GEOLOGIC MAP OF THE NELSON SW QUADRANGLE, CLARK COUNTY, NEVADA

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Scale 1:24,000

CONTOUR INTERVAL 10 METERS

Base map: U.S. Geological Survey Nelson SW 7.5' Quadrangle, Digital Raster Graphic (DRG) 1984

Alluvial-fan deposits of Eldorado and Piute Valleys

Alluvial-fan deposits are mapped as allostratigraphic units differentiated on the basis of surface morphology, degree of pedogenic soil development, and inset topographic relations. These deposits are dominately coarse-grained alluvium forming broad footpiedmont complexes derived from the surrounding bedrock terrain of the Eldorado Mountains and the Highland and McCullough Ranges. Clast lithologies are dominantly volcanic in the western part of Eldorado Valley and in the northern part of Piute Valley. Clasts of granite become abundant in the east in the eastern part of Eldorado Valley, where the alluvium is partially derived from the 16.6 Ma Searchlight pluton in the Eldorado Mountains. Alluvial-fan deposits composed predominantly of granitic clasts are shown by the stippled overprint pattern. Clasts of gneiss become more abundant to the south in Piute Valley, where alluvium is partly derived from Early Proterozoic gneiss of the southern McCullough Range.

Qa **Alluvium of active and recently active washes** Pebble-cobble gravel to gravelly sand filling axial washes draining into Eldorado and Piute Valleys. Commonly characterized by braided channels, bars and islands, broad, bar-and-swale microtopography; poorly consolidated; generally poorly sorted, except in areas with granitic provenance where decomposed granite (grus) is moderately well sorted; poorly to locally moderately stratified. Deposits include modern channel alluvium as well as adjacent areas of recently active (late Holocene) alluvial fans that may be subject to intermittent flooding from active channels.

Qf_y **Young alluvial-fan deposits** Fan-piedmont and interfluvial wash terrace remnants; pebble-cobble to boulder gravel; small alluvial fans and washes; dominated by grus. Deposits are commonly thin (<2 m) veneers overlying older alluvial-fan units. In the eastern part of Eldorado Valley, unit consists of broad anastomosing fan-piedmont remnants that may contain numerous inset and stacked, undifferentiated, near-surface Qf_y deposits. Surfaces are inset slightly below (1-2 m) Qf_o deposits and are characterized by subdued bar-and-swale microtopography, and incipient to moderately developed desert pavement and rock varnish. Unit mapped where granitic clasts predominate. Soils contain a 3-5 cm weak to moderately developed Av, 15-30 cm weak to moderately reddened Bw, and 30 cm stage I k carbonate. Geomorphic character and weak degree of soil development indicate that the unit is early to mid-Holocene in age based on correlation with similar deposits in the Las Vegas Valley area (Bell and others, 1998).

Qf_o **Late Pleistocene alluvial-fan deposits** Fan-piedmont remnants composed predominantly of pebble-cobble to boulder gravel. Deposits are poorly sorted; generally matrix supported; poorly to moderately stratified. Clasts are subangular to subrounded and range up to 35 cm in length. Surfaces are inset several meters below older Qf_i and Qf_p deposits, and are flat with no remaining bar-and-swale microtopography; well-developed desert pavement and dark rock varnish. Soils are very distinctive. Soils in Piute Av, 40-60 cm strongly reddened (7.5 YR) and prismatic argillic Bt, and 100 cm cemented stage III Bk horizons. The unit is ubiquitous throughout most of Eldorado and Piute Valleys where it lies at generally shallow depths beneath the younger alluvium; the distinctive red Bt soil horizon commonly crops out in shallow cuts and along road exposures. In the southern and eastern parts of Eldorado Valley, numerous dissected remnants occur within and beneath younger Qf_y deposits forming a complex, anastomosing pediment system on weathered volcanic bedrock. Based on the degree of soil development, this deposit is likely similar in age to deposits dated in the Spring Mountains area at about 129 ka (Bowers, 1985).

Qf_i **Mid-Pleistocene alluvial-fan deposits** Fan-piedmont remnants; gravel; poorly sorted; poorly to moderately stratified. Surfaces are inset several meters below older Qf_o remnants; they are well dissected but contain relatively well preserved flat interfluvial surfaces containing local patches of well developed desert pavement and dark rock varnish. Soils are characterized by a thick (>2 m) strongly cemented stage III- to IV Bqkm horizons directly underlying pavement surfaces; Bt horizons have been stripped. Calcrete horizons form resistant platforms beneath the remnant surfaces and are commonly visible on aerial photographs, forming light-toned alluvial surfaces due to the presence of abundant white to light-gray calcrete fragments. Based on the degree of development of calcrete horizons, the unit is on the order of a few hundred thousands of years in age.

