≤0.7	
Nine Hill Tuff	Tnh	100			sanidine		unknown; beneath Carson Sink?	12, 15	<1-2	1, 2	<1	1, 2	3, 8	1, 4	<1	≤1			anorthoclase,
	Tnhl		25.06					5			<1	1, 2	2, 3	1, 4	<<1	≤1			clinopyroxene
tuff of Winnemucca Ranch	Tw	50	28.36	0.05	sanidine	H02-11	unknown	20	1	≤1	3	≤1	15	≤1.5	0.5	≤1			
			28.40	0.05	sanidine	H01-31													
tuff of Campbell Creek	Tcc	160	28.67	0.05	sanidine	H01-61	caldera, Desatoya Mts	10, 15	2, 6	1, 2	5, 1	<1-5	4, 6	1, 3	<1	1, 2			
			28.67	0.03	sanidine	H02-24													
tuff of Dogskin Mountain	Tdm	120	29.13		plagioclase		unknown	25-35	20-25	1, 3	≤1	1, 2	<1	≤1	2, 4	1, 2			
punky tuff	Tdp	20	~29.1				unknown	10, 15	10, 15	≤2			tr?	1	0-1	1			
Tw30	Tw3	30					unknown	15-20	8, 10	≤2			5, 7	≤1.5	2	<1-2			
tuff of Mine Canyon	Tmc	30	29.70		sanidine		unknown	15	8, 10	<1-3			3, 5	1, 4	1, 2	<1-2			
tuff of Cove Spring	Twcu	50					unknown	10, 12	6, 8	<1-3	tr	1, 2	3, 4	1, 5	0-1	1, 2			
	Twc		29.94	0.03	sanidine	H01-184													
bedded tuff and sediment	Tts	100						30-40	25-30	<1-4	tr	<1	0-1	≤1	2, 8	1, 3			
tuff of Sutcliffe	Ts	100	30.22	0.04	sanidine	H02-41	unknown	20-30	10, 20	1, 3	1	<2	5, 8	1, 4	1, 4	≤3			clinopyroxene
			29.85	*0.04*	sanidine	JF00-496													
tuff of Rattlesnake Canyon	Trc	100	30.92	0.04	sanidine	H02-52	?caldera, Clan Alpine Mts	20	8	1, 4	1	≤1.5	12	1, 5	1	≤2			
tuff of Hardscrabble Canyc	Thc	20	31.13	0.04	sanidine	H02-58	unknown	10	2		5	≤2	3	≤2	<1	1			
"windous butte"	Twb	>60	31.11	0.04	sanidine	H02-59	unknown	20	13	<1-2	<1	≤2	4	<1-2	2, 3	≤3			
			31.04	0.04	sanidine	H02-60		8	3		tr	≤2	4	<1-2	1	≤2			

* age with ± value was determined on sample from Dogskin Mountain Quadrangle; age without ± is mean of multiple dates from other areas; age with ~ is constrained from stratigraphy; age in italics is too low, probably because of alteration

Table 2. Sanidine 40Ar/39Ar dates of Ash-flow Tuffs, Dogskin Mountain Quadrangle.

								Latitude		Longitude	
sample #	Age (Ma)	±	K/Ca	±	n	map unit	Formation	Degree	Minutes	Degrees	Minutes
H01-31	28.40	0.10	8.6	8.5	14	Tw	tuff of Winnemucca Ranch	39	58.000	119	48.970
H02-11	28.36	0.10	9.5	8.7	15	Tw	"	39	56.820	119	49.840
H01-61	28.67	0.06	57.5	5.8	16	Tcc	tuff of Campbell Creek	39	56.400	119	48.860
H02-24	28.67	0.10	59.6	6.6	15	Tcc	tuff of Cove Spring	39	58.120	119	50.370
H01-184	29.94	0.06	29.3	4.5	16	Twc	"	39	56.120	119	50.580
H02-41	30.22	0.07	32.4	5.2	15	Ts	tuff of Sutcliffe	39	57.546	119	51.506
JF00-496	29.85	0.07	30.8	7.9	13	Ts	"	39	56.260	119	50.330
H02-52	30.92	0.08	39.0	8.0	15	Trc	tuff of Rattlesnake Canyon	39	57.251	119	51.988
H02-58	31.13	0.09	69.3	47.4	15	Thc	tuff of Hardscrabble Canyon	39	58.219	119	52.006
H02-59	31.11	0.09	46.7	12.1	16	Twb	"Windous Butte"	39	58.182	119	51.973
H02-60	31.04	0.09	43.9	8.6	15	Twb	"	39	58.164	119	51.889

All analyses at New Mexico Geochronological Research Laboratory, New Mexico Institute of Mining and Technology
Neutron flux monitor Fish Canyon Tuff sanidine (FC-1). Assigned age = 27.84 Ma (Deino and Potts, 1990)

Table 3. Petrographic data for rocks of the Pyramid sequence.

		Phenocrysts														
		total %	plagioclase		olivine		clinopyroxene		orthopyroxene		biotite		hornblende		other
Map unit	symbol		%	size	%	size	%	size	%	size	%	size	%	size	
Basalt to basaltic andesite	Tpb	≤5			0-5	≤1									
Porphyritic basaltic andesite	Tpp	15-30	10, 25	5, 20	5, 8	0.1-1	3	≤0.5							
Sparsely porphyritic basaltic andesite	Tpb'	≤10	3, 5	5, 10	0-5	≤1									
Finely porphyritic basaltic andesite	Tpp'	25-35	20-25	2, 5	1, 5	0.5-2	4, 8	1, 5							
Bimodal porphyritic basaltic andesite	Tpp"	25-35	20-30	2-4, ≥10x2	<1	1, 2	3, 8	1, 4							
Porphyritic rhyolite	Tpr	25	24	1, 5			<1	<1			<1	≤1	<1	<1	
Tuff of Mullen Pass	Tpm	25-30	20-25	<1-3			2	<-2	<1	≤0.7	≤1	≤1	≤1	0.5-3	magnetite
Basaltic andesite dike	Tpbi	12, 25	10, 20	≤2	1, 3	1	1, 2	1							

Olivine is altered to iddingsite in many samples

Table 4. Chemical Analyses of Rocks of the Dogskin Mountain Area.

Pyramid sequence

sample	C98-176	H99-57	H00-14	H01-152	H00-15	H00-20	H00-40	H01-155	H01-33	H01-153	H01-151	H00-25	H01-156	H01-119	H01-154	H01-171	H01-123
map symbol	Tpb	Tpb	Tpb	Tpb	Tpb	Tpb	Tpb	Tpp'	Tpp"	Tpb'	Tpp'	Tpp	Tpb'	Tpbi	Tpb	Tpr	Tpr
rock name	basalt	bas-and	bas-and	basalt	basalt	basalt	bas-and	bas-and	bas-and	bas-and	bas-and	bas-and	bas-and	bas-and	andesite	rhyolite	rhyolite
Quadrangle	MR	TP	TP	SF	TP	TP	TP	D	D	D	D	TP	D	D	D	D	D
Longitude 119°	35.95'	38.1	44.4	47.1	44.5	43.6	44.5	45.6	48.2	46.7	46.6	43.1	45.2	47.8	46.1	48.3	47.5
Latitude 39°	51.38'	53.7	55.5	40° 00.5	55.5	56.2	56.0	58.0	57.9	58.4	59.7	55.4	56.9	55.5	58.0	40° 00.0	40° 00.0
SiO2	51.20	52.15	52.25	51.46	51.53	51.04	52.57	54.68	56.22	54.22	56.02	56.10	54.10	56.91	62.15	70.47	71.47
TiO2	1.06	1.11	1.94	1.18	1.28	1.32	1.14	1.10	1.03	1.73	0.98	1.37	1.52	0.84	1.28	0.55	0.37
Al2O3	16.36	16.67	16.17	17.18	16.61	16.99	18.22	18.64	18.31	17.23	17.74	17.24	17.48	18.75	16.48	16.00	15.48
FeO*	8.50	9.36	10.45	8.70	9.28	8.92	8.23	8.02	7.09	9.05	7.42	7.83	8.74	6.33	5.93	2.37	1.86
MnO	0.16	0.16	0.19	0.15	0.16	0.16	0.15	0.13	0.13	0.15	0.14	0.13	0.15	0.10	0.12	0.03	0.08
MgO	9.69	7.50	4.95	7.76	7.35	7.02	5.38	4.33	4.32	3.45	4.46	3.59	4.04	2.81	1.57	0.28	0.54
CaO	8.32	8.44	8.18	8.94	9.37	9.94	9.50	7.57	7.49	7.06	7.71	7.19	7.56	9.66	4.10	1.29	1.73
Na2O	3.18	3.31	3.37	3.11	3.14	3.32	3.43	3.86	3.57	4.16	3.55	3.80	3.90	3.10	4.61	4.22	4.05
K2O	1.16	0.97	1.58	1.18	0.96	0.94	1.06	1.38	1.53	2.20	1.67	2.22	1.95	1.29	3.21	4.70	4.33
P2O5	0.373	0.34	0.92	0.34	0.33	0.34	0.31	0.30	0.31	0.75	0.31	0.53	0.56	0.23	0.55	0.09	0.10
Total*	98.95	99.91	99.40	99.44	99.35	99.52	99.60	99.64	100.23	99.50	100.38	99.19	99.40	96.17	99.58	99.38	98.85
Sc	23	25	23	29	28	21	27	15	17	21	18	23	23	18	16	9	0
V	204	217	220	212	216	224	248	215	190	241	196	231	253	173	95	20	14
Cr	308	307	112	271	319	196	87	24	58	17	53	68	37	10	3	0	0
Ni	172	185	46	149	215	95	50	27	30	15	33	51	28	7	3	6	4
Cu	72	78	32	67	45	39	67	79	68	171	42	143	149	49	32	6	3
Zn	93	91	134	85	94	84	83	96	89	115	89	106	103	83	113	42	51
Ga	15	17	17	17	18	16	19	18	21	22	20	20	24	22	22	19	17
Rb	13	12	22	23	17	17	13	25	20	43	34	51	38	28	86	140	105
Sr	737	514	590	509	506	525	684	682	642	549	679	566	611	674	410	239	271
Y	16	22	45	22	25	27	22	21	21	36	22	30	32	18	39	34	19
Zr	88	102	258	115	106	109	92	106	123	212	124	178	181	113	240	303	200
Nb	6.4	5.2	18.7	7.0	8.4	9.6	4.5	5.4	7.4	12.1	6.3	9.9	10.2	3.7	13.2	14.2	9.5
Ba	512	471	1015	553	636	465	507	583	794	872	656	836	790	731	1144	1536	1137
La	21	22	25	19	10	13	22	21	18	31	19	26	18	18	47	47	22
Ce	25	53	87	44	48	41	32	32	44	73	50	54	65	26	68	74	41
Pb	7	9	9	3	5	3	6	15	7	11	10	11	15	9	17	19	18
Th	0	2	5	3	2	3	1	3	7	5	5	4	7	2	11	15	12

Quadrangles: D = Dogskin Mountain, MR = Moses Rock, S = Sutcliffe, SF = Spanish Flat, TP = Tule Peak

