

TEXT AND REFERENCES ACCOMPANYING NEVADA BUREAU OF MINES AND GEOLOGY MAP 196

Geologic Map of the Ruby Dome Quadrangle, Elko County, Nevada

by

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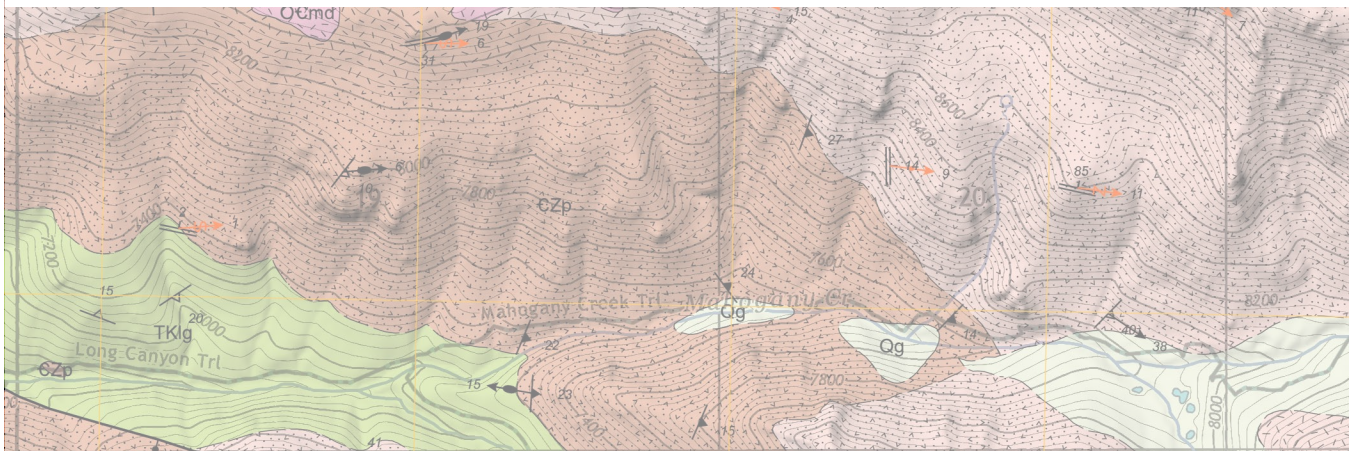
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ABSTRACT

The Ruby Dome quadrangle, Nevada, exposes a central part of the metamorphic infrastructure of the Ruby Mountains–East Humboldt Range metamorphic core complex. Much of this bedrock comprises Cretaceous and Paleogene granites that intrude amphibolite-facies metamorphosed Prospect Mountain Quartzite (Cambrian and Neoproterozoic) and strata assigned to the marble of Verdi Peak (Ordovician and Cambrian). These strata form a ghost stratigraphic framework, pervasively intruded by granite sills and other bodies, that outlines the pre-folding Ogilvie thrust fault and the northeastward-facing Lamoille Canyon fold nappe and Box Canyon recumbent syncline below it. The nappe here bends, becomes detached as a thrust fault, and disharmonically loses amplitude southwestward, where it faces the north-facing King Peak fold-and-thrust nappe. A brittle Miocene low-angle normal fault structurally superposes part of the King Peak nappe onto originally deeper rocks. Steep normal faults and basalt dikes also cut the infrastructure. Late Pleistocene glaciation extensively sculpted the region, deposited lateral valley moraines, and left a legacy of alpine glacial lakes that have yielded core records of Holocene climatic variations.

INTRODUCTION

The Ruby Mountains form an imposing range rising above basins on either side. The Ruby Dome quadrangle straddles the crest of this rugged range, and includes its highest peaks and a large area of the Ruby Mountains Wilderness in Humboldt-Toiyabe National Forest (figs. 1, 2). Elevations in the quadrangle range from 11,387 ft (3,471 m) at Ruby Dome, on a northern east-west spur of high peaks, to about 6,960 ft (2,121 m) at Battle Creek near the east foot of the range and 6,500 ft (1,981 m) at Long Canyon in the west (fig. 3; U.S. Geological Survey, 1990). Westward drainages in the quadrangle form the headwaters of the South Fork Humboldt River; those on the narrower east side of the range drain into Ruby Valley. Extensive glaciation sculpted the range into picturesque U-shaped valleys, cirques, and horns.

The upper end of the Lamoille Canyon Scenic Byway along Lamoille Creek in the northeast provides access to the Ruby Crest National Recreation Trail that extends south through the east part of the quadrangle. Other trails access other parts of the area. 4WD accessible roads in the southeast near Battle Creek and in the southwest near

Segunda Creek and Long Canyon lead to inactive mines and prospects in the Lee and the Ruby Valley mining districts.

Field guides can lead a visitor to informative outcrops and features in and near the Lamoille Canyon Scenic Byway and Castle Lake areas of the quadrangle (Snoke and Howard, 1984; Howard, 1987; Lee and Barnes, 1997; Snoke et al., 1997; Hyslop, 1999; Strike, 2000; Munroe and Laabs, 2011). Figure 4 shows the mapping responsibilities for the quadrangle.

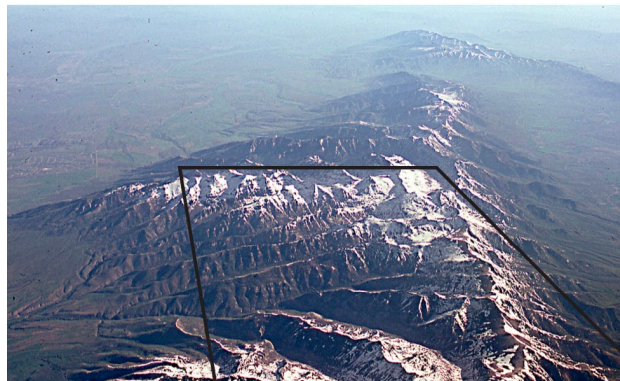


Figure 1. The Ruby Dome quadrangle approximately outlined on a northeastward aerial view of the northern Ruby Mountains and distant East Humboldt Range. Photo by W.B. Hamilton (*by permission*).

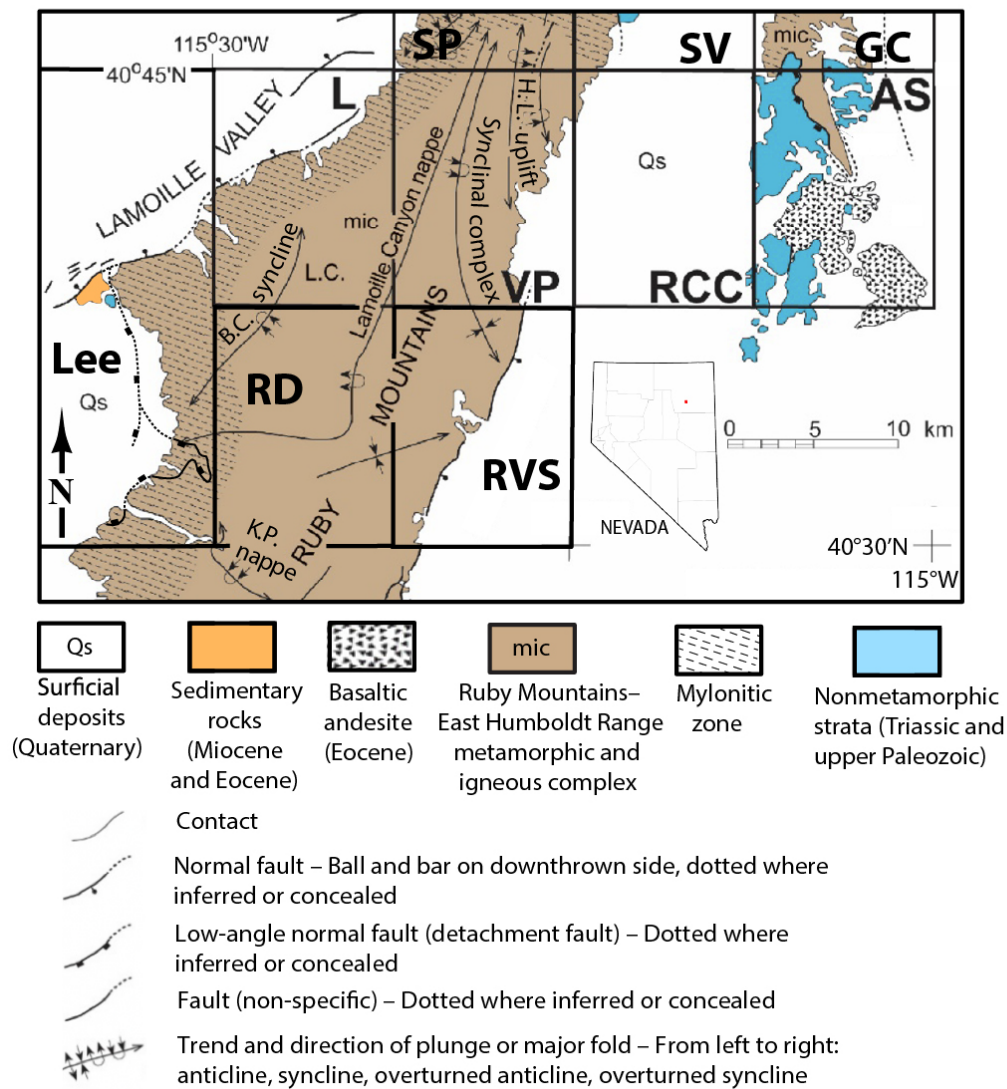


Figure 2. Generalized geologic map (modified after Howard et al., 1979; Snoke et al., 2021) showing major structures in the Ruby Dome quadrangle (**RD**) relative to other 7.5-minute quadrangles in the northern Ruby Mountains area, abbreviated as **RVS** (Ruby Valley School, Howard, 2024), **L** (Lamoille, Howard, 2000), **VP** (Verdi Peak, Howard and MacCready, 2004), **RCC** (Ruby City Creek), **AS** (Arizona Spring, Taylor et al., 2025), **SP** (Soldier Peak, Snoke et al., 2022), **SV** (Secret Valley, Snoke et al., 2021), **GC** (Gordon Creek, Sicard and Snoke, 2020), and the 15-minute **Lee** quadrangle (Smith and Howard, 1977). K.P. nappe is King Peak nappe. B.C. syncline is Box Canyon recumbent syncline. H.L. uplift is Hidden Lakes uplift.

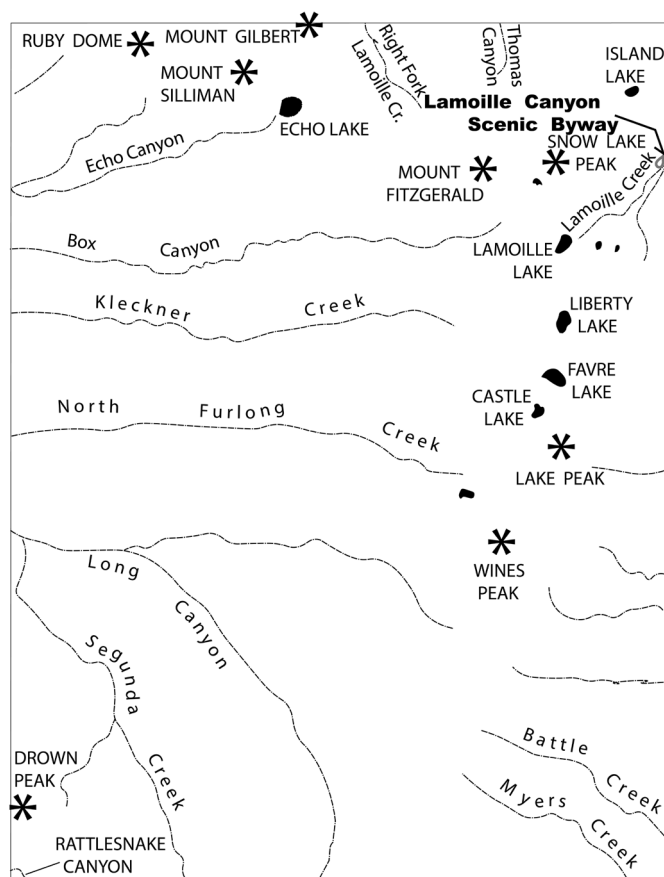


Figure 3. Geographic features in the Ruby Dome quadrangle. Named peaks shown by asterisks.

