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Geologic Map of the Calavera Canyon Quadrangle, Humboldt County, Nevada

by

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ABSTRACT

The Calavera Canyon 7.5' quadrangle covers the western margin of the 16.4 Ma McDermitt caldera, one of the oldest expressions of the Yellowstone hotspot and site of major lithium-clay deposits, and the eastern part of the adjacent Kings River Valley, a significant agricultural center. The ~800-m-high topographic scarp between the two areas exposes the caldera ring-fracture zone, extensive pre-caldera rocks, and a complete section of intracaldera tuff. The oldest pre-caldera rocks are a diverse suite of Jurassic intrusive rocks (table 1) that mostly consist of granodiorite but spans from high-Si felsite, aplite, and pegmatite to gabbro (table 2). Two major pulses of Eocene volcanism at 46–47 Ma and 39–41 Ma (table 3) produced dacite to rhyolite lavas and andesite-dacite(?) lavas, respectively (table 2). The lavas and volcaniclastic rocks coeval with the younger pulse filled a west-trending paleovalley cut into the Jurassic intrusive rocks. After a hiatus until ~17 Ma, intensive volcanic activity resumed with eruption of basalt and basaltic andesite lavas that are some of the southernmost expressions of Columbia River Basalt magmatism. Volcanism became more silicic with time, initially with anorthoclase-bearing rhyolite lavas, followed by biotite rhyolite lava domes, and peralkaline rhyolite lavas. Volcanism culminated with ~16.4 Ma eruption of ~1000 km^3 of McDermitt Tuff, which is zoned from aphyric, peralkaline, high-Si rhyolite to abundantly anorthoclase-phyric trachydacite and icelandite (Fe-rich andesite). Eruption induced collapse of the ~40 x 22–30 km McDermitt caldera. Collapse along the western margin in the Calavera Canyon quadrangle was accommodated by an as much as 1-km-wide zone of east-dipping, high-angle faults and monoclinal downwarps into the caldera. A lake that formed within the caldera was subsequently filled with tuffaceous sediments until ~15.7 Ma.

Normal faulting that probably began about 11–12 Ma in the McDermitt region (Colgan et al., 2006) cut through the western edge of the caldera, exposing the considerable intracaldera sequence in the quadrangle. The resulting, west-dipping Montana Mountains fault zone separates bedrock in the eastern part of the quadrangle from thick Quaternary and latest Cenozoic deposits in Kings River Valley. An as much as ~8-m-high scarp demonstrates that faulting has continued to the present. Quaternary deposits include alluvium, alluvial-fan deposits, and extensive colluvium and talus in drainages and slopes in bedrock and extending out into the valley. A pluvial lake occupied the valley into the Holocene, deposited both fine sediments in the lake bottom and gravel along shorelines and spits, and generated numerous shorelines during lake recession.

Three types of mineralization are present in the quadrangle. 1. Lithium-rich clays in the intracaldera sedimentary deposits, first recognized in the 1970s (Rytuba and Glanzman, 1979), are currently most important because of demand for Li for Li-ion batteries. The deposits also contain significant K, Rb, Mo, As, Sb, Mg, and F (Castor and Henry, 2020). The uncertain origin of these deposits involves diagenesis of the host tuffaceous sediments and possibly hydrothermal activity during the waning stages of caldera magmatism (Castor and Henry, 2020; Benson et al., 2017a, 2023). 2. U-Zr mineralization in pre-caldera volcanic rocks in and along caldera collapse faults at the Moonlight Mine and in Horse Canyon formed from hydrothermal solutions immediately following collapse (table 1; Castor and Henry, 2000). These deposits mostly consist of U-rich zircon, are accompanied by As, Sb, and Hf; minor amounts of Cu, Zn, Y, Hg, and Pb; and locally Mo, Ag, and Tl (table 4). 3. Quartz-sulfide veins in the Jurassic granitic rocks

produced an unknown but probably small amount of Au and Ag in the early 1900s (Willden, 1964; Minor et al., 1988). Analyses of two vein samples for this study show minor enrichment in Co, Cu, As, Mo, Ag, Sb, Hg, and Bi (Au not analyzed; table 4).

DESCRIPTION OF MAP UNITS

Quaternary Units

Qm Man-made features (Historic) Culturally disturbed areas. Includes two areas of placer workings and test pits along Horse Creek, some small earthen dams, and numerous mine and prospect dumps at the Moonlight Mine and in the upper part of Ikes Canyon.

Qay Younger alluvium (late Holocene) Gravel and sand in small valleys or in narrow pathways through alluvial fans. Contains subangular to subrounded clasts up to 1.5 m diameter. Both matrix- and clast-supported gravel beds. Subject to frequent flooding. Post-pluvial. The Montana Mountains fault cuts this unit in only a few places.

Qfy Younger alluvial-fan deposits (late Holocene) Gravel, sand, silt, and clay in alluvial fans. Non-dissected to very slightly dissected by shallow gullies. Contains subangular to subrounded clasts up to 1.5 m diameter. Post-pluvial. Subject to frequent flooding. Offset in a few areas by the Montana Mountains fault.

Qfpb Braided alluvial-floodplain deposits (Holocene) Sand, silt, and minor gravel along the wide river floodplain of Kings River Valley and a tributary 3 km south of the mouth of Calavera Canyon. Mostly mixed braided channels and overbank deposits. Contacts with adjacent units are gradational and difficult to locate accurately. Most of this unit is now under cultivation for alfalfa and fodder corn.

Qt Talus (Holocene and Pleistocene) Unconsolidated, very coarse, clast-supported deposits that lack significant fine matrix. Includes large areas of the steep escarpment from the Montana Mountains downslope into Kings River Valley, especially in areas of McDermitt Tuff, where it consists of coarse, angular blocks of the tuff or other rocks. Individual blocks vary from <1 m to several meters in diameter. Also present as smaller areas along steep valley sides in other parts of the quadrangle.

Qc Colluvium (Holocene and Pleistocene) Unconsolidated, fine to very coarse deposits with abundant fine matrix, which distinguishes the unit from commonly adjacent talus (Qt). Clasts up to 1 m diameter that are little displaced from older units in the map area.

Qpl Pluvial-lake bottom deposits (Holocene and Pleistocene) Sand, silt, and clay deposited by the former pluvial Lake Lahontan forms nearly flat-lying deposits along the margins of Kings River Valley between the distal lower edges of alluvial fans and the braided flood plain. Also includes small ranch ponds and abandoned reservoirs.

Qps Pluvial-lake shoreline deposits (Holocene and Pleistocene) Gravel and sand at the margins of Lake Lahontan. Former shorelines, eroded during the recession of pluvial Lake Lahontan since 13070 ± 60 annum (Adams and Wesnousky, 1998), are shown by "purple" lines. Map units mostly are beach ridges consisting of only slightly reworked lower alluvial-fan material. Mostly cut into segments by younger valley alluvium and alluvial fans. Beach ridges are well developed along the eastern margin of the Kings River Valley but almost non-existent along the northern and western margins. Northward-extending gravel spits are developed at the margins of larger alluvial fans at the mouths of larger canyons, including Calavera Canyon and Garden Creek, where the fans provided a large quantity of coarse gravel. Several borrow pits and test pits are located in these spits. One active gravel pit in section 8 (T 45 N, R 34 E) contains two, very well sorted, clast-supported, 5-m-thick gravel beds of 4–8 cm clast size separated by a 1-m-thick arched bed of limonitic, tuffaceous sand. This borrow pit is at the north end of a 10-m-high spit. Another active pit operated by Humboldt County is in Section 36, T 46N R33 E, and produces finer gravel. This pit occurs where younger alluvium (unit Qay) cuts across subtle beach ridges. The characteristics of shoreline deposits indicate that the strongest winds during pluvial times were from the southwest. Beach ridge deposits range in elevation from 4210 ft. (1283 m) to 4320 ft. (1316 m). The largest spits are at elevations near the highstand at 4320 ft. (1317 m) and also at 4220 ft. (1286 m).

Qae Eolian deposits (Pleistocene) Eolian silt and fine sand, generally in topographically sheltered upland areas, especially along the Montana Mountains range front. Probably sourced from units Qfpb, Qay, and Qfy. Nearly all occurrences are stabilized by vegetation.

Qls Landslide deposits (Pleistocene?) Slumped and broken areas within the McDermitt caldera moat sediments along the east edge of the quadrangle, and a few somewhat interpretive small mudflow and slump deposits in upland valleys within the Jurassic granitic rocks.

Qao Older alluvium (Pleistocene?) Gravel and sand, mostly at higher elevation than the younger alluvium (Qay) along the margins of upland stream valleys. Contains subrounded to subangular clasts up to 1.5 m diameter.

Qfo Older alluvial-fan deposits (Pleistocene?) Gravel and sand forming deeply dissected gentle slopes showing distinct alluvial-fan topography on their upper surface but cut by moderate to deep gullies. Mostly on higher ground between younger alluvial fans and upland bedrock. These are pre-pluvial and universally cut by the Montana Mountains fault. Contains subangular to subrounded clasts up to 2.5 m diameter.

Qg Gravel (Quaternary) Unconsolidated gravel that cannot be assigned to one of the above deposit types. Contains angular to subangular clasts up to 2.5 m diameter.

Rocks of the McDermitt Caldera

Intracaldera sedimentary deposits (middle Miocene)

Poorly exposed, poorly to moderately lithified, heterogeneous sedimentary deposits that accumulated inside the caldera following its collapse. Divided into a lower Mrs$_1$ of interbedded clay and sandstone with minor conglomerate layers and an upper Mrs$_2$ predominantly of clay with minor sandstone. Both rarely crop out and are mostly expressed as clayey soil with pieces of the more resistant rock types, especially variably silicified, platy sandstone and siltstone, from a few to 30 cm in diameter. Sandstone and clay-rich layers in each unit form light- and dark-colored bands, respectively, on air photos and satellite images. These differences reflect substrate type, moisture retention, and greater abundance of thick sage brush on clay layers. The combined deposits in the Calavera Canyon quadrangle, where the top is eroded, are ~120 m thick. Less eroded deposits in the northeastern and southern part of the caldera are as much as 210 and 190 m thick, respectively (Henry et al., 2017). A $^{40}Ar/^{39}Ar$ date on coarsely sanidine-phyric tephra in the upper part of Mrs$_1$ is 15.954±0.012 Ma (table 3). Geologic relations and $^{40}Ar/^{39}Ar$ dates on tephra throughout the caldera demonstrate that the intracaldera sediments began accumulating immediately after eruption of the McDermitt Tuff and resulting caldera collapse at ~16.4 Ma to about 15.7 Ma (Castor and Henry, 2020; C.D. Henry, unpublished data).

