Text and references accompanying Nevada Bureau of Mines and Geology Open-File Report 15-4

Preliminary Geologic Map of the Heelfly Creek Quadrangle and Adjacent Parts of the Tent Mountain, Soldier Peak, and Secret Valley Quadrangles, Elko County, Nevada

by

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DESCRIPTION OF MAP UNITS

Quaternary Deposits

Qfy_1 – Youngest alluvial-fan deposits (late Holocene) – Deposits of silt, sand and pebble gravel in active alluvial fans and active ephemeral stream channels. Includes sub-rounded to sub-angular clasts of basalt, rhyolite, chert, mylonitic quartzite, siltstone, gneiss and granitic rocks derived from the East Humboldt Range. Surfaces are generally smooth at mid- and distal-fan locations but have subtle bar and swale morphology near fan heads and within active channels. Slightly inset below adjacent Qfy_2 deposits but with prominent topographic separation from older deposits. At the mouth of Boulder Creek the unit is comprised of boulder rich reworked glacial outwash deposits. Post-dates most recent surface rupturing earthquake on the Ruby Mountains fault.

Qay_1 – Youngest active alluvium (late Holocene) – Deposits of mud, silt and sand in active channels and floodplains west of the Ruby Mountains fault and silt, sand and pebble gravel in active channels incised into the foothills east of the fault. In the floodplain of Secret Creek and Soldier Creek includes sloughs, overflow channels and subtle meander belts.

Qfy_2 – Young alluvial-fan deposits (early to mid-Holocene) – Deposits of silt, sand and pebble to cobble gravel in inactive alluvial fans, with boulders up to 0.5 m diameter in the Boulder Creek drainage. Includes sub-rounded to sub-angular clasts of basalt, rhyolite, chert, mylonitic quartzite, siltstone, gneiss and granitic rocks derived from the East Humboldt Range. Surfaces are generally planar and mildly dissected by gully incision. Well preserved near the mouths of drainages where the unit has been uplifted 1–2.5 m in the footwall of the Ruby Mountains fault by the most recent surface rupturing earthquake. Carbon obtained from the unit in a paleoseismic trench at Reed Creek yielded an age of 7500 $\pm$ 70 cal yr B.P (Wesnousky and Willoughby, 2003).

Qay_2 – Young alluvium (early to mid-Holocene) – Deposits of silt, sand and pebble to cobble gravels on abandoned fluvial terraces adjacent to active channels and floodplains. Terrace surfaces have a mantle of eolian silt and sand up to 1 m thick and are topographically separated from Qay_1 by 3–7 m. Includes rounded to sub-rounded clasts of basalt, rhyolite, chert, mylonitic quartzite, siltstone, gneiss and granitic rocks derived from the East Humboldt Range. Surfaces are generally planar and mildly dissected by gully incision.

Qfy_3 – Young alluvial-fan deposits (latest Pleistocene to early Holocene) – Deposits of silt, sand and pebble to cobble gravels in inactive alluvial fans and terraces preserved adjacent to Reed Creek. Terrace surface at Reed Creek is 7–8 m in elevation above the active Reed Creek drainage.

Qfi – Intermediate-age alluvial-fan deposits (late Pleistocene) – Deposits of silt sand and pebble to cobble gravel with boulders. Includes sub-rounded to sub-angular clasts of basalt, rhyolite, chert, mylonitic quartzite, siltstone, gneiss and granitic rocks derived from the East Humboldt Range. Surfaces are broadly rounded, dissected and topographically separated from Qfy deposits. Well

preserved on fault bounded blocks uplifted by surface rupturing earthquakes outboard (west) of the main trace of the Ruby Mountains fault. Also preserved at fan heads and terraces beveled onto Ts deposits in the footwall of the Ruby Mountains fault.