Previous Work

Sharp (1938, 1939, 1940, 1942) analyzed the geomorphology and glacial geology of the Ruby Mountains and followed Hill (1916) in suggesting that marbles and quartzites there may represent metamorphosed Paleozoic strata. Geochronologic reconnaissance by Armstrong and Hansen (1966) determined that the metamorphic and igneous complex in the quadrangle had a geologically young history based on an Oligocene (about 25 Ma) K-Ar cooling age on biotite monzogranite in the northeast part of the Ruby Dome quadrangle. Subsequent studies outlined the stratigraphic, structural, and metamorphic framework of the northern third of the quadrangle (Howard, 1966; 1971; 1987) and contributed to a geologic map of the Ruby Mountains (Howard et al., 1979) and structural syntheses (Howard, 1980, 2003). Areas adjacent to the quadrangle (figs. 1, 2) were geologically mapped and interpreted in more detail (Willden and Kistler, 1969; Smith and Howard, 1977; Howard, 2000, 2024; Jones, 1999). Topical studies report local detail and analysis from investigations of petrology and geochemistry, intrusion geochronology and petrology, stable and radiogenic isotopes, mineralization, and

metamorphic and intrusive structure (Kistler et al., 1981; Lee and Barnes, 1997; Jeon, 1999; Strike, 2000; Berger et al., 2000; Lee et al., 2003; Howard et al., 2011; Snoke et al., 2024). Detailed geologic mapping of parts of the quadrangle were presented by Snoke et al. (2024) and Strike (2000).

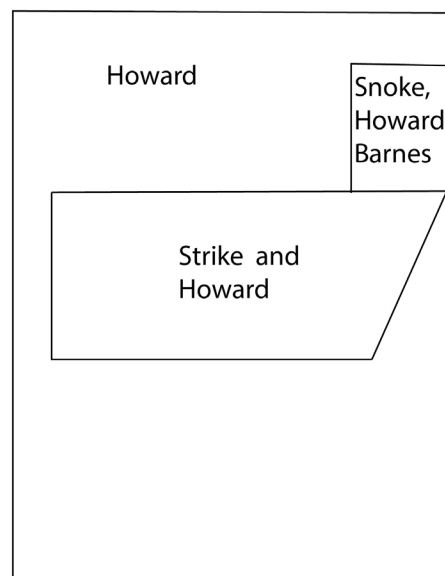


Figure 4. Geologic mapping responsibilities for the Ruby Dome quadrangle.

Geologic Framework

The bedrock exposes metamorphic infrastructure of the Ruby Mountains–East Humboldt Range metamorphic and igneous complex in an archetypical metamorphic core complex. Cretaceous and Paleogene granites intricately intrude a framework of the metamorphosed Prospect Mountain Quartzite (CZp, Cambrian and Neoproterozoic) and strata assigned to the Ordovician and Cambrian marble of Verdi Peak (OCm, fig. 5). Relics of these metamorphosed sedimentary rocks form a structural framework defined by ghost stratigraphy (Howard, 1980), intensely intruded by granitic sills and dikes, that outlines the Lamoille Canyon and King Peak nappes and the pre-folding Ogilvie thrust fault. An extensional mylonitic shear-zone overprints these structures as a carapace in the west, and in turn is partly excised by post-metamorphic low-angle-normal faulting. Adjacent geologic maps to the north (Howard, 2000), west (Smith and Howard, 1977), east (Howard, 2024), and south (Howard et al., 1979; Jones, 1999) express parts of these structures (fig. 2).

GEOLOGY

Metamorphic and Intrusive Rocks

Metamorphosed Strata

Feldspathic quartzite (€Zp) in the quadrangle correlates on the basis of stratigraphic position to the Prospect Mountain Quartzite (Lower Cambrian and Neoproterozoic); it possibly extends into the stratigraphically underlying McCoy Creek Group (Neoproterozoic). The stratigraphically overlying marble of Verdi Peak (Howard, 1980; O€m) crops out through larger areas of the quadrangle and correlates to a succession of Cambrian and Ordovician limestones and interbedded shales. A brown dolomitic marble subunit (O€md) at and near the marble unit's stratigraphic base recalls similarly positioned brown Cambrian dolomite facies in the southern Ruby Mountains and in western Utah (Howard, 1971).



Figure 5. Aerial view southward in the quadrangle at canyons draining west (to right) from the main crest of the Ruby Mountains. The inferred approximate trace of the Box Canyon recumbent syncline (dashed) in marble of Verdi Peak (O€m) is sketched on the south wall of the canyon of Kleckner Creek in the foreground, above right-way-up metamorphosed Prospect Mountain Quartzite (€Zp, below to the right). The Castle Lake intrusion of biotite monzogranite (Tm) intrudes all but small patches of an inverted, structurally higher (Castle Lake) outlier of the quartzite in the syncline's detached upper limb. Marble of Verdi Peak, interlayered with light-toned sills of pegmatitic leucogranite, underlies most of the rest of this view's mountain landscape except for quartzite in the lower limb in lower Long Canyon and North Furlong Creek (on the right). Ruby Valley lies beyond the quadrangle. Photo by Keith Howard.

Intrusive Rocks

A migmatite terrain underlies most of the area, in which profuse sheets, sills, dikes, and irregular bodies of granite intimately intrude the ghost stratigraphy framework of metamorphosed strata of the Cordilleran miogeosynclinal assemblage (fig. 6). Myriad small intrusions pervade the mapped metamorphosed stratigraphic units, where the proportion of granite is indicated on the map by overlay

patterns. Gneissic pegmatitic leucogranite gneiss greatly dominates, but medium-grained granite gneiss, commonly containing feldspar augen, is abundant, particularly in the mylonitic northwest part of the quadrangle. Pegmatitic leucogranite (TKlg) is mapped separately only where metasedimentary relics are lacking or nearly so, at the lowest structural levels in deep canyons. Medium-grained granite gneiss, biotite granite and granodiorite gneiss are common in the northwest part of the quadrangle. Medium-grained biotite granodiorite gneiss within the mapped metamorphosed Prospect Mountain Quartzite unit (€Zp) near lower North Furlong Creek resembles the Jurassic gneiss of Seitz Canyon mapped in adjacent areas (Smith and Howard, 1977; Howard, 2000; Howard et al., 2011). Other mapped intrusions are of gneissic equigranular granite gneiss (TJeg), granite gneiss of Thorpe Creek (Kt), biotite monzogranite (Tm), and areas of small gabbroic bodies mapped as a pattern of random v's. Chemical and isotopic analyses of some intrusive rocks in the quadrangle are reported in Lee et al. (2003), du Bray et al. (2007), Moscati et al. (2024), and Snoke et al. (2024).

Gneiss of Thorpe Creek and Equigranular Two-mica Granite Gneiss

The granite gneiss of Thorpe Creek (Kt) forms a sill-like body in the core of the Lamoille Canyon fold nappe, as it does farther north (Howard, 2000; Howard and MacCready, 2004; Snoke et al., 2022). The rock features scattered small garnets in a medium-grained biotite-muscovite monzogranite orthogneiss. It was dated using U-Pb on zircon as about 91 Ma in the adjacent Lamoille quadrangle (Snoke et al., 2024); Eocene U-Th-Pb ages on monazite (Wright and Snoke, 1993) are now interpreted to represent metamorphic ages (Snoke et al., 2024). Unmapped similar rock occurs within the mapped marble of Verdi Peak and metamorphosed Prospect Mountain Quartzite within 2 km of Echo Lake in the northwest part of the quadrangle and near Wines Peak in the east.

Small sheets of folded Late Cretaceous equigranular biotite-muscovite gneiss (in TJeg) in the northeast part of the quadrangle, mostly too small to map here, are intruded by the gneissic pegmatitic leucogranite, and date to about 91 Ma (fig. 7; Lee et al., 2003; Snoke et al., 2024). Similar two-mica orthogneiss but of undetermined age underlies a larger mapped area (TJeg) in the southwestern part of the quadrangle and more extensively into the adjacent quadrangle on the south, where it intrudes and postdates the King Peak nappe. Small unmapped bodies of biotite-muscovite granite gneiss also occur elsewhere in the map area.

Pegmatitic Leucogranite

Voluminous, mostly gneissic pegmatitic leucogranite (TKlg) forms myriad small to coalescing sills, sheets, and dikes, increasing in abundance structurally downward in valley bottoms. Typically this rock type is white where intruding calcareous rocks (O€m) and weathers brownish where intruding metamorphosed quartzite (€Zp). In the west part of the map area and in Lamoille Canyon north of the quadrangle, a downward proportional increase in this granite without regard to the Lamoille Canyon fold nappe implies that some of the pegmatitic leucogranite intrusions postdate the fold nappe (fig. 6b of Howard et al., 2011). The pegmatitic leucogranite has yielded Late Cretaceous U-Pb ages of about 90 to 60 Ma, and indications from U-Pb data that some of this rock type was partially remelted and recrystallized in Eocene time (Howard et al., 2011; Snoke et al., 2024). Muscovite-rich pegmatitic and equigranular leucogranite dominates the crest of the Ruby Mountains from Wines Peak to and beyond the south edge of the quadrangle.



Figure 6. Deformed, light-toned irregular pegmatitic leucogranite dikes and thin gneissic sills cut darker calc-silicate rock and marble of Verdi Peak (O€m) on 80-m-high northwest face of Lake Peak overlooking Castle Lake. The lower quarter exposes a sheet, angling down left (east), at least 50 m thick of dark younger biotite monzogranite (Tm), part of the Castle Lake intrusion. Photo by Keith Howard.

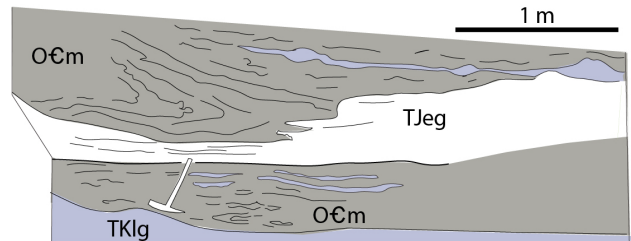


Figure 7. Sketched outcrop relations in upper Lamoille Canyon between folded diopside-phlogopite marble (O€m), light-toned less-folded equigranular two-mica granite gneiss (TJeg) and gneissic pegmatitic leucogranite (TKlg). Nearby the equigranular two-mica granite gneiss has been dated as about 91 Ma and the younger gneissic pegmatitic leucogranite has yielded ages of about 90 to 60 Ma, locally overprinted with Eocene zircon (Snoke et al., 2024). Folding during Cretaceous intrusion of the equigranular two-mica granite gneiss can explain the marble's greater folding. The folds trend NNE (015–025°) parallel to the Lamoille Canyon nappe. Photo by Keith Howard.

