Text and references accompanying Nevada Bureau of Mines and Geology Open-File Report 16-5

Preliminary Geologic Map of the Herder Creek Quadrangle, Elko County, Nevada

by

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DESCRIPTION OF MAP UNITS

Quaternary Deposits

Qx Anthropogenic (Historic) Areas of extensive anthropogenic disturbance and modification, including Interstate Highway 80.

Qc Colluvium (Holocene) Unconsolidated, angular to slightly rounded boulders to pebbles of bedrock in a variably sandy matrix. Commonly 1–5 m thick on north and west facing slopes within the range front.

Qls Landslide deposit (Holocene to Pleistocene) Minor slope failure deposits with a wide range of 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 vary from sharp and fresh to rounded and indistinct.

Qay Active alluvium (late Holocene) Deposits of mud, silt, sand, and pebble- to cobble-sized gravel in active and ephemeral channels and floodplains.

Qt Travertine (Holocene) Tan, fine grained, laminated, calcareous travertine. Forms mounds and terraces around springs above the active range front fault.

Qfy_1 Youngest alluvial-fan deposits (late Holocene) Deposits of silt, sand and pebble- to cobble- sized gravel in active alluvial fans and active ephemeral stream channels. Includes subrounded to subangular clasts of mylonitic quartzite, 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. Post-dates most recent surface rupturing earthquake on the Ruby Mountains fault.

Qfy_2 Young alluvial-fan deposits (early to middle Holocene) Deposits of silt, sand and pebble- to cobble-sized gravel in generally inactive alluvial fans. Includes subrounded to subangular clasts of mylonitic quartzite, 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).

Qfi Intermediate-age alluvial-fan deposits (late Pleistocene) Deposits of silt, sand, and pebble- to cobble-sized gravel with boulders. Includes subrounded to subangular clasts of mylonitic quartzite, gneiss, and granitic rocks derived from the East Humboldt Range. Surfaces are broadly rounded, dissected, and topographically separated from Qfy deposits. Well preserved near the range front and on fan heads and terraces beveled onto Ts deposits in the footwall of the Ruby Mountains fault. Absent at the mouths of glaciated drainages suggesting Qfi may be time correlative with glacial outwash deposits associated with latest Pleistocene Angel Lake glaciation (Qgo_1).

Qgo Glacial outwash deposits, undivided (late Pleistocene) Deposits of silt, sand, and pebble-to cobble-sized gravel with boulders up to 3 m in diameter. Alluvial outwash from an undistinguished glacial advance.

Qgm Glacial moraine deposits, undivided (late Pleistocene) Deposits of poorly sorted sand, gravel, and boulders from an undistinguished glacial advance.

Qgo_1 Glacial outwash deposits (late Pleistocene) Deposits of silt, sand, and pebble-to cobble-sized gravel with boulders up to 3 m in diameter. Includes rounded to subrounded clasts of mylonitic quartzite, gneiss, and granitic rocks. Alluvial outwash from the Angel Lake glacial advance

Qgm_1 Glacial moraine deposits (late Pleistocene) Deposits of poorly sorted sand, gravel, and boulders up to 6 m in diameter forming lateral moraines from the Angel Lake glacial advance, moraine crests shown. Includes subangular to subrounded clasts of mylonitic quartzite, gneiss and granitic rocks. Moraine crests are sharp with abundant boulders. Locally inset adjacent to Lamoille age moraines.

Qgo_2 Glacial outwash deposits (middle Pleistocene) Deposits of silt, sand, and pebble-cobble gravel with boulders up to 6 m in diameter. Includes rounded to subrounded clasts of mylonitic quartzite, gneiss and granitic rocks. Alluvial outwash is likely from the middle Pleistocene Lamoille glacial advance.

Qgm_2 Glacial moraine deposits (middle Pleistocene) Deposits of poorly sorted sand, gravel, and boulders up to 6 m in diameter forming lateral moraines likely from the middle Pleistocene Lamoille glacial advance, moraine crests shown. Includes subangular to subrounded clasts of mylonitic quartzite, gneiss and granitic rocks. Moraine crests are rounded with fewer boulders exposed on the crest than Qgm_1.