All analyses normalized to 100% anhydrous. FeO* = all Fe expressed as FeO; Total* = total before normalization to 100% anhydrous

bas-ande = basaltic andesite

Table 4. Chemical Analyses of Rocks of the Dogskin Mountain Area.

	tuff of Mullen Pass		Oligocene ash-flow tuff	Clast in conglomerate	Rhyolite domes and related dikes and tuffs					Tuff of Perry Canyo	"Kate Peak"	
sample	H99-67	C98-246C	H00-10	MC-7	H00-27	H99-50	C98-79	H00-19	H00-39	C98-185	FM184	C98-201
map symbol	Tpmm	Tmpu	Tdm	Tca	Tdi	Tdi	Tri	Trt	Trt	Tpu	Tfd	Ta
rock name	dacite	dacite	rhyolite	bas-and	andesite	andesite	rhyolite	dacite	dacite	dacite	dacite	andesite
Quadrangle	TP	S	TP	TP	TP	TP	S	TP	TP	MR	MR	MR
Longitude 119°	52.6	37.25'	44.1	41.2	38.8	55	39.28'	43.0	44.4	36.43'	36.1'	36.18'
Latitude 39°	53.2	53.2'	55.3	54.0	52.7	52.8	52.55'	54.8	55.6	51.6'	49.45'	49.83'
SiO2	65.84	67.73	75.57	53.22	61.79	60.60	70.21	67.51	66.28	65.44	65.84	57.96
TiO2	0.72	0.59	0.110	1.19	0.67	0.74	0.43	0.55	0.55	0.55	0.49	0.82
Al2O3	16.01	16.27	13.33	19.07	16.73	16.87	15.15	17.02	16.78	16.82	17.33	18.35
FeO*	3.56	2.63	0.98	8.12	5.49	5.48	2.76	3.22	4.02	3.84	3.38	6.75
MnO	0.12	0.08	0.046	0.16	0.12	0.30	0.04	0.04	0.03	0.09	0.06	0.18
MgO	1.37	0.76	0.41	3.83	2.30	1.65	1.06	0.74	1.14	1.68	1.30	3.71
CaO	3.83	2.39	0.95	9.47	6.22	7.90	2.43	3.40	3.60	4.08	4.25	6.22
Na2O	3.53	4.43	3.35	3.16	3.75	3.69	3.73	3.70	3.96	4.05	4.46	3.61
K2O	4.73	4.95	5.22	1.35	2.70	2.54	4.04	3.64	3.44	3.25	2.73	2.19
P2O5	0.29	0.164	0.027	0.43	0.22	0.23	0.149	0.17	0.18	0.199	0.182	0.211
Total*	95.15	98.17	96.60	97.71	97.31	96.99	99.09	98.58	99.05	98.64	99.38	97.94
Sc	7	12	5	26	14	19	11	10	7	11	14	19
V	44	54	8	267	142	135	59	77	76	85	68	143
Cr	3	2	5	26	27	32	8	15	13	11	9	15
Ni	17	3	18	8	15	16	4	13	14	7	2	3
Cu	4	3	3	13	20	22	5	8	12	15	15	26
Zn	85	70	46	114	73	72	51	68	74	63	62	172
Ga	19	16	17	20	19	18	18	17	20	16	20	19
Rb	79	93	154	56	63	52	107	103	87	83	69	59
Sr	454	294	99	1024	623	632	322	499	517	554	631	533
Y	27	30	14	26	15	15	13	16	31	14	13	20
Zr	278	339	111	135	118	120	154	164	163	143	137	131
Nb	14.7	18	12.0	6.1	5.8	6.6	10.9	8.6	9.5	10.4	5.9	8.1
Ba	1633	1,468	727	1001	990	961	1242	1093	1158	1087	1,276	874
La	43	18	35	13	26	23	34	37	59	29	13	19
Ce	62	70	66	49	50	28	50	64	85	47	42	37
Pb	17	20	19	10	18	19	21	16	15	17	16	38
Th	7	6	18	5	12	9	12	9	9	11	3	5

Dogskin Mountain Quadrangle

Christopher D. Henry, James E. Faulds, Craig M. dePolo, and David A. Davis

Rock Descriptions

Qa Active Alluvium. Recently to annually active alluvium in washes consisting of cobble-pebble gravels and sands, with boulders in proximal reaches. The alluvium occupies channels inset up to 2 m into fan or terrace surfaces. Clasts are generally subrounded to rounded, but subangular clasts are locally common. The main channel that crosses Winnemucca Ranch Road contains pebbly sands with anastomosing braided bars and swales. These deposits are typically 0.5 to more than 3 m thick.

Qa2f Fine-grained alluvium (late Pleistocene to Holocene) Unconsolidated silt deposited in a shallow basin formed adjacent to a strand of the Warm Springs Valley fault in Winnemucca Valley.

Stream Channel Deposits of Winnemuccca Valley

Qt1 Alluvial Terrace Deposits (mid to late Holocene). Cobbly and pebbly coarse to medium sands, dominantly poorly sorted and matrix supported, but locally clast supported; intercalated with well-sorted, medium-grained sand deposits up to 10 cm thick. Clasts are generally subrounded to rounded, although some subangular clasts exist. In Winnemucca Valley sands and small pebbles are dominantly granitic rocks, whereas larger clasts are dominantly volcanic rocks. In Dry Valley clasts are dominated by volcanic rocks. Surface is generally smoothed with up to a few centimeters thick, eolian silt cap, but broad, subdued bar and swale topography typically exists. Soils are typically absent or have a weak cambic horizon. Where spring deposits create a meadow environment on the surface, moderately well developed mollic epipedons exist. Deposits unconformably overlie Qt_2 deposits and are typically 60 cm thick.

Qt2 Alluvial Terrace Deposits (latest Pleistocene to earliest Holocene). Pebbly coarse sands, fine sands, and white to pale-brown diatomaceous earth. Some pebble gravels and isolated boulders are also present. Bedding is thin, parallel, wavy with some cross-beds; diatomaceous earth is a thick-bedded unit with parallel, cross-bedded, and convolute sedimentary structures, and some minor very thin beds intercalated with overlying sands. Clasts are well- to poorly-sorted and subangular to subrounded. In Winnemucca Valley sands are up to 99% granitic rocks, whereas pebbles are dominantly volcanic rocks. In Dry Valley clasts are made up of volcanic rocks. Some iron staining occurs locally in coarser sands, and incorporated twigs are replaced by hematite. Surface is smooth, relatively flat, and locally moderately dissected. Soils range from cambics and weak argillic B horizons to mollic epipedons, where the surface is wet from springs and meadow environments. Deposits are up to 4 m thick; diatomaceous earth likely originated from the high stand of Lake Lahontan.

Qc Undifferentiated Quaternary Colluvium and Talus. Active to Quaternary, small- to large colluvial and talus deposits generally developed at the base of steep slopes of resistant Oligocene welded tuffs (e.g., Tnh) and Miocene basaltic andesite lavas (Tp…). Stone stripes are common on talus slopes. Deposits typically consist of poorly sorted, angular to subangular, clast-supported cobbles and boulders. Thickness is generally less than 3 m.

Qls Landslide deposits. Coarse, unconsolidated debris composed of local bedrock, particularly basaltic andesite lava of the Pyramid sequence. Clasts range from silt to large blocks, up to 15 m in diameter. Probably as much as 20 m thick. Original headwall scarp is commonly unrecognizable.

Qf Undifferentiated Quaternary Fanglomerates. Small- to medium-size fans that typically form along the base of steep slopes. Bouldery, cobbly, pebbly sand deposits that are typically clast-supported and dominated by subangular to angular clasts. Clasts are derived from local sources and, thus, are almost all Tertiary volcanic rock; however, rare clasts of Cretaceous granite or Mesozoic metasedimentary rock occur in some deposits. Surfaces range from smooth to irregular and commonly have active parts. In some cases, well-developed argillic horizons are present, especially near the base of the fans, but exposures of the deposits are not common. Thickness may locally exceed 20 m. **Qfb** deposits are made up most of basaltic andesite.

Alluvial Fan and other Deposits of Dogskin Mountain

Qtd1 Alluvial terrace deposits

$Qfdy_1$ Younger Alluvial Fan Deposits (mid to late Holocene). Cobbly, pebbly, coarse sands with isolated boulders in proximal parts; generally non-indurated, poorly to moderately stratified, moderately sorted, matrix-supported deposits with angular to subangular clasts that are dominantly granitic in composition. Surfaces commonly have depositional microtopography, including bars and swales, and broadly undulating and pocketed surface morphology. Soil development ranges from absent to A/Bw/C profiles, where the colored cambic horizon is weakly developed and up to 20 cm thick. Deposits are up to 3 m thick.

$Qfdy_2$, $Qfdy_{2b}$ Younger Alluvial Fan and Megabreccia Deposits (latest Pleistocene to early Holocene) Cobbly, pebbly, silty, coarse sands with isolated boulders in proximal parts; generally non-indurated to weakly indurated, poorly to moderately stratified, moderately sorted, matrix-supported deposits with angular to subangular clasts, that are dominantly granitic in composition. Surfaces are commonly smoothed with poorly to moderately developed pavements and local relict cobble or boulder gravel bars that have had the fines winnowed from them. Soil development ranges from A/Bw/C to A/Bt/Bk/C profiles with colored cambic or weak argillic horizons 20 to 50 cm thick. Calcic horizons (Bk) are nonexistent to weakly developed (up to stage II CO_3 development). Deposits are up to 4-m thick. **$Qfdy_{2b}$** are monolithic megabreccia deposits made up of subangular and subrounded granitic blocks up to 3 m in diameter; deposits are likely formed from rock and debris avalanches.

Qfdi, Qfdib Intermediate Age Alluvial Fan and Megabreccia Deposits (mid to late Pleistocene). Cobbly, pebbly, silty, coarse sands with isolated boulders in proximal parts; generally weakly to moderately indurated, poorly to moderately stratified, moderately sorted, matrix-supported deposits with angular to subangular clasts, that are dominantly granitic in composition. Surfaces are smoothed to slightly irregular, and are moderately to well dissected. Notable lack of cobbles on surfaces, even in proximal reaches, indicates they have been grusified and disintegrated. Soils are typically A/Bt/Bk/Cox/C profiles, where argillic horizons (Bt) are well developed, structured, and up to 50-cm thick, calcic horizons (Bk) are intermittent, but with up to stage III CO_3 development, and oxidized, iron-stained horizons (Cox) are up to 2-m thick. Deposits are up to 4-m thick. **Qfdib** are monolithic megabreccia deposits made up of subangular and subrounded granitic blocks up to 3 m in diameter; deposits are likely formed from rock and debris avalanches.