Paleogene Intrusions

Paleogene biotite monzogranite (Tm) forms the sill-like Snow Lake Peak and Castle Lake intrusions in the northeast and central parts, respectively, of the quadrangle and smaller unmapped sills, sheets, dikes, and irregular bodies elsewhere (fig. 6). It is part of a rock group that includes biotite-muscovite leucogranite and also hornblende-bearing dikes. Foliation (including schlieren) typically parallels contacts against host rocks. The monzogranite typically forms irregular sheetlike masses, commonly near inverted contacts between calcareous rocks of the marble of Verdi Peak (O€m) and structurally higher metamorphosed Prospect Mountain Quartzite (€Zp). The body near Castle Lake locally contains randomly oriented xenoliths of quartzite indicative of blocks stoped from the Prospect Mountain Quartzite and sunk (Strike, 2000). Elsewhere the body includes intrusion breccia of paler monzogranite intruding into darker monzogranite, or it contains enclaves of gneissic pegmatitic leucogranite. Eocene ages determined by U-Pb dating of zircon for the Snow Lake Peak intrusion help document major Eocene intrusion and reheating in the core complex during regional southward migrating magmatism

in the Basin and Range Province (Snoke et al., 2024). Some biotite monzogranite dikes and sills in the Ruby Mountains and East Humboldt Range have been dated as Oligocene, 30–29 Ma (Wright and Snoke, 1993). Isotopic and geochemical evidence indicates that some associated pegmatitic and aplitic leucogranite dikes and other small bodies were derived by Paleogene anatexis and remobilization of the gneissic Cretaceous leucogranites (Howard et al., 2011; Snoke et al., 2024).

Rarer small unmapped intrusions of fine-grained tonalitic rock associated with the biotite monzogranite were also dated by U-Pb on zircon as Eocene (Snoke et al., 2024). They intrude the marble of Verdi Peak in very irregular shapes. Gabbro of the same Eocene magmatic episode (Snoke et al., 2024) occurs locally and is mapped (by a pattern) as areas of dispersed small unmapped amphibolite bodies of metamorphosed hornblende-cummingtonite $\pm$ plagioclase $\pm$ olivine $\pm$ phlogopite-biotite $\pm$ magnetite $\pm$ titanite. The amphibolites where associated with mylonitic shear zone near the western edge of the quadrangle include epidote-green amphibole-plagioclase-quartz-magnetite-titanite assemblages. Most intrude into the marble of Verdi Peak in the footwall of the Ogilvie thrust fault, as indicated by mapped gabbro overlay pattern.

Crosscutting steep Paleogene dikes of coarse muscovite pegmatite (unmapped) occur in the northeastern part of the quadrangle, where they typically strike east-northeast as where mapped in the nearby Verdi Peak quadrangle (Lee and Barnes, 1997; Howard and MacCready, 2004; Snoke et al., 2024).

Basalt Dikes

Rare olivine basalt dikes (Tb) cut the metamorphic and granitoid rocks. They strike north, dip vertically or steeply west, and some fill pre-existing brittle normal faults. Similar dikes have been dated as middle Miocene (about 15–17 Ma) by K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ in other parts of the Ruby Mountains and East Humboldt Range (Hudec, 1990; Zuza et al., 2021a). They represent the youngest magmatic episode in the quadrangle. The presence of amygdules indicate intrusion of the basalt at shallow levels after the host rocks had been largely exhumed.

Metamorphic Mineral Assemblages

Rocks in much of the quadrangle display amphibolite-facies mineral assemblages of the muscovite-K-feldspar-sillimanite-zone. Sillimanite-quartz-biotite-plagioclase schist ($\pm$ garnet or muscovite) layers or lenses occur in the marble of Verdi Peak and locally (near Mount Silliman) in the metamorphosed Prospect Mountain Quartzite unit

(CZp). Feldspathic quartzite in that unit and some gneissic pegmatitic leucogranite (TKlg) can contain sillimanite-muscovite-K-feldspar-biotite and locally sillimanite-garnet-feldspar assemblages. The sillimanite typically is intergrown with muscovite especially and also with biotite or in kernels of sillimanite and quartz. Decreasing amounts of muscovite in the quartzite correlate with increasing amounts of sillimanite and K-feldspar. Rocks in which muscovite exceeds biotite volumetrically generally lack sillimanite, although the muscovite may appear fibrous. Sillimanite in quartzite in the lower Long Canyon area is partly retrogressed to muscovite. Feldspathic quartzite along the southern margin of the quadrangle lacks sillimanite but nearby pelitic schist in the southwest contains it. Ridgetop klippen of likely lower metamorphic-grade Prospect Mountain Quartzite that lack sillimanite in southwestern parts of the quadrangle feature coarsely crystalline biotite, muscovite, and quartz. K-feldspar in quartzofeldspathic rocks includes both orthoclase and microcline.

Diopside is nearly ubiquitous in calc-silicate rocks, which also may feature scapolite, titanite, vesuvianite, clinozoisite, quartz-calcite, phlogopite, white mica, amphibole, garnet, plagioclase, vesuvianite, epidote, graphite, K-feldspar, calcite, dolomite, and other minerals. Forsterite-calcite marble containing secondary brucite occurs in and near the brown dolomite marble unit (Ocmd) in western parts of the Long Canyon and Segunda Creek drainages, locally in association with dolomite and tremolite. Wollastonite is absent but occurs very locally a few kilometers south of the quadrangle. Garnet amphibolite occurs very locally, as does cordierite-anthophyllite-phlogopite-magnetite rock. K-feldspar porphyroblasts are common in marbles. Some calcareous rocks contain secondary actinolite.

Minerals stable during mylonitization in the mylonitic shear zone include quartz, muscovite, and K-feldspar in quartzofeldspathic rocks, epidote and calcite in biotite-hornblende schists, actinolite-calcite in metacarbonate rocks, and epidote and green hornblende in metamorphosed gabbro. Sheared granite below a brittle low-angle normal fault near Segunda Creek features a retrograded greenschist-facies chlorite-biotite assemblage.

Skarn

Skarns have formed near some contacts of the pegmatitic leucogranite against calc-silicate rocks and marble of the Verdi Peak unit. Oxygen isotopic data indicate that skarns near Island Lake relate to adjacent pegmatitic leucogranite and not to biotite monzogranite (Jeon, 1999).

The skarns typically contain coarse crystals of orange grossular garnet, vesuvianite, $\pm$ diopside, calcite, and quartz, and may include scapolite, epidote, mica, forsterite, and other minerals. Green diopside zones 5 cm thick in places circumscribe calcareous rocks against the gneissic pegmatitic leucogranite. Skarn-quartz veins are also present. Diopside marble locally fills spaces between grossularite-diopside skarn boudins. Skarn in places features inclusion-rich euhedral grossularite garnet crystals 1–15 cm across rimmed by a retrogressed diopside-feldspar assemblage, in a matrix of calcite-diopside-plagioclase or phlogopite-graphite schist or adjacent to garnet-vesuvianite-plagioclase skarn; some of these large rimmed garnets weather to hexagonal cross sections marked by recessive-weathered spokes radiating to each corner.

Mineralization and Mines

Mineralized skarns and veins in the Lee and Ruby Valley mining districts in the southwest and southeast parts of the quadrangle, respectively, were prospected and mined intermittently in the 20th century for lead-zinc-silver sulfides and other ores including incidental amounts of gold (Smith, 1976; Stager and Tingley, 1988; La Pointe et al., 1991; Berger and Oscarson, 1998; Mindat.org, 2025a, 2025b). The Lee mining district includes the American Beauty Mine and Knob Hill Mine in Long Canyon and others in Segunda Creek canyon. The Ruby Valley mining district includes mines and prospects in and around Battle Creek and Myers Creek.

The mineralized rocks occur near the stratigraphic base of the marble of Verdi Peak (O ϵ m), typically in or near exposures of the brown dolomite marble subunit (O ϵ md). Marble locally contains galena. Quartz-sulfide assemblages (galena-sphalerite) are superposed on skarns associated with pegmatitic leucogranite (Berger and Oscarson, 1998). Quartz-sulfide veins at the American Beauty Mine contain barite and the barium feldspar celsian, formed in retrogressive hydrothermal contact-metamorphic skarn mineralization at about 300°C (Berger et al., 2000) apparently after metamorphic and mylonitic deformation. Scheelite-bearing skarn at the Battle Creek Mine has produced tungsten in addition to lead and zinc (Stager and Tingley, 1988; Berger and Oscarson, 1998).

The consistent position of the ores near the stratigraphic base of the marble of Verdi Peak stratigraphically resembles the site of Pb-Zn-Ag-Au-Cu-Mn deposits in limestone beds in Cambrian Pioche Shale in the Pioche mining district of Lincoln County, Nevada, where a stratabound origin has been proposed (James and Knight,

1979; Zantop, 1981). Lead and sulfur isotopic studies there led to an alternative interpretation that the metals were introduced by intrusions (Vikre and Browne, 1999). In the Ruby Dome quadrangle, ore Pb isotopic signatures that differ from the granites led Berger et al. (2000) to favor a stratabound rather than a magmatic origin of the ore metals.

Cordierite-anthophyllite rock containing magnetite and phlogopite occurs locally within the mapped metamorphosed Prospect Mountain Quartzite 500 m northwest of Echo Lake. Cordierite-anthophyllite rock commonly associates with Cu-Pb-Zn ore deposits and has been modeled as metamorphosed hydrothermally altered sea-floor rocks (Schreurs and Westra, 1985). The local occurrence in the Ruby Dome quadrangle may relate to that model or may instead represent a small mafic intrusion metasomatized to its unusual composition during metamorphism.

Geologic Structure

An infrastructure of recumbently folded rocks in the quadrangle includes parts of the SE- to S-facing Lamoille Canyon nappe in the north (fig. 8) and the NE-facing King Peak nappe in the south (figs. 2, 9). Inverted stratigraphy on the lower limb of the Lamoille Canyon nappe occupies a large northern part of the quadrangle (fig. 10). The nappes' hinge lines trend NE-SW (fig. 11). A right-way-up stratigraphic section in the southwest under the two nappes dips eastward toward a synclinal complex east of the Lamoille Canyon nappe (figs. 8, 2).

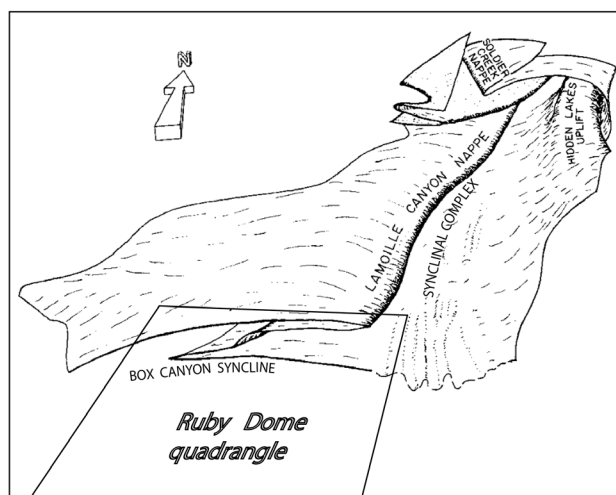


Figure 8. Cartoon sketch showing the northern part of the Ruby Dome quadrangle relative to some major folds in the Ruby Mountains (after Howard, 1980). Folds shown are outlined by the stratigraphic top of the metamorphosed Prospect Mountain Quartzite (and in the north also by the stratigraphically higher metamorphosed Eureka Quartzite).