Qf_p **Early Pleistocene alluvial-fan deposits** Deeply dissected fan-piedmont remnants composed of rounded, long-range quartzite clasts; remnants consist of rounded, linear digitate surfaces (ballenas) occurring topographically above the younger alluvial fan surfaces by a few to tens of meters. Composed predominantly of sandy cobble-boulder gravel; includes both clast- and matrix-supported beds; dominantly volcanic lithologies with a few scattered gneissic and granitic clasts; subangular clasts dominate and range up to 2 m in length; poorly to moderately stratified, moderate to strong silica- and carbonate-cementation of the matrix results in locally strong indurated zones. Where in many outcrops it may be characterized as a fanglomerate. Ballena surfaces typically contain stage V laminar calcrete horizons; the calcrete is 1-3 m thick with laminar horizonation conforming to the slope of ballena surfaces indicating that the calcrete developed in the deposits subsequent to deep dissection of the original alluvial-fan surfaces. Occurrence of laminar calcrete fragments on ballena hillslopes produces white to light-gray outcrops visible on aerial photography. In the Yucca Mountain region, similar ballena deposits contain Bishop or Glass Mountain G volcanic ash, indicating that the deposits may be in the range of 0.7-1.1 Ma in age (Peterson and others, 1995). In the Spring Mountains area, Bowers (1985) estimated similar deposits to be >730 ka based on paleomagnetism.

Qbl **Boulder lag deposit** Lag deposit of undetermined Quaternary age consisting of boulders of the tuff of Bridge Spring; boulders commonly exceed 1 m in length; found only on ridge top in the southernmost part of the quadrangle. Thickness is less than 5 m.

Middle to late Miocene volcanic and sedimentary rocks

The middle to late Miocene stratigraphy of the Nelson SW Quadrangle consists, in ascending order, of sandstone and conglomerate (Tsc), megabreccia of probable rock avalanche origin (e.g., Tta), two regionally extensive ash-flow tuffs (15.2 Ma tuff of Bridge Spring [Tb] and 15.0 Ma tuff of Mount Davis [Ttd]) with a thin lenticular megabreccia that usually range from one to between the tuffs (Tbc), and a capping sequence of conglomerate, sandstone, and fluviolacustrine sedimentary rocks (Tc and Tcl). The middle to upper parts of this section (above Tb) are temporally correlative with the Mount Davis Volcanics to the east and northeast of the Nelson SW Quadrangle. The Mount Davis Volcanics of Anderson (1971) primarily consist of synextensional basalt and basaltic andesite lavas but also include sequences of conglomerate and monolithologic megabreccia, as well as the 15.0 Ma tuff of Mount Davis (Faulds, 1995, 1996). The most complete sections crop out near the western margin of the Mount Davis Quadrangle (Faulds, 1995) and in the northern Eldorado Mountains northeast of Nelson, Nevada (Anderson, 1971, 1977). The Mount Davis Volcanics were deposited during Tertiary extension, as evidenced by well-developed growth-fault relations (i.e., tilt fanning) within the section.

Mafic lavas, temporally correlative with the Mount Davis Volcanics, which are prevalent in the Eldorado and Black Mountains to the northeast and east, are not exposed within the Nelson SW Quadrangle. Such lavas do crop out, however, to the north of the quadrangle on the east flank of the northern Highland Range. A basalt flow from that area has yielded an $^{40}Ar/^{39}Ar$ whole-rock age of 12.79±0.22 Ma (Faulds and others, 2002). Tits within the middle to late Miocene section range from ~35-60° in the tuff of Bridge Spring (Tb) to ~15° in capping basalt flows directly underlying the quadrangle. This tilt fanning suggests that the middle to late Miocene section within the Nelson SW Quadrangle is synextensional.

Tct **Tuffaceous sedimentary rocks (late Miocene)** Medium- to fine-grained, weakly indurated, noncalcareous tuffaceous sandstone and subordinate reworked nonwelded tuff and pebble conglomerate; confined to the northwestern part of the quadrangle, where it caps Tc; conglomerate is matrix supported and moderately sorted; sand grains are subrounded and consist of feldspar, clinopyroxene, and lithic fragments; more tuffaceous layers include pumice fragments; pebbles are subangular and consist of rhyolite (Thr), welded tuff (Tb and Ttd), and lesser basaltic andesite (Thb). Thickness is as much as 40 m.

