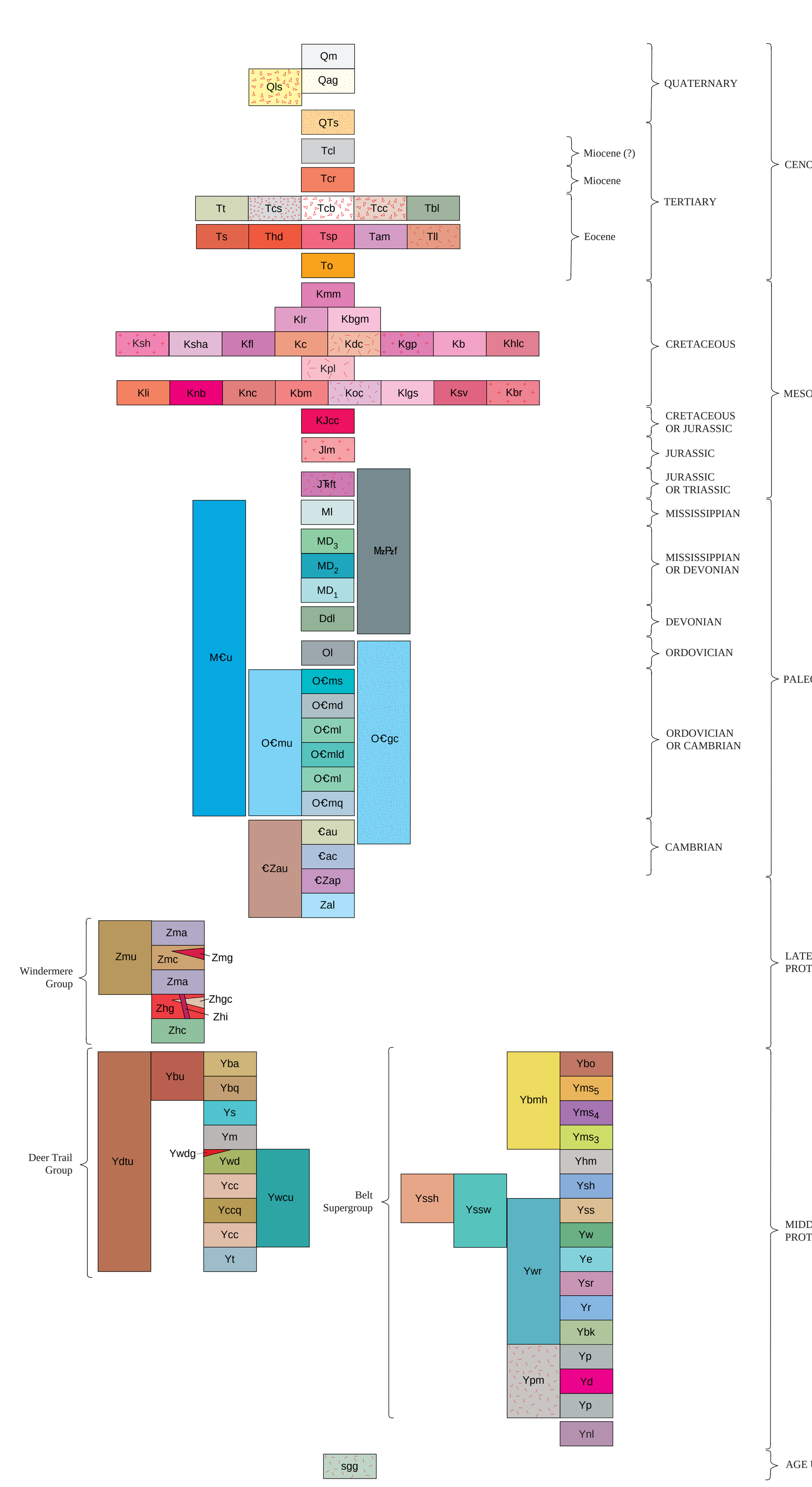
CORRELATION OF MAP UNITS



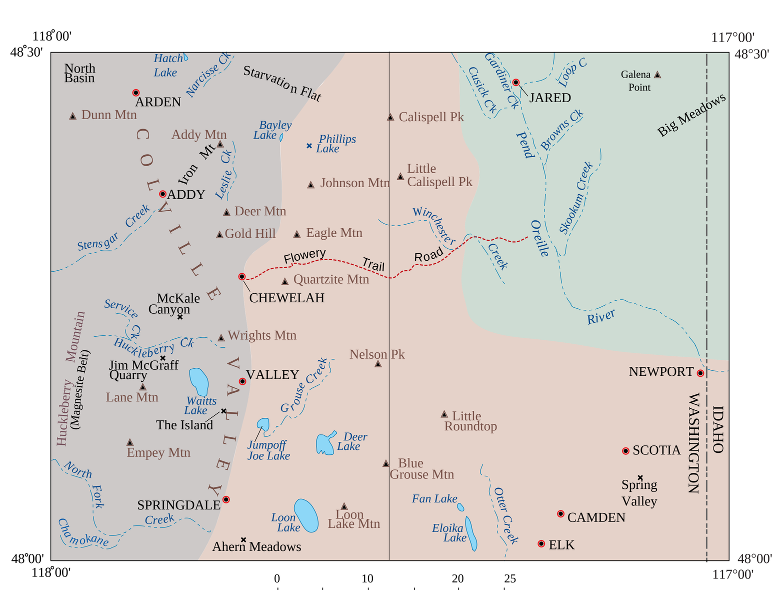


Figure 1. Index map of Chewelah 30'x60' quadrangle showing geographic and cultural features referred to in the text. Also shown are the approximate areas predominently underlain by (1) Deer Trail Group and thick Paleozoic formations, warm-gray; (2) Chewelah sequence of the Belt Supergroup, thin Paleozoic formations, and