Qai – Intermediate-age alluvium (late Pleistocene) – Deposits of silt, sand and pebble to cobble gravel with local boulders up to 40 cm diameter. Includes rounded to sub-rounded clasts derived from the East Humboldt Range including abundant clasts of chert, mylonitic quartzite, gneiss and granitic rocks, with lesser rhyolite, basalt and siltstone. Preserved as terrace surfaces beveled onto and/or inset into QTa deposits. Surfaces are dissected, broadly rounded and topographically separated from the active Secret Creek and Soldier Creek floodplains by 20–30 m. Possibly correlative with glacial outwash deposits associated with latest Pleistocene Angel Lake (LGM) glaciation.

Qgo_1 – Glacial outwash deposits, Angle Lake-aged? (late Pleistocene) – Deposits of silt, sand and pebble to cobble gravel with boulders up to 0.7 m diameter. Includes rounded to sub-rounded clasts of mylonitic quartzite, gneiss and granitic rocks. A planar Qgo_1 surface is preserved at the mouth of the Boulder Creek drainage Qgo_1, topographically below the higher Qgo_2 surfaces. Likely correlative with Angel Lake (LGM) glaciation.

Qgo_2 – Glacial outwash deposits, Lamoille-aged? (late Pleistocene) – Deposits of silt, sand and pebble to cobble gravel with boulders up to 1 m diameter. Includes rounded to sub-rounded clasts of mylonitic quartzite, gneiss and granitic rocks. In the Boulder Creek drainage Qgo_2 surfaces are sparsely preserved as dissected remnants along the flanks of the drainage mouth. Possibly correlative with the Lamoille (penultimate) glaciation.

Qsp – Sag pond (Pleistocene to Holocene) – Fine-grained deposits preserved behind rotated slide blocks or in depressions on hummocky landslide deposits.

Qls – Landslide deposit (Pleistocene to Holocene) – Minor slope failure deposits with a wide range in characteristics and compositions. Locally dominated by highly fractured or jumbled bedrock, with a varying percentage of poorly to moderately sorted gravels and fines. Typically form uneven, hummocky surfaces. Head scarps are commonly rounded and indistinct.

Qmlsu – Mega-landslide deposit (mid-Pleistocene?) – Undivided mega-landslide deposit with intermixed, fractured blocks of rhyolite, basalt and tuffaceous sedimentary rocks up to 100 m long. Forms a broad (>2 km^2), uneven hummocky surface. In the western part of the Tent Mountain quadrangle, the landslide deposits overlie the eastern range-front fault and mylonitic Paleozoic marble and quartzite in its footwall. The landslide was deposited into a valley inset lower than the Qfo_3 and Qfo_4 surfaces and therefore is interpreted to post-date those deposits.

$Qmlsr_1$, $Qmlsr_2$ – Slide block of porphyritic rhyolite in Quaternary mega-landslide deposit (mid-Pleistocene?) – Displaced landslide blocks of units Tr_1 and Tr_2 within a Pleistocene mega-landslide. See unit description for Tr_1 and Tr_2 below.

Qmlsbp – Slide block of porphyritic basalt in Quaternary mega-landslide deposit (mid-Pleistocene?) – Dark gray, porphyritic mafic rock exposed in a single, low-relief outcrop that is interpreted to be a displaced block within a Pleistocene mega-landslide. Appears basaltic in hand specimen, but a single chemical analysis contains ~62% SiO_2, which indicates andesite. Phenocrysts consist of ~7% plagioclase, 3–14 mm long. Probably displaced from an original lava flow or dike occurrence.

Qmlss – Slide block of tuffaceous sedimentary rock in Quaternary mega-landslide deposit (mid-Pleistocene?) – Displaced landslide blocks of unit Ts within a Pleistocene mega-landslide. See unit description for Ts below.