Tc **Conglomerate and sandstone of the Highland Range (middle to late Miocene)** Pale brown to grayish-brown, pebble-cobble conglomerate and lesser medium- to coarse-grained sandstone. Conglomerate is matrix and clast supported, moderately well stratified, and poorly to moderately sorted with subangular to locally subrounded clasts; clasts of Thr dominate in south-central part of the quadrangle, whereas clasts of Thb and Tha prevail in the northwest; clasts of Proterozoic gneiss are relatively sparse (<5%) in the central part of the quadrangle but increase in size and abundance toward the west, suggesting a source in the crystalline terrane of the southern McCullough Range. Average clast size is less than 3 cm but ranges to 35 cm; locally derived boulders of volcanic rock to 1.5 m occur near basaltic exposures; 2 m long boulders of Proterozoic gneiss occur near the western margin of the quadrangle more than 10 km from probable source areas in the southern McCullough Range; weakly to moderately indurated; silica cement dominates the matrix; calcite cement found locally; conglomerate supported by a coarse-grained sandy matrix with subangular to lesser subrounded grains; sand grains largely composed of lithic fragments and feldspar; bedding thickness generally ranges from 2.5 to 25 cm, but 1.5-m-thick beds were locally observed; thicker beds are generally matrix supported and probably represent debris flows. Sandstone is pale-brown to light-gray, medium- to coarse-grained, and weakly to moderately indurated with silica cement; contains sparse subangular volcanic pebbles; grains are subrounded to subangular and composed primarily of lithic fragments, lesser feldspar, and minor quartz and mafic minerals. Tc locally includes 2- to 3-cm-thick beds of very fine-grained sandstone and nonwelded, generally reworked tuff to 4 m thick. In the western part of the quadrangle, Tc generally rests disconformably on Tdt and locally fills paleochannels cut into Tdt and Tb; rests in angular unconformity on Thr in the south-central part of the quadrangle; accumulated in a west-tilted half graben in the west-central part of the quadrangle. Tc may locally include thin deposits of Tct, Tcbb, and Tcbt. Thickness in the west-tilted half graben exceeds 400 m.

Tcbt **Nonwelded tuff breccia (middle Miocene)** Isolated deposit of brecciated, white nonwelded tuff intercalated in Tcbb; found only in the northwest corner of section 31 T27S R63E; interpreted as a rock avalanche deposit primarily because of its association with Tcbb. Contains ~15% phenocrysts of sanidine, biotite, biotite and quartz, and accessory plagioclase and clinopyroxene. Thickness is as much as 15 m.

Tcbb **Basaltic andesite breccia (middle Miocene)** Lens-shaped bodies of massive monolithologic breccia of basaltic andesite intercalated in Tc; contains ~5% phenocrysts of plagioclase, aegirine-augite and augite, and apatite; generally poorly exposed except in steep outcrops of washes; probably originated as rock avalanche deposits (cf., Yamold and Lombard, 1989) derived from the higher terrain of the central Highland Range. Most west of the quadrangle, may represent seismically induced ancient landslides; confined to the west-central part of the quadrangle; generally intercalated within conglomerate and sandstone in the lower part of Tc; one large body rests directly on Tdt at the base of Tc. Thickness of individual sheets is as much as 60 m; cumulative thickness is as much as 100 m.

Tdt **Tuff of Mount Davis (middle Miocene, 15.0 Ma)** Pale-brown, brownish-brown, weathering dark-brown, generally moderately welded, rhyolitic ash-flow tuff; contains 15-35% phenocrysts of sanidine and significantly lesser amounts of plagioclase (mainly oligoclase), biotite, and augite; of the total rock volume, sanidine phenocrysts constitute 10-25%, biotite 1% to 3%, augite <1% to 2%, and plagioclase <1% to 3%; ~1% titanomagnetite is ubiquitous; sphene is very rare (e.g., only observed in 10 thin sections); by volume, sanidine consistently makes up >62% of the total assemblage of phenocrysts; sanidine phenocrysts range up to 5 mm in length, whereas the maximum size of other phenocrysts is typically 2 mm; moderately welded part generally has fewer phenocrysts (~15%) than moderately welded zone (25-35%); lithic fragments of basaltic andesite are common; thickness of white to pinkish-white basal nonwelded zone increases from 1 to 10 m to the north; basal nonwelded zone is thickest in the southeast 1/4 of section 19 T27S R63E; locally includes a thin (<1m thick) vitrophyre above the basal nonwelded zone. In contrast to the tuff of Bridge Spring, Tdt emblematic sole sphene, contains more phenocrysts in welded parts, has slightly more plagioclase and biotite phenocrysts, locally contains coarser-grained sanidine, and is darker colored. Tdt thickens northwestward in the quadrangle and appears to have accumulated in structural-topographic lows, including the west-tilted half graben in the hanging wall of the Highland fault and northeast-trending syncline in the northwestern part of the quadrangle; also locally filled small paleochannels cut into Tb. Sanidine from two samples in the quadrangle yielded $^{40}Ar/^{39}Ar$ dates of 15.00±0.04 and 15.01±0.03 Ma. The age, composition, and stratigraphic position strongly suggest a correlation with the 14.97±0.02 Ma tuff of Mount Davis to the east in the Lake Mohave area (Faulds, 1995; Faulds and others, 1995); reverse polarity. Thickness is as much as 70-100 m in west-central part of the quadrangle.