Mrs$_2$ Upper part Outcrops of the clay-rich, upper part of intracaldera sedimentary deposits are extremely rare. The deposit is mostly expressed as soil with pieces of moderately indurated sandstone and siltstone. Core from lithium-exploration drillholes indicate most of the unit consists of finely laminated to massive clay and mudstone.

Mrs$_1$ Lower part Exposed deposits and float pieces consist of planar laminated, moderately well-sorted, fine to coarse sandstone, siltstone, and pebble conglomerate. Beds are <1 mm to rarely as much as 30 cm thick and variably dark red, pink, and light gray. These beds locally exhibit cm- to 10's of cm-scale soft-sediment deformational features. Worm burrows and mud cracks are preserved in float pieces.

A poorly sorted, locally silicified conglomerate consisting of angular to rounded clasts of McDermitt Tuff, icelandite, and other pre-caldera volcanic rocks up to 30 cm in diameter is present sporadically at the base of the unit at the top of the western escarpment. The conglomerate resulted from erosion of the nearby caldera wall soon after collapse and is somewhat analogous to fine mesobreccia (Mrmtm). The presence of commonly rounded clasts, which demonstrate some fluvial transport, distinguishes the conglomerate from mesobreccia.

McDermitt Tuff (middle Miocene)

Poorly to densely welded to strongly rheomorphic, petrographically and chemically zoned, abundantly anorthoclase-phyric trachydacite and icelandite to aphyric, peralkaline rhyolite ash-flow tuff (Starkel et al., 2012, 2014; Starkel, 2014; Henry et al., 2017; see also Benson et al., 2017b). The McDermitt Tuff is as much as 500 m thick along the western escarpment; all of it is within the McDermitt caldera or along its complex structural margin. Ponding of the tuff in the caldera demonstrates that collapse occurred during eruption of the McDermitt Tuff. Mrmt makes prominent, variably continuous, faintly columnar-jointed cliffs that are 10 m to rarely as much as 100 m high and huge talus slopes (Qt) that cover large parts of the western escarpment. Where access on the steep escarpment allowed observation, we divide the tuff into several petrographic variants, stratigraphic units, and breccia deposits. The rocks including meso- and megabreccia are complexly interbedded and rheomorphically intrafolded, which reflects the complex eruption, deposition, and rheomorphism of the multi-flow unit McDermitt Tuff and contemporaneous caldera collapse (e.g., Hargrove and Sheridan, 1984).

Although complicated by the intense rheomorphic intrafolding, the McDermitt Tuff generally progresses stratigraphically upward from aphyric, peralkaline rhyolite to abundantly porphyritic trachydacite and icelandite. This pattern suggests eruption from a vertically zoned magma chamber with the most evolved, peralkaline rhyolite at the top erupting first and progressing downward to least evolved trachydacite and icelandite that erupted last. The weighted mean age of the three of six $^{40}Ar/^{39}Ar$ anorthoclase dates on tuff around the caldera with the lowest individual uncertainties is 16.39± 0.01 Ma (weighted mean of all six 16.37±0.03 Ma; Henry et al., 2017). Obviously, all dates are on porphyritic tuff, aphyric tuff having no alkali feldspar phenocrysts to date.

Most of the tuff is devitrified, but vitrophyre is common, mostly where quenched against mega- and mesobreccia. Variable rheomorphism ranges from open to overturned folds within individual ignimbrite flow units that form individual cliff bands to intensely intrafolded deposits (the megarheomorphic folds of Hargrove and Sheridan, 1984) that make thick, irregular deposits.

Notes on ubiquitous characteristics are described below, followed by individual descriptions of the different variants.

Phenocryst assemblage: McDermitt Tuff varies from aphyric to abundantly porphyritic (~30%) with phenocrysts of anorthoclase (0–30%, ≤2 mm), clinopyroxene (augite, 0–1%, ≤2 mm), fayalite (<1%, 0.5 mm), sodic amphibole (arfvedsonite?, trace, 0.2 mm), magnetite, ilmenite, and apatite. Conrad (1984) also reports aenigmatite.

Lithic fragments: lithics vary in size, abundance, and rock type, which include all(?) pre-caldera rock types exposed adjacent to and immediately west of the caldera. Pumice: 0–20%, rarely as much as 50%, spanning all the petrographic types of the host tuff.

Pumice in non-rheomorphic parts is as large as 25 x 4 cm but elongated to at least 1 m in rheomorphic parts.

Mrmt Undivided tuff and breccia Mapped where not examined because of difficult access along the steep escarpment. Could be any of the mapped rock types.

Mrmtu Upper ignimbrite A sparsely anorthoclase-phyric (5%, to 1.5 mm), lithic-rich, densely welded to slightly rheomorphic ash-flow tuff crops out discontinuously at the top of the Moonlight Mine section, generally overlying late mesobreccia (Mrmtm). The rock is pervasively altered, with destruction of feldspars, and variably silicified. The upper ignimbrite postdates the megarheomorphism that generated the interfolded deposits (Mrmtc) and appears to be a late eruption that is possibly significantly younger (years to 1000s of years?) than the underlying tuff. Maximum thickness about 50 m.

Mrmtm Late mesobreccia Late mesobreccia forms two lenses that underlie upper ignimbrite (Mrmtu) and overlie all other McDermitt Tuff. The lenses are mostly expressed as a lag of angular to subrounded boulders of pre-caldera rocks up to about 1 m diameter. Probably deposited as debris flows off the caldera wall following most caldera collapse. Maximum thickness about 20 m.

Mrmtb Meso- and megabreccia Breccia consisting mostly of pre-McDermitt Tuff rocks and minor tuff. Mesobreccia, which forms semi-continuous lenses primarily in the middle and upper parts of the intracaldera tuff sequence, consists of clasts mostly ≤1 m and as large as 4 m. Matrix, which is rarely exposed, is mostly more finely clastic material but is locally tuffaceous. These characteristics indicate mesobreccia was deposited as large debris flows, landslides, or rock falls from the developing caldera wall. Individual megabreccia blocks are as large as 10 m and probably formed by individual rock falls from the wall. Highly irregular thickness as much as 70 m.

Mrmtv Vitrophyre tuff bands Numerous vertical to steeply inclined, east-northeast-striking bands of vitrophyre extend through tuff and breccia southeast of Calavera Canyon. The bands are 10 to 50 m thick and up to 700 m long. Some bands are quenched against breccia, but other bands are entirely within devitrified tuff. They may be in megarheomorphic folds similar to those in intracaldera tuff 7 km to the southeast described by Hargrove and Sheridan (1984).

Mrmtc Interfolded porphyritic and aphyric types Highly rheomorphic tuff in which the aphyric and porphyritic types are folded together into a strongly banded, commonly lava-like rock in which primary tuff features such as pumice and other particulate characteristics are difficult to recognize. In contrast, in some interfolded deposits, strain was partitioned between narrow, highly sheared zones where tuffaceous characteristics were destroyed and larger, unsheared zones where pumice and welding are well preserved. At large scale, these form the "megarheomorphic folds" of Hargrove and Sheridan (1984). Thickness as much as about 400 m.

Mrmtp Moderately to abundantly porphyritic, low-SiO_2 rhyolite to trachydacite and icelandite The porphyritic variant of McDermitt Tuff is concentrated in upper parts of intracaldera tuff, particularly making almost all of the outcrop immediately underlying intracaldera sediments (Mrs1). Brown on fresh surfaces, and darker brown on weathered surfaces. Thickness as much as about 150 m.

Mrmta Aphyric to very sparsely porphyritic, high-SiO_2 rhyolite Phenocryst- and mostly lithic-poor, massive rhyolite tuff is most extensive at and near the bottom of intracaldera tuff and also occurs interfolded with porphyritic tuff in unit Mrmtc. Devitrified rock is dark brown on weathered surfaces and light tan on fresh surfaces. Vitrophyre bands are dark brown to black on both weathered and fresh surfaces. Thickness mostly less than about 100 m.

Pre-caldera Miocene Volcanic Rocks

Mrcr Peralkaline rhyolite lava of Calavera Canyon (middle Miocene) Peralkaline rhyolite lava makes prominent cliffs along an 8 km length of the western escarpment, especially above the Moonlight Mine, where it is as much as 180 m thick. The rock contains ~15% phenocrysts consisting of commonly chatoyant sanidine (8%, 2–4 mm long), commonly smoky quartz (5%, 1–2 mm), clinopyroxene (≤1%, ≤2 mm), aenigmatite (trace), monazite, magnetite, ilmenite, and apatite. Hydrated vitrophyre makes a poorly exposed layer near base and as boulders from a probable upper breccia near top. Most of the flow is light-tan, crystalline, and variably massive to flow-banded. Probable arfvedsonite is common as a vapor-phase. Sanidine $^{40}Ar/^{39}Ar$: 16.399 ± 0.016 Ma; C95-107.

Mrmr Biotite rhyolite lava of Moonlight Mine (middle Miocene) Porphyritic, biotite rhyolite crops out discontinuously along the western caldera margin, especially at and above the Moonlight Mine (uranium) where it is at least 150 m thick, extends 1 km north and south, and the base is not exposed. These dimensions suggest emplacement as a lava dome. The rock contains 10–16% phenocrysts consisting of sanidine (1–3%, 2.5 mm), plagioclase (6–10%, 1.5 mm, mostly altered), biotite (1–3%, 1.5 mm), pyroxene (~1%), quartz (trace, ≤1 mm), ilmenite, magnetite, apatite, and zircon. Groundmass is variably light purple, light gray, and white, commonly in a single hand sample. The lower part of Mrmr is intensely altered at and around the Moonlight Mine, including formation of coarse quartz, adularia as disseminations and replacing feldspar phenocrysts, pyrite, arsenopyrite, fluorite, and various uranium minerals especially uranium-rich zircon (Castor and Henry, 2000). The altered rock has a bleached-white groundmass with phenocrysts preserved only as faint outlines. Biotite rhyolite is common as lithics in McDermitt

Tuff and as blocks in mega- and mesobreccia (Mimtb, Mimtm). Sanidine $^{40}Ar/^{39}Ar$: 16.619 ± 0.020 Ma; C95-103A.

