Description of Map Units

Nevada Bureau of Mines and Geology

Map 146

GEOLOGIC MAP OF THE FRASER FLAT QUADRANGLE and the WEST HALF of the MOSES ROCK QUADRANGLE

WASHOE COUNTY, NEVADA

by

L.J. Garside, S.B. Castor, C.M. dePolo, and D.A. Davis

Qa **Active alluvium** Annually active cobble, gravel, and sand deposits in washes, locally with boulders in proximal fan reaches. The alluvium occupies channels inset up to 2 m and that flow across the basin floor; anastomosing bar and swale topography is generally ubiquitous. Deposits are moderately to poorly sorted, poorly to moderately stratified, and generally non-indurated. Clasts are angular to rounded. Deposits are 0.2 to 4 m thick.

Qe **Eolian deposits** Active Holocene eolian sand and silt deposits including small dunes up to 1 m in height. Located principally on the basin floor and north-central parts of the Fraser Flat Quadrangle. Deposits are well to moderately sorted and generally non-indurated, and grains are angular to subrounded. Deposits are 0.5 to 3 m thick.

Qc **Colluvial deposits** Active Pleistocene and Holocene colluvial and talus deposits that include sand, gravel, boulders, and cobbles shed from upslope bedrock exposures and deposited proximal to the base of exposures. Some eolian silt input. Deposits are poorly sorted and clasts are generally angular and subangular.

Qba **Basin alluvial deposits** Holocene-active alluvium deposited by streams on the basin floor of Warm Springs Valley. Deposits consist of brown, gravelly silty sands with some cobbles. Clasts are moderately sorted, generally non-indurated, and angular to subangular. The surface is generally smooth with occasional broad, subdued longitudinal bar forms. Surface pavements are not common.

Qt_1 **Alluvial terrace and floodplain deposits** Mid to late Holocene floodplain of Mullen Creek. Gravelly sands with bar and swale topography that form a terrace above the active drainage.

Qt_2 **Latest Pleistocene to middle Holocene terrace deposits** Alluvial terraces of Winnemucca Valley Creek. Composed of moderately to poorly sorted, gravelly and pebbly coarse to fine sand. Generally massive with some moderately developed bedding. Commonly nonindurated with a weak, darker cambric soil locally. Gravel clasts are mostly felsic volcanic rocks, whereas the sand was mostly derived from granitic rocks. Deposits, which are 0.5–1.5 m thick, locally overlie lacustrine deposits, including diatomaceous beds. Includes some inset lower terraces along the creek. The uppermost terrace has a smoothed surface with minor coppice dunes and muted beach bar landforms.

Qfy **Quaternary fan alluvium** Undifferentiated late Pleistocene to Holocene alluvium generally deposited on alluvial fans with some channel deposits and active alluvium. Most areas mapped as Qfy contain both Qfy_1 and Qfy_2 or are areas where the characterization into these subunits is difficult. Deposits are 0.5 to 2 m thick.

Qfy_1 Qfd_1 **Young alluvium** Holocene alluvium generally deposited on alluvial fans with some channel deposits, basin alluvial deposits, and active alluvium. The unit includes deposits of sand, gravel, and cobbles with sparse boulders in the proximal parts of fans, and generally gravelly, silty sands in the mid and distal parts of the fans. The deposits are poorly to moderately sorted, poorly to well stratified, and non-indurated to poorly indurated. Surfaces commonly have depositional microtopography including bar and swale morphology, and broadly undulating and pocketed surface morphology. Soil development ranges from no distinct development to generally A/C profiles. Some soils in these deposits have up to 0.2 m cambic (Bw) horizons consisting of slight reddening or darkening of the upper part of the deposit. Deposits are 0.5 to 2 m thick. Qfy_1 denotes alluvium composed mostly of Tertiary volcanic detritus; Qfd_1 denotes alluvium composed mostly of granitic detritus shed from Dogskin Mountain and the Warm Springs Mountain.

Qfy_2 Qfd_2 **Late Quaternary alluvium** Late Pleistocene to early Holocene alluvium deposited on alluvial fans and some fluvial terraces. The deposits consist of sands, gravels, and cobbles with sparse boulders in the proximal parts of fans, and generally gravelly, silty sands in the mid and distal parts of the fans. The deposits are poorly to moderately sorted, poorly to moderately stratified, and have angular to subrounded clasts. Surfaces are usually smoothed with poorly to moderately developed pavements, and occasional relict gravel, cobble, or boulder bars that have had the fines winnowed from them. Soil development usually includes cambic (Bw) or argillic (Bt) horizons 0.2 to 0.5 m thick, and occasionally has a weak calcic horizon (Bk) with up to Stage II CO_3 development. Deposits are 0.2 m to over 2 m thick. Qfy_2 denotes alluvium composed mostly of Tertiary volcanic detritus; Qfd_2 denotes alluvium composed mostly of granitic detritus shed from Dogskin Mountain and the Warm Springs Mountain.

SEHOO FORMATION

Qsls **Alluvium covering lacustrine deposits** Light-brown to gray, alluvial, silty sands and sandy silts overlying lacustrine sandy silt deposits. Weakly to moderately stratified. Alluvial deposit thickness varies from 0.1 to about 1 m. A hummocky surface is common, and pea-gravel lags are locally found at the surface.

Qsle **Eolian deposits covering lacustrine deposits** Light-brown, eolian sandy silt deposits overlying lacustrine sandy silt deposits. Irregular hummocky surface with broad, low coppice dune forms. Eolian deposits are 0.1 to 1 m thick.

Qslf **Lacustrine deposits** Lacustrine deposits of Pleistocene Lake Lahontan; deposits are tan to brown and gray sandy-clayey silts to clayey-silty sands, commonly with white salt-encrusted surfaces. The deposits are poorly to moderately sorted, weakly indurated to non-indurated, and are moderately to strongly horizontally stratified. The deposits generally have a smooth to hummocky surface with small coppice dunes and minor salt-crusted flats; they are more than 1 m thick.

Qslb **Nearshore lacustrine deposits with strandlines** Deposits of silty sand that are largely beach, shoreline, and near-shore deposits from Pleistocene Lake Lahontan. The deposits are moderately sorted with a few cobbles; clasts are subangular to subrounded, with cobbles and gravel that are subrounded to rounded. Deposits are light brown and gray, and are non-stratified to moderately stratified. The surface is irregular but smoothed with occasional bar forms of strandlines up to 1 m high. Soil development in these Qslb deposits is commonly similar to that in Qfi and Qfdi deposits, with cambic (Bw) or weak argillic (Bt) horizons up to 0.5 m thick. In some cases, the upper 1 m of the deposit appears reddened. Deposits are 0.5 to 3 m thick.