Tbc **Volcanic megabreccia and conglomerate (middle Miocene)** Pale-brown to reddish-brown or light-gray monolithologic megabreccia, pebble to boulder conglomerate, and minor volcaniclastic sandstone and nonwelded tuff; poorly to moderately well stratified; poorly to moderately indurated typically with calcite cement. Megabreccia is primarily composed of basaltic andesite but includes isolated lenses of Proterozoic gneiss; mainly crackle and jigsaw breccia facies (cf., Yarnold and Lombard, 1989); probable rock avalanche origin; gneiss in megabreccia resembles Proterozoic bedrock in the southern McCullough Range rather than that in the northern Newberry Mountains (Ruppert and Faulds, 1998) or southeastern part of the quadrangle. Sandstone and conglomerate consist primarily of subangular, coarse-grained sand; conglomerate is generally matrix supported and poorly sorted with subangular clasts; commonly includes matrix supported boulder-size blocks of basaltic andesite (derived from Tbb), which probably originated as debris flows. Tbc pinches out to north as lower nonwelded part of Tdt thickens; bracketed between 15.2 and 15.0 Ma. Thickness is as much as 80 m.

Tb **Tuff of Bridge Spring (middle Miocene, 15.2 Ma)** Purplish-gray to light-gray, weathering pale-brown, moderately to densely welded, rhyolitic ash-flow tuff; contains 5-15% anhedral to subhedral phenocrysts of sanidine and significantly lesser amounts of biotite, augite, plagioclase (mainly oligoclase), and sphene (in typical order of decreasing abundance); of the total rock volume, sanidine phenocrysts typically constitute 5-15%, biotite <1% to 3%, augite 0-1%, and plagioclase <1 to 2%; traces of sphene and titanomagnetite are ubiquitous; by volume, sanidine consistently makes up >80% of the total assemblage of phenocrysts; sanidine phenocrysts range up to 3 cm in length, whereas the maximum size of other phenocrysts is typically less than 1 mm; lithic fragments of basaltic andesite are common; generally includes 0.5- to 4-m-thick vitrophyre at or near (within 2 m) base of densely welded section below which lies 1 to 6 m of basal, nonwelded tuff. In contrast to the tuff of Mount Davis (Ttd), Tb has a lighter color, ubiquitous sphene, generally fewer phenocrysts, generally finer-grained sanidine, and slightly less abundant biotite and plagioclase. Sanidine from three samples in the quadrangle yielded $^{40}Ar/^{39}Ar$ dates of 15.21±0.04, 15.22±0.04, and 15.26±0.04 Ma. The age, composition, and stratigraphic position strongly suggest a correlation with the tuff of Bridge Spring (Anderson, 1971; Darvall, 1991) in the northern Eldorado Mountains; found throughout most of the map area, where appropriate part of the section is exposed; possibly erupted from a caldera in the northern Eldorado Mountains (Gans and others, 1994); reverse polarity; thickness is as much as 125 to 200 m in the west-central part of the quadrangle.

Tt **Megabreccia deposits (middle Miocene)** The section directly beneath the tuff of Bridge Spring and above the basaltic andesite lavas of Thb is largely composed of monolithologic megabreccia deposits. Breccia lithologies include basaltic andesite (Tbb), dacite-rhyodacite (Ttd), and Proterozoic gneiss (Tbi). Individual megabreccia sheets are monolithologic, but a single section of Tt may contain multiple sheets of different lithologies. Megabreccia of Proterozoic gneiss dominates in the south-central part of the quadrangle on the east flank of the southern Highland Range, whereas megabreccia of volcanic rock prevails in the southern and western parts of the quadrangle. The megabreccia generally consists of crackle and jigsaw breccia facies (cf., Yarnold and Lombard, 1989). These deposits probably originated as rock avalanches (essentially landslides) induced perhaps by ground shaking associated with earthquakes. Their 15.7 to 15.2 Ma age indicates deposition during the major episode of Tertiary extension.

Ttbt **Megabreccia undifferentiated (middle Miocene)** Undifferentiated lens of breccia containing several monolithologic sheets; breccia lithologies include basaltic andesite, dacite-rhyodacite, and Proterozoic gneiss; includes both crackle and jigsaw breccia facies; dacite clasts contain ~25% phenocrysts of plagioclase (17% of rock), oxyhornblende (5%), and biotite (3%); found only in the west-central part of the quadrangle. Thickness is as much as 115 m.

Ttx **Gneiss megabreccia (middle Miocene)** Sheets of pale-reddish-brown to light-gray monolithologic breccia of orthogneiss that resembles Early Proterozoic gneiss exposed in the southeastern part of the quadrangle; generally poorly exposed; best exposures occur in cutbanks of washes (e.g., on north side of wash in west-central part of section 3 T28S R63E); a common lithology in Ttx consists of 60-65% quartz, 25-30% potassium feldspar, 10% hornblende (altered to chlorite), and traces of garnet and zircon; includes both crackle and jigsaw breccia facies; also includes blocks and thin megabreccia sheets of rhyolite, andesite, and porphyritic dacite; bracketed between 15.7 and 15.2 Ma. Thickness is as much as 125 m.