Three other features help define the quadrangle's geologic structure: (1) The folded pre-nappe Ogilvie thrust fault; (2) a post-nappe mylonitic shear and attenuation zone that overprints the upper part of the folded infrastructure in the west as a structural carapace; and (3) younger brittle low-angle and steep normal faults further attenuate the structure. In addition, we discuss complex patterns of mesoscale deformation fabrics in the infrastructure (fig. 11).

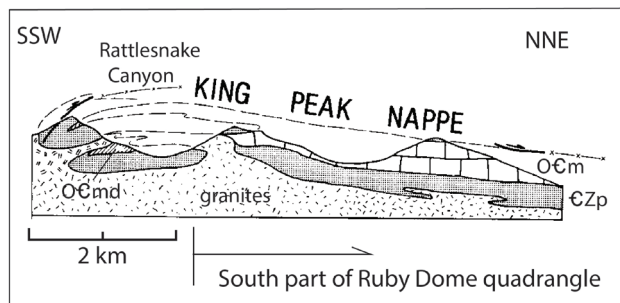


Figure 9. Cross section (not vertically exaggerated) portraying the complex root zone south of the quadrangle in Rattlesnake Canyon of the northward-facing King Peak nappe (after Howard, 1980). Cambrian and Neoproterozoic quartzite (plus granite) shown shaded, marble of Verdi Peak (plus granite) shown as bricks, granite lacking stratigraphic relics indicated by dash patterns. The nappe overrides synclinal structure that here is referred to as the Rattlesnake syncline.

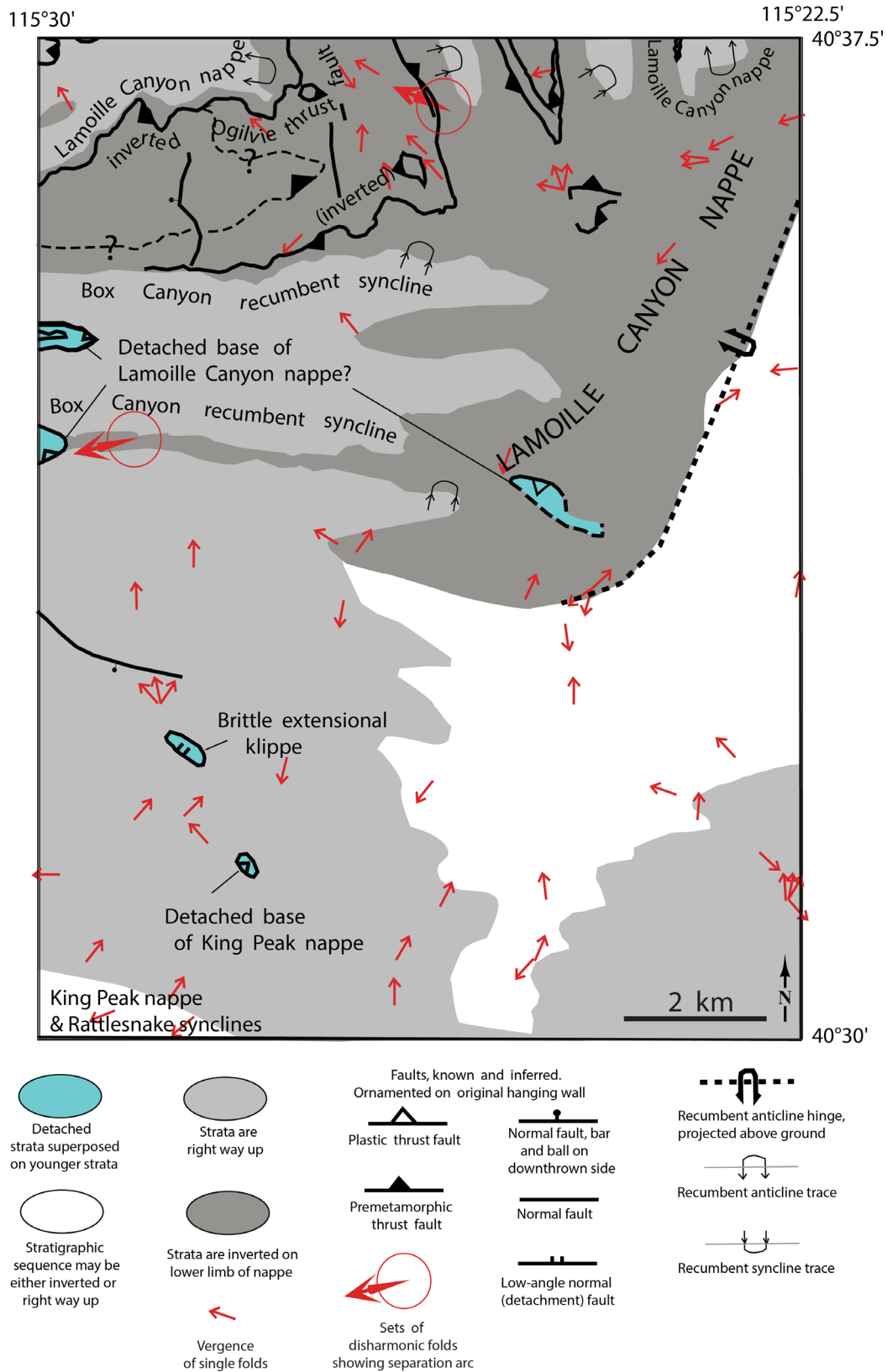


Figure 10. Map of the Ruby Dome quadrangle showing areas either stratigraphically right-way-up or structurally inverted. Medium-dark shading showing the inverted lower limb of the Lamoille Canyon nappe (upper limb of the Box Canyon recumbent syncline) is well defined in the north but its southern extent is uncertain. Small red arrows indicate vergence of mesoscopic folds perpendicular to fold axes.

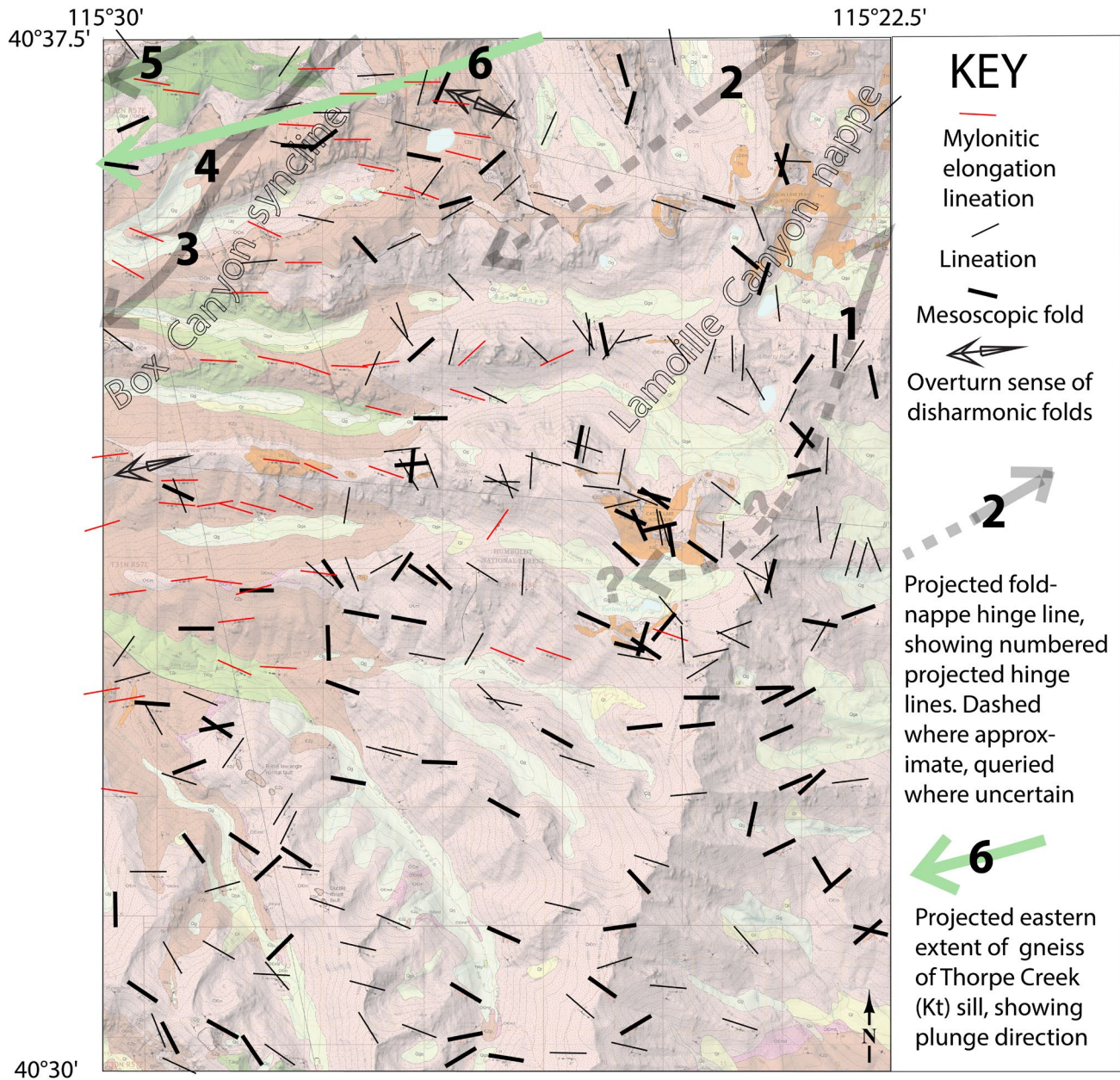


Figure 11. Ruby Dome quadrangle showing numbered hinge lines of large folds and the trends of lineations and mesoscopic fold axes. Area of mylonitic lineations (red lines) approximates the extent of the mylonitic shear-zone carapace. Unspecified lineations include mineral alignments, intersection lineations, mullions, wrinkles, and some elongation lineations. Projected hinge lines of Lamoille Canyon fold nappe as numbered in figure 12C are: 1. Eastern nose of $\mathcal{C}Zp$ (in hanging wall of Ogilvie thrust fault), 2. Nose of folded Ogilvie thrust in nappe, 3. Box Canyon syncline defined by $O\mathcal{C}m/\mathcal{C}Zp$ contact below the nappe, 4. Quartzite monocline on lower limb of the nappe, 5. Nappe nose of $\mathcal{C}Zp$ in footwall of Ogilvie thrust fault, 6. Eastern extent of intrusive sill of Kt.

Pre-folding Ogilvie Thrust Fault

Mapped structural duplications of the metamorphosed stratigraphic sequence records thrust faulting that predates metamorphism and recumbent nappe folding. The metamorphosed and folded Ogilvie thrust fault duplicates the sequence of marble of Verdi Peak over Prospect Mountain Quartzite, both fault plates now folded around the Lamoille Canyon nappe. By inference the Ogilvie thrust fault connects cryptically through thick quartzite to lens-like bodies of Prospect Mountain Quartzite that wedge out into the marble of Verdi Peak and are interpreted as thrust horses. These thrust splays as exposed in this quadrangle are inverted (as near Mts. Fitzgerald and Gilbert) but point upward to the northwest if folding is restored, a geometry taken to indicate originally northwestward overthrusting of a few kilometers, as cartooned in figure 12A, B). The thrusting may date to the Elko orogeny of regional Jurassic contraction described elsewhere (Thorman et al., 1991; Zuza et al., 2021b).