Qfo_1, Qfo_2, Qfo_3, Qfo_4 – Older alluvial-fan deposits (mid-Pleistocene?) – Deposits of silt, sand and pebble to cobble gravel with boulders up to 1 m diameter. Includes rounded to sub-rounded clasts of chert, quartzite, and mylonitic quartzite, and lesser amounts conglomerate, gneiss and granitic rocks, derived from the East Humboldt Range. Soils have stage III Bk horizons up to 0.3 m thick. Includes four distinct and topographically correlative terrace and pediment surfaces (Qfo_1, Qfo_2, Qfo_3, and Qfo_4) beveled onto Ts deposits in the footwall of the Ruby Mountains fault. Surfaces are typically rounded and dissected along their margins. The Qfo units are interpreted to be a complex of alluvial fan, channel, and pediment deposits in the basin adjacent to the, now inactive, "paleo- range front fault" located along the eastern edge of the map area. Qfo deposits may predate initiation of uplift along the Holocene-active Ruby Mountains fault in the late(?) Pleistocene.

QTa – Older alluvium (Pliocene to early Pleistocene?) – Deposits of silt, sand and pebble gravel. Poorly exposed in the basin west of the Ruby Mountains fault. Soils have stage III to IV Bk horizons up to 0.3 m thick. May be distal alluvial-fan deposit with lacustrine interbeds. Clasts are sub-angular to sub-rounded chert and mylonitic quartzite with lesser siltstone and granitic rocks. Unit includes multiple inset surfaces that are broadly rounded and dissected. Surfaces have a prominent northeast tilt of unknown origin.

Tertiary Rocks

Tb – Aphyric basaltic dike – Dark gray, nonfoliated, microcrystalline basaltic andesite with 57% SiO_2 in one analysis. Matrix consists of plagioclase, clinopyroxene,

opaques, and altered mafic, possibly olivine. Sparse, round, partly calcite-filled vesicles up to 1 mm in diameter. These small intrusions cross-cut mylonitic foliation in Paleozoic rocks. A K-Ar age of 17 Ma was reported from a basaltic dike in this vicinity, (T35N, R60E, Section 30) and may have been obtained from the same unit (Snoke, 1980).

Tr_1, Tr_2 – Porphyritic rhyolite [Jarbidge-type rhyolite] (Miocene) – Finely (Tr_1) and coarsely (Tr_2) porphyritic rhyolite lavas from two in-situ flows and occur as numerous blocks in the mega-landslide deposit ($Qmlsr_1$ and $Qmlsr_2$). Both consist of gray to pinkish-gray, porphyritic rhyolite that contain 25–30% phenocrysts of distinctive smoky quartz, sanidine, plagioclase, clinopyroxene, and generally altered mafic rocks that could be orthopyroxene or fayalite (Fe-rich olivine). Phenocrysts are generally less than 2 mm in diameter in finely porphyritic rhyolite and commonly 6 mm and up to 12 mm in diameter in coarsely porphyritic rhyolite. The northern, coarsely porphyritic flow (Tr_2) is as much as 50 m thick, has an irregularly exposed, black basal vitrophyre as much as 4 m thick overlain by massive to strongly flow-banded and locally columnar-jointed devitrified rock, and forms a resistant ledge that crops out for about 2 km. The southern, finely porphyritic flow (Tr_1) is as much as 10 m thick, has a thin, poorly exposed basal vitrophyre overlain by massive, devitrified rock, and crops out discontinuously over a 1.5 km length.

All phenocryst phases in both rhyolite types are rounded and embayed, with pockets of matrix in the phenocrysts. Plagioclase is faintly albite-twinned to more strongly grid-twinned, which suggests either anorthoclase or microcline. Similar grid-twinned feldspar occupies pockets in sanidine, and glomerocrysts of sanidine, grid-twinned feldspar, clinopyroxene, and opaque minerals (Fe-Ti oxides) occur in both rock types. Clinopyroxene has reaction rims with matrix. Microlites of feldspar laths are common in the glassy matrix of vitrophyres. Chemical analyses show the rocks are Fe-rich rhyolites with ~75–76% SiO_2 in Tr_2-type and ~70% SiO_2 in Tr_1.

Large blocks, up to ~50 m across, of both rhyolite types are common in mega-landslide deposits in the southeastern part of the Heelfly Creek quadrangle. Both phenocrysts and matrix are commonly argillicly altered in these blocks. In the western part of the Tent Mountain quadrangle, the landslide deposits overlie the eastern range-front fault and mylonitic Paleozoic marble and quartzite in its footwall.