Qfi Qfdi Middle to late Pleistocene alluvium Pleistocene alluvium deposited on alluvial fans and some fluvial terraces; deposits consist of sands, gravels, and cobbles with sparse boulders in the proximal parts of fans. The deposits are poorly to moderately sorted, moderately to poorly stratified, and moderately to well indurated. Landforms developed on Qfi and Qfdi deposits are notably eroded, some into ballenas. Surfaces on Qa_3 deposits are smoothed, have poorly to moderately developed pavements, and have well-developed drainages. Soil development usually consists of a reddened, sticky clayey argillic horizon (Bt) up to 0.5 m thick, and a lower calcic horizon (Bk) with up to stage III CO_3 development and/or a silica pan (Bq). Deposits are 1 to 4 m thick. Qfi denotes alluvium composed mostly of Tertiary volcanic detritus; Qfdi denotes alluvium composed of granitic detritus shed from Dogskin Mountain and the Warm Springs Mountain. A tephra bed in Qfdi has an estimated age of 0.23 Ma (table 1) on the basis of chemical correlations with the Summer Lake NN tephra (M. Perkins, personal commun., 2003). The dated tephra is 2–10 cm thick, brownish white, and lies on an eroded surface within Qfdi. The tephra is mostly reworked, but is nevertheless fairly pure and may have some primary air-fall texture at its base.

Qao Older Quaternary alluvium Early to mid Pleistocene alluvial and colluvial deposits similar to Qfi and Qfdi deposits except they lack geomorphic position. Generally, remnants or eroded deposits of alluvium with poorly to moderately developed pavements. Deposits commonly have a reddened, oxidized appearance.

QTls Landslide, debris flow, and fanglomerate deposits Predominantly deposits resulting from rock avalanche, debris flow, rotational slump(?) and possibly alluvial fan formation consisting of chaotic mixtures of sand, cobbles, boulders, and very large blocks of rock. Boulders to 1–2 m are common and larger blocks (up to 12 m) are found in rock avalanche deposits up to 1 km or more from their origin. Even larger blocks may be present in a large rotational slump(?) south of Rattlesnake Canyon. Individual deposits are commonly derived from a single map unit, but some include several rock types. A spectacular exposure of QTls is found in the NE¼ Sec. 14, T23N, R21E in the northeast part of the map area, where failure of a steep-sided body of basaltic tuff breccia (map unit Tpb) produced a northwest-trending slide nearly 1 km long and as much as 300 m wide. Individual blocks in this slide are as much as 5 m in diameter, and much of the slide is composed of a jumble of such blocks with little or no fine matrix. Deposits of QTls are commonly deeply eroded and clearly older than most Quaternary units, which lie at lower levels and are inset into the landslides and debris flows. This erosion has removed or obscured primary morphologic characteristics of most of the deposits, and in most cases, exact source areas cannot be determined. Because of the large clast size, QTls may have been mapped locally as older units. Matrix material is generally very poorly exposed and it is impossible to determine if the deposits are matrix or clast supported. Rock material in these deposits consists primarily of Tpn, Tnh, Tcs, Tpu, Tob, and Tpb. Ash-flow tuff units may be susceptible to mass wasting because of the formation of boulder-mantled slopes of corestones. Because there is no similar stratigraphic control on landslide deposits in upland areas, some could be age equivalent to unit Tsls. Deposits are tens of meters thick.

QTa Quaternary-Tertiary alluvium Uplifted, Pliocene to early Quaternary alluvial fan deposits consisting of basaltic and rhyolitic sand, gravel, cobble, and boulder deposits uplifted into a linear ridge along the Warm Springs Valley fault system. Sanidine from a tephra bed in fine-grained granitic sedimentary deposits that underlie QTa north of the Fraser Flat Quadrangle gave an $^{40}Ar/^{39}Ar$ age of 3.57 ± 0.17 Ma (C.D. Henry, personal commun., 2001). QTa is younger than this tephra, and perhaps much younger given the differences in texture and composition between QTa and the granitic sediments.

QTg Gravel Poorly consolidated beds of gravel, sand, and silt. In the southeastern part of the map area, channel-like deposits lie with angular unconformity on Tpn, Tcs, and northwest-striking high-angle faults. The deposits apparently are slightly (15°) tilted. The surfaces of the unit are littered with a lag of cobbles and boulders of Tertiary volcanic rocks. The unit is 15 to 30 m thick. It is probably older than all other surficial alluvial units of the map area.

Ts Tsls Sedimentary rocks, including landslide deposits White, very light-gray, very pale-orange, and greenish-yellow, tuffaceous, coarse to fine fluvial and lacustrine volcaniclastic to feldspathic and arkosic bedded sandstone, pebbly sandstone, and conglomerate interbedded with tuffaceous siltstone that lies with angular unconformity or nonconformity on most older Tertiary and pre-Tertiary rocks. Sandstone units are commonly poorly sorted and immature, with subangular grains. Pebbles (commonly 1 cm) in sandstone and conglomerate beds consist of rhyolitic ash-flow tuffs or vesicular andesite. Contains several massive beds (10–60 cm) of andesitic (plagioclase +hornblende +biotite) lacustrine fine (2–3.5 mm) lapilli tuff. One of these, a hornblende-plagioclase andesitic lapilli (0.4–4 mm) tuff, exposed near the base of the Ts section in the southeastern part of the map area has been dated by $^{40}Ar/^{39}Ar$ methods at 8.75 Ma (table 1). Sandstones are locally cemented with calcite or, rarely, iron oxide minerals. Ash in some tuffaceous beds is converted to zeolite minerals (chabazite and heulandite). Rare large mammal and fish bones are found in the unit. Rocks of the unit at the north end of Hungry Ridge are estimated to be about 8–7 Ma, based on Hemphillian fossil vertebrates and a fossil flora, both from that area (H. Schorn, written commun., 2001). Thickness probably <100 m on Hungry Ridge, 1 km or more northwest of Hungry Mountain.

Tsls denotes landslide deposits resulting predominantly from rock avalanches and consisting of chaotic mixtures of sand, cobbles, boulders, and very large blocks of rock; 1–2 m boulders are common and blocks up to 3x5 m are found in rock avalanche deposits up to several kilometers from their origin. Individual deposits are predominantly monolithologic but some deposits are composites of more than one flow or avalanche; internal map contacts within the unit separate some of these. The deposits, which crop out as 3-km-long ridge-capping rock avalanche deposits northwest of Hungry Spring, contain several such monolithologic units. The most extensive and farthest traveled clast type is Kmr (monzodiorite), which crops out to the south in the Griffith Canyon Quadrangle (Garside and Nials, 1999). Rock avalanche deposits that consist mostly of Tertiary ash-flow tuff clasts are found closer to their probable areas of origin, and appear to underlie the monzodiorite-clast unit. This relationship suggests that the rock avalanches have an inverted stratigraphy, with youngest avalanches derived from the oldest and last exhumed rocks. The exact area or areas of origin of the rock avalanches cannot be determined. Based on sparse outcrops of lacustrine tuffs between outcrops of avalanche deposits in NW¼ Sec. 22, T22N, R20E, we conclude that the avalanche deposits are interbedded at several levels in unit Ts. Matrix material is generally very poorly exposed and it is commonly impossible to determine if the deposits are matrix or clast supported. The monzodiorite source rock may have been susceptible to mass wasting because of the formation of boulder-mantled slopes of corestones, which now make up the larger clasts in the avalanche deposits. The deposits are up to 10 m or more thick.