Tbb **Basaltic andesite megabreccia (middle Miocene)** Sheets of light-gray/pink-brown to reddish-brown monolithologic volcanic breccia composed primarily of basaltic andesite (Tbb), but rhyolite (Thr) and dacite (Ttd) locally dominate the lower part of the section; includes crackle and jigsaw breccia facies with negligible matrix; also includes matrix-supported breccia; matrix consists primarily of subangular sand-size grains of volcanic rock, feldspar, and biotite. Most of Tbt originated as rock avalanches, but matrix-supported deposits probably represent debris flows; bracketed between 15.7 and 15.2 Ma; thickness ranges up to ~95 m.

Ttd **Dacite megabreccia (middle Miocene)** Pale-brown/reddish- or pinkish-gray dacite or rhyodacite monolithologic breccia and lesser pale brown, matrix and clast-supported pebble to cobble dacite conglomerate; dacite clasts contain 15-20% phenocrysts of plagioclase (andesine; 12-15% or rock), biotite (3-4%), oxyhornblende (1-2%), and traces of zircon; possibly derived from Ttrd or Thr; breccia probably originated as rock avalanche deposits. The dacite conglomerate is found only in section 16 T28S R63E; it is weakly indurated with calcite cement and has 2- to 15-cm-thick beds, subangular clasts to 35 cm composed almost entirely of dacite with sparse andesite and basaltic andesite, and a coarse-grained sandy matrix. Ttd is bracketed between 15.7 and 15.2 Ma; thickness may locally approach 100 m.

Tsc **Sandstone and conglomerate (middle Miocene)** Mainly pale-brown to purplish-brown or light-gray volcaniclastic, matrix- to locally clast-supported, poorly to locally moderately sorted pebble-cobble conglomerate and sandstone; clasts are subangular and generally consist of rhyolite, dacite, and basaltic andesite in varying proportions, but commonly includes minor amounts of Proterozoic gneiss; volcanic clasts range up to 20 cm in length. Proterozoic clasts are to 30 cm; matrix of conglomerate and sandstone is medium to coarse grained and consists of subangular to subrounded grains of lithic fragments, feldspar, quartz, and biotite; weakly to moderately indurated; noncalcareous to weakly calcareous; locally includes beds of fine-grained sandstone or siltstone. Tsc locally consists of cross-bedded white tuffaceous surge deposits, nonwelded ash-flow and air-fall tuffs to 2 m thick, reworked tuff, tuffaceous fine- to medium-grained sandstone, and tuffaceous matrix-supported conglomerate; nonwelded tuff contains 2-4% phenocrysts of sanidine and lesser quartz, biotite, augite, and plagioclase, as well as lithic fragments of basaltic andesite (Tbb) and abundant pumice fragments; tuffaceous sandstone and matrix of tuffaceous conglomerate consist of glass shards and subrounded to subangular grains of feldspar, volcanic lithic fragments, and biotite. In the west-central part of the quadrangle, Tsc locally contains thin poorly exposed monolithologic megabreccia of basaltic andesite and dacite (which probably represent rock avalanche deposits and massive debris flows) and thin andesite and basaltic andesite lavas. Thickness is as much as 80 m.

Tta **Andesite lavas (middle Miocene)** Medium- to light-gray and reddish-gray porphyritic andesite lavas; contain phenocryst assemblages of either plagioclase (andesine), oxyhornblende, aegirine-augite, and biotite (central part of section 6 T28S R63E) or plagioclase (andesine), augite, oxyhornblende, and biotite (eastern part of section 6 T28S R63E); confined to the west-central part of the quadrangle. Age is bracketed between ~16.0 Ma and 15.2 Ma. Thickness is as much as 55 m.

Ttrd **Rhyodacite-rhyolite lavas (middle Miocene)** Medium-gray to light-gray porphyritic rhyodacite and rhyolite lavas. Thrd contains 30-35% phenocrysts mainly of plagioclase (andesine), oxyhornblende, subordinate sanidine, aegirine-augite or augite, quartz, minor biotite, and sparse sphene and apatite; greatly resembles the Trdi plug exposed in the northwest part of section 5 T28S R63E; largely confined to sections 29, 30, 31, and 32 T27S R63 but isolated unmapped flows of Ttrd are found elsewhere within Thb. Age is bracketed between ~16.0 Ma and 15.2 Ma. Thickness is as much as 65 m.

Middle felsic sequence, volcanics of the Highland Range (middle Miocene) The intercalated rhyolite lavas and tuffaceous rocks (Thr and Thi) are thickest in the southwestern part of the quadrangle and appear to pinch out to the northwest and east. They are virtually absent from the central Highland Range directly west and northwest of the quadrangle. Although no rhyolite domes were identified, the thickness (>900 m) of the rhyolite lavas and tuffaceous rocks suggests a nearby source, perhaps a rhyolite dome complex now buried beneath the southern part of Eldorado Valley. The quartz-bearing rhyolite dikes and plugs (Trd) mapped in the southernmost part of the quadrangle may have been the source for some of the rhyolite lavas.