Qfdo Alluvial Fan of Granite (early to mid Pleistocene). Cobbly, pebbly, silty, coarse sands with local boulders in proximal parts; generally weakly- to moderately-indurated, poorly- to moderately-stratified, moderately-sorted, matrix-supported deposits with angular to subangular clasts that are dominantly granitic. Surfaces are smoothed to slightly irregular, and are moderately to well dissected. Soils are typically A/Bt/Bca/Cox/C profiles, where argillic horizons (Bt) are well developed, structured, and up to 50-cm thick, calcic horizons (Bca) are intermittent, but with up to stage III CO_3 development, and oxidized, iron-stained horizons (Cox) are up to 1- to 2-m thick. Soil profiles are commonly missing the silty, eolian A horizon due to the vertisolic nature of the argillic horizon. Deposits are as much as 4-m thick.

Qdao Older/deformed fan deposits (early Pleistocene to Holocene?). Coarse conglomerate forms low ridges along the Warm Springs fault zone at the toe of alluvial fans emanating from Dogskin Mountain. Clasts consist mostly of Cretaceous quartz monzodiorite (Kqmd) and Jurassic(?) metavolcanic rocks (Jmv) with lesser Oligocene ash-flow tuff. Matrix is not exposed but appears to consist of uncemented sand, silt, and fine gravel. Age of this unit is uncertain but may span early Pleistocene to Holocene. Unit Qdao is equivalent to units Qfc and Qff, deformed alluvial fan deposits derived from the Virginia Mountains.

Alluvial and other Deposits of the Virginia Mountains

Qs Spring Deposits. Fine silt and clay around and downhill from active springs. The fine material is probably largely aeolian material trapped by spring waters but may include some material transported by spring waters. These areas, located in the northeast part of Winnemucca Valley, are vegetated with grasses and scrub-brush and consequently trap eolian sediments. The deposits are variably calichified and locally weakly stratified. Most springs appear to be along faults and make a slight topographic high, especially noticeable where springs are on Quaternary fans.

Qfy_1 Alluvial Fan and Stream Terrace Deposits (mid to late Holocene). Bouldery, Cobbly, pebbly, coarse to fine sands. Deposits are non-indurated to weakly indurated, moderately stratified, poorly sorted, matrix- and clast-supported with angular to subangular clasts; some clasts are subrounded in distal parts of fans. Clasts are volcanic rocks, mostly felsic and mafic in nature. Surfaces commonly have bars and swales and include active distributive portions of fans. Soils are typically absent, but some A/C profiles exist where thin (<3-cm thick) eolian silts have been deposited on the surface. Deposits are commonly 0.5- to 1-m thick.

Qfy_2 Alluvial Fan and Stream Terrace Deposits (latest Pleistocene to early Holocene). Bouldery, cobbly, to pebbly, coarse to fine sands. Deposits are non-indurated to weakly indurated, moderately stratified, poorly sorted, matrix- and clast-supported with angular to subangular clasts; some clasts are subrounded in distal parts of fans. Clasts are volcanic rocks. Surfaces are generally smoothed with moderately-well- to well-developed interlocking pavements. Clasts on surfaces are commonly iron-stained or covered with moderately developed rock varnish. Soils typically have A/Bw/Bk/C profiles with eolian silt caps (A) up to 10 cm thick, colored cambic (Bw) horizons with some clay up to 30 cm thick, and discontinuous calcic horizons (Bk) with stage I CO_3 development. Deposits are commonly 0.5 to 3 m thick.

Qlo Lacustrine deposits. Light-colored, silty, clayey, finely stratified sand with some alkaline salt crusts deposited in closed basins at the toe of the large alluvial fan along the east side of the quadrangle. The basins are located where the distal ends of fans pond against linear ridges produced by the Warm Springs Valley fault zone and apparently resulted from blockage of drainages by displacement along the fault zone. The fault has created a local high water table east of the fault and possibly directly blocks local drainages during earthquake events. This high water table promotes spring-like conditions, and traps eolian sediments in addition to distal fan sediments. The deposits appear to overlie or intercalate with Qfy_2 deposits and are locally overlain by Qfy_1 deposits. The ponded deposits are greater than 2 m thick.

Qfi Intermediate Age Alluvial Fan Deposits (mid to late Pleistocene). Bouldery, cobbly, pebbly, coarse to fine sands. Deposits are non-indurated to weakly indurated, moderately stratified, poorly sorted, matrix- and clast-supported deposits with dominantly angular to subangular clasts, and some subrounded clasts. Clasts are dominantly volcanic rocks, with some granitic rocks near the central stream channel of Winnemucca Valley. Surfaces are generally eroded with moderately developed pavements, littered with weakly to moderately varnished cobbles and boulders. Soils typically have A/Bt/Bk/C profiles. Argillic horizons (Bt) are reddened, commonly well structured, and up to 50 cm thick. Calcic horizons are discontinuous and variable, but locally have up to stage III CO_3 development.

Qfo Alluvial Fan Deposits (early to mid Pleistocene?). Bouldery, cobbly, to pebbly coarse to fine sands. Similar to Qfi but, where the two deposits occur together 0.5 km north of Dry Valley Creek, Qfo caps a higher, older erosion surface approximately 5 m above Qfi. Qfo in the Warm Springs Valley fault zone in the northwestern part of the quadrangle is marked by a lag of Pyramid sequence boulders and is difficult to distinguish from unit Tpc.

Qfc Coarse deformed fan deposits (early to late Pleistocene?). Coarse conglomerate forms a series of hills along the Warm Springs fault zone at the toe of the large alluvial fan complex along the east edge of the quadrangle. Clasts are dominated by Pyramid sequence rocks up to 2 m in diameter but include common Pyramid conglomerate (Tpc) and rocks of the rhyolite group and Oligocene ash-flow tuffs. Pyramid conglomerate and the silicic rocks crop out in The Cove, a large canyon in the Tule Peak Quadrangle immediately to the east that forms the headwaters for the alluvial fan. The presence of Pyramid conglomerate and the silicic rocks distinguishes unit Qfc from

Pyramid conglomerate, in which these rocks are absent or extremely rare, and indicates the deposits are deformed alluvial fan. Matrix consists of very poorly indurated sand, silt, and fine gravel but is rarely exposed. Age of units Qfc and Qff is uncertain but may span early to late Pleistocene. Units Qfc and Qff are equivalent to unit Qdao, deformed alluvial fan deposits derived from Dogskin Mountain.

Qff Finer deformed fan deposits (early to late Pleistocene?). Conglomerate similar to unit Qfc but in which maximum clast size is about 50 cm. Matrix is better exposed than in unit Qfc and consists of poorly indurated and poorly bedded, brown sandstone and mudstone containing scattered cobbles and boulders.

Late Pliocene-Quaternary (?) Alluvial Deposits

QTa Late Pliocene to Pleistocene (?) Alluvial Deposits. Coarse alluvial deposit that forms a boulder lag consisting almost entirely of moderately rounded clasts of Pyramid sequence rocks up to 1m in diameter. Matrix is not exposed. Age is uncertain. The deposit is lithologically similar to Pyramid conglomerate (Tpc) but forms a gentle slope above moderately tilted ash-flow tuffs. This structural setting indicates it is younger than Pyramid sequence rocks, which are conformable with the tuffs. The deposit is also similar to Quaternary fan deposits and may in part be deformed fan deposits.

QTk Late Pliocene to Pleistocene (?) Sediments. Poorly exposed pebble conglomerate and sandstone crops out beneath deformed fan deposits in one ridge along the Warm Springs fault. Pebbles are exclusively Cretaceous granitic rock (Kqmd), well rounded, and up to 2 cm in diameter. Most exposures consist of a lag of granitic pebbles. A small quarry in similar deposits in the Tule Peak Quadrangle shows steeply south-dipping pebble conglomerate, sandstone, and tephra. Age: 3.57±0.17 Ma, plagioclase, CD00-TP01, tephra in Tule Peak Quadrangle.

Pyramid Sequence

The informally named Pyramid sequence (Bonham and Papke, 1969), which crops out extensively in the northeastern part of the quadrangle and in a few areas in the western part, consists of complexly interbedded basaltic to basaltic andesite lavas, one silicic lava, coarse to fine clastic rocks, and a dacitic tuff. The lavas range, apparently gradationally, from aphyric to abundantly and coarsely porphyritic and are subdivided on the basis of phenocryst content and known or inferred chemical composition. Two end members are aphyric to very finely porphyritic basalt to basaltic andesite (Tpb) and coarsely porphyritic basaltic andesite (Tpp). Other mappable units are sparsely porphyritic basaltic andesite (Tpb'), finely porphyritic basaltic andesite (Tpp'), bimodal porphyritic basaltic andesite (Tpp"), and rhyolite lava or breccia (Tpr). Lava types are distributed throughout the stratigraphic sequence.

A few dikes and possible vent areas have been identified in the Dogskin Mountain Quadrangle. However, most lavas were probably derived from a large volcanic complex that was centered on the northern Virginia Mountains to the east in the adjacent Tule Peak Quadrangle (Fig. Geol index; Faulds et al., 2001). Similar lavas of similar age, also mapped as Pyramid sequence, are present to the southeast in the Pah Rah Range in the Moses Rock and Olinghouse Quadrangles (Garside et al., 2003) and to the northwest in the Stateline Peak Quadrangle (Grose, 1984). Cinder cones and intrusions are present in these other areas, which suggests the Pyramid sequence erupted over a large area of northwestern Nevada.

Conglomerate, breccia, sandstone, and other clastic rocks dominated by clasts of lava (Tpc) occur throughout the distribution and stratigraphic interval of the Pyramid sequence. Distal exposures of the Pyramid sequence, e.g., along the Warm Springs fault zone, are dominated by clastic rocks. Locally, the clastic rocks fill deep channels cut into lavas. Diatomite forms mostly thin, discontinuous lenses within the sedimentary rocks and was mapped locally where relatively thick or laterally continuous (Tpd).

A dacitic tuff (tuff of Mullen Pass; Tpm) crops out discontinuously in the lower part of the Pyramid sequence. It correlates with the upper of two dacitic tuffs mapped to the east and southeast in the Tule Peak and Moses Rock Quadrangles (Castor et al., 1999; Faulds et al., 2001).

Both isotopic ages of lavas and leaf fossils in diatomite (Axelrod, 1956) demonstrate that the Pyramid sequence is middle Miocene. However, $^{40}Ar/^{39}Ar$ ages on different parts of the sequence are contradictory, with ages around 13.7 Ma in the lower part and ~15 Ma in the upper part. Hornblende from the tuff of Mullen Pass in the lower part of the Pyramid sequence gives an age of 13.77±0.15 Ma, and the matrix of a basaltic lava (Tpb) at the base of the sequence gives 13.62±0.12 Ma. However, lavas in the upper part of the sequence in the Tule Peak Quadrangle give ages around 15 Ma, and plagioclase from the rhyolite is 14.88±0.10 Ma. Dates on Pyramid sequence or similar rocks more regionally are mostly about 14 Ma but range from 13 to 18 Ma (Fig. Geol index).