Steens Basalt and related rocks

A sequence of middle Miocene lavas, the oldest Miocene rocks in the quadrangle, is divided into four map units based on stratigraphic position, phenocryst assemblage and chemical composition. The sequence becomes more silicic upward, varying from basalt to low-SiO_2 rhyolite. At least the lower two map units are part of the Steens Basalt based on age, chemical, petrographic, and isotopic characteristics (Starkel et al., 2012; Starkel, 2014; Henry et al., 2017), although what constitutes Steens Basalt is interpreted differently on the basis of stratigraphy and chemical composition (Brueseke et al., 2007; Camp et al., 2013). Steens Basalt eruption is interpreted to have begun about 16.85 or 16.74 Ma (Camp et al., 2013; Mahood and Benson, 2017, respectively) and lasted about 0.3 Ma. All the rocks of this sequence underlie the peralkaline rhyolite of Calavera Canyon (Micr, 16.399±0.016 Ma), and all except one icelandite lava underlie the biotite rhyolite of the Moonlight Mine (Mimr, 16.619 ± 0.020 Ma). From youngest to oldest, these rocks are divided into:

Misr Anorthoclase-phyric rhyolite lava (middle Miocene) A single, sparsely porphyritic, low-SiO_2 rhyolite lava ~20 m thick is interbedded with icelandite and aphyric basalt in the western wall of the caldera on the east side of Horse Canyon. The flow is devitrified except for an irregular basal vitrophyre ~2 m thick. Phenocrysts (1–3% total) consist of anorthoclase (1–2%, ≤2 mm) and clinopyroxene (≤1%, 0.5 mm).

Misi Icelandite lava (middle Miocene) Numerous, moderately porphyritic icelandite (Fe-rich andesite and dacite or trachydacite) lava flows with common upper and lower breccias overlie unit Mis. Phenocrysts (5–15% total) consist of plagioclase (4–10%, 1–3 mm), anorthoclase (0–2%, 1–2 mm), clinopyroxene (2–3%, ≤0.8 mm), Fe-Ti oxides, and apatite. Thickness ~150 m but poor exposure prohibits good estimate.

Mis Aphyric to finely porphyritic mafic lava (Steens Basalt, middle Miocene) Aphyric to finely porphyritic basalt and basaltic andesite lavas and breccias overlie the coarsely plagioclase-phyric lavas with sharp contact. Individual flows are a few to 20 m thick, and the entire unit is ~250 m thick. Phenocrysts consist of plagioclase (0–10%, ≤2 mm), pyroxene (<1–3%, ≤2 mm), olivine (0–2%, ≤1 mm), and Fe-Ti oxides. Groundmass is mostly dark gray to dark purple, but locally dark green where highly weathered. Generally vesicular near the tops and bottoms of flows.

Misb Coarsely porphyritic basalt lava (Steens Basalt, middle Miocene) Basalt lava flows distinguished by large, commonly aligned plagioclase phenocrysts as much as 10 cm long are the oldest Miocene volcanic rocks in the quadrangle and around the McDermitt caldera. They overlie the Eocene volcanic rocks or Jurassic granodiorite and make up much of the western wall of the caldera. Individual flows are a few to 20 m thick, and the entire unit is ~120 m thick in a well-exposed section in the caldera wall. Phenocrysts consist of plagioclase (as much as 40%), pyroxene (<1–5%, ≤2 mm), olivine (0–3%, ≤2 mm), and Fe-Ti oxides. Extremely coarsely plagioclase-phyric basalts are a minor but prominent constituent of Steens Basalt; presence of the coarsely porphyritic basalt in the McDermitt area is part of the evidence for correlation.

Miocene to Eocene(?) Sedimentary Rocks

Volcaniclastic sandstone and conglomerate overlie Jurassic granitic rocks and Eocene volcanic rocks and underlie middle Miocene volcanic rocks along the east side of Horse Canyon. These undated rocks are between ~39 and 17 Ma old, the age of well-dated, underlying and overlying rocks.

Eovs Volcaniclastic sandstone and conglomerate (Miocene to Eocene?) Volcaniclastic sandstone and minor conglomerate composed mostly of Eocene volcanic clasts. Rarely exposed other than in artificial cuts. Mostly expressed as a lag of massive to rarely planar-bedded, coarse to fine sandstone composed of feldspar, quartz, and volcanic matrix. Some clasts have ripple marks or leaf impressions; petrified wood pieces up to 10 cm long are common. Conglomerates are laterally discontinuous and mostly consist of clasts ≤5 cm diameter. A few coarser lenses contain clasts to 30 cm and rarely 1.5 m in diameter. Conglomerates are probably channel deposits. A few dark beds consist entirely of finely reworked andesite. As much as ~270 m thick in possible remnant of paleovalley mostly occupied by Eocene volcanic rocks.

Eoc Conglomerate (Miocene to Eocene?) Conglomerate up to ~40 m thick and exposed as a cobble to boulder lag of Jurassic igneous rocks, mostly more resistant felsite, and Eocene volcanic rocks rests on Jurassic granodiorite (Jgd) on the slopes east of Horse Canyon. The subrounded to subangular clasts include felsite (Jf), aplite (Ja), and minor granodiorite (Jgd) to 20 cm, porphyritic andesite (Eoa) to 50 cm, and finely porphyritic rhyolite (probably Eor) to 10 cm. Despite its "basal" stratigraphic position, the presence of Eocene volcanic rocks demonstrates that it postdates them and probably was deposited on higher flanks of the paleovalley.

Eocene Volcanic Rocks

Eocene volcanic rocks are the oldest Cenozoic rocks in the Calavera Canyon quadrangle. They crop out in two areas: 1) in a west-northwest-trending paleovalley cut into Jurassic granodiorite from Horse Canyon to Dry Canyon. 2) the headwaters of Cherry Creek at the north edge of the quadrangle and north into the adjacent Disaster Peak quadrangle. $^{40}Ar/^{39}Ar$ dates demonstrate that the Eocene volcanic rocks erupted in two episodes at ~39–41 Ma and 46–47 Ma (table 3; see also Henry et al., 2017).

Eoa Porphyritic andesite lava (Eocene) Dark gray porphyritic andesite is present as several thick flows both in the Dry Canyon–Horse Canyon paleovalley, where they total about 85 m thick, and in the headwaters of Cherry Creek at the north edge of the quadrangle, where they total about 65 m thick. The andesite is mostly crystalline with a dark gray matrix. Black, commonly vesicular, basal vitrophyre is present in some flows. Two distinct petrographic types are flows with clinopyroxene as the only mafic phenocryst and flows with common hornblende. Phenocrysts consist of plagioclase (10–25%, <1–5mm), clinopyroxene (2–10%, <1–5mm), hornblende (0–10%, <1–8mm), Fe-Ti oxides, apatite, and zircon. Rounded inclusions up to 15 cm diameter of more abundantly porphyritic andesite in a finely crystalline matrix are probable autoliths. One 15 cm inclusion of Jgd. Plagioclase step-heating $^{40}Ar/^{39}Ar$ date: 39.18 ± 0.12 Ma (11-McD-311; table 3). Hornblende $^{40}Ar/^{39}Ar$: 40.77 ± 0.02 Ma (H22-CC278).

Eod Biotite-hornblende dacite lava and tuff? (Eocene) A distinctively platy (because of biotite aligned parallel to layering) dacite as much as 200 m thick underlies andesite (Eoa) in a ~600-m-long belt east of Horse Creek. Most of the unit is probably lava, but an upper, probably pyroclastic part consists of matrix-supported dacite clasts to 2 cm in an ashy matrix. Phenocrysts (20–25%) consist of plagioclase (15–20%, 1–2 mm), biotite (2–5%, 1–2 mm, locally chloritized), and hornblende (2–8%, 1 mm, generally altered).

Eop Altered feldspar porphyry (dacite?) (Eocene) Highly altered, poorly exposed limonitic to olive brown, porphyritic lavas underlie porphyritic andesite (Eoa) along the north side of Dry Canyon. The lavas overlie Jurassic granitic rocks, apparently near the bottom of the paleovalley. The lavas are probably dacite because of phenocryst assemblage of plagioclase (altered to clay), biotite (altered to sericite or illite), and quartz (0–5%, 1–2 mm). Limonite pseudomorphs after pyrite. Alteration increases to the west near the mouth of Ikes Canyon, where it forms some prominent outcrops consisting of sparse dikes within an area of limonitic brecciated granitic rock. Some of the porphyry in this area contains a fine network (<1mm) of thin (<0.5mm) chalcedonic quartz veinlets.

Eox Sedimentary breccia (Eocene) Breccia consisting of closely packed, clast-supported, angular fragments of granitic rocks, with a few subrounded to subangular granitic clasts. Forms both large, tall outcrops and low, flat outcrops. Very sparse matrix consists of granitic sand. Locally granitic blocks are encased within the overlying unit Eop. Some granitic clasts contain milky quartz veins. Maximum thickness about 50 m.

Eor Rhyolite lava dome and dike (Eocene) A finely porphyritic, strongly flow-banded and folded to massive, light-colored rhyolite forms a 170-m-wide and about 30-m-high lava dome in Ikes Canyon. A carapace breccia composed of angular rhyolite clasts to 10 cm in a silicified matrix caps the dome, which demonstrates that the dome is extrusive and emplaced onto the surface at the time. Phenocrysts consist of quartz (5%, 0.5–2 mm), sanidine (3%, 1 mm, commonly clay altered), biotite (3%, 1–2 mm, distinct equant thick books, commonly chloritized), plagioclase (3%, up to 2 mm everywhere altered to white, limonitic powder). A north-striking, more abundantly porphyritic dike 700 m south of the lava dome is included in this unit. The dike has a light gray groundmass in which reside phenocrysts of plagioclase (25%, up to 3mm, altered to limonitic cores and white rims), partly chloritized biotite (3%, equant thick books to 2 mm), and clear quartz (~0.3% to 1.5mm). Sanidine $^{40}Ar/^{39}Ar$: 46.214 ± 0.031 Ma (H22-CC271), which shows that it is part of the older Eocene igneous episode that includes porphyritic dacite north of the quadrangle dated at 46.74±0.41 (MD-6; plagioclase; table 3; Henry et al., 2017).