Thba **Welded ash-flow tuff (middle Miocene, ~16 Ma)** Pale-brown/pink-gray, lithic-rich, poorly to moderately welded ash-flow tuff; contains 10-15% subhedral phenocrysts of sanidine (to 3 mm long), quartz (to 2 mm), plagioclase, and sparse biotite. Of the total rock volume, sanidine phenocrysts generally constitute ~5-8%; quartz 2-4%, plagioclase 1-2%, and biotite <1%. Lithic fragments of basaltic andesite and andesite are common and contain phenocrysts of clinopyroxene and/or hornblende. This was mapped in only in section 6 T28S R63E directly beneath Thb, but it may be more extensive, locally comprising perhaps a nonwelded ash-flow tuff in the upper part of Tht elsewhere in the quadrangle. Probably about 16 Ma on the basis of the 15.98 Ma age of the base of Thb. Thickness is as much as ~60 m.

Tht **Tuffaceous sedimentary rocks and non-welded tuffs (middle Miocene)** White to pale-yellowish-brown air-fall and nonwelded ash-flow tuffs, surge deposits, and tuffaceous conglomerate and sandstone commonly interfingering with Thr; locally includes a few thin rhyolite lavas; beds are generally 2 to 3 cm thick but commonly range from 1 to 30 cm thick; at least one nonwelded ash-flow tuff is as thick as 10 m; in order of decreasing abundance, nonwelded tuff contains 3-15% phenocrysts of sanidine and quartz with lesser plagioclase (mainly oligoclase), biotite, and clinopyroxene; sparse sphene and hornblende were also observed in a few tuffs; nonwelded tuff also contains abundant pumice fragments and lithic fragments of basaltic andesite; feldspar and biotite phenocrysts are commonly altered to sericite and chlorite-iron oxides, respectively. Tuffaceous sandstone and conglomerate typically represent reworked tuffs; conglomerate contains varying amounts of subangular to locally angular clasts that usually range from 1 to 20 cm in length; Tht locally pinches out abruptly against rhyolite lavas and possible domes (e.g., peak at 1,319 m elevation along boundary of sections 7 and 8, T28S R63E); both crackle and jigsaw breccia facies; dacite clasts contain ~25% phenocrysts of plagioclase (17% of rock), oxyhornblende (5%), and biotite (3%); found only in the west-central part of the quadrangle. Thickness is as much as 115 m.

Thr **Rhyolite lavas (middle Miocene)** Pale brownish-gray, light-gray/pink-white, and pinkish- to reddish-gray commonly flow-banded rhyolite and lesser trachydacite lavas; locally interfingers with the tuffaceous rocks of Tht; includes spherulitic and vitrophyric flows; contains 5-35% phenocrysts. Phenocryst assemblages in individual flows include (1) sanidine (to 6 mm) and lesser quartz (to 3 mm), plagioclase (oligoclase), and biotite; some with sparse sphene, augite, and/or oxyhornblende; (2) sanidine (to 3 mm) and lesser biotite, plagioclase, augite, and sphene; (3) plagioclase (oligoclase; to 5 mm) and lesser sanidine, biotite (to 4 mm), and aegirine-augite or augite; and (4) plagioclase (oligoclase and some andesine), biotite, and lesser sanidine and augite. Assemblage #1 is most common; #4 is least common. Frothy rhyolite (phenocryst type #2) crops out in the western part of section 3 and southeast part of section 34 T28S R63E. Plagioclase-rich, quartz-free varieties (# 3 and 4) appear to be more common in the southwestern part of the quadrangle (e.g., sections 7 and 18, T28S R63E). Conspicuous 2- to 6-m-thick vitrophyre occurs at the base of the section directly above Thb in southern part of sections 4 and 5 and northern part of section 8 T28S R63E. Lower part of Thr locally includes thin rhyodacite or dacite flows containing phenocrysts of plagioclase, biotite, and clinopyroxene. Biotite from the vitrophyre at the base of the section yielded an $^{40}Ar/^{39}Ar$ date of 16.26±0.15 Ma. The bulk of the section is bracketed between 16.26 and 16.21 Ma, but flows intercalated in the lower part of the Thb section may be as young as ~15.9 Ma; may correlate with the volcanics of Red Gap Mine in the central Black Mountains to the east (Faulds, 1995; Faulds and others, 1995). Thickness is as much as 620 m.