Qra_1 Active floodplain alluvium (late Holocene) Deposits of well-sorted clay, silt, and sand within the active floodplain and major channels of the Humboldt River, Marys River, and Tabor Creek. Includes seasonally inundated terrace surfaces, meander belts, sloughs and overflow channels.

Qra_2 Recently abandoned floodplain alluvium (late to early Holocene) Deposits of well-sorted clay, silt and sand, and rare gravels within recently abandoned floodplain terraces of the Humboldt River, Marys River, and Tabor Creek. Includes abandoned terrace surfaces and meander belts with 1 to 3 m of topographic separation from Qra_1. May be inundated during infrequent flooding.

Qra_3 Abandoned floodplain alluvium (late Pleistocene) Deposits of well-sorted silt, sand, and gravels within abandoned terraces of the Humboldt River and Marys River. Includes rounded to subrounded clasts of mylonitic quartzite, gneiss, rhyolite, basalt, welded tuff and granitic rocks derived from a large regional catchment. Commonly buried by 0.5–1 m of eolian silt. The Qra_3 terrace forms several extensive flat surfaces that are 6 to 9 m above the active floodplain.

Qra_4 Older floodplain alluvium (late Pleistocene) Deposits of well-sorted silt, sand, and gravels within abandoned terraces of the Humboldt River. Includes rounded to subrounded clasts of mylonitic quartzite, gneiss, rhyolite, basalt, welded tuff, and granitic rocks. The Qra_4 is preserved in isolated terrace remnants that are 13 to 16 m above the active floodplain.

Qfo, Qfo_1, Qfo_2, Qfo_3 Older alluvial-fan deposits (middle Pleistocene) Deposits of silt, sand, and pebble- to cobble sized gravels with boulders up to 2 m diameter. Includes subrounded to subangular clasts of mylonitic quartzite, gneiss, and granitic rocks, derived from the East Humboldt Range. Soil development varies, with stage III Bk horizons locally up to 0.3 m thick. Four distinct and topographically correlative terrace and pediment surfaces (Qfo_1, Qfo_2, Qfo_3, and Qfo_4) are preserved on the uplifted footwall of the Ruby Mountains fault along the west side of the East Humboldt Range. South of Herder Creek, Qfo surfaces are beveled on to Tertiary sediments and to the north they are preserved as small remnants deposited on crystalline bedrock. Qfo_3 is a regionally extensive surface that Sharp (1940) named the "Lee" surface.

Tertiary Sedimentary Rocks

Ts Tertiary sediments, undivided (Pliocene to Miocene) A heterogeneous sequence of tuffaceous sandstone, siltstone, conglomerate, tephra, minor diatomite, and lacustrine sediments at least part of which is the middle Miocene Humboldt Formation but in the Herder Creek quadrangle likely includes younger deposits in the basin west of the Ruby Mountains fault. All of the deposits are non-resistant and very poorly exposed, so it is currently not possible to establish a comprehensive stratigraphy. Subhorizontal bedding was measured in a wash north of Deering Creek. Tilt fanning and growth stratigraphy depicted with form lines in cross section A–A' are projected from seismic reflection profile CT1 interpreted in Satarugsa and Johnson (2000).

The most common rock types in the 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. Fluvial, pebble-cobble conglomerates are sparsely interbedded with sandstone and siltstone throughout the section. Conglomerate clast types vary but locally include subrounded to well-rounded, non-foliated Paleozoic sedimentary rocks, gneiss, mylonitic quartzite, and granitic rocks. 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 15 cm to ~3 m, and composite sections of layered and variably reworked tephra are locally >5 m thick.