Tpb Basalt to basaltic andesite lava. Aphyric to very finely and sparsely porphyritic basalt or basaltic andesite makes up numerous flows throughout the Pyramid sequence. Flow interiors, which make the most prominent outcrops, are typically black or dark gray, massive to platy and faintly flow banded. The platy foliation distinguishes aphyric from most porphyritic lavas, which generally make rounded, rubbly outcrops. Basal and upper breccias are generally scoriaceous and oxidized and rarely crop out. Individual flows are 10 to 30 m thick and appear to have greater lateral continuity than do porphyritic flows. Matrix consists of pilotaxitic, subophitic to intergranular plagioclase, pyroxene, olivine, and opaque minerals. Age: 13.62±0.12 Ma, matrix; H00-14, Tule Peak Quadrangle. **Also, 15.6±2.4 Ma, whole rock, K/Ar,** from sample near the base of the Pyramid sequence in Sutcliffe Quadrangle (Bonham and Papke, 1969).

Tpp Porphyritic basaltic andesite lava. Coarsely porphyritic flows distinguished by prominent, tabular plagioclase phenocrysts 5 to 20 mm long. Massive, resistant interiors make rounded, rubbly outcrops, whereas scoriaceous upper and lower breccias rarely crop out. Individual flows are mostly 10 to 30 m thick and can terminate abruptly, suggesting steep flow margins or that they locally filled paleovalleys. Flows generally occur as complexes of several flows totalling as much as 100 m thick. Matrix consists of plagioclase, olivine, clinopyroxene, opaques, and variably altered, interstitial glass.

Tpb' Sparsely porphyritic basaltic andesite lava. A variant of the basalt to basaltic andesite lavas (Tpb) that contains 3 to 8% large, tabular plagioclase phenocrysts. These flows commonly overlie basalt (Tpb) and underlie porphyritic basaltic andesite (Tpp) flows, which suggests the sparsely porphyritc basalts are transitional. They weather much like the aphyric basaltic lavas (Tpb).

Tpp' Finely porphyritic basaltic andesite lava. A variant of the porphyritic basaltic andesite lavas (Tpp) is characterized by abundant plagioclase phenocrysts less than 5 mm long and by abundant pyroxene phenocrysts up to 5 mm in diameter. Plagioclase varies from tabular to more equant. They occur as individual flows about 20 m thick or as groups of flows totalling about 75 m thick.

Tpp" Bimodal porphyritic basaltic andesite lava. What is probably a single, thick flow in the northeastern part of the quadrangle is distinguished by a bimodal population of plagioclase phenocrysts, both large, tabular and small, more equant grains. The highly resistant flow is 20 to 40 m thick, holds up prominent ridges, and commonly weathers to 10 to 20 cm thick slabs.

Tpr Porphyritic rhyolite lava. A horizon of probable breccia of coarsely porphyritic rhyolite lava crops out in Black Canyon at the northern edge of the quadrangle, where it is about 25 m thick. The "outcrop" is marked by abundant boulders of strongly flow-banded and commonly brecciated lava; similar but highly weathered rock is very poorly exposed beneath soil and talus. Most boulders are devitrified but a few are glassy. The $^{40}Ar/^{39}Ar$ age, combined with the contradictory ages of Pyramid sequence, allows the rhyolite to be either in place or reworked. Age: 14.88±0.10 Ma, plagioclase, H01-171.

Tpd Diatomite. Massive to finely laminated, white, nonresistant diatomite forms discontinuous layers less than 1 to about 20 m thick and commonly interbedded with fine sandstone and siltstone. The soft diatomite rarely crops out but is shown by a lag of numerous white chips. Much diatomite was probably included with map unit Tpc. The diatomite appears to have accumulated in local closed basins, probably mostly resulting from blockage of drainages by lavas.

Tpc Conglomerate, sandstone, and breccia. Massive to moderately well stratified, matrix supported, poorly to moderately sorted, pale brown to light gray pebble to cobble conglomerate, breccia, and sandstone occur throughout the Pyramid sequence. The conglomerate is complexly interbedded with Pyramid lavas and diatomite and, in areas of poor exposure, may include thin lavas or diatomite. Clasts are subangular to subrounded and dominantly Pyramid lavas with rare ash-flow tuff or Cretaceous granitic rocks. Conglomerate commonly includes lenses of fine- to coarse-grained and pebbly sandstone; sand grains are subangular to subrounded and consist mainly of volcanic lithics and feldspar. The deposit is noncalcareous and weakly to highly indurated. Thicker, up to 10 m, more massive beds are generally unsorted and probably originated as debris flows. Finer deposits include planar bedded, more moderately sorted, matrix- to locally clast-supported conglomerate with clasts up to 25 cm in diameter interbedded with pebbly, planar to rarely cross-bedded, commonly ferruginous sandstone. Conglomerate of unit Tpc that fills a deep (≥100 m) channel cut into early parts of the Pyramid sequence is spectacularly well exposed in the Tule Peak Quadrangle immediately east of the Dogskin Mountain Quadrangle; similar channels probably occur in the Dogskin Mountain Quadrangle but are not as well exposed. Unit Tpc rock types indicate deposition as a fanglomerate derived from the Pyramid sequence.

Tpm Tuff of Mullen Pass. Gray to dark gray, glassy to devitrified, dacitic ash-flow tuff with prominent dark gray, glassy, flattened pumice. The soft tuff is locally preserved in the lower part of the Pyramid sequence but was eroded or poorly exposed in most areas. The tuff is a single cooling unit, composed of several individual ash flows, that is mostly moderately welded. Maximum preserved thickness is about 10 m. The pumice is up to 40 cm long and 5 cm thick and makes up 10% to as much as 50% of the whole rock. Small (≤1cm) fragments of basaltic andesite (Tpb?) are common. Age:13.77±0.15 Ma, hornblende; C98-246; Sutcliffe Quadrangle. 13.84±0.15 Ma; plagioclase, KA1244, probably from this tuff (Swisher, 1992). **Also, 12.7 Ma (**no ± reported), plagioclase K/Ar, KA1244 (Evernden and James, 1964).

Tpbi Basaltic andesite dike. Two small, west-northwest-striking basaltic andesite dikes, probably equivalent to the finely porphyritic basaltic andesite lavas (Tpp'), crop out in the quadrangle. One dike, approximately 2 m wide and possibly 200 m long, cuts Cretaceous quartz monzondiorite (Kqmd) along the east face of Dogskin Mountain. Olivine is largely altered to iddingsite. Another dike, approximately 2 m wide and no more than 50 m long, cuts tuff of Chimney Spring (Tcs) and porphyritic dacite (Tdi) in the northwestern part of the quadrangle. The tuff of Chimney Spring is strongly baked along the contact; reheating by the dike commonly converted tuff matrix to glass.

Miscellaneous Intrusions

Tdi Porphyritic dacite intrusions. Two coarsely porphyritic dacite or andesite(?) intrusions cut ash-flow tuff in the northwestern part of the quadrangle. A dacitic dike crops out discontinuously over about 2.5 km, with a western, west-striking, steeply north-dipping segment approximately 1 km long and 5 to 100 m wide separated by a gap of ~300 m from an eastern, west-northwest-striking, steeply south-dipping segment that is about 1.5 km long and ~100 m wide. A dark gray, sparsely porphyritic andesite(?) sill as much as 15 m thick and about 500 m long intrudes platy tuffaceous rocks of unit Tts along the north canyon wall of Dry Valley Creek. The lack of basal breccia, presence of vesicles at both top and bottom contacts, and strong baking and compaction of both over- and underlying tuff demonstrates an intrusive origin. The coarse phenocryst assemblage, especially presence of quartz, suggests a relation to the rhyolite to dacite domes (Tri) in the Tule Peak Quadrangle. However, imprecise $^{40}Ar/^{39}Ar$ data allow an age of either 13 or 15 Ma, much younger than the rhyolites and probably related to the Pyramid sequence. The dated dike is cut by one of the basaltic andesite dikes, which suggests the 15 Ma date is more likely. Phenocrysts dacite (~20-25%): plagioclase (15-20%, 1-15 mm), biotite (1-4%, 1-5 mm), hornblende (1-3%, 1-7 mm), quartz (≤1%, 1-4 mm). andesite (~6%): plagioclase (5%, 1-7mm), biotite (1%, 1-2mm), and minor quartz (trace, ≤2mm). Hornblende is commonly altered to iron oxides.

Tih Hornblende andesite dike. Several short dikes or plugs of andesite(?), distinguished by sparse to moderately abundant, large hornblende rods in a fine-grained, felty groundmass, are present in the northwestern part of the quadrangle. Dikes strike west-northwest and are up to 50 m long and 4 to 10 m wide. Dikes intrude Oligocene ash-flow tuffs; age relative to Pyramid sequence or rhyolite group unknown. Tuffs are baked and reddened along contacts. Phenocrysts (2-10%): hornblende (2-10%, prisms to 1 cm long); plagioclase (0-1%, ≤1.5mm).

Rhyolite Group

The rhyolite group in the Dogskin Mountain-Virginia Mountains-Pah Rah Mountains region consists of rhyolitic to dacitic intrusions and lava domes; related, commonly more mafic dikes; rhyolitic to dacitic tuff and lava; related megabreccia; and rhyolite-clast conglomerate. Only the rhyolite or dacite tuff, megabreccia, and rhyolite-clast conglomerate are present in the Dogskin Mountain Quadrangle. The intrusions, domes, and dikes are concentrated in the southern part of the Tule Peak and Sutcliffe Quadrangles (Faulds et al., 1999) and northern part of the Fraser Flat Quadrangle (Garside et al., 2003). Slumping from the flanks of steep intrusive domes generated the megabreccia, and clasts of rhyolite are a prominent constituent of megabreccia. Two domes are precisely dated at 23.51±0.04 and 23.67±0.06 Ma in the Tule Peak and Sutcliffe Quadrangles, respectively (Faulds et al., 1999; Faulds and , in prep.).

Trds **Rhyolite-clast conglomerate**. Poorly exposed and probably poorly indurated, coarse conglomerate marked by lag of well-rounded clasts. Clasts are up to 1 m in diameter and consist mostly of rhyodacite tuff (Trt) or rhyolite intrusion (Tri) and minor older tuffs and porphyritic andesite. The unit is similar to the tuff and rhyolite breccias (Tbt and Tbd) except that clasts are well-rounded, indicating stream transport. The conglomerate is younger than rhyolite and, given the absence of Pyramid sequence rocks, probably older than the Pyramid sequence. It probably represents erosion immediately following formation of the domes and related tuffs. Preserved thickness is about 20 m.

Trt **Rhyodacite ash-flow tuff.** Densely to moderately welded, light to medium gray, abundantly and coarsely porphyritic ash-flow tuff crops out discontinuously above the Oligocene ash-flow tuffs and below rocks of the Pyramid sequence. The presence of common flattened pumice to 10 cm long and sparse lithic fragments of biotite-hornblende rhyodacite distinguish the tuff from rhyodacite lava or intrusions, which contains the same phenocryst assemblage. The tuff is as much as 50 m thick. Many outcrops consist of boulders up to 5 m in diameter in which the compaction foliation is somewhat irregularly oriented, which suggests some outcrops mapped as tuff may be rhyodacite-rhyolite breccia (Tbd) containing only blocks of unit Trt. The tuff is petrographically similar to and probably the same age (~23.6 Ma) as the intrusive domes.