Thl **Lower intermediate sequence, volcanics of the Highland Range (early to middle Miocene)** The lower intermediate composition sequence of the volcanics of the Highland Range consist primarily of trachydacite and trachyandesite lavas. This sequence may correlate with the volcanics of Dixie Queen Mine in the Mount Perkins area of the central Black Mountains in northwestern Arizona (Faulds and others, 1995), ~31 km east of the Nelson SW Quadrangle, as evidenced by similarities in stratigraphic position, composition, and age. The volcanics of Dixie Queen Mine are generally preextensional in the region. In the Nelson SW Quadrangle, the magnitude of tilting within Thl differs only slightly (~10°) between the lower and upper parts of the section, suggesting deposition prior to any appreciable extension. Thl is probably widely distributed throughout the area but is only exposed in the southern part of the quadrangle. The age of Thl is bracketed between 18.5 and ~16.2 Ma by the underlying 18.5 Ma Peach Springs Tuff (Tp) and $^{40}Ar/^{39}Ar$ dates on overlying rhyolite lavas in Thr. Biotite from a dacite lava within the volcanics of Dixie Queen Mine directly south of the quadrangle has yielded an $^{40}Ar/^{39}Ar$ date of 17.59±0.06 Ma. Trachydacite and trachyandesite lavas in the northern Newberry Mountains ~8 km to the southeast of the quadrangle have yielded $^{40}Ar/^{39}Ar$ dates ranging from 18.58±0.05 to 16.75±0.26 Ma (Ruppert and Faulds, 1998). Thl locally interfingers with the lower part of the felsic sequence in the volcanics of the Highland Range and is temporally correlative with the lower part of the Patsy Mine volcanics of Anderson (1971). Within the Nelson SW Quadrangle, Thl is divided into (1) an upper unit of biotite-rich trachydacite and trachyandesite lavas (Thlb), (2) sequences of trachyandesite lavas (Thla), (3) sparse rhyodacite lavas (Thlr), (4) an isolated exposure of dacitic tuffaceous rock (Thld), and (5) thick sections of mainly trachydacite lavas (Thld). In cross section A-A', the sequence is shown as undifferentiated (Thl). The overall thickness of Thl approaches and possibly exceeds 1,500 m.

Thlb **Biotite-rich trachydacite-trachyandesite lavas (early to middle Miocene)** Medium- to light-gray to reddish-brown trachydacite and/or trachyandesite lavas containing 15-20% phenocrysts of andesine plagioclase, augite, and biotite (in order of decreasing abundance), as well as accessory apatite, titanomagnetite, and possibly hypersthene; in contrast to Thld or Thla, biotite and augite, where phenocrysts are typically nearly as common as plagioclase and are locally more abundant; pilotaxitic to hyalopilitic textures. Thickness is as much as 165 m.

Thla **Trachyandesite-trachydacite lavas (early to middle Miocene)** Light- to dark-gray trachyandesite and trachydacite lavas containing 20-30% phenocrysts of plagioclase (generally andesine), oxyhornblende, augite or aegirine-augite, biotite, and trace clinopyroxene and apatite (in typical order of decreasing abundance); the relative abundance of oxyhornblende, clinopyroxene, and biotite varies, but oxyhornblende or clinopyroxene are generally more abundant than biotite; pilotaxitic to trachytic textures prevail; plagioclase phenocrysts range up to 6.5 mm in length, clinopyroxene to 3 mm, and biotite to 2.5 mm; plagioclase and the mafic constituents are commonly partly to largely altered to sericite and chlorite-iron oxides, respectively; degree of alteration increases southward and southeastward toward the Searchlight pluton; commonly interfingers with Thld; distinguished from Thld by darker color, greater abundance of hornblende or clinopyroxene, less biotite, and presence of both hornblende and clinopyroxene in most lavas; interfingers with the lower part of Tht in the southwestern part of the quadrangle. Overall thickness is as much as 415 m.

Thrd **Rhyodacite lavas (early to middle Miocene)** White to pale-brown porphyritic rhyodacite or rhyolite lavas intercalated in Thld; contain ~35% phenocrysts of andesine plagioclase (to 5 mm), biotite (to 2 mm), and hornblende (to 2 mm); accessory minerals include titanomagnetite and apatite. Thickness is as much as 70 m.

Thld **Dacitic tuffaceous rocks (early to middle Miocene)** Medium- to light-gray to pale-brown to purplish-white bedded dacitic air-fall tuff; beds are 2-10 cm thick and consist of clasts and lapilli of Thld; found only in the south-central part of the quadrangle (southeast part of section 17 T28S R63E). Thickness ranges up to 100 m.