PYRAMID SEQUENCE

Tba Basaltic andesite Dark-gray, dense, platy flow rock to mottled medium-gray and grayish-red, massive, vesicular flow rock. Similar to Tob, but generally lighter colored and appears to contain less olivine. Tba is fine-grained, dense rock with pilotaxitic, sub-ophitic to intergranular plagioclase + pyroxene matrix and less than 1% olivine phenocrysts to 0.8 mm long that are partially altered to iddingsite. Very little is exposed in the map area and the thickness of the unit is not known.

Tmu Tuff of Mullen Pass, upper unit Light-gray welded ash-flow tuff with dark-gray perlitic compressed pumice fragments up to 2 cm thick and 30 cm in diameter. In the Moses Rock Quadrangle, this unit ranges in thickness from 3 m to 30 m, but

in the Sutcliffe Quadrangle to the north it is as much as 50 m thick. Compressed pumice fragments at the latter site are as much as 7 cm thick and 50 cm in diameter, with about 25% phenocrysts. As percentage of the rock, these are 20–25% plagioclase, 2% pyroxene (both augite and hypersthene), 1% biotite, 1% opaque minerals, and a trace of hornblende. On the basis of hand examination, both matrix and fiamme in the unit in the Moses Rock Quadrangle seem to have a similar mineral assemblage. The unit is equivalent to Member 7 of the Pyramid Formation of McJannet (1957). Its age is 13.77 Ma (table 1).

Tml Tuff of Mullen Pass, lower unit Dark-gray poorly welded to moderately welded ash-flow tuff. Thickness is at least 10 m in the Moses Rock Quadrangle, and is estimated elsewhere to be as much as 50 m (as Member 5 of the Pyramid Formation of McJannet, 1957). This tuff consists of brownish-gray to dark-gray glassy pumice fragments as large as 3 x 10 cm that contain plagioclase and pyroxene phenocrysts. The matrix is light-brownish-gray and contains some small gray lithic fragments and sparse broken phenocrysts. The lithic fragments are composed mainly of finely pilotaxitic plagioclase-clinopyroxene flow rock. Sparse phenocrysts in the matrix include be plagioclase, clinopyroxene, and hornblende.

Tob Tl Olivine basalt Medium-gray to very dark-gray flow rock, dense to vesicular, with phenocrysts of olivine, plagioclase, and pyroxene. Textures range from seriate to porphyritic with intersertal to intergranular matrices. As percentage of the rock, larger crystals are 7–21% olivine, 2–17% plagioclase, and 0–6% augite. The olivine, which is generally replaced in part by iddingsite, occurs in crystals as much as 5.5 mm long. Finer grained material is mostly plagioclase, pyroxene, an opaque phase, and locally, minor glass. The Tob sequence, which is as much as 100 m thick, includes rarely exposed volcaniclastic breccias (Tl) that are interpreted as lahars. The best exposures of these lahars are in SE$^{1}_{4}$ Sec. 24, T23N, R21E, where pebble- to boulder-sized clasts of basaltic flow rock along with minor amounts of Tpu in a light-olive-gray matrix of fine to granule sand make up a well-bedded to massive sequence at least 10 m thick. A basal basalt flow in the Tule Peak Quadrangle to the north has been dated by $^{40}Ar/^{39}Ar$ methods at 13.62 Ma (table 1; Faulds and others, 2000).

Tpb Volcanic breccia Several exposures of tuff breccia as much as 500 m across in the basal parts of the Pyramid sequence in the north central part of the Moses Rock Quadrangle. On aerial photographs these masses resemble vent deposits, and one appears to be dome-shaped with a central crater. In outcrop, this exposure and others in the area are composed of massive to well-bedded breccia, locally interbedded with fine-grained tuffaceous rocks similar to those in Tps. The geometry of the exposures suggests that these are tuff cones as defined by Cas and Wright (1987). Bedding attitudes in the breccia are highly variable and commonly steep. The breccia contains abundant, pebble- to boulder-size, angular clasts of dense to scoriaceous basalt and sparse fragments of Tpu and Trf. The breccia matrix, which makes up 30–40% of the rock, consists of fine basalt fragments, crystal fragments, light-olive-gray pumice, possible accretionary lapilli, and fine-grained volcanic debris. In thin section, basalt clasts have hyalopilitic to pilotaxitic, intersertal to intergranular, and seriate textures and contain olivine, plagioclase, and pyroxene. Tpu fragments, where present, are generally sericitized and silicified. The tuff breccia masses are shown with feeders on cross section B–B´, but may be rootless phreatic explosion vents.

Tps Basal sedimentary rocks of the Pyramid sequence Bedded rocks that consist of siltstone, fine-grained to pebbly tuffaceous sandstone, diatomite, air-fall tuff, volcaniclastic breccia, and possible nonwelded ash-flow tuff are found at the base of

the Pyramid sequence, although exposures are generally poor. In many places, only small chips of diatomite and sandstone are seen. The thickest exposed section of Tps observed in the map area is 50 m. The basal part of the section generally consists of as much as 10 m of light-olive-gray, fine-grained, tuffaceous sandstone with or without white siltstone and diatomite. Locally, volcaniclastic breccia and interbedded sandstone as much as 30 m thick occur in the lower and middle part of the unit. Fine to granule sandstone with some pebbly beds generally makes up the upper part. The sandstone includes olivine basalt fragments, glass shards, and fragments of plagioclase and olivine crystals. The volcaniclastic breccia contains clasts as much as 10 cm in diameter that are similar to those in Tpb and are set in matrix that includes glass shards. On this basis, some of the breccia in Tps is thought to have come from contemporaneous vents represented by Tpb and therefore to have originated as lahars. Tps is stratigraphically equivalent to a sequence of diatomite and associated tuffs and sandstone found to the northwest in the Tule Peak Quadrangle (Member 2 of the Pyramid Formation of McJannet, 1957). There, the diatomite contains fossils of the Pyramid flora, which Axelrod (1956, 1992) considered to be middle Miocene.

Tal Tali Andesite lahars and intrusive rocks Reddish-brown-weathering, medium-gray, massive to very rarely crudely layered lahars consisting of blocks and clasts (a few centimeters to 1 m or larger in diameter) of light- to dark-gray, glassy to microcrystalline porphyritic andesite in a light-gray matrix of finer andesitic material. Commonly matrix supported and monolithologic, although blocks of older ash-flow tuff up to 10 m in length are found locally near the base. Andesite clasts are hiatal to locally seriate, containing phenocrysts (15–25%, <5 mm) of plagioclase ± basaltic hornblende ± pyroxene ± biotite in a fluidal groundmass of fine plagioclase and pyroxene. Includes a very few areas of flows that are too small to map(?). A probable intrusive andesite, **Tali**, is also included. This intrusive andesite contains phenocrysts (30%) of plagioclase (20%, 0.1–1 mm), hornblende (5%, 0.2 mm up to 0.4 x 2.5 mm), and pyroxene (5%, 0.2–0.75 mm). At its base, the lahar contains large, rounded boulders (commonly as large as 1 m, rarely 1.5 m) of pale reddish-brown- to light-olive-weathering dacitic ash-flow tuff containing phenocrysts (~22%) of distinctive yellowish- to light-orange quartz (1%), plagioclase (15%), biotite (5%), and hornblende (2%). Crops out on northern Hungry Ridge, where it overlies (with angular unconformity) Tpn, Tph, and Tcs and underlies Ts. Thickness <200(?) m.