Jurassic Intrusive Rocks

Jurassic granitic rocks (loosely defined to include diorite, gabbro, and other mafic intrusive rocks) comprise most of the large wedge (4 x 5.5 km) of bedrock north and west of Horse and Cherry creeks and in a narrow belt extending ~3 km south-southeast from the mouth of Horse Creek between the McDermitt caldera and Kings River Valley. Granitic rocks continue ~11 km north of the Calavera Canyon quadrangle to The Granites topographic feature, where they are overlain by Steens Basalt. The granitic rocks, which comprise most of the western wall of the caldera, are variably exposed. Scattered prominent outcrops reside among large areas of deeply weathered soil, which greatly hampered placement of contacts between the three major granodiorite types (Jgd, Jgf, Jgb). We refer to the area of granitic outcrop in the quadrangle as the "granitic area". Although many granitic intrusions in the region are Cretaceous (~115–94 Ma; Wyld and Wright, 1997; Brown et al., 2018), new U-Pb zircon dates demonstrate the three major types were emplaced between about 185 and 187 Ma (table 1). One sample also contains abundant zircon xenocrysts that yielded a U-Pb age of 230.81±1.75 Ma (Triassic), presumably derived from an unexposed(?) igneous rock of that age. Some late pegmatite, aplite, and mafic to felsic dikes are undated but closely spatially associated with the larger intrusions and are most likely also Jurassic. Similar Jurassic and Triassic age intrusions are present in the Pine Forest Range and Jackson Mountains, 40 km to the west and 50 km to the southwest, respectively (Quinn et al., 1997; Wyld, 1991; Wyld and Wright, 1997).

We divide the granitic rocks into 11 map units based on petrographic character, crosscutting relations, and distribution, which understate the variety and complexity of rock types. Inclusions of and complex intermixing (sharp to gradational contacts) of biotite megacrystic granodiorite (Jgb) with hornblende gabbro (Jgh), biotite diorite (Jdb), diorite (Jdi), and fine- and medium-grained granodiorite (Jgf, Jgd) suggest they are evolving parts of a single, major intrusive episode. Chloritized mafic minerals, pyrite, and

common epidote veinlets indicate propylitic alteration, which is present in all except aplite (Ja) and pegmatite (Jp).

Jp Pegmatite (Jurassic) Coarse feldspar-quartz, locally black tourmaline- or biotite-bearing pegmatites form scattered thin dikes throughout the granitic area. The dikes are commonly zoned from feldspar-rich margins to quartz-rich cores, which locally contain late tourmaline crystals to 3 cm. Tourmaline also occurs as non-pegmatitic fracture coats. Where present, biotite is as large as 1.5 cm. Most pegmatite dikes strike northwest to west, are ≤20 cm wide, and can be tracked laterally no more than about 10 m. Because they weather recessively, they are only exposed in outcropping granitic rock. The only mapped pegmatite is poorly exposed at a small prospect 1 km north of the mouth of Horse Canyon, where it is probably >2m thick, and can be tracked in float for about 100 m. It contains large (30 cm) feldspar crystals and is by far the largest and coarsest-grained pegmatite encountered.

Ja Aplite dikes (Jurassic) White- to cream-colored, sugary-textured aplite dikes that consist entirely of ≤1 mm quartz and feldspar with trace to 0.5% rounded quartz phenocrysts up to 0.5 mm diameter occur through most of the granitic area. Most aplites strike west to northwest, are ≤1 m thick, and can be traced for ≤100 m, but some dikes are as much as 10 m thick and can be traced for 400 m. Strongly jointed, with weak limonite staining on joints. Aplite dikes are prominent in the field, where they are resistant to weathering and host little vegetation.

Jf Biotite felsite dikes (Jurassic) Numerous, generally northwest-striking, steeply dipping, finely porphyritic felsite dikes. Felsite dikes are prominent in the field because they form light-toned resistant ridges ~1 m high and host less vegetation than surrounding granitic rocks. Dikes occur throughout the granitic area but are concentrated within 2.5 km of the range front between Horse and Ikes canyons. Individual dikes are as much as 40 m wide and can be traced for as much as 1 km. Sparse phenocrysts of plagioclase, quartz, and biotite to 1 mm occur in an aphanitic groundmass of plagioclase, potassium feldspar, quartz, biotite, minor hornblende, and accessory apatite and titanite. The aphanitic matrix distinguishes biotite felsite from fine-grained granodiorite, which has a fine-grained matrix.

Jd Fine-grained diorite (Jurassic) Heterogeneous, aphyric to biotite- to hornblende-phyric diorite makes numerous thin dikes (≤5 m wide) in the northern part of the quadrangle. Two larger bodies along the range front north of Horse Creek are assigned to this unit, although the relationship to the dikes is uncertain. Phenocrysts of plagioclase (0–5%, 1–3 mm), biotite (0–10%, 0.5–2 mm), and hornblende (3%, 1–3 mm needles) reside in a fine, dark matrix. Similar to diorite (Jdi) and biotite diorite (Jdb) but spatially separated, and the variants do not make separate dikes.

Jm Mafic dikes and larger intrusions (Jurassic) Two large bodies and numerous north-northwest- to north-striking dikes of mostly black to medium gray, aphanitic, mafic intrusions cut medium-grained granodiorite (Jgd) south of Horse Creek. The larger bodies are as much as 300 m across, and edges are covered by Quaternary deposits. Most of the rock is massive and so fine-grained to be featureless. Thin section shows abundant trachytic plagioclase microlites, altered biotite plates to 0.3 mm long, and altered, equant hornblende to 0.2 mm. Slightly coarser parts are fine diorite with matrix plagioclase to 1 mm.

Jgf Finer-grained granodiorite (Jurassic) Heterogeneous, relatively fine-grained (1–2 mm) granodiorite forms a large, contiguously mapped body northwest of Horse Creek as well as numerous dikes. Finer grain size and more felsic composition distinguishes this unit from "coarser-grained granodiorite" (Jgd), which contains a similar but coarser mineral assemblage. Mineral assemblage in the large body consists of plagioclase (45–70%, 0.5 to rarely 2 mm, locally altered to sericite), quartz (15–25%, ≤0.5 mm, interstitial to plagioclase), microcline (15–25%, irregular poikilitic grains <1–3 mm), biotite (1–3%, ≤1mm), hornblende (<1–2%, 0.5–1 mm), and equant opaque grains probably magnetite (<1%, ≤0.5 mm). Dikes commonly have the lowest plagioclase, biotite, and hornblende and highest quartz and microcline contents. Titanite, apatite, and zircon are ubiquitous accessory minerals. A U-Pb zircon date is 187.56±1.44 Ma (H22-CC229, table 1). This sample also contained the abundant, 230.81±1.75 Ma zircon xenocrysts.

Three minor rock types, not mapped separately and described in more detail below, are (1) leucocratic granodiorite, (2) moderately biotite-rich granodiorite with a foliation from oriented biotite, and (3) microporphyritic granodiorite with 5–20% rounded, white plagioclase phenocrysts up to 2 mm diameter. Where exposed, the four rock types show both sharp and gradational contacts between each other. Finer-grained granodiorite dikes cut both medium-grained granodiorite (Jgd) and larger bodies of fine-grained granodiorite. Finer- and coarser-grained variants are locally gradational. These relations indicate complex intrusive history and suggest that the different grain sizes may partly reflect variable cooling rate of an overall large body of granodiorite.

The predominant finer-grained granodiorite is medium gray, equigranular, has 1–2 mm diameter grains, and 10–20% mafic minerals. Rarely weakly foliated. Common prominent joints form sheeted, parallel to acutely intersecting sets that result in resistant pyramidal outcrops. Most sheeted joints strike NE, approximately parallel to the four major canyons within the granitic area, which suggest that the canyons may contain covered fault/fracture zones. This type covers large areas in the northern part of the quadrangle, in the upper parts of Cherry, Ikes, and Gold Hill creeks. In the canyon of Gold Hill Creek, forms prominent, small to large outcrops surrounded by leucocratic granodiorite float.

(1) Leucocratic granodiorite is pale brownish gray, equigranular, has ≤1% mafic minerals, and 1 mm grains. Commonly strongly jointed. Mostly recessive and forms

slopes with angular blocks among sparse outcrops. Flow banded, where it intrudes the predominant finer-grained granodiorite. Locally forms small dikes containing abundant rounded enclaves of fine- to medium-grained diorite. In a few places appears to intrude itself, forming 5-m-wide, long, linear zones of more resistant rock. Leucocratic granodiorite underlies large areas of the lower slopes in upper Ikes Canyon, Gold Hill Creek, and along the range front between Dry Canyon and the north boundary of the quadrangle.

(2) Biotite-rich, apparently more mafic, gray, equigranular granodiorite has a foliation formed by oriented biotite. This recessive unit forms few outcrops but may underlie large areas of non-outcropping, partly limonitic grus exposed in dozer cuts and numerous small pits in the lower slopes on the east side of upper Ikes Canyon.

(3) Moderately mafic, microporphyritic, light gray granodiorite with 5–20% rounded, white plagioclase phenocrysts up to 2 mm diameter occurs only as small, scattered outcrops.

Steeply dipping limonitic shear zones and coarsely banded (1–20 cm) milky quartz-pyrite (now limonite) pods and veins are present in all rock types. Nearly all quartz veins strike WNW. Shear zones are more variable but mostly strike NW. Some quartz veins and shear zones are at the contact of this unit with biotite felsite (Jf).

Jgd Coarser-grained granodiorite (Jurassic) Medium-grained, speckled, mostly equigranular granodiorite forms most of the southern exposures of granitic rock in and south of Horse Canyon and is present as far north as the ridge northwest of Ikes Creek. Forms both prominent blocky outcrops and large areas that consist of sandy soil (grus) without outcrop. Minerals same as fine-grained granodiorite (Jgf) except coarser grained size of the major constituents: plagioclase (60–70%, 1–4 mm, anhedral), quartz (3–15%, <1–3 mm, commonly strained), microcline (10–15%, irregular poikilitic grains <1–4 mm), biotite (2–7%, 1–4 mm), hornblende (3–8%, 1 to rarely 10 mm), and equant opaque grains probably magnetite (<1%, ≤0.5 mm). Titanite, apatite, and zircon are ubiquitous accessory minerals. Locally moderately chloritized and with epidote veinlets. Rounded enclaves of diorite up to 20 cm diameter are scattered throughout.

Jdb Biotite diorite (Jurassic) Diorite with abundant biotite makes numerous northeast- to north-striking dikes mostly cutting biotite megacrystic granodiorite (Jgb) in the northernmost part of the quadrangle. The dikes vary from ~1 to 100 m thick, and the larger dikes can be traced for ~600 m. Consists of plagioclase (50–70%, 0.5–1 mm), biotite (10–15%, ≤1.5 mm), hornblende (10–15%, ≤1 mm), quartz (0–3%, 0.1–0.3 mm, interstitial), and potassium feldspar (0-trace, 0.2 mm, interstitial). Titanite and apatite are minor constituents. Contains inclusions of hornblende gabbro (Jgh) and biotite megacrystic granodiorite (Jgb). Biotite is aligned parallel to dikes and wraps around inclusions.