Tbt **Tuff breccia.** Purplish- to reddish-brown, brick red, or mustardy yellow megabreccia composed primarily of blocks of ash-flow tuff and minor rhyolite or rhyodacite. Blocks of tuff of Chimney Spring (Tcs) are most common, but clasts of Nine Hill Tuff (Tnh), the lower and upper tuffs of Painted Hills (Tpl, Tpu), and a few older tuffs are also present. Megablocks (>20 m) of tuff of Chimney Spring and Nine Hill Tuff present in unit Tbt are separately identified. Many of the blocks appear to be slightly silicified. Matrix, which is rarely exposed, consists of still finer and variably silicified breccia. Tuff breccia probably originated as rock avalanches induced by slumping and catastrophic failure of steeply dipping intruded strata around the flanks of rhyolite domes. Thickness is as much as 70 m.

Tbd **Rhyodacite-rhyolite breccia**. Grayish brown to pale brown megabreccia composed mostly of rhyolite and rhyodacite blocks and minor blocks of tuff. Clasts range from a few centimeters to ~6 m in diameter. Outcrops typically consist of bouldery rubble. Matrix, which is rarely exposed, consists of still finer and commonly silicified breccia. Unit Tbd probably originated as rock avalanches induced by slumping and catastrophic failure of the steep-sided rhyolite domes. Thickness is as much as 50 m.

Oligocene Ash-Flow Tuffs

A thick sequence of Oligocene ash-flow tuffs crops out in the Dogskin and Virginia Mountains and is representative of tuffs that are extensive in western Nevada. The tuffs in the Dogskin Mountain Quadrangle fall into three distinct age groups. The oldest group (31.1-28.4 Ma) includes at least 11 mappable units, of several petrographic types, and had been informally termed the tuffs of Whiskey Spring, tuff of Coyote Spring (Garside and Bonham, 1992), and tuffs of McKisnick Spring (Hutton, 1978). "Whisky" tuffs contain up to 10% sanidine phenocrysts, commonly as large glassy grains, along with plagioclase and generally minor biotite. "Coyote" tuffs are dominated by plagioclase and biotite and contain relatively little or no sanidine. Two tuffs contain a few percent quartz phenocrysts. A middle group consists of a petrographically diverse suite ranging from 25.1 to 24.7 Ma. Our ongoing study and published work (Deino, 1989; Best et al., 1989; John, 1995; Brooks, 2003) has allowed correlation of many of the tuffs throughout western Nevada and the eastern Sierra Nevada. Source calderas are known for several of the tuffs and are 100 to 200 km to the east in central Nevada. These include calderas in the Stillwater Range (John, 1995; Hudson et al., 2000), Desatoya Mountains (McKee and Conrad, 1987), and in the Clan Alpine Mountains (Riehle et al., 1972). The rhyodacite ash-flow tuff (Trt) is the youngest tuff and the only one with a possible local source. It is petrographically similar to, probably related to, and therefore probably the same age (~23.6 Ma) as a series of rhyolite to dacite domes in the adjacent Tule Peak, Sutcliffe, Fraser Flat, and Moses Rock Quadrangles (Faulds et al., 2001; Garside et al., 2003).

The tuffs are either entirely or mostly devitrified. Basal vitrophyres are present in a few tuffs and are described below. Internal contacts within individual units indicate separate ash flows within composite units, cooling breaks, or vitrophyres.

All ash-flow tuffs are laterally discontinuous because they were deposited almost exclusively in a deep paleovalley that is cut into Mesozoic rocks across the northern Dogskin Mountains and commonly variably eroded before deposition of the next tuff. Fine to coarse to extremely coarse clastic deposits are complexly interbedded with the tuffs. The coarsest and thickest deposit developed during the long interval between the older and younger group of tuffs. However, sedimentary deposits of some type are found locally between all tuffs. The oldest currently recognized tuff, Windous Butte Formation? (Twb), has a steep depositional contact on Mesozoic metavolcanic rocks (Jmv) in Dry Valley Creek in the northwestern part of the quadrangle. This contact dives beneath alluvium in the creek. It is possible that still older ash-flow tuffs are present in deeper, unexposed parts of the paleovalley.

Tpu **Upper tuff of Painted Hills**. Medium gray, poorly to moderately welded, relatively pumice poor, moderately porphyritic ash-flow tuff. It typically forms a ledge or low cliff above the white, slope forming but petrographically similar lower tuff of Painted Hills (Tpl) and beneath megabreccia (Tbt). However, it was eroded before deposition of megabreccia or Pyramid sequence in most of the quadrangle. Darker color, greater welding, and lesser abundance of pumice distinguish the upper tuff from the lower tuff. Also, local presence of red soil zone on top of the lower tuff and of rounded cobbles of older tuffs between the two tuffs indicate they are separate ash-flow tuffs. The upper tuff correlates with the orange tuff of the Tule Peak Quadrangle (Faulds et al., 1999). All these tuffs may correlate with the tuff of Eleven Mile Canyon of the Stillwater Range (John, 1995), which is petrographically similar and has an indistinguishable age. Age: 24.74±0.06 Ma, sanidine; MC-15, Tule Peak Quadrangle.

Tpl **Lower tuff of Painted Hills**. White to light gray, nonwelded to poorly welded, nonresistant, pumiceous, moderately porphyritic ash-flow tuff. The lower tuff of Painted Hills makes rounded hills or slopes beneath the more resistant upper tuff of Painted Hills (Tpu) or megabreccia (Tbt). The lower tuff contains up to 20% white pumice up to 10 cm long and 3% fragments of porphyritic andesite up to 8 cm in diameter. The lower tuff is petrographically similar to and, as mapped, may locally include the upper poorly welded part of the tuff of Chimney Springs. However, the lower tuff is distinguished by fewer phenocrysts, more abundant biotite, less abundant quartz, and relatively sparse smoky quartz. Also, common presence of a red soil zone on top of the tuff of Chimney Springs and a white, platy, fine tuffaceous sandstone between the two tuffs indicate they are separate ash flows with some erosion and weathering between them. Nevertheless, stratigraphic position and phenocryst assemblage suggest that both the lower and upper tuffs of Painted Hills are related to the tuff of Chimney Springs; all may have erupted from calderas in the Stillwater Range (John, 1995).

Tcs/Tcsl **Tuff of Chimney Spring.** Red-brown weathering, pinkish gray, densely to poorly welded, abundantly porphyritic ash-flow tuff characterized by smoky quartz and adularescent sanidine. Most of the tuff is densely welded and devitrified and has undergone vapor phase crystallization. A basal, white, poorly welded part (**Tcsl**) capped by a black vitrophyre is locally present in deeper parts of paleovalleys. An upper white, poorly welded tuff is rarely preserved. Greater abundance of biotite and plagioclase in the lower and upper, poorly welded parts than in the densely welded part suggests compositional zoning; however, intense devitrification and vapor phase crystallization in the welded part has destroyed most mafic minerals. The massive, densely welded part mostly contains little pumice, so eutaxitic texture is poorly developed, whereas upper and lower parts contain as much as 20% white pumice to 15 cm long. Lithic fragments, most abundant in the lower part, consist of porphyritic, silicic to intermediate volcanic rocks, and lesser quartzite and indurated shale. The tuff of Chimney Spring is as much as 50 m thick in an intratuff paleovalley southwest of the Winnemucca Ranch, but it thins, becomes less welded, and pinches out over thick deposits of Nine Hill Tuff. Based on its age and distinctive phenocrysts, the tuff of Chimney Spring correlates with the tuff of Poco Canyon in the Stillwater Range and with the New Pass Tuff east of Austin, Nevada (John, 1995; Hudson et al., 2000). The Poco Canyon caldera in the Stillwater Range was the source (John, 1995; Hudson et al., 2000). Age: 24.91±0.06 Ma, sanidine, MC-12, Tule Peak Quadrangle.

Tnh/Tnhl **Nine Hill Tuff** Sparsely porphyritic, commonly highly pumiceous ash-flow tuff that consists mostly of dark red-brown, densely welded tuff containing 12-15% phenocrysts. This passes downward into a light brown, poorly welded (**Tnhl**) base that contains ~5% phenocrysts. Thickness and welding are highly variable because the tuff filled paleovalleys. Maximum thickness is about 100 m where it forms a syncline within the Warm Springs fault zone. The tuff is at most about 40 m thick in the intratuff paleovalley southwest of the Winnemucca Ranch and thins and locally pinches out over paleoridges. Prominent pumice fragments make flattened lenses up to 40 cm long in welded tuff and ellipsoids up to 20 cm long in poorly welded tuff. The tuff contains sparse lithic fragments of porphyritic to aphyric silicic volcanic rocks up to a few centimeters in diameter. The Nine Hill Tuff is widely distributed through western Nevada and the Sierra Nevada (Bingler, 1978; Deino, 1985). Deino (1985, 1989) demonstrated that it also correlates with the "D" unit of the Bates Mountain Tuff in central and eastern Nevada and suggested a source beneath the Carson Sink. Age: 25.09±0.06 Ma, sanidine, MC-10, Tule Peak Quadrangle.

Tca Ash-flow tuff and andesite-clast conglomerate/breccia. An extremely coarse, variably indurated conglomerate and/or rock avalanche deposit consisting of rounded to subangular boulders of ash-flow tuff up to 12 m in diameter and porphyritic andesite up to 8 m in diameter. Tuff clasts are dominantly tuff of Dogskin Mountain (Tdm). Some andesite clasts are from the Mesozoic metavolcanic unit (Jmv), as indicated by complete chloritization of mafic phenocrysts and albitization of plagioclase. Phenocrysts in other andesite clasts are unaltered, which suggests they are Cenozoic. The rarely exposed matrix of the deposit shows angular to well-rounded, matrix-supported clasts. The largest clasts are internally brecciated, with angular fragments in a silicified(?) matrix. This deposit fills a deep, narrow, intratuff channel that crops out in a semi-continuous, east-northeast-striking belt across the northern part of Dogskin Mountain. The mapped unit is mostly overlain by the tuff of Chimney Spring or the Nine Hill Tuff. It is possible but not certain that some conglomerate is post Nine Hill Tuff. The conglomerate is as much as 50 m thick within this intratuff paleovalley.

Tw Tuff of Winnemucca Ranch. Light brown or tan weathering, finely porphyritic, densely to poorly welded, rhyolitic ash-flow tuff. It is found only in two areas, immediately south of Dry Valley Creek, where it forms low ridges, and about 2 km west of Winnemucca Ranch. A thin but continuous, medium gray, moderately welded vitrophyre containing glass lumps up to 2 cm in diameter occurs near the base of the unit. The vitrophyre is overlain by a thick devitrified zone in which the glass lumps form spherulitic clots. Much of the upper part is highly pumiceous, with fragments to 4 cm, and has undergone vapor phase crystallization. Unit Tw is at least 50 m thick and the top is faulted in the deeper part of the paleovalley. It thins to only about 5 m and is poorly welded but silicified southward along one strand of the Warm Springs fault. Age: 28.36±0.05 Ma, sanidine, H02-11; 28.40±0.05 Ma, H01-31.