Ta Andesitic intrusive rock Small intrusive masses, mainly steeply dipping dikes a few meters thick, of medium-gray and greenish-gray to dark greenish-gray, very fine-grained to porphyritic andesite crop out in the Pyramid mining district. A sill-like mass of Ta crops out about half-way between the Nevada Dominion and Jones-Kincaid Mines; a similar sill-like mass, which rolls into a steeply dipping dike, lies along a major northwest-striking fault about 2.5 km to the west. Ta intrusions generally contain sparse to abundant blocky plagioclase phenocrysts up to 3 mm in diameter and clinopyroxene that occurs both as intergranular matrix grains and phenocrysts as much as 5 mm long. The plagioclase, which comprises most of the rock, generally has seriate size distribution. Lesser amounts of hornblende, opaque minerals, and possible altered biotite are also present. Trace amounts of quartz occur in a few dikes. Some of the dikes contain abundant blocky plagioclase phenocrysts as much as 8 mm long, and some contain sparse hornblende phenocrysts to 1.5 cm long. Dikes in the Pyramid mining district are weakly to strongly altered with secondary chlorite and carbonate, and locally clay. $^{40}Ar/^{39}Ar$ ages of 22.33 and 22.54 have been determined for two unaltered hornblende-bearing dikes (table 1).

Tfd Fine-grained diorite Mostly light-gray to light-greenish-gray fine-grained to very fine-grained, hypidiomorphic-granular rock that consists of 60–70% plagioclase laths with intergranular clinopyroxene. Accessory hornblende and biotite are present and,

together with pyroxene, comprise about 25% of the rock. Fine Fe-Ti oxide grains and minor interstitial quartz ± alkali feldspar are also present. Average grain size is 0.5–1 mm, but has seriate size distribution and may contain relatively large grains of plagioclase, hornblende, and pyroxene (some of which are zoned). Some of this rock is porphyry with phenocrysts of plagioclase (35%), orthopyroxene (5%), biotite (3%), and hornblende (1%) in microcrystalline matrix. The rock is found as intrusive masses as much as 600 m across on the west-trending ridge between Perry and Moses Rock Canyons. In addition, a pod about 25 m in diameter was observed in the central portion of an exceptionally wide andesite dike (map unit Ta) about 1 km south of the Jones Kincaid Mine shaft. Based on this occurrence, the diorite is presumably closely related to unit Ta. Tfd is partially altered to propylitic assemblage minerals, particularly epidote and chlorite that replaced biotite and hornblende.

Tha Hornblende andesite intrusive rocks Dikes and sill-like and irregular intrusive masses of light-brownish-gray-weathering, light-gray to medium-light-gray andesite which crop out in the south-central part of the map area. Contains phenocrysts (20–30%, rarely 50%) of plagioclase (<1 mm to several millimeters, rarely to 1 cm; having complex oscillatory zoning and spongy cores mantled by clear plagioclase rims), and black hornblende (commonly as elongate euhedral crystals a few millimeters long, but very rarely 2 x 4 cm; commonly rimmed by a thin zone of dark magnetite and pyroxene(?) in a pilotaxitic groundmass containing small plagioclase laths. Locally, phenocrysts of biotite and rarely pyroxene are observed. Commonly unaltered, but locally propylitized (epidote, chlorite, albite?, ± pyrite). Apparently coeval with unit Tal (e.g., sample FM52, table 1). Ages of 20.69 and 20.82 Ma (table 1) have been determined for the unit.

Trf Rhyolite and dacite flow rock Massive to distinctly flow-banded low-silica rhyolite and dacite are found in flows that overlie Tpu in the Moses Rock Quadrangle. Most of this rock is medium-gray with light-gray to pinkish-gray flow bands. As percentage of the rock, it generally contains 10–20% phenocrysts of plagioclase as much as 1 cm long, 5–15% mafic mineral grains up to 3 mm long, and 1–2% phenocrysts of quartz up to 5 mm in diameter. The microcrystalline matrix consists of plagioclase laths and granular minerals that include quartz and minor potash feldspar. On the basis of staining, light-colored flow bands contain more potash feldspar than the rest of the rock. In general, the rock is altered, with plagioclase veined by silica + calcite and mafic phases (hornblende ± biotite) partly to wholly replaced by hematite + calcite. Dacite(?) between Tpu and Tmu near the northeast corner of the map area has different mineralogy, but is also mapped as Trf. This rock is massive dark-gray rock with 20% plagioclase, 14% hornblende, 2% pyroxene, and a trace of quartz phenocrysts in a microcrystalline matrix. Wallace (1975) reported a plagioclase K-Ar age of 21.2 ± 0.6 Ma (recalculated) for a sample of Trf; however, it is likely that the unit is close in age to the petrographically similar and probably related Tri, and thus about 23.5 Ma.

Tri Intrusive rhyolite of Mullen Pass Intrusions of light-gray to light-greenish-gray low-silica rhyolite to high-silica dacite form large craggy outcrops along both sides of Pyramid Highway in Mullen Pass. Continuous exposures at least as much as two kilometers across are found along the northern edge of the Fraser Flat Quadrangle and appear to be separated by screens of older ash-flow units and to be locally covered by remnants of intruded ash-flow sheets. Intrusive contact exposures are rare, but at 39° 51' 26" N, 119° 38' 45" E, a highly irregular contact with host tuff can be observed to dip variably away from and into the intrusive mass. The rock has porphyritic texture and is nearly everywhere massive, with distinct flow banding only in a few places. Stubby plagioclase tablets as much as 1.5 cm long make up 20–30% of the rock, biotite books to 3 mm comprise 5–10%, and minor hornblende phenocrysts make up less than 2%. Rounded and embayed quartz phenocrysts are distinctive because they are large (as much as 1 cm in diameter) and have variable colors (clear to distinctly gray or faintly rosy). Rounded xenoliths, present in minor amounts, mainly consist of finely granular feldspar and hornblende. Age, 23.51 Ma (table 1).