These rhyolites are the southwesternmost known occurrences of Jarbidge-type rhyolites, which have the same distinctive phenocrysts and chemical characteristics (Coats, 1987; Brueseke et al., 2014). Jarbidge Rhyolite is most extensive near Jarbidge near the Idaho border where individual flows are more than 200 m thick, cumulative sections are at least 480 m thick, and total volume is estimated to be 500 km^3 (Brueske et al., 2014). Similar Jarbidge-type rhyolites are present along the east side of the East Humboldt Range in the Welcome and Humboldt Peak quadrangles (McGrew and Snoke, 2014).

Ts – Miocene and older sedimentary sequence – A heterogeneous sequence of tuffaceous and/or volcanic sandstone, siltstone, conglomerate, tephra, minor diatomite, and lacustrine sediments at least part of which is middle Miocene Humboldt Formation. The southernmost exposures, near CR 229, are divided into a lower sequence mostly of gray sandstone, dark gray shale, and minor conglomerate (Tsl) and an overlying sequence of volcaniclastic sandstone and conglomerate (Tsu); these units may be older than middle Miocene. All of the deposits are non-resistant and very poorly exposed, so it is currently not possible to establish a comprehensive stratigraphy.

The most common rock types in the undivided sedimentary sequence (Ts) are well-bedded to platy, variably calcite-cemented, fine- to coarse-grained, commonly tuffaceous sandstone and siltstone. Fragments of quartz, feldspar, and chert are the main constituents. Outcrops are sparse, and these rocks are mostly encountered as 1–2 cm angular chips of tan or white float, including some diatomite, and subcrop. Fluvial pebble-cobble conglomerates are sparsely interbedded with sandstone and siltstone throughout the section. Conglomerate clast types are dominated by sub-rounded to well-rounded non-foliated Paleozoic sedimentary rocks, including tan and white quartzite, dark brown and gray siltstone, chert, and micrite, derived from the East Humboldt Range. Several conglomerates in the southeastern part of the Heelfly Creek quadrangle also contain clasts of augen gneiss, mylonitic quartzite, and finely porphyritic rhyolite, though these rock types are not observed in conglomerates elsewhere in the section. Conglomerates commonly occur as nested channels, 2–10 m wide and 1–2 m thick with no outcrop exposed above or below.

Horizons of white and silvery gray tephra occur throughout the section. Discrete tephra horizons range in thickness from 20 cm to ~3 m, and composite sections of layered and variably reworked tephra are locally >5 m thick. The thickest observed section underlies the coarsely porphyritic rhyolite (Tr_2), where primary and reworked tephra total ~45 m thick. Reworked, deposits are indicated by cross beds, rounded grains, common non-volcanic clasts, and irregular sedimentary layering. Cuspate glass bubble walls and welded triple point bubble intersections are commonly well preserved. Feldspar phenocrysts consisting of sanidine or anorthoclase are present in most tephra. Phenocrysts are mostly ≤0.5 mm long, but anorthoclase phenocrysts as large as 2 mm occur in tephra in the thick section underlying the coarsely porphyritic rhyolite.

The entire sequence could be as much as 2.8 km thick if the generally north-northwest-dipping deposits are a continuous, unfaulted sequence from near CR 229 to the coarsely porphyritic rhyolite flow (Tr_2) along the northeastern edge of the map area.

Tsu – Volcaniclastic sedimentary sequence [Humboldt Formation] (Miocene) – Exposed parts of this unit consist of poorly consolidated, nonresistant, volcaniclastic sandstone and conglomerate that crop out very sparsely. Sandstone is irregularly planar bedded, poorly sorted, and variably calcite cemented. Conglomerate is exposed only as a lag of rounded cobbles. Clayey soils suggest some, unexposed finer deposits. Clasts are predominantly non-metamorphosed limestone and dark chert, with lesser biotite-plagioclase±quartz-bearing volcanic rock and light-colored granitic rock, and very minor quartzite. Most clasts are ≤10 cm in diameter and rarely up to 30 cm. This sequence crops out on the western, down-dropped side of the major normal fault, where unit Ts with an interbedded finely porphyritic rhyolite (Tr_1) is present in the footwall. This relationship suggests unit Tsu is younger than the rhyolite and no older than middle Miocene. However, the absence of rhyolite or tephra and presence only of biotite-bearing and, therefore, probably Eocene or Oligocene volcanic rocks suggest these deposits preceded middle Miocene volcanism. The deposits occupy a north-northeast trending syncline that lies ~500 m west of and parallel to the major normal fault.