Tcc Tuff of Campbell Creek. A dark to light gray to cream-colored, sparsely porphyritic, pumiceous, densely to mostly moderately or poorly welded ash-flow tuff characterized by common, smoky, vermicular quartz phenocrysts and minor plagioclase. The tuff grades upward from a relatively sparsely and finely porphyritic, poorly welded and glassy base, which is commonly silicified, to more abundantly and coarsely porphyritic, densely welded, devitrified, nubbly weathering main part, to moderately or poorly welded top. Widespread in the intratuff paleovalley west of the Winnemucca Ranch, where it is as much as 160 m thick. Quartz and total phenocryst abundance decreases abruptly upward from the densely to moderately welded parts; biotite and plagioclase abundance increases. All parts have abundant pumice up to 40 cm long, which makes the tuff platy in the densely and moderately welded parts. Shards are easily visible with a hand lens. The age and petrographic character indicate correlation with the rhyolite of Campbell Creek (McKee and Conrad, 1987), which is an intracaldera tuff in the Desatoya Mountains approximately 190 km to the east-southeast. Age: 28.67±0.03 Ma, sanidine, H01-61. 28.67±0.05 Ma, sanidine, H02-24.

Tcy Conglomerate beneath tuff of Campbell Creek. The tuff of Campbell Creek is locally underlain by a coarse conglomerate marked by a lag of well-rounded boulders. Boulders are dominantly tuff of Dogskin Mountain (Tdm) but include a few pre-Cenzoic rocks.

Tdm Tuff of Dogskin Mountain. A thick, complex sequence of at least three cooling units of similar, plagioclase- and biotite-rich ash-flow tuff interbedded with platy, compacted, probably mostly reworked tuff and definite tuffaceous sedimentary rocks. The ash-flow tuffs are dark red-brown to medium gray, moderately pumiceous, and densely to poorly welded. Poorly welded parts form slopes, whereas dense parts locally form resistant ledges. Moderately to densely welded vitrophyres are common. White pumice that weathers to form ellipsoidal cavities up to 25 cm long is common in dense parts of the tuffs; darker, crystal-rich pumice up to 25 cm long that resembles porphyritic andesite is abundant in upper, densely to moderately welded parts. The ash-flow tuffs are laterally discontinuous, probably reflecting both nondeposition and erosion. Individual cooling units are 8 to 30 m thick. The composite unit, including reworked tuff, is as much as 120 m thick. The tuff of Dogskin Mountain correlates with the tuff of Coyote Spring of Garside and Bonham (1992) and is widely distributed through the region. Age: 29.02±0.10 Ma, sanidine, MC-6, Tule Peak Quadrangle.

Thick-bedded, dense but nonresistant, greenish gray to gray, plagioclase- and particularly biotite-rich tuff dominates the lower part of the unit and locally separates cooling units. The thick bedding is most apparent from a distance; close up, the tuffs are platy. This platy tuff is relatively dense throughout and shows no evidence of welding zonation. Pumice is present mostly as thin seems. Lithic fragments up to ~10 cm in diameter are scattered randomly through the unit. Based on these characteristics and local presence of thin (≤50 cm) lenses of pebble to cobble conglomerate and conglomeratic sandstone, most and possibly all of the platy tuff is reworked. The dense character may result from sedimentary compaction rather than welding. The platy tuff forms easily eroded and commonly bare slopes. The massive, pumice-rich, variably welded character of ash-flow tuffs distinguish them from the bedded, platy, reworked tuff.

Tdp **Punky tuff**. A light gray, generally poorly welded, nonresistant, sparsely and finely porphyritic ash-flow tuff. Overlies Mesozoic rocks along the Dogskin Mountain range front southwest of the Warm Springs fault zone in what is probably the edge of the major paleovalley. Tuff typically contains at most only a few percent small pumice fragments. Locally contains carbonaceous fragments near the base. As much as 20 m thick and locally pinches out over bedrock highs. Probably lies stratigraphically within the lower part of the tuff of Dogskin Mountain (Tdm).

Tcd **Debris-flow deposit and conglomerate within the tuff of Dogskin Mountain**. Coarse, probable debris-flow deposit, conglomerate, and sandstone. Includes channel-filling debris-flow deposit, conglomerate, and sandstone about 25 m thick exposed on the north side of the south fork of Dry Valley Creek in the western part of the quadrangle. Debris-flow deposit there consists of blocks of older tuffs, especially the tuff of Cove Spring (Twc, and some granitic rock (Kqmd) in a muddy matrix. Also includes conglomerate that fills an intratuff paleovalley cut into the tuff of Mine Canyon (Tmc) within the Warm Springs fault system south of Dry Valley Creek. Conglomerate consists of large, rounded boulders, commonly more than 1 m and up to 2.5 m in diameter, almost entirely of tuff of Mine Canyon. Boulders form a surficial lag and no matrix is exposed. This same paleovalley was apparently reeroded and subsequently filled with later tuffs (Tw30, Td, Tw31).

Tw3 **Tuff 30**. Moderately and finely porphyritic, densely welded, white to light pink or gray and weathering to brown, rhyolitic ash-flow tuff. It is a resistant, ridge-forming unit in its only occurrence in the intratuff paleovalley south of Dry Valley Creek. Although resistant, it was partly eroded before deposition of unit Tdm. Unit Tw3 is similar to unit Tw but distinguished by abundant, aligned biotite and generally sparse pumice or lithic fragments. Unit Tw3 is about 30 m thick and has not been found elsewhere in the region.

Tmc **Tuff of Mine Canyon**. Red-brown to pinkish gray, moderately porphyritic, densely welded tuff containing large, glassy sanidine and smaller, cloudy white plagioclase phenocrysts. It is distinguished from the similar tuff of Cove Spring (Twc) by more abundant biotite phenocrysts. The tuff contains sparse pumice fragments up to 2 cm long and lithic fragments of porphyritic andesite and metasedimentary rock (greenish-gray siltstone).. An upper poorly welded zone present in the Tule Peak Quadrangle is absent here. The tuff of Mine Canyon is as much as 30 m thick and crops out intermittently in the west-central part of the quadrangle and within the Warm Springs fault zone in the north-central part. This distribution and obvious erosion in the fault zone suggests it was removed by erosion through much of the area. In contrast, it is widely distributed through the Virginia and Pah Rah Mountains. Age: 29.73±0.04 Ma, sanidine, MC-2, Tule Peak Quadrangle.

Tcm **Conglomerate beneath the tuff of Mine Canyon.** Exposed only in one location in the northwest part of the quadrangle, immediately north of Dry Valley Creek. Consists of lag of rounded boulders up to 1 m in diameter.

Twc/Twcu Tuff of Cove Spring. A sparsely to moderately porphyritic ash-flow tuff with a thick, red brown to tan, densely welded lower part that passes upward into a light gray, poorly welded upper part (**Twcu**), which is mapped separately where it can be easily delineated. The densely welded part commonly makes prominent, columnar-jointed cliffs. The tuff is characterized by large, abundant sanidine, fine, mostly altered plagioclase, and sparse biotite: much less than 1% in the densely welded tuff to ~1% in the upper, poorly welded part. The lesser biotite content distinguishes unit Twc from unit Tmc, which is otherwise similar. Ellipsoidal cavities produced by weathered pumice fragments are common in the densely welded part. A lithophysal zone a few meters thick is locally present a few meters above the base. Unit Twc is mostly 15 to 30 m thick but reaches 50 m in the intratuff paleovalley just south of Dry Valley Creek. Age: 29.94±0.06 Ma, sanidine, H01-184.

Tts **Bedded tuff and tuffaceous sedimentary rock.** A sequence of thick bedded, dense but nonresistant, greenish gray to gray, plagioclase- and particularly biotite-rich tuff, similar to the platy, reworked tuff within unit Tdm. Unit Tts forms easily eroded and commonly well exposed slopes. The thick bedding is most apparent at a distance; close up, the tuffs are platy. Rocks of unit Tts are relatively dense throughout and show no evidence of welding zonation. Pumice is absent through much of the deposits; where present, it occurs only as thin, shaly seems. Lithic fragments up to ~10 cm in diameter are scattered randomly through the unit. Based on these characteristics and local presence of definite sedimentary interbeds, most and possibly all of unit Tts is reworked, probably from the tuff of Sutcliffe (Ts) and other older ash-flow tuffs.

Ts **Tuff of Sutcliffe**. Light red, dark red-weathering, densely welded, mostly abundantly porphyritic and commonly columnar jointed ash-flow tuff. Zoned upward from moderately porphyritic, plagioclase-sanidine tuff with ~1% biotite to abundantly porphyritic, plagioclase-biotite rich tuff with lesser sanidine. Similar appearance to the plagioclase-biotite-rich welded tuffs in the tuff of Dogskin Mountain (Tdm) but distinguished by the presence of common, large sanidine. Pumice content is highly variable from ~1% in most of the tuff to 10-15% in a lithophysal zone in the middle of the tuff where pumice is up to 40 cm long. Small fragments of porphyritic andesite and shale are common. Thickness averages about 50 m but is highly variable from >100 m where it fills a probable intratuff paleovalley just northeast of Jackass Spring to less than about 10 m where it rests on quartz monzodiorite (Kqmd) in the south fork of Dry Valley Creek. Age: 30.22±0.04, sanidine, H02-41; 29.85±0.04 Ma, sanidine, JF00-496 (age probably too low because of alteration).

Tcu **Sedimentary rocks below tuff of Sutcliffe**. Poorly exposed sequence of sedimentary rocks consisting mostly of platy tuffaceous sandstone interbedded with thin pebble to cobble conglomerate lenses similar to rocks of unit Tts. One outcrop just east of Jackass Spring consists of conglomerate marked by lag of rounded cobbles of metavolcanic rock (Jmv) in dark red soil, presumably weathered matrix.

Trc **Tuff of Rattlesnake Canyon**. Light red, densely grading upward to poorly welded ash-flow tuff characterized by large and abundant sanidine. Dense part is commonly columnar jointed and shows nubbly weathering. Upper, poorly welded part is more finely porphyritic and contains ~10% pumice up to 15 cm long. Fragments of porphyritic andesite and quartzite up to 1 cm across are common near the base. Age: 30.92±0.04 Ma, sanidine, H02-52.

Tcr **Sedimentary rocks below tuff of Rattlesnake Canyon**. Poorly exposed sequence of platy, poorly bedded tuffaceous rocks interbedded with thin lenses of coarse sandstone and pebble to cobble conglomerate similar to those in unit Tts and Tcs. Mostly covered by colluvium. May also include some tuff of Hardscrabble Canyon (Thc).

Thc **Tuff of Hardscrabble Canyon**. Poorly exposed, moderately to poorly welded, sparsely and finely porphyritic, light gray ash-flow tuff distinguished by the presence of about 5%, small, angular, smoky quartz phenocrysts. The tuff contains a few small (<1 cm long) pumice and few if any lithic fragments. The tuff is exposed only in two areas: in the northwestern part of the quadrangle on the north side of Dry Valley Creek and in the western part near Carls Spring north of the south fork of Dry Valley Creek. It is about 20 m thick in both areas. However, it may be more widely distributed in the largely colluvium-covered interval between the overlying tuff of Rattlesnake Canyon (Trc) and Windous Butte Formation? (Twb). Age: 31.13±0.04 Ma, sanidine, H02-58.