western Priest River complex, tan; and (3) Newport sequence of the Belt Supergroup, pale-green. Town. Mountain peak. Specific feature.

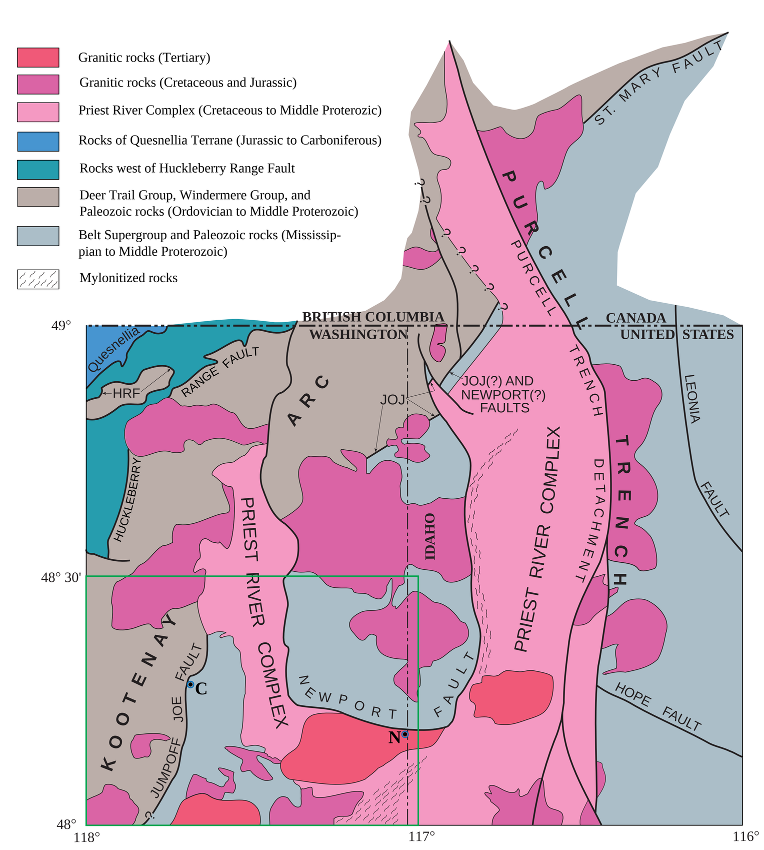


Figure 3. Simplified geologic map showing relations of major structures in Chewelah quadrangle to other major structures in the region. Chewelah quadrangle outlined in green. HRF, Huckleberry Range Fault; JOJ, Jumpoff Joe Fault; N, Newport; C, Chewelah. Town.