Tsl – Sandstone, shale, and conglomerate (Miocene?) – The stratigraphically lowest exposed Cenozoic rocks in the map area are a thick sequence of nonresistant, dark gray, variably calcareous shale and sandstone. Sandstones are cross-bedded and poorly sorted. Conglomerate layers, 0.5–4 m thick, are poorly bedded and sorted and consist of moderately rounded cobbles to 15 cm in a granular to muddy matrix. Clasts are predominantly non-metamorphosed Paleozoic sedimentary rocks including argillite, commonly crinoidal limestone, chert, and chert-pebble conglomerate, along with lesser biotite-bearing volcanic and granitic rocks. A plagioclase-biotite dacite is the most common volcanic clast.

These rocks are best exposed in roadcuts along CR 229. To the north, the unit forms sparse outcrops and moderately dark gray-weathering slopes partly covered by light-colored colluvium from overlying Quaternary fan deposits. Unit Tsl forms a north-northeast-striking anticline and is overlain by deposits of unit Tsu in the parallel syncline to the east.

The age of this unit is uncertain. It underlies definite middle Miocene deposits and contains no clasts probably younger than Eocene or Oligocene volcanic rocks. Tsl could be as old as Eocene and equivalent to Elko Formation to as young as middle Miocene but preceding any middle Miocene volcanism.

Tsi – Undivided silicified rocks (Miocene?) – Silicified rocks of diverse lithology and alteration, found in the footwall of the eastern high-angle range front fault. Silicified rocks include altered rhyolite, limestone, mylonitic marble and fault breccia. Minor amounts of black and red jasperoid are common. Alteration and silica replacement is likely associated with hydrothermal fluids circulating through both high- and low-angle fault zones.

Non-Metamorphosed Paleozoic Rocks (modified from Hurlow, 1987 and McGrew and Snoke, 2014)

Pu – Permian undivided – Limestone, conglomerate, and sandstone for which precise stratigraphic relationships have not been determined. The oldest part of the unit is a resistant chert-limestone conglomerate, consisting of pebble- to boulder-sized clasts of Ely Limestone and dark chert derived from the Diamond Peak or Ely Formations. Other rock types are: 1) dark gray, silty, fusulinid-bearing micrite, 2) fine-grained tan sandstone, and 3) medium to dark gray, coarse- and fine-grained bioclastic limestone.

IPPe – Ely Formation (Pennsylvanian) – Medium gray, bioclastic micrite with brown and tan chert nodules. Contains beds of packstone and wackestone <1 m thick that consist of brachiopods, echinoderms, corals, bryzoans, and crinoids.

IPpMdp – Diamond Peak Formation (Pennsylvanian to Mississippian) – Gray and tan, chert-clast conglomerate, quartz-chert sandstone, and small lenses (<5 m thick) of massive gray micrite. Conglomerate clasts are black, gray, white, and green chert in a gray to tan matrix of medium-grained sand. Limestone lenses contain sparse brachiopods and crinoids.

Metamorphosed Paleozoic Rocks

Mmc – Metaclastic rocks undivided (Carboniferous?) – Quartzite, schist, and metaconglomerate, metamorphosed to greenschist grade and strongly mylonitized. Rock types are: 1) reddish-brown weathering, fine-grained quartzite with minor muscovite and plagioclase, 2) dark-colored, reddish-brown weathering, fine-grained schist, 3) gray, fine-grained schist containing muscovite porphyroclasts, 4) quartz-rich metaconglomerate with a strong foliation defined by deformed chert grains ~8 mm long. Porphyritic gneiss is sparsely distributed throughout this unit.