TUFF OF PERRY CANYON

Tpu Tuff of Perry Canyon, upper part Light-gray to light-greenish-gray and light-brownish-gray dacite ash-flow tuff sequence that is at least 300 m thick. The tuff is crystal-rich and locally lithic, and contains sparse to abundant pumice fragments that are moderately to strongly flattened. The rock contains phenocrysts (30–50%) of plagioclase (20–40%), hornblende (3–10%), biotite (2–5%), quartz (2–3%), and opaque minerals (1–2%). Some samples contain a little sanidine. The rock is slightly to strongly altered everywhere. Alteration is generally propylitic with plagioclase partly to wholly replaced by calcite ± albite ± illite; hornblende generally altered to iron oxide ± calcite and chlorite, and biotite generally altered to iron oxide ± chlorite ± illite. Color ranges from light gray where weakly altered to light greenish gray where it is more strongly propylitized. It generally weathers to grus-like soil and forms low hills, but locally forms large steep-sided outcrops. Quartz phenocrysts are generally slightly smoky or rose colored grains as large as 5 mm. Matrix shards are indistinct to conspicuous. The tuff of Perry Canyon forms extensive exposures for more than 5 km along and just south of the Pyramid Highway but thin, possibly correlative tuffs are exposed to the north in the Tule Peak Quadrangle (Faulds and others, 2000). Compaction foliation in the unit mostly dips shallowly north to northwest. In Perry Canyon, Tpu is at least 300 m thick and may be as much as 500 m thick. In this area it is typified by platy, compaction-parallel fracturing and columnar jointing, suggesting that it is an intracaldera unit. The tuff of Perry Canyon has an $^{40}Ar/^{39}Ar$ age of 23.23 Ma (table 1).

Tmb Megabreccia Megabreccia is found in places between the lower and upper tuff of Perry Canyon. The largest exposure in the map area is in the SW¼ Sec. 21, T23N, R21E, and most of the information that follows was collected from this area. The megabreccia is composed mostly of shattered clasts of medium gray andesite as much as 10 m in diameter or larger. The matrix of this breccia, where it can be distinguished, is pulverized tuff of Perry Canyon. In general, exposures of the breccia consist only of blocks of andesite, and Wallace (1975) referred to it as an andesite flow. The andesite contains 15% plagioclase laths up to 2 mm long and 20% hornblende prisms to 2 mm that are totally replaced by hematite + calcite ± chlorite in a microcrystalline matrix of plagioclase + chlorite + illite + hematite. The megabreccia seems to grade upward into lithic-fragment-rich upper tuff of Perry Canyon with pebble to boulder-sized clasts of andesite, dacite, and sparse tuff of Chimney Spring. Locally, the contact between Tpu and Tpl is marked by reddish-brown clay with clasts of andesite and rhyolite.

Tpl Tuff of Perry Canyon, lower part The basal unit of the tuff of Perry Canyon has phenocryst mineralogy that is intermediate between that of Tpu and Tcs. It is included in the former unit because it is found with it and resembles it more closely than the latter; however, age and chemical data are not available, and the relationship is equivocal. It could be a more strongly welded equivalent of the upper part of Tcs. Thinly bedded volcaniclastic rock is found in places at the base of Tpl, generally as loose platy chips. In NE¼ NE¼ Sec. 29, T23N, R21E, this rock seems to overlie soil atop Tcs. It consists of thin-bedded tuffaceous sandstone with well-sorted layers containing 10–40% angular plagioclase, quartz, biotite, and opaque grains with the balance composed of glass shards, rock fragments, and a trace of pumice fragments. The overlying lower tuff of Perry Canyon is dacitic welded ash-flow tuff, commonly with jointing parallel to the compaction foliation. It contains the following phenocrysts as a percentage of the rock: 15–25% plagioclase, 5–15% sanidine, 3–5% biotite, 2–4% quartz, 0–3% altered hornblende, 2% opaque minerals, and traces of zircon, allanite, and monazite. Flattened spheroidal pumice fragments comprise about 5–15% of the rock, and dacitic ash-flow and mafic volcanic lithic fragments comprise 0–15%. Tpl is typically propylitized, with feldspar partially replaced by albite ± calcite ± sericite, biotite replaced by chlorite + hematite ± sericite, and hornblende wholly replaced by chlorite, hematite, and calcite.

Tph Tuff of Painted Hills Commonly white to pale-pinkish-gray rhyolite ash-flow tuff that overlies Tcs. It contains more biotite and plagioclase than Tcs but is otherwise megascopically similar. It was mapped separately where possible but was not distinguished everywhere from Tcs, particularly along the roughly east-west contact between Tpl and Tcs. The unit has previously been informally called the tuff of Gary's Ridge (H.F. Bonham, oral commun., 1998) or the upper tuff of Chimney Spring in the Olinghouse area (Garside and Bonham, 1992). It is herein informally named for colorful outcrops in the Painted Hills in the Tule Peak Quadrangle to the north (Faulds and others, 2000). Samples of this rock are found to have the following phenocryst content: sanidine (3–12%), plagioclase (5–10%), smoky quartz (3–12%), biotite (1–3%), and 1% Fe-Ti oxide minerals. Age, 24.73 Ma and 24.68 Ma (table 1). Sample H02-165 (table 1) of the tuff of Painted Hills was collected from an area where it was not mapped separately from Tcs. Thickness ~150 m; no upper contact is present in the map area where Tph has been mapped separately.

Tcs Tuff of Chimney Spring Pinkish-gray, very pale- orange to pale-red, locally reddish-brown-weathering, crystal-rich, rhyolite ash-flow tuff. Slightly to moderately welded, containing phenocrysts (~40%) of smoky, bipyramidal to equant quartz (10–20%, 1–3 mm); equant to euhedral or broken, locally adularescent, sanidine (15–20%, 1–3 mm), plagioclase (1–2%, ~1–2 mm), rare biotite plates (<1%, 0.5 x 0.9 mm), and accessory opaque Fe-Ti oxides (0.2 mm). Totally devitrified. Contains indistinct compressed pumice (15%) up to 3 x 20 mm and sparse lithic fragments of flow-banded rhyolite, intermediate lava, and Nine Hill Tuff(?). Portions are spheroidally weathered to rounded, reddish boulders of decomposition. Appears to include more than one cooling unit in the map area. In the vicinity of the Pyramid mining district, sanidine in the tuff of Chimney Spring loses its adularescence and is cloudy and partially to totally altered to albite ± calcite ± sericite, and the biotite is totally altered to hematite ± chlorite ± sericite. The tuff of Chimney Spring overlies units Tpn and Tnh with apparent disconformity. Thickness 100–150 m. Age, 24.90 Ma (table 1; Garside and Nials, 1999).