Two tephras exposed in a drainage north of Deering Creek and east of the range front fault were sampled for single-crystal $^{40}Ar/^{39}Ar$ dating. Sample H15-42 was taken from a gray, subhorizontal, sandy, 50-cm-thick reworked tuffaceous bed. A mean of all 24 dated K-feldspar grains is 30.3 ± 2.9 Ma with a range of 23.3 to 660 Ma; all except three grains give Cenozoic ages. The wide range of ages indicate the grains are likely detrital making ~23.3 Ma a maximum depositional age. Sample H15-43 was taken from a white, subhorizontal, minimally reworked, 15-cm-thick, ash bed and yields a 5.15 ± 1.82 Ma age from a coherent group of six plagioclase grains that are the youngest present.

A tephra exposed in a road cut south of I-80, one mile west of the Herder Creek quadrangle (N41.083569, E-115.267745) yields an $^{40}Ar/^{39}Ar$ age of 2.0 ± 0.1 Ma from sanidine grains. The sampled tephra bed is white, subhorizontal, 50 cm thick, and moderately reworked. The age suggests correlation with the Huckleberry Ridge Tuff of the Yellowstone volcanic field (Ellis et al., 2012).

In the Heelfly Creek quadrangle to the south $^{40}Ar/^{39}Ar$ ages from minimally reworked tephras and rhyolite flows interbedded within Ts yield ages ranging from 8.3–15.8 Ma. The entire sequence could be as much as 2.8 km thick if the generally north-northwest-dipping deposits observed in the Heelfly Creek quadrangle are a continuous, unfaulted sequence (Dee et al., 2015).

Intrusive Rocks (modified from McGrew and Snoke, 2015)

Tmg Biotite monzogranite orthogneiss (early Oligocene to middle Eocene) Weakly to moderately foliated, medium-grained, equigranular biotite monzogranite and lesser tonalite and granodiorite (Batun, 2000). Protomylonitic fabrics indicate west– to northwest–directed shear. Contains approximately 10% biotite and subequal proportions of oligoclase, alkali feldspar, and quartz. Commonly forms tabular sheets that are concordant to slightly discordant, up to 70 m thick but typically 1–10 m. Forms prominent dark gray to dark brown cliffs on south-facing slopes. U-Th-Pb zircon and monazite dating from Lamoille Canyon in the Ruby Mountains by Wright and Snoke (1993) yielded an age of 29 ± 0.5 Ma.

TKlg Leucogranite and leucogranitic orthogneiss (Paleogene to Cretaceous) Moderately to strongly foliated, coarse grained, granitic pegmatite. Includes lesser trondhjemitic pegmatite, muscovite-rich two-mica leucogranite, and weakly foliated, fine-to medium-grained late-stage garnet aplite dikes (Batum, 2000). Mylonitic fabrics indicate west-to northwest-directed shear. Foliated leucogranite commonly forms discontinuous meter to sub-meter scale concordant sheets, pods or lenses throughout the rocks in the metamorphic core complex. Mappable lenses of Tklg are up 50 m thick. Leucogranite bodies are commonly bounded by biotite-sillimanite melanosomes. The weakly foliated aplite dikes typically cut the foliation. A leucogranite in the adjacent Welcome quadrangle yielded a $^{207}Pb/^{206}Pb$ zircon date of 85 ± 3 Ma (McGrew and Snoke, 2015), resembling leucogranite ages from the southern East Humboldt Range and Ruby Mountains (Snoke et al., 1990).

Metamorphosed Sedimentary Rocks (modified from McGrew and Snoke, 2015)

M€mu Calcite and dolomite marble, undivided (Mississippian to Cambrian) Undivided carbonate rocks including coarse-grained white marble, medium- to coarse-grained micaceous gray marble, dolomitic marble and coarse-grained cream- to yellow-weathering marble with garnet. Locally mylonitic but commonly the marbles were coarsely recrystallized following mylonitization. Intruded by sheets and boudins of mylonitic leucogranite. The marbles are an extremely attenuated section correlated with the carbonate-dominated part of the Cordilleran miogeoclinal sequence (McGrew and Snoke, 2015). Up to 120 m thick.