Jgh Hornblende gabbro dikes (Jurassic) Fine to coarse hornblende gabbro to diorite forms several thin dikes along the northern edge of the quadrangle. Rock consists of hornblende (30–70%, mostly 0.1–2 mm and up to 8 mm in the dike represented by sample H22-CC180), plagioclase (10–70%, 0.1–2 mm), biotite (1–5%, to 1 mm), and clinopyroxene (0–1%; cores in some hornblende grains). Titanite as large as 1 mm constitutes nearly 1% of one sample. Fine-grained dikes are porphyritic with 0.5–1.5 mm plagioclase phenocrysts in a fine matrix of plagioclase and hornblende. Common as inclusions in diorite (Jdi) and biotite diorite (Jdb).

Jgb Biotite megacrystic granodiorite (Jurassic) Medium-grained, dark gray granodiorite containing prominent, large (generally 1 to 2.5 cm in diameter and some to 5 cm) but thin (≤1 mm), "shreddy", light-golden brown to black biotite plates is the oldest rock in the Calavera Canyon quadrangle. The locally poikilitic megacrysts vary from sparse to 10% and unoriented to locally forming a weak foliation. Mineral assemblage consists of plagioclase (65–70%, <1–3 mm), quartz (5–8%, ≤1 mm, interstitial), orthoclase (1–8%, <1–3 mm, interstitial to poikilitic), biotite (10–15%, 1–25 mm), hornblende (5–10%, 1–3 mm), clinopyroxene (<1% as cores to a few hornblende grains), and opaque minerals (<1%, ≤0.3 mm). Mafic minerals are distinctly more abundant than in medium- or fine-grained granodiorite (Jgd, Jgf). Granophyre is present in one thin section. Titanite and apatite are ubiquitous, and zircon is present in one thin section. Intruded by and commonly forms inclusions in all other granitic rocks. Contacts with medium- and fine-grained granodiorite are sharp to gradational, which indicates the biotite megacrystic granodiorite was hot when the younger granodiorites intruded. Forms distinctive 1–20 m high, dark outcrop clusters of rounded blocks with a "lumpy" 5–20 mm scale surface texture as well as difficult-to-map areas of poorly exposed grus. Covers large areas at higher elevations along the range front between Dry Canyon and the north boundary of the quadrangle.

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Table 1. U-Pb zircon ages of Jurassic intrusions, Calavera Canyon quadrangle, McDermitt caldera, Nevada.

Sample	Unit		Age (Ma)[1] weighted mean	±2s	n/nt[2]	MSWD	Latitude NAD83	Longitude NAD83
H22-CC229	Jgf	Finer-grained granodiorite	187.56	1.44	24/24	2.10	41.83218	-118.17557
H22-CC229 xenocrysts	"	"	230.81	1.75	23/26	0.75	"	"
H22-CC362	Jgd	Coarser-grained granodiorite	187.08	1.10	49/50	0.87	41.84522	-118.16223
H22-CC165	Jgb	Biotite megacrystic granodiorite	184.51	0.89	50/50	0.33	41.87150	-118.20788

Analyses at Arizona LaserChron Center, University of Arizona.

[1] Age is weighted mean of $^{206}Pb/^{238}U$ dates.

[2] Number of grains in weighted mean age/number of total grains analyzed.

Table 2. Geochemical analyses of igneous rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada.

Sample	H22-CC276	H22-CC271	H22-CC171	H22-CC265	H22-CC136	H22-CC229	RJL22015
Map Unit	Eoa	Eor	Jf	Jm	Jgf	Jgf	Jgf
Latitude	41.83858	41.85251	41.86911	41.85806	41.86114	41.83218	41.87467
Longitude	-118.18008	-118.19588	-118.20657	-118.19506	-118.19609	-118.17557	-118.18803
Lab	ALS	ALS	ALS	ALS	ALS	ALS	ALS
Major oxides (wt %)							
SiO2	57.60	78.28	69.92	56.07	74.38	69.40	76.38
TiO2	1.15	0.16	0.31	0.86	0.15	0.35	0.12
Al2O3	15.77	15.15	15.00	18.25	14.45	14.74	13.3
Fe_2O_3	6.95	1.30	3.17	7.73	1.22	3.11	1.08
MnO	0.12	0.02	0.05	0.11	0.02	0.07	0.02
MgO	5.21	0.23	1.07	3.55	0.30	1.65	0.17
CaO	6.49	0.17	2.80	7.50	1.76	3.27	0.94
Na_2O	3.56	0.46	4.06	3.68	4.34	4.16	3.99
K_2O	2.38	4.00	3.30	1.80	3.16	2.94	3.80
P_2O_5	0.48	0.07	0.12	0.29	0.05	0.13	0.04
Cr_2O_3	0.03	<0.002	0.00	0.00	0.00	0.01	<0.002
SrO	0.12	0.01	0.07	0.08	0.05	0.06	0.03
BaO	0.13	0.15	0.13	0.07	0.13	0.11	0.13
LOI	1.71	3.78	0.62	0.89	0.47	0.53	0.65
Total[1]	99.16	99.60	101.66	99.28	101.98	100.30	100.79
Minor and trace elements (ppm)							
Li	*10*	*70*	*10*	*10*	*10*	*10*	*<10*
Sc	*15*	*1*	*3*	*14*	*1*	*6*	*<1*
V	191	20	63	213	18	76	14
Cr	184	9	20	22	26	38	10
Co	*22*	*2*	*7*	*17*	*2*	*8*	*1*
Ni	*40*	*4*	*4*	*6*	*3*	*12*	*2*
Cu	*26*	*6*	*3*	*40*	*2*	*7*	*4*
Zn	*110*	*53*	*29*	*41*	*15*	*32*	*9*
Ga	22.4	23.8	17.4	23.3	16	17	14
As	*17*	*9*	*<5*	*<5*	*5*	*<5*	*<5*
Rb	58.3	118.5	92	56.6	81.8	89.6	97.8
Sr	1055	122	634	701	442	555	253
Y	18.1	7.4	12	21.8	7.7	12.6	8.6
Zr	152	85	118	105	104	114	73
Nb	10.4	8.74	5.15	4.93	4.92	4.74	3.89
Mo	*1*	*<1*	*<1*	*<1*	*1*	*1*	*2*
Ag	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Cd	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Sn	1.4	4	0.5	1.5	<0.5	0.7	0.5
Cs	13.55	8.56	1.42	2.41	6.31	1.34	2.89
Ba	1120	1240	1145	573	1145	989	1170

Sample	H22-CC276	H22-CC271	H22-CC171	H22-CC265	H22-CC136	H22-CC229	RJL22015
Hf	3.98	3.12	3.15	3	2.7	3.09	2.17
Ta	0.6	0.7	0.4	0.3	0.4	0.4	0.5
W	0.8	1.2	2.2	1.7	0.7	<0.5	1
Tl	*<10*	*<10*	*<10*	*<10*	*<10*	*<10*	*<10*
Pb	*13*	*28*	*6*	*<2*	*9*	*6*	*9*
Th	5.72	2.69	7.95	2.79	9.37	6.74	11.25
U	2.15	3.58	2.46	1.41	3.36	2.67	2.31
La	30.4	11	21.7	15.2	14.1	14.3	13.3
Ce	63.6	17.5	40.8	31.2	30.5	28.1	20.3
Pr	7.8	2.8	4.61	4.15	2.84	3.33	2.19
Nd	34.2	11.7	17.2	18.8	9.6	14.1	8
Sm	7.09	2.58	3.03	4.48	1.94	2.61	1.46
Eu	1.8	0.66	0.69	1.24	0.52	0.81	0.38
Gd	5.31	2.15	2.36	4.42	1.37	2.34	1.26
Tb	0.62	0.25	0.37	0.56	0.2	0.35	0.17
Dy	4.05	1.27	2.01	3.87	1.42	2.29	1.05
Ho	0.7	0.24	0.42	0.83	0.28	0.43	0.28
Er	2.1	0.7	1.07	2.46	0.92	1.35	0.84
Tm	0.29	0.1	0.16	0.35	0.15	0.19	0.14
Yb	1.62	0.63	1.5	2.19	1.15	1.46	1.27
Lu	0.24	0.06	0.2	0.35	0.19	0.2	0.18

Table 2. Geochemical analyses of igneous rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada (continued).

Sample	**H22-CC101**	**H22-CC246**	**H22-CC362**	**RJL22020**	**H22-CC139**	***H22-CC238***	**H22-CC173**
Map Unit	Jgd	Jgd	Jgd	Jgd	Jdb	Jdb	Jgh
Latitude	41.85994	41.8701	41.84522	41.84075	41.85953	41.87605	41.86958
Longitude	-118.18601	-118.19328	-118.16223	-118.18609	-118.1961	-118.19586	-118.20547
Lab	ALS	ALS	ALS	ALS	ALS	ALS	ALS
Major oxides (wt %)							
SiO2	65.36	62.45	65.46	57.56	61.98	57.82	55.02
TiO2	0.48	0.65	0.61	0.85	0.62	0.84	0.75
Al2O3	16.27	15.74	15.73	18.03	16.61	16.61	13.33
Fe_2O_3	4.06	5.46	4.80	6.58	5.25	7.23	8.91
MnO	0.10	0.11	0.06	0.11	0.13	0.14	0.16
MgO	1.64	3.37	2.25	3.46	2.35	4.20	6.76
CaO	4.12	5.28	4.36	6.82	4.89	7.01	8.37
Na_2O	4.79	4.09	3.55	4.43	4.68	3.76	2.43
K_2O	2.83	2.45	2.86	1.69	3.05	1.93	3.72
P_2O_5	0.18	0.22	0.14	0.25	0.26	0.25	0.37
Cr_2O_3	0.00	0.01	0.00	0.01	0.00	0.01	0.03
SrO	0.06	0.07	0.04	0.10	0.08	0.09	0.08
BaO	0.09	0.10	0.12	0.10	0.09	0.10	0.07
LOI	0.47	0.68	0.99	0.84	1.77	1.01	0.87
Total	100.82	98.14	100.05	99.72	100.76	100.22	100.91
Minor and trace elements (ppm)							
Li	*10*	*10*	*20*	*10*	*10*	*10*	*10*
Sc	*7*	*13*	*10*	*14*	*10*	*19*	*29*
V	87	156	126	191	117	238	236
Cr	22	66	32	47	22	42	184
Co	*8*	*16*	*15*	*20*	*12*	*21*	*35*
Ni	*5*	*17*	*13*	*25*	*6*	*9*	*39*
Cu	*1*	*12*	*46*	*49*	*18*	*17*	*71*
Zn	*60*	*69*	*31*	*71*	*101*	*72*	*82*
Ga	19.6	18.2	19.8	22.8	21.1	21.2	16.2
As	*<5*	*<5*	*<5*	*<5*	*<5*	*<5*	*<5*
Rb	54.6	66.1	100	57.3	95.1	47.9	94.6
Sr	562	651	397	843	703	762	665
Y	22.5	18.2	19	20.2	31.7	17.6	19
Zr	153	105	169	140	174	94	82
Nb	6.53	5.34	5.56	4.49	7.18	4.3	4.45
Mo	*<1*	*1*	*<1*	*<1*	*<1*	*<1*	*<1*
Ag	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Cd	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Sn	0.9	1	1.2	1.3	1.3	0.9	1
Cs	2.12	1.42	4.66	3.02	2.77	1.12	1.52
Ba	785	855	1065	876	832	853	602