Twb Windous Butte Formation?. Densely welded, moderately pumice-rich, pink to light brown, dark red-brown weathering ash-flow tuff, the oldest exposed tuff in the quadrangle. Grades upward from sparsely porphyritic base with sanidine more abundant than plagioclase and 1% biotite to upper part with plagioclase much more abundant than sanidine and 2-3% biotite. This upper part is similar in appearance to the tuff of Sutcliffe (Ts). Both parts contain common white pumice up to 10 cm long. Exposed in three areas: along Dry Valley Creek, near Carls

Spring just north of the south fork of Dry Valley Creek (where it overlies meta-andesite (Jmv)), and in the canyon just north of Jackson Spring (where it reaches its maximum thickness of ~60 m, and the base is not exposed). Age: 31.11±0.04 Ma, sanidine, H02-60; 31.04±0.04 sanidine, H02-59

Tck **Basal Tertiary conglomerate**. Conglomerate composed exclusively of pre-Cenozoic clasts. Crops out only in Dry Valley Creek where it overlies the meta-andesite (Jmv). Exposed as a lag of rounded boulders of meta-andesite and a few granitic rock up to 50 cm in diameter.

Mesozoic Rocks

Cretaceous granitic rocks

Kgg **Granite of Granite Peak**. Massive, medium grained, speckled light gray to white, mostly deeply weathered granite in the Sand Hills at the southwest corner of the quadrangle. Area within the quadrangle is almost entirely weathered to a deep sand, so that the division between granite and alluvial fan derived from granite is very approximate. Mineralogy: orthoclase (30%, to 1 cm, commonly enclosing plagioclase, biotite, and hornblende), plagioclase (40%, to 5mm), quartz (25%, to 4mm), biotite (5%, to 3mm), and hornblende (2%, to 5mm). Same as quartz monzonite of Granite Peak in the northeastern part of the Granite Peak Quadrangle (Garside, 1987).

Kgb **Granodiorite of Black Canyon**. Massive, coarse grained, speckled light gray to light pink, mostly deeply weathered quartz monzonite crops out in Black Canyon at the north edge of the quadrangle. Outcrop consists of deep grus with scattered knobs of moderately rounded boulders. The rock contains, in decreasing order of abundance, plagioclase, perthitic orthoclase as poikilitic grains up to 1 cm in diameter, quartz, biotite, minor hornblende, which can form elongate grains up to 1.5 cm long, magnetite, and euhedral sphene. Lighter color, greater abundance and large size of potassium feldspar, preponderance of biotite over hornblende, and lack of foliation distinguish unit Kgb from unit Kqmd. Cut by minor pegmatitic and aplitic dikes.

Kf **Aplitic to pegmatitic dikes and irregular intrusions.** Dikes and irregular shaped intrusions of aplite and pegmatite in quartz monzodiorite (Kqmd). All rocks consist of orthoclase, quartz, lesser plagioclase, and minor biotite; black tourmaline is present in rare vugs. Grain size in aplites is generally less than 2 mm. Pegmatites can contain orthoclase up to 6 cm in diameter and quartz up to 10 cm long. Aplite dikes zone to or contain irregular pods of pegmatite. Larger intrusions commonly show parallel, gradational bands of aplite and pegmatite.

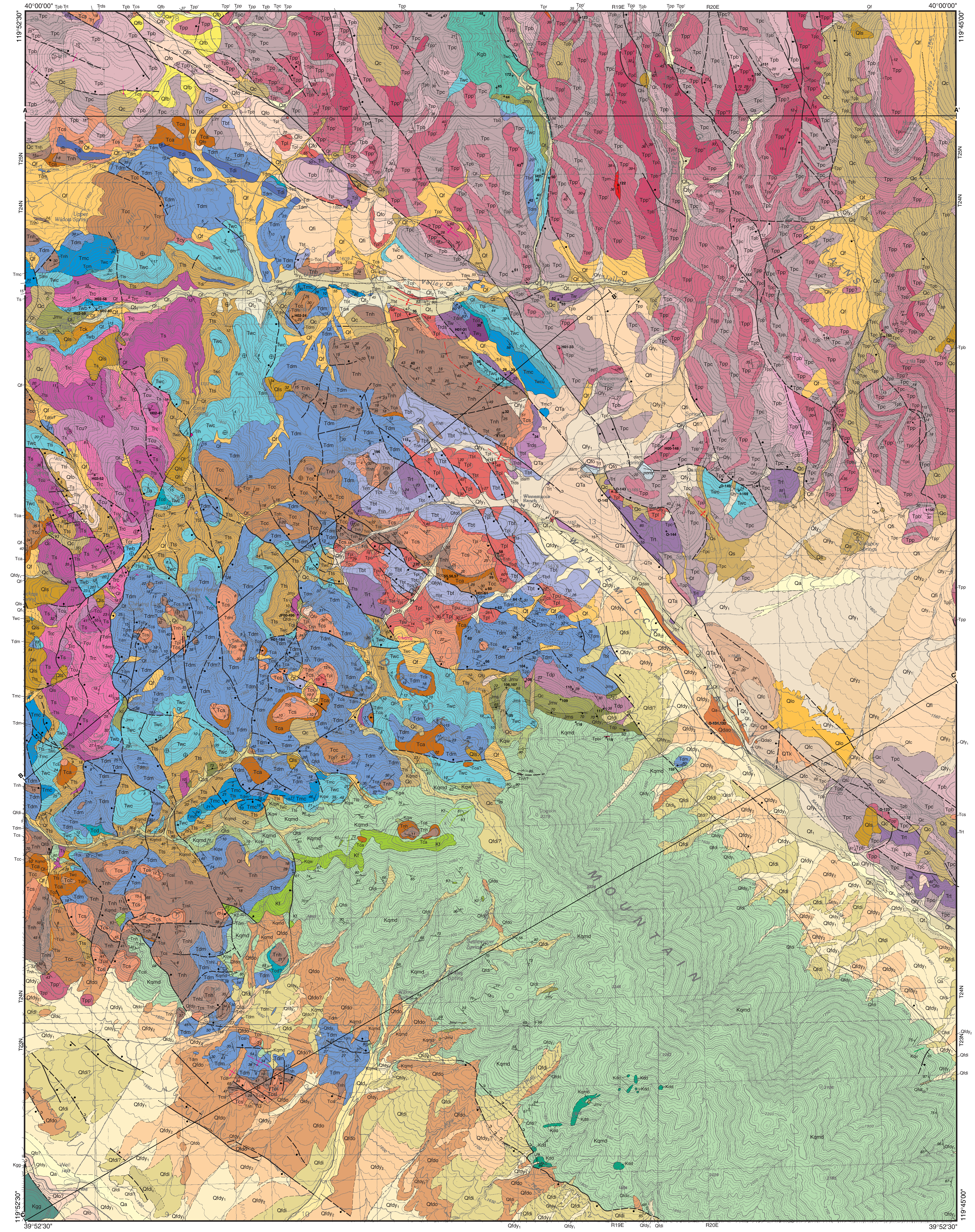
Kdd **Diorite dikes.** Dikes, small stocks, and large inclusions of fine- to medium-grained, medium gray diorite and lesser quartz diorite consisting of mostly anhedral to subhedral plagioclase (60-75%, locally less than 50%), potassium feldspar (1-5%), quartz (1-10%), hornblende and biotite (25-30%, locally up to 50%), and minor magnetite, hematite, limonite, chlorite, sericite, and epidote. Hornblende is mostly 4 to 5 times more abundant than biotite, but locally they occur in subequal amounts. Crystals are generally 0.1 to 2 mm long, but subhedral to euhedral plagioclase up to 7 mm long can constitute 1-2% of the rock. The diorite dikes are petrographically similar to the small lens-shaped diorite inclusions common to Kqmd.

Kqw **Weathered quartz monzodiorite.** Distinct, discontinuous paleoweathering zone as much as 15 m thick developed in quartz monzodiorite along the unconformity with Cenozoic rocks. Distinguished by its bright red appearance on the ground and air photos. Biotite, which is probably altering to mixed layer clay, and a dark red stain on all minerals are particularly prominent and give the appearance of a mafic rock unlike the quartz monzodiorite.

Kqmd **Quartz monzodiorite**. Coarse-grained, light to medium gray quartz monzodiorite and granodiorite consisting of, in decreasing order of abundance, plagioclase, microcline, quartz, hornblende, biotite, and accessory titanomagnetite, anhedral sphene, and zircon, make up most of the southern part of the Dogskin Mountain. A weak foliation defined by the preferred orientation of hornblende is common. Enclaves of diorite similar to and probably comagmatic with diorite dikes range up to 20 cm long. Local veinlets of black tourmaline. Generally weathers to large angular blocks or rounded boulders surrounded by grus. Much greater abundance of plagioclase relative to potassium feldspar and quartz, weak foliation, and occurrence of potassium feldspar as microcline distinguish this from granodiorite of Black Canyon (Kgb). This unit is identical to, and in continuous outcrop with, unit Kqmd in the Fraser Flat (Garside et al., 2003) and Tule Peak Quadrangles (Faulds et al., 2000).

Jurassic(?) metamorphic rocks

Jmv/Jms **Jurassic(?) metavolcanic and metasedimentary rocks**. Metamorphosed porphyritic andesite, ash-flow tuff(?), volcanic conglomerate, and sandstone to shale (schist) form roof pendants in granitic rocks along the northeast flank of Dogskin Mountain, in Black Canyon, and in deeper canyons along the west side of the quadrangle. Andesite is petrographically variable but contains 20-40% aligned plagioclase phenocrysts (1-4mm long) and 3-6% chloritized hornblende or pyroxene to 4 mm long in a biotitized and slightly schistose matrix. Volcanic conglomerate contains clasts of andesite up to 25 cm in diameter in a fine, biotitic matrix. Metamorphosed ash-flow tuff(?) contains 25% feldspar phenocrysts in a very felsic matrix containing abundant, white, disk-shaped lenses (pumice?) up to 20 cm long. Siltstone and shale are metamorphosed to platy biotite schist in which foliation parallels variably preserved sedimentary layering. Contains many thin granitic and pegmatitic dikes near contacts with granitic rocks.



- Qa — Active alluvium
- Qa_{2f} — Fine-grained alluvium (late Pleistocene to Holocene)

Stream Channel Deposits of Winnemucca Valley

- Qt_1 — Alluvial terrace deposits (mid to late Holocene)
- Qt_2 — Alluvial terrace deposits (latest Pleistocene to earliest Holocene)
- Qc — Undifferentiated Quaternary colluvium and talus
- Qls — Landslide deposits
- Qf — Undifferentiated Quaternary fanglomerates
- Qfb — Undifferentiated Quaternary fanglomerates (basalts)

Alluvial Fans and other Deposits of Dogskin Mountain

- Qtd_1 — Alluvial terrace deposits
- $Qfdy_1$ — Alluvial fan deposits (mid to late Holocene)
- $Qfdy_2$ — Alluvial fan deposits (latest Pleistocene to early Holocene)
- $Qfdy_{2b}$ — Megabreccia of granite (latest Pleistocene to early Holocene)
- Qfdi, $Qfdi_c$, $Qfdi_b$ — Alluvial fan of granite (late to mid Pleistocene); $Qdfi_c$, calcic horizon; $Qdfi_b$, megabreccia deposits
- Qfdo — Alluvial fan of granite (early to mid Pleistocene)
- Qdao — Older/deformed fan deposits (early Pleistocene to Holocene?)