Thtd **Dacite lavas (early to middle Miocene)** Purplish- to reddish-gray, light-gray, reddish-brown, or greenish-gray trachydacite lavas containing 15-35% phenocrysts of plagioclase (andesine and lesser oligoclase), biotite, augite or aegirine-augite, oxyhornblende, and traces of hypersthene and apatite (in typical order of decreasing abundance); relative abundance of clinopyroxene and hornblende varies; some lavas lack either clinopyroxene or hornblende; pilotaxitic to hyalopilitic textures dominate; plagioclase phenocrysts range up to 9 mm in length, whereas phenocrysts of mafic minerals rarely exceed 2.5 mm; a few flows, however, contain hornblende up to 6.5 mm long. Plagioclase and mafic constituents are commonly partly to largely altered to sericite and chlorite-iron oxides, respectively, with degree of alteration increasing southward and southeastward toward the Searchlight pluton; alteration is especially prevalent near the poorly exposed base of the section in the western part of section 13 and eastern part of section 14 T28S R63E, where abundant generally unmapped intermediate to felsic dikes cut Thtd—small zones of silicification occur in this area; commonly interfingers with Thla; locally includes minor trachyandesite lavas (Thla), biotite-rich trachydacite-trachyandesite lavas (Thlb), and rhyodacite lavas (Thlr); distinguished from Thla by lighter color, greater abundance of biotite, less hornblende and clinopyroxene, and lack of either hornblende or clinopyroxene in some lavas; also includes isolated lenses of dark purplish-brown volcaniclastic sandstone that contains subangular to subrounded grains of largely sericitized feldspar (mainly plagioclase) and lesser biotite (altered to iron oxides and lesser chlorite), quartz, and lithic fragments within a hematite-rich matrix (e.g., overturned beds in northeast part of section 14 T28S R63E). Overall thickness of Thtd is as much as 810 m.

Ttp **Peach Springs Tuff (early Miocene, 18.5 Ma)** Poorly to moderately exposed, purplish-gray, moderately welded rhyolite tuff containing ~10-15% phenocrysts primarily of sanidine and plagioclase, with lesser biotite and sparse quartz and sphene; feldspars are largely altered to sericite; biotite is altered to iron oxides; intruded by several unmapped intermediate to felsic dikes; probably correlates with the 18.5 Ma Peach Springs Tuff (cf., Glazner and others, 1986; Nelson and others, 1990); as evidenced by stratigraphic position, lithology, and phenocryst assemblage; exposed only in the southeastern part of the quadrangle. Thickness is as much as ~30 m.

Tcs **Arkosic conglomerate (early Miocene)** Poorly exposed, pale-brown to reddish-brown, poorly to moderately sorted, generally matrix supported arkosic pebble conglomerate at base of Miocene section; predates onset of widespread volcanism; clasts are subangular and consist of Proterozoic gneiss and small pebble size potassium feldspar grains; matrix consists of subangular coarse-grained sandstone composed of feldspar, quartz, and lithic fragments; noncalcareous; weakly indurated; intruded by several unmapped intermediate to felsic dikes; correlative with the conglomerate of Cottonwood Pass of Faulds (1995); exposed only in the southeastern part of the quadrangle. Tca is locally intercalated with ~19 Ma alkaline basalt flows elsewhere in the region (Faulds and others, 1995). Thickness ranges up to ~30 m.

Miocene intrusions

Ttsd **Basaltic andesite dikes (middle Miocene)** North- to northwest-striking dikes of basaltic andesite, which contain 20-30% phenocrysts of plagioclase (12-15% of rock), augite (~10%), and subordinate iddingsitized olivine (0-3%). Groundmass consists of intergrown plagioclase and pyroxene laths. Confined to section 32 T27S R63E, where intruded along east-dipping normal faults that cut Tht; lithologically identical to typical Tha lavas; may have fed some Tha lavas; probably 16.0 to 15.7 Ma.

Ttsd **Rhyodacite plug (middle Miocene)** Isolated plug of pale-light-gray porphyritic rhyodacite containing ~25% phenocrysts of plagioclase; lesser sanidine, quartz, augite, and biotite; and sparse oxyhornblende. Trdi has large sanidine phenocrysts to 1.1 cm in length; plagioclase phenocrysts range up to 3 mm in length; pilotaxitic texture; margin marked by 30-cm-thick rind of vitrophyre; intrudes Tht in northwest corner of section 5 T28S R63E; probably fed nearby Thrd lavas; probably also related to 2 m thick layer of unmapped rhyodacite breccia within the uppermost part of Tht directly south of the plug; probable age is ~16 Ma.

Tri **Rhyolite intrusions (middle Miocene)** Grayish-white to pinkish-white rhyolite dikes and plugs. Tsw-bounding and/or sphenultites characterize some intrusions; generally contain 2-10% phenocrysts of sanidine, quartz, and sparse biotite and plagioclase; sanidine and quartz commonly occur in subequal amounts, but sanidine dominates in some intrusions; some bodies lack quartz, biotite, or plagioclase; accessory minerals include titanomagnetite and hematite; in some dikes feldspars and biotite are largely altered to sericite and chlorite, respectively.

Tcv **Calcite veins (early to middle Miocene)** Generally easterly striking grayish-white veins composed primarily of coarse-grained calcite and lesser quartz; quartz typically constitutes ~5-10% of the veins but locally approaches or exce