LIST OF MAP UNITS

[See pamphlet for more detailed Description of Map Units]

Qm **Mine tailings (Quaternary)**—Tailings and waste rock from magnesite and silica quarrying operations

Qls **Landslide deposits (Quaternary)**—Unconsolidated basalt rubble mainly along steep erosional scarps formed in basalt flows of Columbia River Basalt Group

Qag **Glacial and alluvial deposits (Quaternary)**—Till from continental glaciation and all alluvial material in modern drainages. Pale tan or pale gray; some alluvial deposits locally reflect colors of bedrock source. Unconsolidated boulders, gravel, sand, and silt. Semi-consolidated to consolidated clay, silty clay, and sandy clay. Clay-bearing parts well bedded to indistinctly bedded. Coarser parts are well bedded, indistinctly bedded, and massive; some sand and gravel deposits are well bedded, displaying large- and small-scale cross bedding. Clasts in alluvial deposits reflect local bedrock sources. Clasts in glacial deposits are mostly from bedrock units recognized in quadrangle, but also include exotic metamorphic, granitic, and volcanic clasts. Thickness highly variable, ranging from thin, discontinuous deposits near bedrock or in steep canyons to possibly more than 100 m in major river valleys

QTs **Consolidated alluvial and (or) glacial deposits (Quaternary and (or) Tertiary)**—Conglomerate, sedimentary breccia, minor arkosic and lithic sandstone, iron-oxide-cemented sandstone and conglomerate, and mudstone

Tcl **Clay deposits (Miocene?)**—Clay, silty clay, sandstone, and siltstone. Also contains layers of bog iron

Tcr **Columbia River Basalt Group (Miocene)**—Fine-grained tholeiitic basalt comprising several flows. All considered to be N_2 flows of Grande Ronde Basalt by Swanson and others (1979)

Tt **Tiger Formation (Eocene)**—Conglomerate, lithic arkose, and siltstone. Highly variable laterally and vertically. Poorly to moderately well indurated

Tcs **Conglomerate and sedimentary breccia (Eocene)**—Moderately well-indurated pebble to boulder conglomerate exposed in a limited area between Addy Mountain and Bayley Lake (fig. 1)

Tcb **Chlorite breccia and cataclastic rocks associated with the Newport Fault Zone (Eocene)**—Green or gray, finely comminuted cataclastic rocks and highly fractured and chloritized rocks in footwall of Newport Fault Zone. Close to fault plane, includes nearly aphanitic chlorite breccia containing millimeter- to centimeter-long, angular, internally fractured, matrix-supported feldspar fragments. Grades outward into progressively less fractured rock

Tcc **Tectonic breccia of Cusick Creek (Eocene)**—Breccia and gouge ranging in size from powder to house-size blocks; many larger blocks consist of recemented breccia

Tbl **Cataclastic rocks of Bayley Lake (Eocene)**—Highly comminuted cataclastic rocks and breccia associated with Eocene extensional tectonism. Much of unit is chlorite breccia

Ts **Sanpoil Volcanics (Eocene)**—Volcanic flow rocks, sedimentary and volcanic breccia, conglomerate, and lithic arkose. Includes rocks comprising Pend Oreille Andesite of Schroeder (1952), previously unnamed volcanic flows and sedimentary rocks south of Waitts Lake, flow or intrusive andesite northeast of Waitts Lake, and isolated outcrops of flow and sedimentary rocks east of Dunn Mountain (fig. 1)