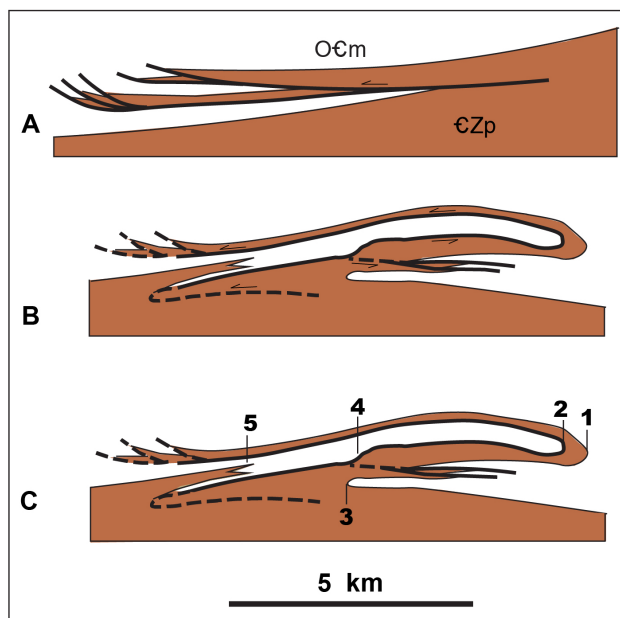


Figure 12. Cross-sectional cartoons of the Lamoille Canyon nappe as viewed northward, based on this and adjacent quadrangle maps (Smith and Howard, 1977; Howard, 2000; Howard and McCready, 2004). **A.** Ogilvie thrust fault and its presumed imbricate splays, restored before folding. O€m = marble of Verdi Peak. €Zp = Prospect Mountain Quartzite. Faults are inferred (dashed in B and C) to connect the imbricate horses through quartzite to the main Ogilvie thrust fault. The splays imply originally northwestward overthrusting. **B.** Folded thrust faults in the Lamoille Canyon nappe; dashed where inferred. **C.** Numbered fold hinges mapped in figure 11. Thrust splays between numbers 2 and 4 are mapped in the northern part of the Ruby Dome quadrangle.

Upright Stratigraphy below the Nappes

Much of the southern half of the quadrangle exposes an upright (right-way-up) stratigraphic section of metamorphosed Prospect Mountain Quartzite (€Zp) overlain by the marble of Verdi Peak (O€m, O€md; figs. 8, 9, 10), each unit including as much as 90% unmapped granite. The northern part of this upright section forms the lower limb of the Box Canyon recumbent syncline below the Lamoille Canyon nappe (figs. 2, 10). The southern part is beneath the King Peak nappe. In the north, the canyon of Right Fork Lamoille Creek contains the upright lower limb of the Box Canyon syncline as exposed just north of this quadrangle (Howard, 2000), and the lower part of adjacent Thomas Canyon also contains that right-way-up section as expressed by rusty weathering graphitic calc-silicate rock and marble typical of the stratigraphically basal part of the marble of Verdi Peak.

Lamoille Canyon Nappe

The Lamoille Canyon nappe, as well exposed down-plunge north of the quadrangle, recumbently folds the metamorphosed stratigraphic sequence and the Ogilvie thrust fault (fig. 2; Howard, 1980, 1987, 2000; Howard and McCready, 2004). In this quadrangle, inverted contacts between quartzite (€Zp) and calcareous rocks (O€m) define a lower limb 6 km long of this recumbent fold. Rusty-weathering graphitic marble and calc-silicate rock typical of the stratigraphically lowest part of the marble of Verdi Peak are adjacent to the quartzite and confirm that the stratigraphic section is inverted.

Fold hinge lines in the nappe project in map view (fig. 11) by connecting piercing points and other constraints of folded contacts between the marble of Verdi Peak (O€m) and the metamorphosed Prospect Mountain Quartzite (€Zp) (fig. 12C). The hinge lines project from piercing points mapped north of this quadrangle by Howard (1987, 2000; Howard and McCready (2004).

The northwest part of the quadrangle exposes a small part of the stratigraphically upright upper limb of the nappe (fig. 8). The nappe's eastern quartzite nose as exposed north of the quadrangle (number 1 in fig. 12C) bows downward eastward and has a rounded shape that would project southward above ground approximately over Island, Lamoille, and Liberty lakes in the northeast part of the quadrangle. The isoclinally folded Ogilvie thrust fault as exposed 1.5 km NW of Island Lake defines the core of the nappe as a tightly appressed recumbent fold (number 2 in figs. 11, 12C). The fold's converged quartzite limbs in the nose here exceed 250 m thick, akin to the rounded form

exposed north of the quadrangle as mapped in the Lamoille and Verdi Peak quadrangles (Howard, 2000; Howard and McCready, 2004). The right side of cross section A–A' suggests a possible eastward projection of the nappe's east-facing quartzite nose as thinned and extending eastward to include a tiny (a few meters thick) lens of metamorphosed Prospect Mountain Quartzite surrounded by granite and marble 1 km SSE of Island Lake at the quadrangle's eastern edge.

Mapped ghost stratigraphy (Pitcher, 1970; Howard et al., 2011) defines the inverted lower limb of the nappe culminating in the granite-observed hinge (of O $\mathbf{\text{Cm}}$ / $\mathbf{\text{CZp}}$) of the recumbent Box Canyon syncline near the west edge of the quadrangle (no. 3 in fig. 12C). By connecting this approximate piercing point to its equivalent hinge in the Lamoille quadrangle to the northeast (in Right Fork Lamoille Creek canyon, Howard, 2000) and to western constraints in the Lee 15-minute quadrangle (Smith and Howard, 1977), the subsurface synclinal hinge tracks a NE-SW trend (no. 3 in fig. 11). A northwest-facing monocline affecting the inverted Ogilvie thrust fault in the nappe (no. 4 in figs. 11, 12C) likewise trends southwest, through Echo Canyon from northern exposures in the Lamoille quadrangle (Howard, 2000).

Evidence in the quadrangle and to the north dates the Lamoille Canyon nappe as Late Cretaceous, as (1) it developed synchronously with emplacement of the granite gneiss of Thorpe Creek (McCready et al., 1997) and (2) Cretaceous two-mica granite and leucogranite bodies both cut and are folded in outcrop-scale folds parasitic to the nappe here (fig. 7) and where directly dated by U-Pb on zircon in the Lamoille quadrangle (Howard et al., 2011). A Late Cretaceous age of nappe folding is consistent with the timing of dated amphibolite-facies metamorphism in the Ruby Mountains and East Humboldt range (Hallett and Spear, 2015; Snoke et al., 2022, 2024). Curiously, clusters of small Eocene gabbroic intrusions (mapped as overprint) concentrate in the marble of Verdi Peak in the original footwall of the Ogilvie thrust fault, as if the folded thrust fault itself postdates these Eocene intrusions, except that rarely the gabbros also cluster in the same stratigraphic unit nearby in the hanging wall (Howard, 2000; Howard and McCready, 2004). The gabbro in the Verdi Peak quadrangle was dated by U-Pb on zircon (Snoke et al., 2024). Clockwise bending of the incompletely exposed nappe, and complexities in its parasitic folds and fabric (fig. 12), may express structural modifications by both Paleogene mylonitic shearing and a possible northward infrastructure underflow claimed by McCready et al. (1997).

Castle Lake Outlier: Hinge Bend?

Near Castle Lake east of the center of the quadrangle, a ridgetop outlier of metamorphosed Prospect Mountain Quartzite structurally inverted above the marble of Verdi Peak poses a potentially key but cryptic structural constraint. The quartzite ($\mathbf{\text{CZp}}$) here occupies an area nearly 0.9 km long and 195 m in structural relief. It is heavily intruded by biotite monzogranite (Tm). The stratigraphic sequence likely is inverted ($\mathbf{\text{CZp}}$ over O $\mathbf{\text{Cm}}$). The quartzite exhibits diversely oriented mesoscopic folds and is structurally detached over differently oriented diopside-rich marble (in O $\mathbf{\text{Cm}}$) that shows cylindrical ESE-plunging recumbent isoclines.

The outlier occupies a position appropriate for the Lamoille Canyon nappe's eastern quartzite nose exposed farther north near Island Lake and north (Howard and McCready, 2004), here intersecting a high ridge. However, this metamorphosed Prospect Mountain Quartzite exhibits recognizable bedding, annealed coarse biotite and muscovite and little intrusive pegmatitic leucogranite, features suggestive of a lower metamorphic grade and higher structural position than the quartzite nappe nose as exposed to the north. The nappe may be thrust-detached here or the quartzite may be structurally lowered by attenuation faulting from a higher position.

Figure 11 portrays the projected quartzite nose (anticlinal hinge) of the Lamoille Canyon nappe as likely bending abruptly westward from the Castle Lake outlier (fig. 2; Howard et al., 1979; Howard, 1980). If so, the nappe becomes disharmonic westward as its lower limb shortens drastically above the Box Canyon recumbent syncline near the west edge of the quadrangle. As portrayed by Smith and Howard (1977), the shortened nappe transitions to a small-displacement south-facing thrust on the west and just west of the quadrangle. Quartzite interfingers structurally with younger calcareous rocks of the Verdi Peak unit in the hinge area of the Box Canyon syncline, by recumbent isoclines, fault duplications, or both.

Upright stratigraphy forming the lower limb of the Box Canyon syncline merges with lower right-way-up limbs of a complex north-facing recumbent syncline that defines the base of the King Peak nappe (fig. 9; Howard et al., 1979; Howard, 1980).

King Peak Nappe

Prospect Mountain Quartzite in the NNE-facing King Peak nappe projects over or complexly into the south part of this quadrangle to include some ridgetop quartzite ($\mathbf{\text{CZp}}$) exposures. Where exposed 1–3 km south of the quadrangle

at King Peak, the nappe's recumbently folded upper quartzite limb above the inverted marble of Verdi Peak extends 2 km northeastward almost to the Ruby Dome quadrangle before being lost to erosion into the southern part of cross section C–C'. Stratigraphically inverted rusty-weathering graphitic marble and calc-silicate rock at the stratigraphic base of the marble of Verdi Peak sits just below the inverted quartzite limb. Some 1–2 km to the west, the nappe's basal syncline as exposed just south of the Ruby Dome quadrangle includes 2–3 synclinal hinges containing the basal brown dolomitic marble, and the multiple quartzite tongues of the nappe are at least in part structurally detached (fig. 9).

Detached small ridgetop klippen (€Zp) at the nappe's base in the SW part of the Ruby Dome quadrangle 3 km NE of Drown Peak consist of blocky white muscovite-garnet quartzite and about 30% granite (€Zp). They are superposed on unbrecciated Verdi Peak rocks lacking the stratigraphically basal brown dolomitic marble or rusty graphitic rocks, instead consisting of stratigraphically higher marble, granite, and (30 m lower) diopside-biotite schist and garnet amphibolite. These klippen are interpreted as indications that the synmetamorphic King Peak fold nappe transitioned northward into a partly detached overthrust nappe as portrayed in cross section C–C'. (A younger brittle Tertiary fault soles other small quartzite klippen 2 km NNW on the same ridge top).

South of the quadrangle, Jones (1999) interpreted the King Peak nappe as coeval with emplacement of Cretaceous pegmatitic leucogranite, revising an earlier interpretation relating the nappe to intrusion of Jurassic two-mica granite of Dawley Canyon (Hudec, 1990, 1992). Undated two-mica equigranular granite gneiss (TJeg) intrudes and postdates the King Peak nappe at the south margin of the Ruby Dome quadrangle. The mostly eroded King Peak and Lamoille Canyon nappes remarkably face each other in the Ruby Dome quadrangle at approximately the same structural level.