Sample	H22-CC101	H22-CC246	H22-CC362	RJL22020	H22-CC139	*H22-CC238*	H22-CC173
Hf	4.01	3.29	4.68	3.74	4.59	2.67	2.24
Ta	0.5	0.4	0.4	0.3	0.4	0.3	0.2
W	<0.5	0.6	1	0.6	0.5	<0.5	0.6
Tl	*<10*	*<10*	*<10*	*<10*	*<10*	*<10*	*<10*
Pb	*8*	*6*	*2*	*5*	*10*	*3*	*4*
Th	4.14	4.74	12.55	4.78	3.16	4.64	3.5
U	1.94	2.3	3.51	1.69	1.68	2.06	1.6
La	14.9	17.7	13	16.6	16.4	14.1	11.6
Ce	28.3	36.7	29.1	36.3	32.9	30.4	24.8
Pr	3.56	4.78	4.11	5.26	4.18	3.86	3.43
Nd	15.9	19.2	16.5	24.2	19.5	18.7	14.2
Sm	3.68	4.46	3.74	5.06	4.8	4.35	4.12
Eu	1.16	1.16	0.84	1.36	1.42	1.12	1.03
Gd	3.76	3.71	3.61	4.68	4.97	3.66	4.05
Tb	0.61	0.54	0.55	0.63	0.82	0.56	0.61
Dy	4.02	3.47	3.63	4.3	4.97	3.49	3.4
Ho	0.7	0.63	0.66	0.72	1.06	0.63	0.73
Er	2.48	1.85	2.02	2.04	3.21	1.9	2.14
Tm	0.34	0.26	0.3	0.28	0.47	0.27	0.29
Yb	2.86	2.03	1.95	2.03	3.49	2	1.96
Lu	0.33	0.34	0.23	0.28	0.49	0.25	0.34

Table 2. Geochemical analyses of igneous rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada (continued).

Sample	**H22-CC180**	***H22-CC187***	***H22-CC231***	**H22-CC165**	**H22-CC244**	**H22-CC252**
Map Unit	Jgh	Jgh	Jgh	Jgb	Jgb	Jgb
Latitude	41.87263	41.8755	41.8752	41.87147	41.87422	41.85222
Longitude	-118.20058	-118.20151	-118.19316	-118.20793	-118.1965	-118.20278
Lab	ALS	ALS	ALS	ALS	ALS	ALS
Major oxides (wt %)						
SiO2	50.69	57.46	53.15	58.83	61.12	68.31
TiO2	0.50	0.99	1.08	0.88	0.83	0.40
Al2O3	9.70	13.15	17.51	17.33	16.82	15.74
Fe_2O_3	8.17	8.17	9.04	6.62	5.71	3.02
MnO	0.16	0.16	0.16	0.12	0.10	0.06
MgO	17.68	6.94	5.09	3.35	2.98	1.27
CaO	9.04	8.16	8.50	6.26	5.43	3.12
Na_2O	1.64	3.34	3.60	4.17	4.11	4.28
K_2O	1.87	1.23	1.47	1.99	2.48	3.47
P_2O_5	0.15	0.23	0.24	0.28	0.22	0.12
Cr_2O_3	0.26	0.04	0.01	0.01	0.01	0.00
SrO	0.07	0.06	0.07	0.07	0.06	0.07
BaO	0.06	0.05	0.07	0.10	0.12	0.13
LOI	2.00	1.00	0.80	0.68	0.39	0.32
Total	100.15	100.74	100.01	100.69	98.52	99.76
Minor and trace elements (ppm)						
Li	*20*	*10*	*10*	*10*	*10*	*10*
Sc	*31*	*26*	*24*	*15*	*13*	*4*
V	152	264	307	202	172	73
Cr	1885	326	63	32	38	24
Co	*57*	*33*	*26*	*20*	*19*	*8*
Ni	*403*	*77*	*13*	*14*	*20*	*9*
Cu	*26*	*12*	*40*	*33*	*21*	*9*
Zn	*73*	*79*	*69*	*85*	*70*	*39*
Ga	12	19.3	22.5	23.1	20.5	19.2
As	*<5*	*<5*	*<5*	*<5*	*<5*	*<5*
Rb	71.7	26.8	39.3	66	74.9	92.3
Sr	629	576	637	702	563	654
Y	10.2	20.4	22.6	19.7	18.4	11.1
Zr	52	77	92	208	118	137
Nb	2.45	5.8	4.06	4.29	5.02	4.44
Mo	*<1*	*<1*	*1*	*1*	*1*	*<1*
Ag	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Cd	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Sn	0.7	1.1	1.1	0.9	1	0.9
Cs	4.67	0.83	1.03	2	2.32	1.76
Ba	579	451	596	870	1085	1145

Sample	H22-CC180	*H22-CC187*	*H22-CC231*	H22-CC165	H22-CC244	H22-CC252
Hf	1.26	2.59	2.52	5.69	3.24	4.01
Ta	0.2	0.5	0.3	0.3	0.3	0.4
W	0.6	0.5	0.8	0.8	0.8	0.8
Tl	*<10*	*<10*	*<10*	*<10*	*<10*	*<10*
Pb	*<2*	*3*	*<2*	*4*	*5*	*10*
Th	1.8	5.38	2.24	4.86	4.67	9.52
U	0.73	2.19	1.14	2.37	2.58	3.98
La	10.2	18.2	11	16.7	14.8	17.2
Ce	22.2	37.3	25	35.9	32.4	34.1
Pr	2.93	4.74	3.8	5.02	4.32	4.13
Nd	13.3	20.6	17.6	21.5	19.2	17.3
Sm	2.32	4.05	4.14	4.46	4.2	3.22
Eu	0.81	1.33	1.27	1.42	1.1	1.01
Gd	2.31	4.46	4.34	4.44	3.78	2.24
Tb	0.35	0.61	0.69	0.56	0.53	0.33
Dy	2.11	3.85	3.95	3.68	3.82	2.12
Ho	0.38	0.84	0.83	0.73	0.65	0.38
Er	1.21	2.23	2.22	2.01	1.85	1.1
Tm	0.18	0.33	0.35	0.26	0.27	0.17
Yb	1.13	2.25	2.17	1.8	1.66	1.21
Lu	0.17	0.34	0.32	0.27	0.23	0.16

Table 2. Geochemical analyses of igneous rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada (continued).

Sample	11McD307	11McD310	11McD311	11McD313	09McD91	09McD92A	09McD93
Map Unit	Eoa	Eoa	Eoa	Eoa	Jm	Jm	Jm
Latitude	41.87152	41.87476	41.87476	41.86454	41.80889	41.80222	41.80194
Longitude	-118.14674	-118.16085	-118.16085	-118.15392	-118.17611	-118.16611	-118.16722
Lab	WSU	WSU	WSU	WSU	WSU	WSU	WSU
Major oxides (wt %)							
SiO2	63.50	62.49	60.04	61.34	65.78	53.68	52.38
TiO2	1.11	1.13	1.20	1.57	0.98	1.37	1.30
Al2O3	15.84	16.55	16.78	13.19	17.63	16.61	15.17
Fe_2O_3	5.40	6.26	6.60	9.58	2.63	7.24	8.73
MnO	0.07	0.07	0.06	0.27	0.03	0.21	0.17
MgO	0.57	2.11	1.58	1.58	0.38	3.36	6.01
CaO	1.16	3.13	5.04	4.18	3.49	10.90	9.65
Na_2O	3.20	4.29	2.82	3.80	4.97	3.58	3.16
K_2O	8.60	3.40	5.30	3.73	3.64	2.47	2.87
P_2O_5	0.56	0.56	0.56	0.76	0.48	0.59	0.57
Cr_2O_3							
SrO							
BaO							
LOI							
Total	97.16	97.17	93.00	96.73	95.59	92.73	91.68
Minor and trace elements (ppm)							
Li							
Sc	*10*	*13*	*12*	*31*	*10*	*18*	*19*
V	111	120	111	60	87	187	184
Cr	102	137	147	1	45	390	390
Co							
Ni	*35*	*54*	*40*	*5*	*10*	*138*	*187*
Cu	*25*	*37*	*34*	*8*	*28*	*3*	*40*
Zn	*91*	*92*	*76*	*127*	*52*	*95*	*121*
Ga	20	20	19	20	20	20	17
As							
Rb	255	86	150	105	79	45	66
Sr	222	1000	677	195	963	1262	1007
Y	15	16	15	52	19	17	16
Zr	213	189	184	302	216	156	144
Nb	14	13	14	11	12	9	7
Mo							
Ag							
Cd							
Sn							
Cs	4	9	15	5	6	4	2
Ba	1408	1363	1176	2261	1294	2161	1537

Sample	11McD307	11McD310	11McD311	11McD313	09McD91	09McD92A	09McD93
Hf	5	5	5	6	6	4	4
Ta	0.9	0.9	0.9	0.9	0.8	0.5	0.4
W							
Tl							
Pb	*13*	*11*	*11*	*14*	*16*	*14*	*10*
Th	9	8	7	9	9	6	5
U	4	2	2	8	2	2	1
La	45	41	40	30	42	41	35
Ce	85	80	81	63	83	82	73
Pr	11	10	10	8	10	11	10
Nd	43	40	41	36	38	44	39
Sm	8	8	8	9	7	8	8
Eu	2	2	2	4	2	2	2
Gd	6	5	6	9	5	6	6
Tb	1	1	1	2	1	1	1
Dy	3	4	3	10	4	4	4
Ho	1	1	1	2	1	1	1
Er	1	1	1	6	2	2	2
Tm	0	0	0	1	0	0	0
Yb	1	1	1	5	2	1	1
Lu	0	0	0	1	0	0	0

Table 2. Geochemical analyses of igneous rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada (continued).