MDgs Graphitic schist (Mississppian to Devonian) Graphite-bearing micaceous feldspathic schist and lesser quartzite. On the west side of the East Humboldt Range MDgs is generally a slope forming unit that weathers to a rusty red-brown. Characteristic metamorphic mineral assemblages include biotite, sillimanite, kyanite, garnet, plagioclase, and quartz with accessory rutile, ilmenite, and titanite (McGrew and Snoke 2015). Likely correlates with the Pilot Shale. Up to 80 m thick.

Oe Metamorphosed Eureka Quartzite (Ordovician) Medium- to coarse-grained white quartzite with foliation defined by minor muscovite and graphite bands. Outcrops are commonly 1–3 m thick and discontinuous due to extreme tectonic attenuation. Marks the contact between the underlying marble of Verdi Peak (O€m) and the overlying undivided dolomitic marble.

O€m Marble of Verdi Peak (Ordovician to Cambrian) Pale gray, graphitic, muscovite-bearing calcite and dolomite marble; calc-silicate marble; yellow-brown-weathering metadolomite. Situated between the Prospect Mountain Quartzite below and the Eureka Quartzite above.

Intruded by sheets and boudins of mylonitic leucogranite. Up to 80 m thick.

Ꞓ̀Zpm Metamorphosed Prospect Mountain Quartzite (Cambrian to Neoproterozoic) and McCoy Creek Group (Neoproterozoic), undivided Micaceous feldspathic quartzite with lesser biotite-muscovite and biotite-sillimanite-garnet pelitic schist. Quartzite is yellowish gray to white, fine- to medium-grained, with ≤10% biotite and feldspar forming metamorphic segregation bands. Pelitic schist is black and white, medium- to coarse-grained, dominated by scaly aggregates of biotite and muscovite, with quartz, plagioclase, alkali feldspar, garnet, and lesser kyanite and sillimanite. Both rock types are migmatitic with up to 50% leucosomes present in centimeter- to meter-scale concordant pods, sheets, and lenses commonly bordered by mica and sillimanite-rich melanosome. Quartzite dominated stratigraphy correlated with the Prospect Mountain Quartzite and pelitic schists likely correlate with the McCoy Creek Group. Up to 50 m exposed thickness in the Herder Creek quadrangle, over 100 m thick in the Welcome quadrangle.

Gneiss Complex of Angel Lake (modified from McGrew and Snoke, 2015)

Ꞓ̀Zpg Paragneiss (Cambrian to Neoproterozoic) Metapsammitic paragneiss and biotite-sillimanite pelitic schist, migmatitic with >50% leucosomes. Metapsammitic paragneiss observed in the Herder Creek quadrangle is comprised largely of micaceous feldspathic quartzite, which in hand sample appears correlative with the Prospect Mountain Quartzite. It is distinguished from Ꞓ̀Zpm based on the higher volume of migmatization and intense mylonitic deformation in the paragneiss. The pelitic schist in Ꞓ̀Zpg is distinguished from Ꞓ̀Zpm using the same criteria and may correlate with the McCoy Creek Group. Commonly contains lenses of coarse-grained, foliated, black to dark green amphibolite to several meters length. Detrital zircon geochronology of paragneiss in the Angel Lake cirque by Premo et al. (2014) defines a strong minimum provenance of 800–1250 Ma supporting correlation with the McCoy Creek Group. They also report an older minimum provenance age of ~2400 Ma from a sample of fuchsitic quartzite, suggesting that the unit may locally include Paleoproterozoic rocks. Up to 200 m thick.

XWog Orthogneiss (Paleoproterozoic to Neoarchean) Coarse-grained, gray, biotite quartzofeldspathic gneiss with distinctive "striped" metamorphic segregation bands, locally with K-feldspar augen up to 1 cm in diameter. Migmaitic, with biotite-rich foliations between lit-par-lit leucosomes. Local meter-scale sheets and boudins of melanocratic amphibolite and garnet amphibolite. Premo et al. (2014) report a SHRIMP U-Pb zircon age of 2449 ± 3 Ma from the Angel Lake cirque.

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