Alluvial and other Deposits of the Virginia Mountains

- Qs — Spring deposits
- Qfy_1 — Alluvial fan and stream terrace deposits (mid to late Holocene)
- Qfy_2 — Alluvial fan and stream terrace deposits (latest Pleistocene to early Holocene)
- Qlo — Lacustrine deposits
- Qfi — Intermediate age alluvial fan deposits (mid to late Pleistocene)
- Qfo — Alluvial fan deposits (early to mid Pleistocene)
- Qfc — Coarse deformed fan deposits (early to late Pleistocene?)
- Qff — Finer deformed fan deposits (early to late Pleistocene?)

Late Pliocene-Quaternary(?) Alluvial Deposits

- QTa — Late Pliocene to Pleistocene(?) alluvial deposits
- QTk — Late Pliocene to Pleistocene(?) sediments

Pyramid Sequence

- Tpb — Basalt to basaltic andesite lava
- Tpp — Porphyritic basaltic andesite lava
- Tpb' — Sparsely porphyritic basaltic andesite lava
- Tpp' — Finely porphyritic basaltic andesite lava
- Tpp'' — Bimodal porphyritic basaltic andesite lava
- Tpr — Porphyritic rhyolite lava
- Tpd — Diatomite
- Tpc — Conglomerate, sandstone, and breccia
- Tpm — Tuff of Mullen Pass
- Tpbi — Basaltic andesite dike

Miscellaneous Intrusions

- Tdi — Porphyritic dacite intrusions
- Tih — Hornblende andesite dike

Rhyolite Group

- Trds — Rhyolite-clast conglomerate
- Trt — Rhyodacite ash-flow tuff
- Tbt — Tuff breccia; includes megabreccia
- Tbd — Rhyodacite-rhyolite breccia

Oligocene Ash-Flow Tuffs

- Tpu — Upper tuff of Painted Hills
- Tpl — Lower tuff of Painted Hills
- Tcs, Tcsl — Tuff of Chimney Spring; Tcsl, poorly welded basal part of Tcs
- Tnh, Tnhl — Nine Hill Tuff; Tnhl, basal part of Tnh
- Tca — Ash-flow tuff and andesite-clast conglomerate
- Tw — Tuff of Winnemucca Ranch
- Tcc — Tuff of Campbell Creek
- Tcy — Conglomerate beneath Tuff of Campbell Creek
- Tdm — Tuff of Dogskin Mountain
- Tdp — Punky tuffs
- Tcd — Debris-flow deposits and conglomerate within the tuff of Dogskin Mountain
- Tw_3 — Tuff 30
- Tmc — Tuff of Mine Canyon
- Tcm — Conglomerate beneath the tuff of Mine Canyon
- Twc, Twcu — Tuff of Cove Spring; Twcu, upper part of tuff of Cove Spring
- Tts — Bedded tuff and tuffaceous sedimentary rock
- Ts — Tuff of Sutcliffe
- Tcu — Sedimentary rocks below tuff of Sutcliffe
- Trc — Tuff of Rattlesnake Canyon
- Tcr — Sedimentary rocks below tuff of Rattlesnake Canyon
- Thc — Tuff of Hardscrabble Canyon
- Twb — Windous Butte Formation?
- Tck — Basal Tertiary conglomerate

Mesozoic Rocks

Cretaceous granitic rocks

- Kgg — Granite of Granite Peak
- Kgb — Granodiorite of Black Canyon
- Kf — Aplitic to pegmatitic dikes and irregular intrusions
- Kdd — Diorite dikes
- Kqw — Weathered quartz monzodiorite
- Kqmd — Quartz monzodiorite; quartz vein (Kqv)

Jurassic(?) metamorphic rocks

- Jmv, Jms — Jurassic(?) metavolcanic and metasedimentary rocks

Contact Long dashes where approximately located; short dashes between different tuffs, cooling units, or lavas within same map unit; queried where uncertain; dotted where concealed.

Fault Showing dip of fault and trend of striae on fault surface (arrow); bar and ball on downthrown side; double arrows show sense of strike-slip offset; dashed where approximately located, queried where uncertain, dotted where concealed.

Monocline

Syncline axial trace Showing plunge, dashed where approximately located.

Strike and dip of beds

20 Inclined — Vertical — Horizontal

Strike and dip of compaction foliation in ash-flow tuff

30 Inclined — Vertical — 75 Overturned

Strike and dip of flow bands in lava or intrusion

70 Inclined — Vertical

Continuous curving flowbands

Strike and dip of metamorphic foliation

70 Inclined — Continuous curving foliation

Joint

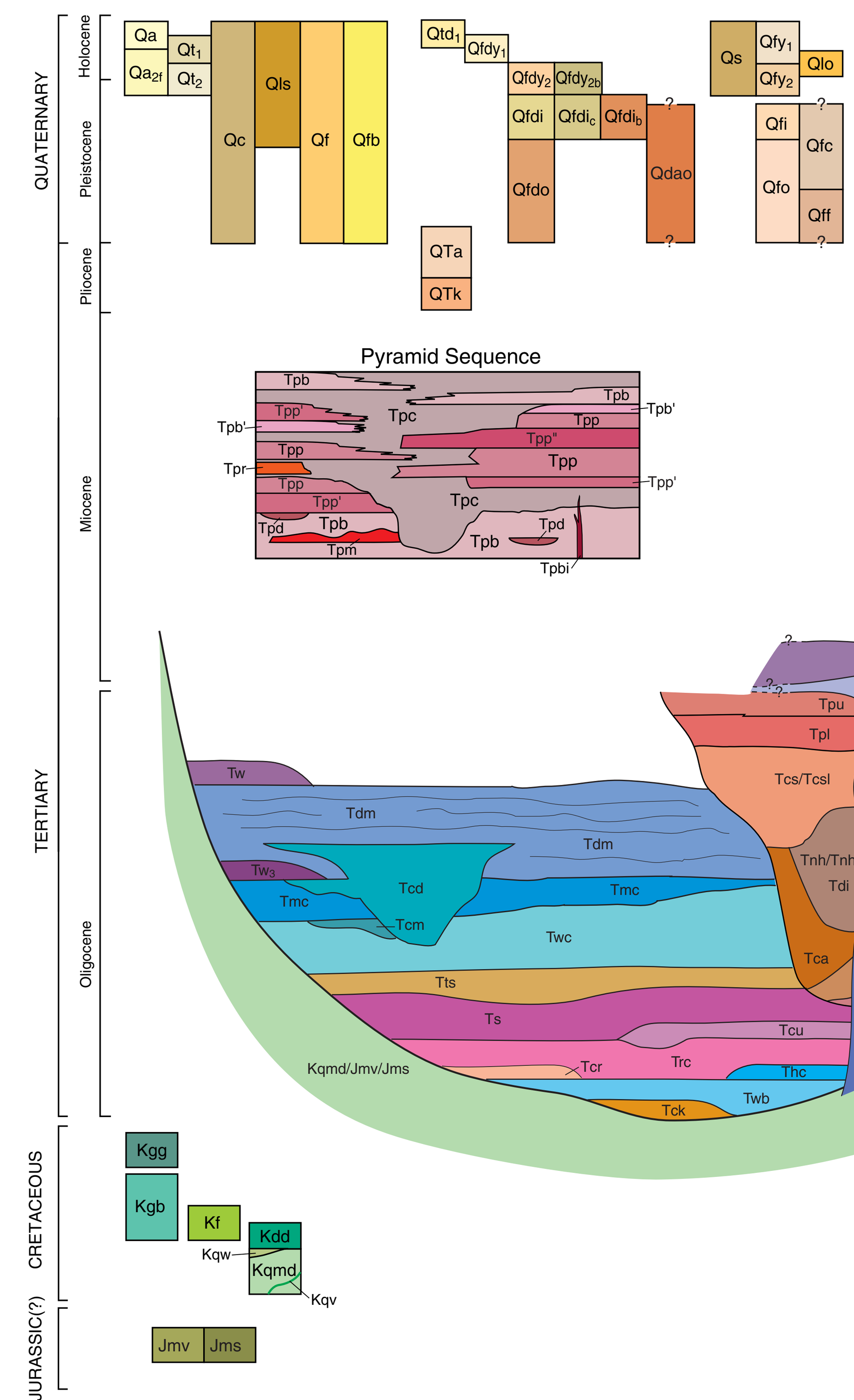
70 Inclined — Vertical

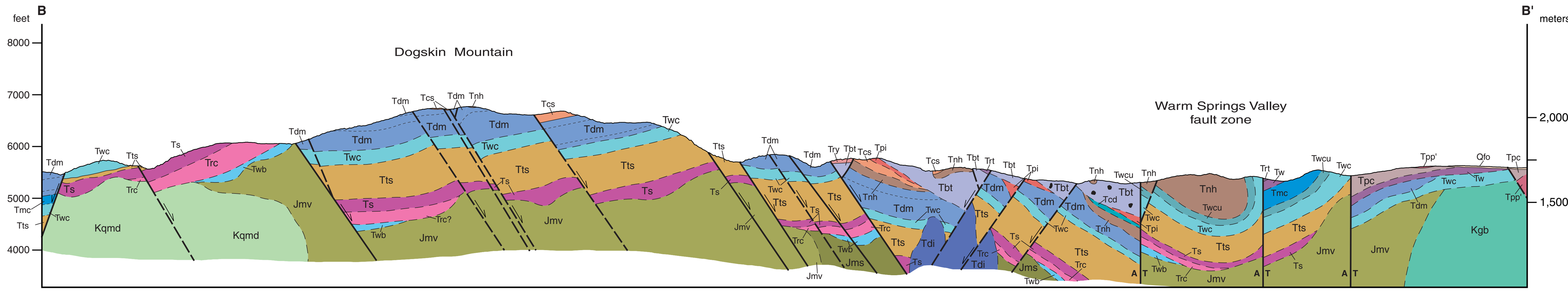
Columnar joint Showing bearing and plunge.

67

Sample location for $^{40}Ar/^{39}Ar$ date or chemical analysis

+ H01-49





PRELIMINARY GEOLOGIC MAP OF THE DOGSKIN MOUNTAIN QUADRANGLE, WASHOE COUNTY, NEVADA

Christopher D. Henry, James E. Faulds, Craig M. dePolo, and David A. Davis

2004

Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 10 METERS

Base map: East half of the U.S. Geological Survey Dogskin Mountain Nevada - California, 7.5'x15' 1:25,000 scale Quadrangle, 1979 Digital Raster Graphic (DRG)

Field work done in 2001-03.

DRAFT

Preliminary geologic map.
Has not undergone office or field review.
May be revised before publication.

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