Tnh Nine Hill Tuff Brownish-weathering, pinkish-gray or grayish, strongly welded rhyolite ash-flow tuff that commonly consists of two parts: a lower nearly aphyric rock that grades upward into a more crystal-rich tuff. Contains phenocrysts (~3–15%) of ~1 mm diameter alkali feldspar, considerably less plagioclase, trace small biotite, and accessory ilmenite(?) that has been converted to hematite. The more phenocryst-rich phase contains subequal amounts of spongy to sieve-textured (resorbed) anorthoclase and equant, fractured sanidine. Some samples contain rare small lithic fragments of glassy, sanidine-bearing silicic volcanic rock similar to the Nine Hill. Common partial to complete vapor-phase alteration, with formation of tridymite and alkali feldspar in cavities (former pumice sites); elsewhere devitrified. Local dark grayish-black vitrophyre at base. Distinctive compressed pumice (1:3 to 1:7 aspect ratio) from less than 1 mm x 5 mm to 15 x 45 cm. A 40-m-thick section of Nine Hill Tuff in the NE¼ Sec. 24, T22N, R21E includes nearly aphyric gray basal vitrophyre about 2 m thick overlain by about 15 m of similar, but devitrified, ash-flow tuff. The aphyric rock grades upward over an interval of less than 1 m into tuff with more phenocrysts, and densely welded, relatively crystal-rich tuff, both devitrified and glassy, makes up most of the rest of the unit, with a small amount of poorly welded, biotite-rich tuff at the top. In the canyon ~1 km south of Coyote Spring in the Curnow Range, strongly welded Nine Hill is underlain by a light-gray, poorly welded to nonwelded ash-flow tuff containing white pumice (up to several cm), small cognate black to dark brown glass fragments and shards, and phenocrysts (~15 %) of alkali feldspar (including strongly resorbed anorthoclase) and sparse, small biotite. Extensive chemical data from Deino (1985), shows that the Nine Hill Tuff is mostly high-silica rhyolite. In the northwest part of the Moses Rock Quadrangle, Nine Hill Tuff is altered, having feldspar phenocrysts partially replaced by albite ± calcite ± sericite/illite and biotite altered to hematite + sericite. Thickness, 0–130 m, variable. The age of the unit is reported as 25.11 Ma (Deino, 1989) and 25.07 Ma (table 1; Garside and Nials, 1999).

Tcc Tuff of Campbell Creek Purplish-gray welded ash-flow tuff characterized by strongly vermiculated ("wormy" or "worm-eaten") quartz phenocrysts. Consists of phenocrysts (10–12%) of sanidine (~5%, >0.5 mm), pinkish, highly vermiculated quartz (5%, 1–2 mm), plagioclase (~1%, 1–1.5 mm), and trace small biotite (1–2 mm) in a matrix of dark gray pumice and distinct axiolitic shards (up to 0.4 mm in diameter) which are clearly visible with a hand lens. Poorly welded base is light gray and rich in lithic fragments. Overlies Tpn disconformably (apparently in a paleochannel) at the head of Perry Canyon on the east edge of the map area, where it is approximately 40 m thick. Probably locally present, but unmapped, in other parts of the map area. The unit has been observed in the Dogskin Mountain Quadrangle to the north, where an $^{40}Ar/^{39}Ar$ age of 28.62±0.07 Ma has been determined on sanidine (C.D. Henry, written commun., 2002). The unit is also present in the Fort Sage Mountains 40 km to the northwest. In both areas, the unit directly underlies the Nine Hill Tuff.

Tc Unnamed conglomerate Poorly exposed conglomerate that contains pebble- to boulder-sized clasts of intermediate volcanic rock and ash-flow tuff. Found beneath Tnh in a small area south of Mullen Pass.

Tdm Tuff of Dogskin Mountain Light-gray, nonwelded to slightly welded, dacite ash-flow tuff with a distinctive phenocryst assemblage (15–30%) of plagioclase (7–17%, <3 mm), sanidine (4–12%, <3 mm) and biotite (1–7%, <2.5 mm) in a glassy, shard-rich groundmass. Contains white, uncompressed pumice lapilli (~5%, most <1 cm, but up to several cm) and sparse light-gray lithic fragments (< 3–4 mm) of glassy biotite-plagioclase volcanic rock similar to the host tuff. Air-fall tuff and tuffaceous sandstone at several small outcrops are also included in the unit. The tuff of Dogskin Mountain is commonly found between units Tnh and Tpn in the map area, but in the western Curnow Range, it lies directly on pre-Tertiary plutonic rocks in a probable paleochannel. Thickness <100 m. Age: 29.02±0.10 Ma, $^{40}Ar/^{39}Ar$ on sanidine, (C.D. Henry, unpub. data, 2002); and 29.13 Ma (table 1; Garside and Nials, 1999). Tdm is correlative with, and replaces, the tuff of Coyote Spring (Garside and Nials, 1999)

Tmc Tuff of "Mine Canyon" Pale or moderate-red to pale-reddish-brown ash-flow tuff that forms several exposures along the south side of Mullen Pass, where it is strongly altered and may include some flow-banded rhyolite. Wallace (1975) mapped it as rhyolite flow rock and noted that it could include some ash-flow tuff. It appears to have been tilted during intrusion of the rhyolite domes (Tri), and is locally intruded by andesite (Ta). In places it contains white collapsed pumice fragments as much as 20 cm long. Phenocrysts (6–15%) consist of altered feldspar (3–12%), which probably originally included plagioclase and sanidine, and biotite (1–3%). Quartz is absent or very rare. Alteration minerals, which include illite and/or sericite, albite, quartz, and hematite, wholly replace biotite, and partially to wholly replace feldspar. Locally silicification is severe. The unit is named for an informally designated canyon that contains uranium mines and prospects in Sec. 36, T24N, R20E, in the Tule Peak Quadrangle.

Tut Unnamed reworked lithic tuff Pale-greenish-gray, lithic-fragment-rich tuff underlies Tmc along the south side of Mullen Pass. In SW¼ SE¼ Sec. 17, T23N, R21E, the unit has a well-exposed contacts with intrusive Tri and overlying Tmc. Tut contains variable amounts of pebble- to cobble-sized lithic fragments, locally as much as 40%, that include ash-flow tuff, intermediate flow rock, and rare metasedimentary rock. It contains sparse to abundant plagioclase (5–25%) and altered biotite. Quartz is lacking or extremely rare.

Tpn Pre-Nine Hill tuffs, undivided The Moses Rock Quadrangle contains large areas of exposure of a thick section of ash-flow tuffs, which lie unconformably beneath the Nine Hill Tuff and the tuff of Chimney Spring. These tuffs are correlated with regional informal units, and may include tuffs as high in the section as the 28.62-Ma tuff of Campbell Creek and as low in the section as

the 31.00-Ma tuff of Axehandle Canyon. In general, Tpn is represented by a stack of ash flows of dacitic to rhyolitic composition that include alternating welded and nonwelded types. Both types are characterized by the presence of biotite and the absence or near absence of phenocrystic quartz. The rocks contain variable amounts of lithic fragments (commonly 1–10 mm), including dark siltstone and intermediate-composition flow or pyroclastic rock. The welded tuff is generally pale red or light brownish gray to medium gray and relatively resistant, and the nonwelded tuff is generally light gray to greenish gray and a slope former. Phenocrysts consist of sparse to moderately abundant plagioclase and sanidine to 3 mm long and biotite to 3 mm in diameter. The nonwelded type, which is megascopically similar to the tuff of Dogskin Mountain, contains phenocrysts (7–40%) of plagioclase (6 to~33%, ~1–4 mm long), thin biotite plates (1–5%, 1–3 mm), small opaque Fe-Ti oxide grains (as much as 5%) and trace quartz (0.5 mm). This type commonly has platy jointing parallel to compaction foliation and forms relatively low-relief slopes. The ledge-forming, welded ash-flows that alternate with these tuffs contain phenocrysts (7–20%) of subequal amounts of plagioclase (4–10%, <1–2 mm long) and sanidine (3–10%, 1–1.5 mm), plus biotite (1–2%, ~1 mm), and opaque Fe-Ti oxide minerals (1%). These rocks, similar to rocks formerly called the tuffs of Whisky Spring in the region (Garside and Nials, 1999), commonly contain shard textures observable with a hand lens, and locally have a distinctive, rough or "nubbly" weathering surface. Tpn is generally somewhat altered with milky feldspar and biotite partially or wholly altered to iron-oxide minerals ± illite and(or) sericite. Individual ash-flow tuffs in Tpn are typically tens of meters thick. In the south part of Perry Canyon, Tpn consists of at least three cycles of welded and nonwelded ash-flow tuff with a total thickness of at least 150 m; the unit may be even thicker (possibly 1.5 km) in Moses Rock Canyon to the south, but it may be repeated by faulting in this area.