Infrastructure Fabric

Foliations, lineations, and folds in the Ruby Mountains north of the quadrangle mostly can be categorized as belonging either to an infrastructure where textures largely are annealed or else to a mylonitic shear zone that overprints the infrastructure (Howard, 1980; Snoke, 1980; Snoke et al., 1997, 2022). Abundant mesoscopic folds and lineations in the infrastructure mostly parallel the axes of large mapped folds. Mylonitic elongation lineations strike roughly perpendicular to the axes of large mapped folds and

transitionally oriented folds and lineations also occur (Howard, 1966; MacCready et al., 1997).

In the Ruby Dome quadrangle, lineations and folds show great complexity. Rock units and foliation dominantly dip gently (fig. 13), more or less eastward in much of the quadrangle but westward in the mylonitic shear zone in the west, where quartzofeldspathic rocks cleave readily and foliation surfaces show ubiquitous east–west mylonitic elongation lineation of strained and stretched elongate quartz and a streakiness on prominent fissile aligned-mineral foliation surfaces.

Foliation in the infrastructure, which occupies most of the quadrangle, includes primary and transposed lithologic layering, mineral concentrations and alignment, and fold features including axial-plane cleavage. Foliations compiled in figures 13 and 14 include a few schlieren and primary intrusion foliations in sills of biotite monzogranite (Tm), features mostly subparallel to country-rock metamorphic foliations. Mesoscopic folds in the infrastructure (fig. 7) vary in style from broad warps to tight recumbent isoclinal folds. Some disharmonic folds notably vary greatly in trend but show a common component of vergence (fig. 15). Refolded folds and folded lineations occur uncommonly, in places by late open folds. Lineations in the infrastructure include trains or clusters of and/or aligned micas, sillimanite, hornblende, diopside, and other minerals, as well as intersection lineations, mullions, rodding, wrinkles and color bands on foliation surfaces, and elongation lineation gradational to the style in the mylonitic shear zone. Calcareous and quartzitic metasedimentary rocks exhibit the infrastructure folds and lineations and so do some granitic rocks. Boudinage is common. The gneissic pegmatitic leucogranite (TKlg), gneiss of Thorpe Creek (Kt), and two-mica granite gneiss (TJeg) units commonly contain infrastructure lineation in the form of trains of elongate mica and (or) sillimanite and some of these rocks display folding. The biotite monzogranite (Tm) in places expresses lineations parallel to fabrics in its infrastructure host rocks.

Just as the major recumbent folds in the quadrangle are largely eroded and incomplete in their mapped geometry, complex orientation patterns of infrastructure mesoscopic folds and lineations shown in figures 10, 11, 13, and 14 likewise pose challenges to interpret. Fabric patterns that vary between the north, central, and southern thirds of the quadrangle are here discussed for each of these three regions (figs. 13, 14).

In the north, some mapped infrastructure folds and lineations roughly parallel mapped hinge lines of the Lamoille Canyon nappe, striking roughly N–S (in the northeast) to NE–SW (in the northwest; figs. 11, 14). Axial

planes of mesoscopic folds in the northeast part of the quadrangle spread in dip about a N–S strike (upper right in fig. 14), likely reflecting coaxial eastward downwarping of the Lamoille Canyon nappe as mapped down-plunge to the north in Lamoille Canyon (Howard, 1987, 2000; Howard and MacCready, 2004). Some roughly E–W lineations in the north likely relate mostly to overprinting by the mylonitic shear zone carapace that projects over the infrastructure, even though some structurally low examples in Thomas Canyon remain poorly understood. Both E–W and N–S oriented lineations affect the biotite monzogranite (Tm), implying a post-Eocene age for some of both styles of deformation (Snoke et al., 2024). Vergence of mesoscopic folds dominates toward the northwest quadrant (fig. 10) as would be expected because most are on the inverted limb of the southeast-facing Lamoille Canyon fold nappe. Some folds that now trend E–W to NW–SE may reflect reorientation by the mylonite-zone shearing. Disharmonic folds exhibit a common vergence component indicating westward shear (figs. 15, 10).

In the south of the quadrangle, folds and lineations mostly strike ESE–WNW parallel both to the King Peak nappe as well as to the lineated mylonitic carapace that projects overhead. Mesoscopic folds in the southwest corner of the quadrangle near double synclines beneath the King Peak nappe show southwestward vergence (fig. 10). Northward fold vergence in right-way-up sections in the rest of the southern third of the quadrangle presumably relate to a northward-facing King Peak fold nappe overhead, now mostly eroded.

The central third of the quadrangle exhibits knotty orientation patterns of folds and lineations in keeping with the poorly defined map-scale structure. Mesoscopic folds and infrastructure lineations in the Castle Lake area (near queried nappe hinge in fig. 11) scatter in trend, with most trending WNW–ESE; some refolded folds are observed. Dispersed and possibly intersecting orientations of linear fabrics may record fabric transitions from infrastructure to the overprinted mylonitic carapace, and possibly record cross folding of the Lamoille Canyon nappe along with its parasitic mesoscale folds..

Roughly perpendicular mesoscopic folds and lineations may both parallel and be perpendicular to a mostly eroded overhead Lamoille Canyon nappe's projected clockwise bend in the Castle Lake area. Dominantly northward fold vergences in right-way-up sections conflict with a southward-facing Box Canyon recumbent syncline. Instead, these vergences seem continuous with the southern domain in the projected north-facing recumbent syncline below the eroded King Peak nappe, a geometry that could extend the

King Peak nappe north to the center of the quadrangle. The relative timing and linkage between these two opposing nappes remain obscure.

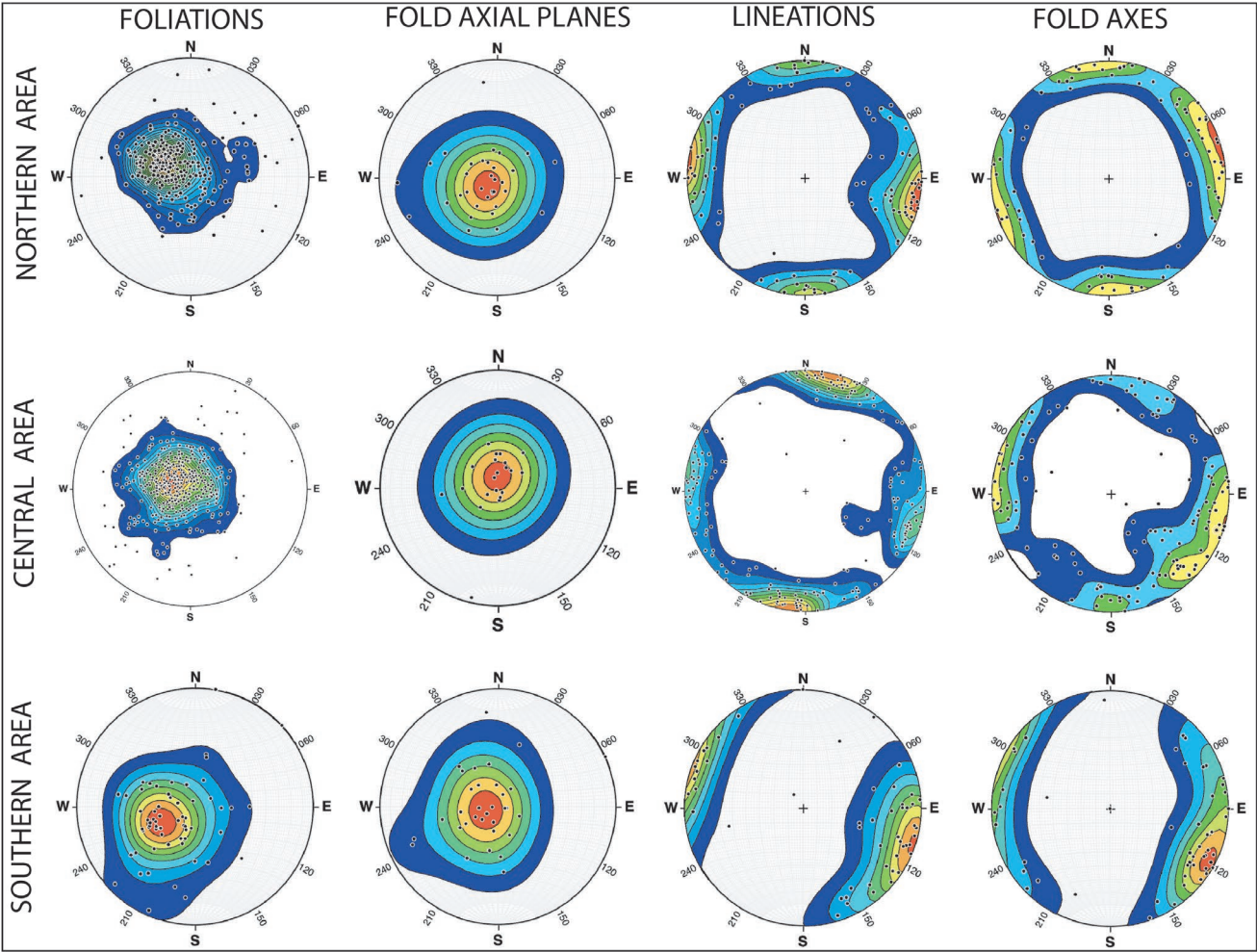


Figure 13. Fabric stereograms for the northern, central, and southern thirds of the Ruby Dome quadrangle. Lower hemisphere equal-area projections of lineations and fold axes and poles to foliations and fold axial planes. The concentrations of data points are contoured by the Kamb method (contour interval 2σ) using Stereonet v. 11 (Allmendinger et al., 2012; Cardozo and Allmendinger, 2013). The data (Howard et al., 2026) are summarized in table 1.

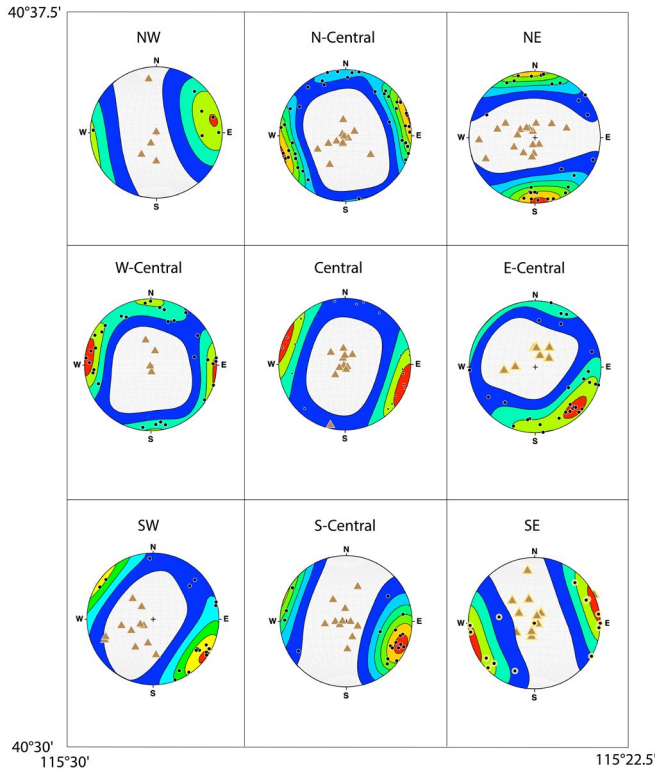


Figure 14. Ruby Dome quadrangle (north at the top) divided into 9 segments showing orientations of poles to fold axial planes (triangles) and contoured fold axes (dots) in lower hemisphere equal-area projection. Fold-axes Kamb contour intervals 2σ , contoured using Stereonet v. 11 (Allmendinger et al., 2012; Cardozo and Allmendinger, 2013). The data (Howard et al., 2026) are summarized in table 2.