Sample	**09McD94**	**09McD95**	**09McD74**	**09McD97A**	**09McD100**	**09McD101**	**10McD236**
Map Unit	Jm	Jm	Jgd	Jgd	Jgd inclusion	Jgd	Jgd
Latitude	41.80416	41.80889	41.83583	41.81278	41.82778	41.82778	41.8445
Longitude	-118.16945	-118.17222	-118.17111	-118.1775	-118.17306	-118.17306	-118.161
Lab	WSU	WSU	WSU	WSU	WSU	WSU	WSU
Major oxides (wt %)							
SiO2	54.30	60.60	66.26	72.97	55.52	69.02	63.93
TiO2	1.00	1.02	0.56	0.42	1.20	0.49	0.67
Al2O3	19.26	16.72	15.67	15.18	18.32	16.59	17.03
Fe_2O_3	9.60	5.49	4.44	1.91	8.98	3.04	4.71
MnO	0.13	0.1	0.06	0.01	0.12	0.06	0.06
MgO	4.18	2.45	2.01	0.23	3.41	1.09	1.83
CaO	6.52	5.27	4.12	0.95	5.86	3.09	4.72
Na_2O	2.08	4.53	3.43	3.72	4.73	3.72	3.86
K_2O	2.62	3.30	3.32	4.51	1.54	2.76	3.01
P_2O_5	0.30	0.52	0.13	0.11	0.31	0.14	0.19
Cr_2O_3							
SrO							
BaO							
LOI							
Total	96.85	97.53	99.36	98.05	99.15	98.99	98.97
Minor and trace elements (ppm)							
Li							
Sc	*16*	*12*	*12*	*7*	*23*	*10*	*12*
V	199	128	112	58	240	82	114
Cr	3	58	29	17	0	28	19
Co							
Ni	*10*	*20*	*14*	*6*	*6*	*12*	*13*
Cu	*25*	*27*	*12*	*38*	*90*	*16*	*29*
Zn	*76*	*87*	*34*	*31*	*45*	*23*	*42*
Ga	21	21	17	16	21	17	20
As							
Rb	104	70	101	129	51	69	81
Sr	458	1102	348	341	603	383	543
Y	18	14	19	9	22	8	26
Zr	91	216	148	149	99	116	203
Nb	4	13	5	4	4	4	5
Mo							
Ag							
Cd							
Sn							
Cs	6	3	6	10	6	3	3
Ba	683	1394	1117	1259	799	1235	1373

Sample	09McD94	09McD95	09McD74	09McD97A	09McD100	09McD101	10McD236
Hf	3	5	4	5	3	3	6
Ta	0.3	0.8	0.5	0.4	0.3	0.3	0.3
W							
Tl							
Pb	*2*	*13*	*6*	*9*	*5*	*6*	*6*
Th	3	9	15	20	3	6	6
U	1	3	4	3	1	2	3
La	11	42	16	16	15	10	18
Ce	25	82	34	29	31	19	42
Pr	4	10	4	3	4	2	6
Nd	15	39	17	13	19	9	24
Sm	4	7	4	3	5	2	5
Eu	1	2	1	1	2	1	1
Gd	4	5	3	2	5	2	5
Tb	1	1	1	0	1	0	1
Dy	3	3	3	2	4	2	5
Ho	1	1	1	0	1	0	1
Er	2	1	2	1	2	1	3
Tm	0	0	0	0	0	0	0
Yb	2	1	2	1	2	1	2
Lu	0	0	0	0	0	0	0

Table 2. Geochemical analyses of igneous rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada (continued).

Sample	**10McD239**	**10McD258**
Map Unit	Jdb?	Jdb?
Latitude	41.84393	41.84392
Longitude	-118.16204	-118.16209
Lab	WSU	WSU
Major oxides (wt %)		
SiO2	59.94	59.74
TiO2	0.78	0.78
Al2O3	14.28	14.39
Fe_2O_3	7.16	7.00
MnO	0.10	0.10
MgO	4.80	4.85
CaO	7.00	6.89
Na_2O	3.34	3.31
K_2O	2.29	2.61
P_2O_5	0.32	0.33
Cr_2O_3		
SrO		
BaO		
LOI		
Total	94.99	95.47
Minor and trace elements (ppm)		
Li		
Sc	*19*	*19*
V	168	170
Cr	160	161
Co		
Ni	*49*	*44*
Cu	*31*	*39*
Zn	*52*	*48*
Ga	17	16
As		
Rb	55	57
Sr	724	732
Y	19	20
Zr	112	113
Nb	5	5
Mo		
Ag		
Cd		
Sn		
Cs	6	6
Ba	1073	922

Sample	10McD239	10McD258
Hf	3	3
Ta	0.3	0.3
W		
Tl		
Pb	*5*	*6*
Th	7	7
U	3	3
La	19	18
Ce	42	43
Pr	6	6
Nd	23	24
Sm	5	5
Eu	1	2
Gd	4	4
Tb	1	1
Dy	4	4
Ho	1	1
Er	2	2
Tm	0	0
Yb	2	2
Lu	0	0

Samples in italics are outside Calavera Canyon quadrangle.
Different elements were analyzed by different methods. Blank cells indicate that element was not analyzed by that method.
All analyses normalized to 100%, anhydrous. Major oxides in %; trace elements in ppm.
[1] Pre-normalization total.
ALS. analyses at ALS Geochemistry: major oxides by fused bead, acid digestion, and ICP-atomic emission spectrometry (ME-ICP06); trace elements (regular type) fused bead, acid digestion and ICP-mass spectrometry (ME-MS81) or (italics) four acid digestion and ICP-atomic emission spectroscopy (ME-4ACD81).
WSU. Analyses at Washington State University Geoanalytical Laboratory: major oxides and trace elements (italics) by X-ray fluorescence; trace elements (regular type) by fusion, acid digestions, and ICP-mass spectrometry.

Table 3. $^{40}Ar/^{39}Ar$ ages of volcanic rocks, Calavera Canyon quadrangle, McDermitt caldera, Nevada.

Sample	Unit	Mineral	Age (Ma) weighted mean	±2σ	K/Ca	±2σ	n/nt[1]							Latitude	Longitude
Single crystal														**NAD83**	**NAD83**
H22-CC60	Lower part, intracaldera sedimentary deposits (MlrS_1)	sanidine	**15.954**	0.012	286.64	27.888	25/25							41.75794	-118.10662
H95-103	McDermitt Tuff (Mlrmtp)	anorthoclase	**16.306**	0.049	4.7	1.4	12/16							41.78911	-118.14612
	Weighted mean of 6 McDermitt Tuff (Mlrmtp)	anorthoclase	**16.37**	0.03											
C95-107	Peralkaline rhyolite lava of Calavera Canyon (Mlrcr)	sanidine	**16.399**	0.016	133	83	14/14							41.78789	-118.15333
C95-103A	Biotite rhyolite of Moonlight Mine (Mlrmr)	sanidine	**16.619**	0.020	26.7	13.4	13/14							41.78864	-118.15296
H22-CC271	Rhyolite lava dome (Eor)	sanidine	**46.214**	0.031	208.3	6.9	18/18							41.85249	-118.19588
Step heating			**plateau**	**±2σ**	**%^{39}Ar[1]**	**n/nt[1]**	**isochron**	**±2σ**	**$^{40}Ar/^{36}Ari$**	**±2σ**	**MSWD**	**total gas**	**±2σ**		
C95-105	alteration, Moonlight Mine, 2023[2]	adularia	**16.35**	0.02										41.78848	-118.15951
C95-105	alteration, Moonlight Mine, 1995	adularia	**16.32**	0.10	94.9	9/13						16.38	0.25	41.78848	-118.15951
11-McD-311	Porphyritic andesite lava (Eoa)	plagioclase	**39.18**	0.12	94.2	7/8	**39.09**	0.22	319.6	86.8	1.19	39.02	0.17	41.87434	-118.16090
H22-CC278	Porphyritic andesite lava (Eoa)	hornblende	**40.77**	0.02	88.5	10/11	**40.79**	0.04	295.1	2.1	1.93	40.38	0.95	41.83855	-118.18158
MD-6	Porphyritic dacite lava (north of quadrangle)	plagioclase	**46.74**	0.41	80.4	8/10	**46.91**	0.27	277.0	14.7	2.62	46.30	0.28	41.91664	-118.18555

Samples in italics are outside Calavera Canyon quadrangle. Ages in bold are best estimates of eruption, intrusion, or depositional age; plateau and isochron ages are valid for several samples.

Minerals were separated from crushed, sieved samples by standard magnetic and density techniques, feldspars were leached with dilute HF to remove matrix, and all samples handpicked.

All analyses at New Mexico Geochronological Research Laboratory, New Mexico Institute of Mining and Technology. Analytical methods in Henry et al. (2017).

Weighted mean $^{40}Ar/^{39}Ar$ ages calculated by the method of Samson and Alexander (1987).

Neutron flux monitor Fish Canyon Tuff sanidine (FC-1); assigned age = 28.201 Ma (Kuiper et al. 2008).

Isotopic abundances and decay constants after Steiger and Jäger (1977) and Min et al. (2000).

[1]Number of single grains in weighted mean age/number total grains analyzed, or percent ^{39}Ar (step heating) used in age calculation.

[2] Re-separation and analysis, 2023; weighted mean of 8 plateau and isochron dates.

Table 4. Geochemical analyses of mineralized samples, Calavera Canyon quadrangle, McDermitt caldera, Nevada.