Dg – Metamorphosed Guilmette Formation (Devonian) – Mylonitized, medium to dark blue-gray, graphitic, calcite marble with sparse white bands; contains recrystallized and deformed fossils.

DOd - Dolomite marble (Ordovician to Devonian) – White to blue-gray, fine-grained, massive dolomite marble with sparse graphite and tremolite.

Oe – Metamorphosed Eureka Quartzite (Ordovician) – White fine-grained quartzite with foliation defined by minor muscovite and graphite bands. Occurs as lens-shaped infolds and boudins less than two m thick within the Horse Creek assemblage (DЄhc) and as infolds within the impure Ordovician–Cambrian marble unit (OЄm).

OЄm – Impure marble (Ordovician to Cambrian) – Variably impure calcite, dolomite, and calc-silicate marble. Three distinct rock types are as follows: 1) fine-grained calcite marble with tan-weathering silty layers. Fresh surfaces are tan- to lavender-gray. Protolith is interpreted to be finely interlaminated limestone and siltstone, 2) white to gray medium- to fine-grained calcite-dolomite marble containing variable amounts (<10%) of graphite, diopside, garnet, tremolite, phlogopite, scapolite, and muscovite. Green segregation bands of diopside and graphite are common. Where mylonitized, the graphitic marble is gray-blue and very fine-grained with diffuse graphitic banding, 3) gray to grayish-green, fine- to medium-grained impure calcite and calc-silicate marble. Locally contains knots and bands of fine-grained, black and pink siliceous material interpreted to be metamorphosed and sheared cherty limestone. The most abundant metamorphic minerals are diopside, plagioclase, and calcite with lesser sphene, scapolite, phlogopite, olivine, and epidote.

DЄhc – Horse Creek Assemblage (Devonian to Cambrian) – Complexly deformed tectonic assemblage of metasedimentary rocks intruded by pegmatite and granitic rocks. This unit overlies the quartzite-schist-gneiss unit (ЄZgs) along a low-angle, ductile-brittle normal fault and has been strongly deformed during mylonitization of structurally lower units. Mineral assemblages in calc-silicate rocks are diopside±plagioclase±garnet, commonly overprinted by tremolite±quartz±chlorite, which indicate that amphibolite-grade metamorphism predated shear zone deformation. Intrusions are pegmatite, strongly sheared granodiorite gneiss, and hornblende gabbro.

ЄZqs – Quartz-schist-gneiss unit (Cambrian to upper Precambrian) – Heterogeneous unit composed of granitic rocks interspersed with quartzite and schist of the Prospect Mountain Quartzite and McCoy Creek Group. Igneous rocks commonly comprise ~50% of the unit, but some areas are 90% igneous rocks, containing sparse lenticular quartzite and schist bodies. Quartzite is gray to white, fine- to medium-grained, with ≤10% biotite and feldspar forming metamorphic segregation bands. Anastamozing bands of pelitic and semi-pelitic schist up to 10 m wide comprise 5–20% of the unit in a pegmatite-quartzite-granitoid matrix.

Two distinct schist types present in this unit are: 1) black and white, medium- to coarse-grained, scaly pelitic schist dominated by aggregates of biotite and muscovite with lesser quartz, plagioclase, alkali feldspar, and sparse garnet ± sillimanite and 2) gray, medium- to fine-grained semipelitic schist consisting of quartz, biotite, muscovite, plagioclase, and alkali feldspar with garnet porphyroclasts.

Monzogranite sills and dikes centimeters to tens of meters thick intrude the main unit with sharp intrusive contacts. The monzogranite is gray and white, fine- to medium-grained, with locally abundant plagioclase phenocrysts. Contains trace to 4% biotite and sparse garnet. Monzogranite mapped in the Tent Mountain quadrangle is petrologically similar to biotite monzogranite in the northern East Humboldt Range that yielded a U-Pb age of 29.2±2 Ma (Wright and Snoke, 1993).

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