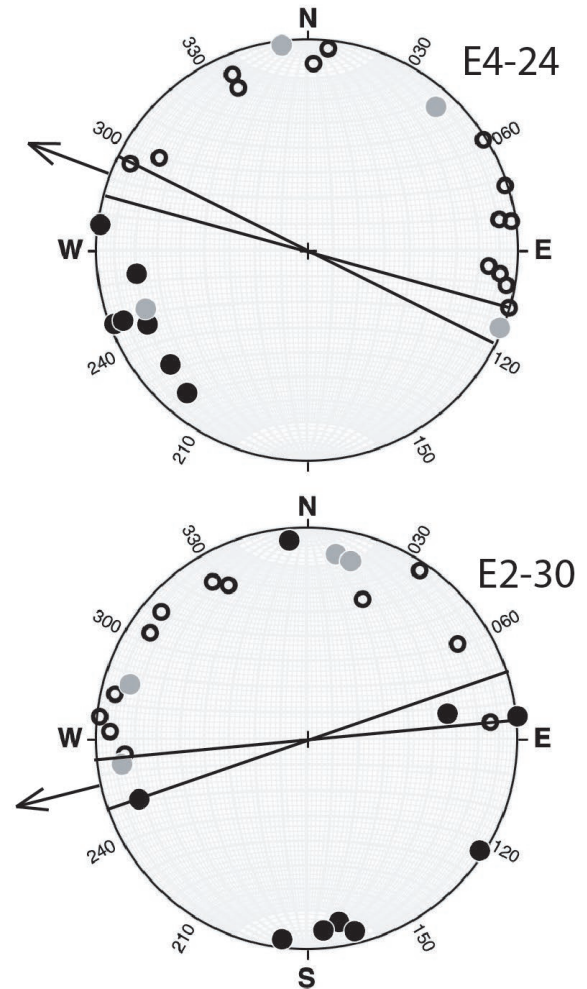


Figure 15. Fold-axes orientations and sense of asymmetry of disharmonic flexural-slip folds that display widely varied orientations at two mapped outcrops of interlayered marble and calc-silicate in the northwest quadrant of the quadrangle (fig. 10). Black dots are S-shaped (anticlockwise) folds, circles are Z-shaped (clockwise) folds, gray dots are folds indeterminate or nearly symmetrical in sense. The arrow and separation arc of uncertainty represent the direction of common overturning and interpreted override drag (Howard, 1968; Hansen, 1971). Lower hemisphere equal-area projection.

Mylonitic Shear Zone

Western and structurally upper parts of the rock architecture in a carapace as thick as 100 m or more are tectonically thinned and have blastomylonitic texture. The equivalent but thicker mylonitic carapace in the northernmost Ruby Mountains has been interpreted as a west-directed and flattened extensional shear zone, superposed on and in part coordinated with folding in rocks in the infrastructure below (Snoke, 1980; MacCready et al., 1997; Howard, 2000; Snoke et al., 2022; Zuza et al., 2021a).

Mylonite foliations generally dip gently westward. Feldspathic quartzite and granite gneisses have strong

mylonitic elongation and streaking lineation, consistently trending W–E to WNW–ESE, and are defined by elongate trains of fine-grain quartz and mica wrapping around intact to bent feldspar augen and porphyroclasts. Figure 11 shows mylonitic elongation lineation trend directions in red.

Notable thinning of rock units and lithologic layering also characterizes the mylonitic zone, and a few outcrops exhibit shear cleavage oblique to foliation. Mylonitic foliation can be intense; the thinned metamorphosed Prospect Mountain Quartzite breaks into flagstones. L-tectonites are common. Rarely the lineation parallels tightly appressed folds as an intersection lineation. Mapped and unmapped biotite monzogranite (Tm) intrusions in the northern part of the quadrangle commonly express lineation parallel to the elongation lineation in the mylonitic shear zone (Snoke et al., 2022).

Fine-grained quartz and mica wrap around undeformed or bent feldspar porphyroclasts. Strongly foliated calc-silicate marbles contain rotated porphyroclasts of K-feldspar, plagioclase, diopside and other calc-silicate minerals, but only rarely exhibit conspicuous mylonitic lineation.

Westward shear is indicated by a common direction of overturning of variably oriented disharmonic folds, including two sites in this quadrangle (figs. 15, 10), where the common vergence orientation coincides with the azimuth of mylonitic lineation and shearing (Howard, 1968; 1980). The most cylindrical folds in these disharmonic-fold outcrops can trend obliquely more NE or SW, paralleling map-scale folds and parasitic mesoscale folds in neighboring outcrops. This asymmetrical pattern can be interpreted to link the mylonitic zone shearing to the southwestward bending and amplitude decrease of the Lamoille Canyon nappe. Possibly sheath-fold-like shearing stretched northern parts of the nappe to greater amplitude.

Low-angle Normal Faults

Extensional ridgetop klippen of metaquartzite (€Zp) are superposed on a brittle low-angle fault 2.6 km NE of Drown Peak in the quadrangle's southwest. Brecciated, sheared, and chloritic retrograded granite containing veins of biotite and chlorite mark their footwall rocks (in O€m). The quartzite klippen lack granite intrusions, preserve sedimentary bedding and feature crystallographically aligned quartz grains and muscovite arranged within larger relict grains(?) 2–10 mm across.

Another klippe 1.4 km ESE of Drown Peak is superposed on retrograded granite containing shear zones and mica-filled cracks cutting fine-grained quartz and other

deformed minerals. The klippe consists of strongly foliated marble (O€m) containing feldspar porphyroclasts and secondary brucite.

The klippen are part of a Miocene extensional detachment fault system that excises and decapitates deep rocks elsewhere in the Ruby Mountains and East Humboldt Range (Snoke, 1980; Colgan et al., 2010). Here the faults lower and excise fragments of the King Peak nappe onto deeper infrastructure. Nearby parts of the adjacent Lee 15-minute quadrangle on the west (Smith and Howard, 1977) expose numerous such extensional klippen, in which metamorphosed and granitic rocks are on similarly brittle faults, some slickenlines transition to the WNW-trending mylonitic elongation lineation, and similarly lineated flinty crush rock occur. The faulting there is more complex than in the Ruby Dome quadrangle; some fault slickenlines trend south. In the East Humboldt Range, the detachment faulting was dated to have last moved in middle to late Miocene time (McGrew and Snoke, 2015; Snoke et al., 2021).

Steep Normal Faults

Steep to west-dipping small-displacement normal faults in the west part of the quadrangle strike north to northwest as the youngest exposed structures. They displace rocks as much as 100 m down to the west. Miocene basalt dikes that locally fill the steepest faults indicate the faulting was Miocene. In addition to the faults, several long through-going fractures striking NNW occur in the northwest part of the quadrangle.

QUATERNARY GLACIATION

Extensive late Pleistocene glaciation sculpted the quadrangle's rugged landscape. The resulting U-shaped valleys, horn peaks, glacial cirques, and tarns make the area among Nevada's most scenic destinations. Glacial drift (Qg) in moraines occupy many valleys, canyons, and cirques. Most cirques face north. Boulders litter the youngest glacial deposits and their crisp moraines.

Sharp (1938) assigned most moraines to the Angel Lake glaciation and smaller areas to the older Lamoille glaciation. Following Sharp (1942) the most conspicuous and youngest moraines are assigned to the Angel Lake glaciation (Qga), which elsewhere in the Ruby Mountains–East Humboldt Range has been dated to 20–15 ka, with outwash dating 27–14 ka (Laabs et al., 2013; Zuza et al., 2021a). Typically, the Angel Lake deposits in the map area occupy cirques and U-shaped valleys and exhibit prominent moraine ridges.

Other mapped glacial deposits (Qg) include those of both the Angel Lake and the older Lamoille glaciations.

Incised pre-Angel Lake glacial deposits occupy V-shaped lower parts of Box, Kleckner, North Furlong, Long, and Segunda canyons. Stream-incised V-shaped lower reaches of some of the west-draining canyons, downstream from the U-shaped upper reaches, either were entrenched into pre-Angel Lake glacial deposits or never were glaciated. The Lamoille glaciation likely correlates to outwash and moraines dated 130–120 ka (Laabs et al., 2020; Zuza et al., 2021a).

Unglaciated uplands on the range crest include Wines Peak and Lake Peak (Sharp, 1940).

Glacial cirque lakes in the quadrangle have yielded core records of high-elevation paleoenvironmental changes over the last 7,700 years since deposition there of the Mazama ash (Thompson, 1984; Wahl et al., 2015; Wanket et al., 2015; Starratt, 2018).

DISCUSSION

The complex structural architecture of metamorphic rocks in the Ruby Dome quadrangle poses still unresolved questions about the timing of nappe development and its place in the regional tectonic context. The southeast-facing Lamoille Canyon nappe veers southwestward from the northern part of the quadrangle. As the nappe loses amplitude southwestward, its upper fold limb becomes partly detached by southward thrust faulting. Erosion that has removed much of the nappe's upper limb obscures the nappe's structure and its relation to the King Peak nappe that faces it from the south. The relative timing of the two nappes and how they came to face each other remain uncertain. Fabric orientations in the infrastructure and in the mylonitic shear-zone carapace are equally complex, and so is the timing of the structural developments. Despite some timing uncertainties, a model that related the variously oriented nappes to diapiric rise and stretching against a more rigid colder roof may offer some useful context for understanding the nappe architecture (Howard, 1980).

DESCRIPTION OF MAP UNITS

Quaternary Deposits

Qy Young alluvium (Holocene) Arkosic gravel and sand along present stream courses, and sand and silt in valley bottoms and beaver-dam meadows. Materials derived from granitic and metamorphic rocks in the Ruby Mountains.

Qo Old alluvium (Pleistocene) Poorly consolidated sandy gravel, poorly sorted. Clasts are granitic and metamorphic rocks derived from the Ruby Mountains.

Qg Glacial drift (late Pleistocene) Unsorted bouldery to sandy till and some sorted cobble gravel outwash deposits. Moraine ridges common. Includes deposits of the Angel Lake, Lamoille, and possibly of older glaciations. Locally subdivided into:

Qga Glacial drift of Angel Lake glaciation (late Pleistocene) Moraines, till, and local outwash, typically exhibiting crisp moraines and bouldery surfaces in U-shaped valleys and cirques. Considered to date from the last glacial maximum and marine oxygen-isotope stage 2, very late Pleistocene (Laabs et al., 2013).

Qt Talus and colluvium (Holocene and Pleistocene) Angular rock fragments and blocks, and in places finer-grained soil. Includes a crisp young rock avalanche deposit 1 km west of Liberty Lake.

Intrusive Rocks

Tb Basalt dikes (Miocene) Fine-grained to aphanitic intersertal olivine basalt. Commonly contains plagioclase phenocrysts. In places exhibits amygdules. Dikes as thick as 5 m. One 3-m-wide dike has diabase texture. Dike near Lake Peak contains amygdules 1–2 mm across of chalcedony and calcite. Dikes typically highly fractured parallel to dike walls, and are weathered recessively. Similar basalt dikes were dated as about 16 Ma in other parts of the Ruby Mountains and East Humboldt Range (Hudec, 1990; Zuza et al., 2021a).