	Sample	**RJL22029**	**RJL22030**			**H22-CC306**	**H22-C307**	**H22-CCrx**	**C95-120**	**MLT8**	**MLT4S**	**MLT18**
	Location	prospect	Iron King Mine			Moonlight Mine	Moonlight Mine	Moonlight Mine	Moonlight Mine	Moonlight Mine	Horse Creek	Horse Creek
	Rock Type	Quartz vein and limonitic shear zone	Pyritic quartz vein			Oxidized breccia	Silicified breccia	Altered Mrmr rhyolite	Oxidized breccia	Oxidized breccia	Sulfidic rhyolite	Sulfide vein in brecciated rhyolite; core 232xc, 783.9'
	Latitude	41.8697	41.87452			41.788245	41.788296	41.788519	41.78778	41.78778	41.83806	41.80639
	Longitude	-118.17554	-118.17416			-118.159764	-118.15958	-118.159639	-118.15917	-118.15917	-118.15833	-118.16306
ME-MS61	**Ti %**	0.029	0.01	ME-MS81	**Ti %**	0.24	0.61	0.18	0.27	0.24	0.07	0.31
ME-MS61	**Al %**	0.8	0.39		**Al %**							
ME-MS61	**Fe %**	20.1	6.04		**Fe %**							
ME-MS61	**Mn ppm**	105	732		**Mn ppm**							
ME-MS61	**Mg %**	0.07	1.05		**Mg %**							
ME-MS61	**Ca %**	0.1	2.59		**Ca %**							
ME-MS61	**Na %**	0.02	0.03		**Na %**							
ME-MS61	**K %**	0.31	0.06		**K %**							
ME-MS61	**P ppm**	1210	160		**P ppm**							
ME-MS61	**S %**	0.2	5.32		**S %**							
ME-MS61	**Li**	8.5	2.3	ME-4ACD81	**Li**	10	10	20	20	20	110	10
ME-MS61	**Be**	0.18	0.14		**Be**							
ME-MS61	**P**	1210	160		**P**							
ME-MS61	**Sc**	3.4	5.7	ME-MS81	**Sc**	<0.5	<0.5	3.3	<0.5	<0.5	13.9	11.4
	Sc			ME-4ACD81	**Sc**	12	13	2	22	34	18	9
ME-MS61	**V**	89	18	ME-MS81	**V**	29	69	14	57	67	60	82
ME-MS61	**Cr**	19	55	ME-MS81	**Cr**	25	82	8	45	40	32	69
ME-MS61	**Mn**	105	732		**Mn**							
ME-MS61	**Co**	12.4	264	ME-4ACD81	**Co**	2	3	1	13	59	3	10
ME-MS61	**Ni**	20	14.9	ME-4ACD81	**Ni**	12	12	3	23	77	48	54
ME-MS61	**Cu**	218	23.7	ME-4ACD81	**Cu**	67	240	7	174	179	78	66
ME-MS61	**Zn**	62	9	ME-4ACD81	**Zn**	200	173	7	299	460	16	102
ME-MS61	**Ga**	3.34	1.2	ME-MS81	**Ga**	12.4	15.4	15.6	13.4	12	4.4	13.4

	Sample	RJL22029	RJL22030			H-22-CC306	H22-C307	H22-CCrx	C95-120	MLT8	MLT4S	MLT18
ME-MS61	**Ge**	0.1	0.11		**Ge**							
ME-MS61	**As**	350	18.2	ME-4ACD81	**As**	2960	6230	281	2580	3850	8960	768
ME-MS61	**Se**	1	2		**Se**							
	Br				**Br**							
ME-MS61	**Rb**	8.8	1.7	ME-MS81	**Rb**	226	268	332	212	198.5	41.6	306
ME-MS61	**Sr**	57.6	49.9	ME-MS81	**Sr**	182	233	85.8	225	240	77.4	603
ME-MS61	**Y**	4.9	7.7	ME-MS81	**Y**	76.3	91.4	30.7	95.7	191	234	81
ME-MS61	**Zr**	4.8	3.2	ME-MS81	**Zr**	>10000	>10000	1430	>10000	>10000	8990	1410
ME-MS61	**Nb**	0.4	0.2	ME-MS81	**Nb**	15.4	18.9	18.55	18	33.9	1.72	12.75
ME-MS61	**Mo**	42.6	11.15	ME-4ACD81	**Mo**	20	33	16	12	96	2250	1060
ME-MS61	**Ag**	2.78	0.5	ME-4ACD81	**Ag**	<0.5	<0.5	<0.5	<0.5	<0.5	>100	8.3
	Ag			Ag-OG62	**Ag**						137	
ME-MS61	**Cd**	0.06	0.1	ME-4ACD81	**Cd**	<0.5	0.5	<0.5	<0.5	1.2	<0.5	0.8
ME-MS61	**In**	0.207	0.028									
ME-MS61	**Sn**	0.2	0.2	ME-MS81	**Sn**	2.5	4.5	1	4.4	7.3	4.4	2.9
ME-MS61	**Sb**	286	9.47		**Sb**							
ME-MS61	**Te**	3.64	9.76		**Te**							
ME-MS61	**Cs**	1.32	0.2	ME-MS81	**Cs**	1.82	2.87	2.34	1.76	2.05	1.87	4.21
ME-MS61	**Ba**	220	20	ME-MS81	**Ba**	548	1445	1205	615	747	1555	541
ME-MS61	**Hf**	0.1	0.1	ME-MS81	**Hf**	103	119.5	11.8	114.5	270	27	12.6
ME-MS61	**Ta**	<0.05	<0.05	ME-MS81	**Ta**	0.6	0.5	1.3	0.6	0.5	0.1	0.9
ME-MS61	**W**	10.6	2.4	ME-MS81	**W**	11.2	29.4	3.1	23.2	21.7	4.4	49.2
ME-MS61	**Re**	<0.002	<0.002		**Re**							
	Ir ppb											
	Au ppb											
Hg-MS42	**Hg**	10.65	4.2	Hg-MS42	**Hg**	1.195	0.795	0.337	2.11	0.544	5.82	1.05
ME-MS61	**Tl**	1.53	0.04	ME-4ACD81	**Tl**	<10	10	<10	<10	30	90	40
ME-MS61	**Pb**	3.7	2.8	ME-4ACD81	**Pb**	24	38	15	39	38	9	45
ME-MS61	**Bi**	71.7	18.25		**Bi**							

	Sample	RJL22029	RJL22030			H-22-CC306	H22-C307	H22-CCrx	C95-120	MLT8	MLT4S	MLT18
ME-MS61	**Th**	1.23	0.25	ME-MS81	**Th**	9.81	9.89	11.95	11.85	10.05	43.8	13.8
ME-MS61	**U**	8.2	8	ME-MS81	**U**	>1000	>1000	44.3	>1000	>1000	>1000	459
ME-MS61	**La**	3.1	52.1	ME-MS81	**La**	14	20.2	35.8	18.1	23.5	7.6	30.4
ME-MS61	**Ce**	5.54	86.9	ME-MS81	**Ce**	32.1	44	71.9	42.3	52.2	25.1	68.1
	Pr			ME-MS81	**Pr**	4.06	6.15	8.36	5.94	6.8	4.82	8.82
	Nd			ME-MS81	**Nd**	16.4	24.8	29.5	24.3	26.1	25.9	35.9
	Sm			ME-MS81	**Sm**	3.93	5.21	5.57	5.92	6.48	9.32	8.67
	Eu			ME-MS81	**Eu**	0.92	1.34	1.14	1.46	1.64	2.02	1.54
	Gd			ME-MS81	**Gd**	4.45	6.66	4.91	7.49	9.91	14.6	8.91
	Tb			ME-MS81	**Tb**	0.92	1.2	0.83	1.46	2	3.2	1.49
	Dy			ME-MS81	**Dy**	8.64	9.59	5.17	12.45	15.3	27	11.35
	Ho			ME-MS81	**Ho**	2.35	2.74	1.05	2.93	3.96	6.8	2.64
	Er			ME-MS81	**Er**	8.77	9.68	3.58	10.65	13.25	28.4	9.34
	Tm			ME-MS81	**Tm**	1.38	1.48	0.53	1.64	1.74	4.74	1.46
	Yb			ME-MS81	**Yb**	9.18	10.4	3.75	11.45	11.9	37.2	10.7
	Lu			ME-MS81	**Lu**	1.36	1.6	0.58	1.78	1.88	5.95	1.57

Table 4. Geochemical analyses of mineralized samples, Calavera Canyon quadrangle, McDermitt caldera, Nevada (continued).

Sample	**C95-120***	**MLT8***	**MLT4S***	**MLT18***
Location	Moonlight Mine	Moonlight Mine	Horse Creek	Horse Creek
Rock Type	Oxidized breccia	Oxidized breccia	Sulfidic rhyolite	Sulfide vein in brecciated rhyolite; core 232xc, 783.9'
Latitude	41.78778	41.78778	41.83806	41.80639
Longitude	-118.15917	-118.15917	-118.15833	-118.16306
Ti %				
Al %				
Fe %	2.11	2.9	3	4.2
Mn ppm				
Mg %				
Ca %	8.42			
Na %	0.13	1.3	0.19	0.14
K %	5.24			
P ppm				
S %				
Li				
Be				
P				
Sc	14.2	33.3	17	9.2
Sc				
V				
Cr	51			73
Mn	0.6	50		10
Co	16	140	79	55
Ni	110	160	67.8	57.9
Cu	137			
Zn	176	389	71	112
Ga	1.88	<0.50	<0.50	<0.50

Sample	C95-120*	MLT8*	MLT4S*	MLT18*
Ge				
As	2240	3210	7830	784
Se	<1.0	<1.0	1.8	<1.0
Br	<0.1	12	22	4
Rb	230	160	<20	300
Sr	273			
Y				
Zr	20,500	49,500	8000	810
Nb				
Mo	10.4	88.3	1925	1097
Ag				
Ag	2.09	4.11	114	7.12
Cd	0.53	1.54	<0.10	1.07
Sn	1.6			
Sb	88	181	145	81
Te				
Cs	0.51	1.82	1.1	0.85
Ba	1	<1	<1	3
Hf	895			
Ta	113	203	9	9
W	0.99	<0.50	<0.50	0.8
Re	16.9	32	<5.0	43
Ir ppb	12			
Au ppb	764	206	8050	<50.0
Hg	1.63	0.42	4.79	0.81
Tl	1.8	47.2	82.6	27.3
Pb	39.1	27.5	8.9	34.7
Bi	1.14	1.21	15.2	9.15

Sample	C95-120*	MLT8*	MLT4S*	MLT18*
Th	10.7	10.0	45.5	16.0
U	1940	4420	997	488
La	5.9			25.0
Ce	31			
Pr				
Nd	14.9			
Sm	6.3			3.5
Eu	1.50			2.00
Gd				
Tb	1.26	1.30	2.30	1.60
Dy				
Ho				
Er				
Tm				
Yb	8.65	20	52	14
Lu	1.42			

Different elements were analyzed by different methods. Blank cells indicate that element was not analyzed by that method.
All analyses except * at ALS Geochemistry. Concentrations in ppm except where noted. *Analyses from Castor and Henry (2000) with methods described there.
ME-MS61, specified elements by four acid digestion and ICP-MS (mass spectrometry).
Hg-MS42, mercury by Aqua Regia digestion and ICP-MS (mass spectrometry).
ME-MS81, specified trace elements by fused bead, acid digestion, and ICP-MS (mass spectrometry).
ME-4ACD81, specified trace elements by four acid digestion and ICP-AES (atomic emission spectrometry).