The lowest part of the pre-Nine Hills tuff sequence includes several commonly moderately welded rhyolitic ash-flow tuffs formerly known as the tuffs of Whisky Spring. These include units Tws, Trc, and Tax in the Griffith Canyon Quadrangle to the south (Garside and Nials, 1999). They are generally light-brown- or reddish-brown-weathering, pale-orange to light-brown rocks containing phenocrysts of platy-fractured glassy sanidine, plagioclase, and biotite, with sparse to trace quartz. Moderately welded ash-flow tuffs commonly contain phenocrysts (~15–18%) of sanidine (6–11%,) plagioclase (4–6%), and biotite (commonly <1%, but >2% in some tuffs, which also may have plagioclase > sanidine). One ash-flow unit contains only ~5% phenocrysts. Lithic fragments (~1%, 0.5–3 cm) include metasiltstone, granodiorite, intermediate lava, and ash-flow tuff similar to the host tuff. The tuff locally has a basal vitrophyre; in places, a "nubbly" weathering surface is developed on rock outcrops by closely spaced joints in devitrified vitrophyre. The basal tuffs were deposited on a locally irregular erosion surface on pre-Tertiary rocks. Compressed pumice (commonly >5%, 1 x 5–8 cm) above basal nonwelded zones may have aspect ratios of 1:5 to 1:10. Thickness 150–250 m. Three samples from near the base average 31.0 Ma (table 1; Garside and Nials, 1999).

Kdi Mafic dikes Fine- to medium-grained, medium-to dark-gray diorite consisting of anhedral to euhedral plagioclase (>60%), potassium feldspar (1–2%), quartz (1–2%), mafic minerals (30–40%), and accessory iron oxides and apatite. Plagioclase is commonly moderately to strongly zoned with sericitized calcic cores. Mafic minerals are approximately equal amounts of hornblende and biotite. Some dikes have phenocrysts up to 1 cm long of either plagioclase or hornblende, the long axes of which show crude alignment. A few mafic dikes have thicknesses of 1 to 3 m and some of these are shown on the map (thicknesses are exaggerated), but most dikes are much narrower. The age of the dikes is uncertain, but they cut all other pre-Tertiary intrusive rocks including the aplite-pegmatite dikes.

Kap Aplite-pegmatite dikes Fine- to medium-grained, very light-gray to pinkish-gray aplite and locally coarse-grained pegmatite dikes consisting of anhedral to subhedral plagioclase (<20%), potassium feldspar (>50%), quartz (>30%), biotite (~1%), and accessory iron oxides, muscovite, garnet, and tourmaline. The dikes range in thickness from less than 1 cm to over 5 m, but irregular masses of garnet-bearing aplite and pegmatite are up to 60 m wide in Rattlesnake Canyon in the southeastern part of the Fraser Flat Quadrangle. Some of the >1 m thick dikes are shown on the map (widths are exaggerated). Also, although the dikes are common throughout all of the plutonic rocks, there is a large concentration in the center and W½ Sec. 4, T22N, R20E. Tourmaline is usually an accessory mineral, but near prospect cuts at the west end of the line between Secs. 9 and 16, T23N, R20E, it forms crystals up to 2 cm long and locally makes up 1–2% of the rock. Also, in these cuts, the dikes exhibit radioactivity of 125–185 cps as measured by a scintillometer against a background of 50–65 cps.

Kgr Granite of "Moon Rocks" Medium- to coarse-grained, very light-gray to white, deeply weathered, somewhat crumbly biotite granite consisting of anhedral to subhedral plagioclase (30–45%), potassium feldspar (30%), quartz (20–30%), biotite (<5%), and accessory iron oxides, muscovite, zircon, and garnet. Zircon is usually found as small inclusions with a dark halo in biotite. Garnet is found as rare, small (<1 mm) subhedral to euhedral red crystals. Outcrops commonly show exfoliation, concave weathering features, iron oxide staining in fractures, and liesegang banding. Unit is an extension of biotite granite mapped on the southeast flank of Dogskin Mountain on the Bedell Flat Quadrangle (Garside, 1993). Included in Kgr is one area of medium-grained biotite-bearing granite in the Curnow Range near the southern map boundary (Rattlesnake Canyon); that rock is correlated with similar, but coarser grained, rock in the Griffith Canyon Quadrangle (Kgr of Garside and Nials, 1999). A very small outcrop of similar biotite granite in lower Moses Rock Canyon (C.D. Henry, personal commun., 2003) is also included in this unit. The unit is named for an informally designated area on the southeast flank of Dogskin Mountain (the "Moon Rocks") where spheroidal and cavernous weathering is particularly well developed.

Kf Felsite Fine- to medium-grained, very light-gray, locally deeply weathered, leucocratic quartz monzonite, consisting of anhedral to subhedral plagioclase (~40%), potassium feldspar (~40%), quartz (10–15%), mafic minerals (~5%), muscovite (~1%), and accessory iron oxides and apatite. The mafic minerals consist of about equal amounts of hornblende and biotite. Plagioclase phenocrysts are generally slightly to moderately zoned, but commonly moderately to heavily sericitized, especially in the cores. Most outcrops are low, blocky or spheroidal weathered and may be either hard or deeply weathered material.

Kqm Quartz monzonite Medium- to coarse-grained, light- to very light-gray, locally deeply weathered quartz monzonite locally grading into granite and consisting of anhedral to subhedral plagioclase (35–40%), potassium feldspar (25–40%), quartz (15–25%), mafic minerals (10–15%), and accessory iron oxides, sphene, and zircon. The mafic minerals consist of hornblende and biotite, with biotite being equal to or slightly more abundant than the hornblende. The plagioclase has some minor sericitization. The rock is generally equigranular, but locally consists of about 50% coarse grains in a fine-grained matrix. Two types of outcrops generally are formed. The more resistant rock forms small blocky to spheroidal weathering corestones or low outcrops surrounded by talus and grus, while the less resistant rock forms low, rounded to flat, commonly grus-covered outcrops of deeply weathered material. On Warm Springs Mountain, the contact with the quartz monzodiorite is probably gradational. In the NE¼, Sec. 33 and NW¼, Sec. 34, T23N, R20E, the contact, though not exposed, is probably sharp.