Tm Biotite monzogranite (Oligocene? and Eocene) Equigranular, medium-grained (1 mm) monzogranite and locally leucomonzogranite. May contain minor muscovite and secondary chlorite. Mafic mineral content typically about 7%. Locally exhibits foliation and (or) lineation. Locally foliated parallel to dike margins. Strongly lineated mylonitic biotite pencil gneiss near Segunda Creek shown queried. Typically occurs in sheetlike bodies. Locally leucogranite variants intrude the monzogranite as intrusion breccias. Associated dark fine-grained tonalite (Snoke et al., 2024) present in bodies too small to map. Intrusion, petrology, geochemistry, and isotopes are detailed by Snoke et al. (2024).

Dated by U-Pb on zircon as 40–33 Ma (Snoke et al., 2024); lithologically similar biotite monzogranite dikes north of the quadrangle dated as 30–29 Ma (Wright and Snoke, 1993).

TKlg Pegmatitic Leucogranite (Paleogene and Late Cretaceous) Whitish, gneissic to massive pegmatitic leucogranite (KPG unit of Lee et al., 2003). Contains biotite, muscovite, commonly sillimanite or garnet. Grain size is

variable but mostly coarse to very coarse. Occurs as coalesced myriad sills and irregular and dike-like bodies. Occurs throughout the Ruby Mountains–East Humboldt Range metamorphic and igneous complex but mapped separately only where metasedimentary relic bodies are absent or very rare, deep in canyons. Upper contacts gradational to mapped units that define a ghost stratigraphy of metasedimentary strata intruded by granite (O $\bar{\text{C}}\text{m}$, O $\bar{\text{C}}\text{md}$, $\bar{\text{C}}\text{Zp}$). Similar granite pervades those mapped metasedimentary rock units in countless intrusions, the proportion relative to metasedimentary relics indicated by overlay patterns. Geochemical evidence and near absence of pre-Cretaceous zircon in the pegmatitic leucogranite were used to interpret the leucogranite as produced from muscovite-dehydration partial melting of pelitic rocks (Lee et al., 2003; Howard et al., 2011). U-Pb dating of zircon from near Lamoille Creek and north of the quadrangle in Lamoille Canyon indicates ages ranging ca. 90 Ma to locally 60 Ma, and evidence that some of this leucogranite underwent anatectic partial remelting and recrystallization in the Eocene (Howard et al., 2011; Snoke et al., 2024). As mapped includes some medium- to fine-grained equigranular biotite granite gneiss (especially in lower Box Canyon), equigranular biotite-muscovite leucogranite, equigranular biotite-muscovite leucogranite gneiss (EG rock type of Lee et al., 2003) and local small bodies of biotite monzogranite (Tm rock type).

TJeg Equigranular two-mica granite (Paleogene, Cretaceous, and/or Jurassic) Gneissic biotite-muscovite monzogranite. Two mapped occurrences: (1) as one of several small patches in the northeast part of the quadrangle (others unmapped) in upper Lamoille Canyon, where Lee et al. (2003) characterized this rock as their “EG” unit, reported a U-Pb monazite age of about 91 Ma, and observed the rock is intruded by gneissic pegmatitic leucogranite. Those authors interpreted its geochemical and isotopic compositions as being sourced from biotite-dehydration partial melting of graywacke-like source compositions in the deep crust (see also Snoke et al., 2024). At the map scale, only one of the numerous small patches of this rock is portrayed. (2) As a sill about 250 m thick in the southwestern part of the quadrangle between Rattlesnake and Segunda creeks. The sill intrudes and postdates the King Peak nappe. This undated sill may relate closely to the biotite monzogranite (Tm), but alternative possibilities are correlation to Cretaceous equigranular granite gneiss (EG of Lee et al., 2003) or to two-mica granite of Dawley Canyon SE of the quadrangle that was dated as 153 ± 1 Ma (U-Pb monazite; Hudec and Wright, 1991).

Kt Granite gneiss of Thorpe Creek (Late Cretaceous)

Medium-grained (1 mm) biotite-muscovite-garnet monzogranite gneiss. Scattered garnet 0.5–1 mm across is characteristic. Typically contains about 5 percent dark minerals but locally, as on the south flank of Ruby Dome, may have more biotite and little muscovite. Forms an extensive sill partly occupying the core of the Lamoille Canyon fold nappe. Upper parts may be blastomylonitic. Weathered exposures commonly display Liesegang banding. Thickness to 180 m. In the Lamoille and Verdi Peak quadrangles, the sill extends much farther east in the core of the nappe, but here it is confined to the northwest part of this quadrangle. Similar rock (not mapped separately) occurs within the marble of Verdi Peak map unit (O $\bar{\text{C}}\text{m}$) in the east part of the map area on the high northeast flank of Wines Peak. Dated about 91 Ma by U-Pb on zircon in the Lamoille quadrangle (Snoke et al., 2024); Eocene U-Pb ages of 38–36 Ma on monazite from other sites in this unit north of the Ruby Dome quadrangle (MacCready et al., 1997) are now interpreted as metamorphic ages.

Metamorphosed Strata Intruded by Granite

O $\bar{\text{C}}\text{m}$ Marble of Verdi Peak (Ordovician and Cambrian strata)

Chiefly diopside-bearing calcitic marble and interlayers of green diopside-rich calc-silicate granofels. Includes layered buff-toned medium-grained (3–4 mm) marble, graphitic marble, thin resistant layers of brown-weathering diopside-feldspar-quartz granofels and biotite calc-silicate granofels. Less common phlogopite-bearing white marble, graphitic marble, and rarer forsterite marble, tourmaline-bearing graphitic biotite-andesine-plagioclase-quartz-sillimanite schist $\pm$ either muscovite or garnet, fine-grained plagioclase-hornblende-biotite $\pm$ diopside schist, feldspathic phlogopite schist, and quartzose biotite gneiss. Dark fine-grained Eocene tonalitic intrusions (Snoke et al., 2024) into the unit closely resemble and are difficult to distinguish from biotite-hornblende $\pm$ diopside schist of likely metasedimentary origin that commonly associates with pelitic schist. Blastomylonitic calcitic rocks in the mylonitic shear zone in the west part of the quadrangle contain rounded porphyroclasts of plagioclase, K-feldspar, diopside, phlogopite, and muscovite. Upper part of unit dominantly calcite marble containing sparse calc-silicate minerals, likely corresponding to Pogonip Group. Lower part of unit dominated by calc-silicate granofels and calc-silicate-rich marble, and contains pelitic schist and biotite-hornblende schist, together likely corresponding to Cambrian formations. Stratigraphically lowest part of unit adjacent to metamorphosed Prospect Mountain Quartzite commonly either rusty-weathering graphitic calc-silicate

granofels interlayered with graphitic marble in northern areas, or brown dolomitic marble facies (O€md) in southern parts of the quadrangle. Heavily intruded by granites, the proportion indicated by overlay patterns. Structural thickness (excluding granitic intrusives) varies from about 30 m to >250 m.

O€md Brown dolomitic marble Deep reddish brown-weathering, massive medium-coarse-grained calc-silicate marble; locally white where freshly broken. Brown dolomite may alternate with calcite marble in layers 2–50 cm thick. Forsterite commonly present. May contain ankerite. Near Battle Creek associated with limonite-altered rock and with massive very coarse-grained green pyroxene and actinolite. Occurs at or near the stratigraphic base of the marble of Verdi Peak in southern parts of the area. Commonly associated with mineralized sulfide-bearing rocks that have been prospected and mined for lead, zinc, silver, tungsten, and gold. Heavily intruded by granites, the proportion indicated by overlay patterns. Structural thickness (excluding granitic intrusives) about 10–20 m.

€Zp Metamorphosed Prospect Mountain Quartzite (Cambrian and Neoproterozoic) Tan to pale brown-weathering, medium-grained, irregularly layered feldspathic metaquartzite, containing micaceous laminae and layers. Quartzite typically contains 80–90 percent quartz and 10–20 percent K-feldspar or plagioclase, biotite, and muscovite. Zircon, hematite, apatite, magnetite, and commonly sillimanite are present in small amounts. Garnet-muscovite quartzite present very locally. The stratigraphically uppermost quartzite locally is graphitic and weathers to rusty brown. Some more pelitic biotite-rich quartzite, biotite schist, biotite-sillimanite-garnet-quartz schist, and feldspathic quartz gneiss, and quartz-biotite gneiss near Echo Canyon and Echo Lake may indicate presence of the underlying Neoproterozoic McCoy Creek Group (metacarbonate rocks typical of part of the McCoy Creek Group interleave with the quartzite 2–5 km west of the south part of the quadrangle—Smith and Howard, 1977). Quartzite feldspathized or partly digested, grading into feldspathic pegmatitic leucogranite, in the canyons of Rattlesnake and lower Segunda Creek canyons, and between mouth of Mahogany Creek and North Furlong Creek. The quartzite is flaggy and blastomylonitic 0.2 km SE of Echo Lake and in high structural positions at western edge of the quadrangle 2 km W of Ruby Dome (where interlayered with dark augen gneiss) and ridge top 1 km N of North Furlong Creek. Ridge-top klippen outcrops above detachment fault 3.3 km NNE of Drown Peak in the southwest show coarsely

recrystallized quartz, biotite, and muscovite, lack metamorphic sillimanite or granite, and locally preserve bedding. Much intruded by granites in most locales, the proportion indicated by overlay patterns. Locally lit par lit on cm scale with leucogranite. Structural thickness (excluding granitic intrusives) varies between 30 and 250 m.

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Table 1. Data attributes for fabric stereograms for northern, central, and southern thirds of Ruby Dome quadrangle (fig. 13). Data from Howard et al., (2026). σ is standard deviation.

Area	Data type	Number of data	Maximum number of contoured intervals	Maximum contoured interval
Northern third	Foliation	311	11	22 σ
Central third	Foliation	452	17	34 σ
Southern third	Foliation	62	8	16 σ
Northern third	Fold axial planes	34	7	14 σ
Central third	Fold axial planes	22	7	14 σ
Southern third	Fold axial planes	33	6	12 σ
Northern third	Lineations	93	7	14 σ
Central third	Lineations	255	11	22 σ
Southern third	Lineations	52	8	16 σ
Northern third	Fold axes	76	5	10 σ
Central third	Fold axes	132	5	10 σ
Southern third	Fold axes	51	7	14 σ

Table 2. Data attributes for fabric stereograms for nine segments of Ruby Dome quadrangle (fig. 14). Data from Howard et al., (2026). σ is standard deviation.

Area	Data type	Number of data	Maximum number of contoured intervals	Maximum contoured interval
NW	Fold axes	6	4	8 σ
NW	Fold axial planes	5		
N-Central	Fold axes	43	6	12 σ
N-Central	Fold axial planes	12		
NE	Fold axes	54	6	12 σ
NE	Fold axial planes	27		
W-Central	Fold axes	31	4	8 σ
W-Central	Fold axial planes	4		
Central	Fold axes	19	4	8 σ
Central	Fold axial planes	11		
E-Central	Fold axes	31	4	8 σ
E-Central	Fold axial planes	7		
SW	Fold axes	17	5	10 σ
SW	Fold axial planes	11		
S-Central	Fold axes	19	6	12 σ
S-Central	Fold axial planes	11		
SE	Fold axes	15	4	8 σ
SE	Fold axial planes	11		