Kqmd Quartz monzodiorite and granodiorite Medium- to coarse-grained, commonly weakly foliated, light-gray, locally deeply weathered quartz monzodiorite locally grading into granodiorite and consisting of anhedral to subhedral plagioclase (50–60%), potassium feldspar (5–25%), quartz (5–20%), mafic minerals (10–30%), and accessory iron oxides, sphene, and zircon. The mafic minerals consist of subequal amounts of anhedral to subhedral biotite and

subhedral to euhedral hornblende. The plagioclase has some minor sericitization. Two types of outcrops are generally formed. The more resistant rock forms blocky to spheroidal weathering ridges and corestones surrounded by talus and grus. The less resistant rock forms low, rounded to flat, commonly grus-covered outcrops of deeply weathered material. Contains sporadic lone or groups of oval to lens shaped inclusions <1 to 40 cm long of fine to medium grained, medium gray diorite. The diorite consists of anhedral to subhedral plagioclase (~65%), potassium feldspar (1–2%), quartz (<5%), and mafic minerals (25–30%). The mafic minerals consist of about three times the amount of hornblende as biotite. Kqmd makes up the main mass of Dogskin Mountain northwest of the map area, and is thus equivalent to "Quartz monzonite of Golden Valley" mapped on the south end of Dogskin Mountain and Warm Springs Mountain on the Bedell Flat Quadrangle (Garside, 1993). A moderately foliated quartz monzodiorite phase of Kqmd, exposed on the southeast flank of Dogskin Mountain, is shown with a stipple pattern. It is medium- to coarse-grained, light- to medium-gray quartz monzodiorite consisting of mostly anhedral to subhedral plagioclase (~60%), potassium feldspar (~10%), quartz (5–10%), mafic minerals (25–30%), and accessory iron oxides and zircon. The mafic minerals consist of about equal amounts of biotite and hornblende. The foliation results from a partial alignment of the long axes of the larger crystals such as plagioclase and clumps of smaller crystals, mostly of mafic minerals. Some plagioclase crystals show slight deformation of the albite twins. The foliated quartz monzodiorite appears to be of the same composition as the unfoliated and slightly foliated major part of Kqmd; the boundary between the two is probably gradational.

Kdf Fine-grained monzodiorite, quartz monzodiorite, and monzonite Commonly fine- to medium-grained, light- to medium-gray dioritic rocks consisting of anhedral to euhedral plagioclase (40–50%), potassium feldspar (5–20%), quartz (5–10%), mafic minerals (25–40%), and accessory iron oxides, sphene, apatite, and zircon. The mafic minerals consist of anhedral to subhedral biotite and subhedral to euhedral hornblende. The proportions of hornblende and biotite are variable among mapped areas, ranging from mostly hornblende to subequal amounts of hornblende and biotite. The plagioclase has some minor sericitization. Northeast of Willow Spring, the unit appears to be a finer-grained phase of the adjacent quartz monzodiorite, Kqmd. The contact may in part be gradational, but locally the two rock types are interspersed in scattered outcrops in a manner that suggests that Kdf is older. Small enclaves of Kdf are separated from the main mass and "float" in Kqmd. A similar situation was observed in the Curnow Range, and Kdf there may be equivalent to microgranular enclaves mapped in granodiorite in the Griffith Canyon Quadrangle just to the south (Garside and Nials, 1999). The monzodiorite also may in part be equivalent to the "hornblende diorite" mapped on Warm Springs Mountain in the Bedell Flat Quadrangle (Garside, 1993), and small bodies are observed in the main intrusive mass of Dogskin Mountain to the northeast of the map area (C.D. Henry and J.E. Faulds, oral commun., 2003). A monzonite body exposed on the east flank of Warm Springs Mountain (SW¼ Sec. 4, T22N, R20E) is also included in the unit. It is medium-gray monzonite consisting of subhedral to euhedral plagioclase (~20%), potassium feldspar (>50%), quartz (1–2%), hornblende (~25%), and accessory iron oxides and sphene. Prospect pits in the unit there expose heavy iron oxide and light copper staining. A prospect pit near the southeast end of the outcrop area exposes a 10-m-long, 30-cm-thick, N30°E, 50°SE vein of iron oxide with minor copper staining.

Kmr Monzodiorite and diorite of Rocky Ridge Medium-gray, porphyritic to subhedral-granular plutonic igneous rock consisting of euhedral gray plagioclase (55–70%, <4 x 8 mm); interstitial, fine-grained, anhedral alkali feldspar (10–25%) and quartz (~3%); distinctive, thin, euhedral books of biotite (~7%, 4 mm); green hornblende (7–14%, 1 cm); and accessory sphene and Fe-Ti oxides (3%). Sphene commonly rims the Fe-Ti oxides. Shown only in cross section; the unit crops out south of the map area (Garside and Nials, 1999).

Kd Diorite Dark-gray, fine- to medium-grained phaneritic rock having a color index of about 50. Originally contained hornblende, biotite, plagioclase, sparse quartz, Fe-Ti oxides. The hornblende and biotite have been partly altered to actinolite and secondary biotite. Intrudes Mzms near the south edge of the Moses Rock Quadrangle and is apparently intruded by Kdf.

Mzmv Metavolcanic rocks Fine-grained, medium- to dark-gray, foliated, spotted hornfelsic porphyritic rock containing 5–15% relict phenocrysts up to 0.3 cm long consisting largely of recrystallized masses of small plagioclase crystals. The groundmass consists of plagioclase (30–60%), potassium feldspar (~5%), quartz (1–2%), mafic minerals (30–60%), and accessory iron oxides. The mafic minerals consist of about equal amounts of hornblende and pyroxene with minor amounts of biotite and chlorite. The spots are largely porphyroblasts consisting mostly of hornblende and some pyroxene. The potassium feldspar may in part be due to metasomatism. The protolith was probably an intermediate composition volcanic or hypabyssal rock, possibly basaltic andesite. The small outcrop near the center of Sec. 3, T22N, R20E, only covers about 1 m^2 and has been exaggerated to show on the map.

Mzms Metasedimentary rocks Fine-grained, very light- and medium-gray, thinly banded, grayish-orange-weathering, hornfelsic metasedimentary unit consisting of plagioclase, quartz, hornblende, pyroxene, and minor iron oxides and biotite. The relative proportions of these minerals vary widely between bands. Light-gray bands consist of 70–90% of variable amounts of quartz and feldspar and 10–30% of variable amounts of hornblende and pyroxene. Medium-gray bands consist of 40–60% of variable amounts of quartz and feldspar and 40–60% of variable amounts of hornblende and pyroxene. Minor bands of carbonate and scattered porphyroblasts of hornblende and pyroxene are also present. The protolith may have been thinly interbedded argillite, impure quartz and quartzo-feldspathic sandstone, and locally, minor limestone. In the southeast part of the map area, the unit includes light- to dark-gray, banded (1 cm to 1 m) and foliated quartzo-feldspathic metasandstone and metasiltstone which have been locally metamorphosed to quartzo-feldspathic hornfels and muscovite schist. The small outcrop in the NW¼, Sec. 3, T22N, R20E, covers only 2 or 3 m^2 and has been exaggerated to show on the map.