Thd **Hypabyssal dikes (Eocene)**—Fine-grained mafic dikes of widely variable composition. Light- to dark-gray. Contain 3- to 12-mm-long phenocrysts of hornblende, biotite, plagioclase, potassium feldspar, quartz, and rare pyroxene. Dikes ranging from 0.5 m to 10 m in width are found throughout quadrangle

Tsp **Silver Point Quartz Monzonite (Eocene)**—Hornblende-biotite monzogranite and granodiorite (fig. 2). Forms two large noncontiguous plutons in southern part of quadrangle. Porphyritic; potassium feldspar phenocrysts average about 3 cm in length. Groundmass has distinctive bimodal grain size. Extremely homogeneous with respect to composition and texture

Tam **Quartz monzodiorite of Ahern Meadows (Eocene)**—Hornblende-biotite quartz monzodiorite and quartz monzonite (fig. 2). Medium to coarse grained, equigranular, nonporphyritic. Sphene extremely abundant, up to 0.5 percent in some rocks. Probably petrogenetically related to Silver Point Quartz Monzonite (Tsp)

Tll **Quartz monzonite of Loon Lake (Eocene)**—Hornblende-biotite quartz monzonite (fig. 2). Fine grained, hypidiomorphic granular, nonporphyritic, no directional fabric. Composition and texture, except for grain size, very uniform. Probably petrogenetically related to Silver Point Quartz Monzonite (Tsp)

To **O'Brien Creek Formation (Eocene)**—Tuff, arkose, arkosic sandstone, and conglomeratic arkose. White to pale gray to tan. Found only in small area in eastern part of sec. 9, T. 33 N., R. 44 E.

Kmm **Monzogranite of Midnight Mine (Cretaceous)**—Leucocratic, quartz-rich, muscovite-biotite monzogranite (fig. 2). Medium to coarse grained; sparsely and irregularly porphyritic. Color index averages about 5

Klr **Monzogranite of Little Roundtop (Cretaceous)**—Very coarse-grained biotite monzogranite (fig. 2). Forms two noncontiguous plutons, one east of Deer Lake and the other south of Deer Lake. Most rock is very deeply weathered and poorly exposed. Average grain size over 1 cm. Average color index of 7

Kbgm **Muscovite monzogranite of Blue Grouse Mountain (Cretaceous)**—Medium- to coarse-grained muscovite monzogranite, locally garnet-bearing. Forms four, aligned, noncontiguous bodies east of Deer Lake. Contains no mafic minerals except for sparse specks of magnetite, limonite, or pyrite

Starvation Flat Quartz Monzonite (Cretaceous)—Hornblende-biotite and biotite granodiorite and monzogranite. Forms three discrete plutons. Most rock medium to coarse grained and homogeneous in appearance. Consists of:

Ksh **Hornblende-biotite monzogranite and granodiorite**—Color index ranges from 13 to 18 in rock of average composition (fig. 2) and 17 to 27 along south and west borders of pluton. Biotite grains distinctive because many are thicker than they are wide. Sphene very abundant. Includes:

Ksha **Arden pluton**—Leucocratic biotite monzogranite and muscovite-biotite monzogranite (fig. 2). Medium to coarse grained, uniform with respect to composition and texture. Average color index 9; contains less than 1 percent muscovite

Kfl **Fan Lake Granodiorite (Cretaceous)**—Hornblende-biotite granodiorite and monzogranite (fig. 2); characterized by large stubby hornblende crystals and high color index. Medium to coarse grained. Average color index of 19. Sphene very abundant

Kc **Biotite monzogranite of Camden (Cretaceous)**—Medium-grained biotite monzogranite. Forms widely separated, poorly exposed, deeply weathered outcrops. Average color index 12. Probably related to Fan Lake Granodiorite

Kdc **Two-mica granodiorite of Dubius Creek (Cretaceous)**—Medium- to coarse-grained muscovite-biotite granodiorite and monzogranite. Average color index of 10. Much of unit contains sparse, pale-yellow-green epidote

Kgp **Galena Point Granodiorite (Cretaceous)**—Porphyritic medium- to coarse-grained biotite granodiorite (fig. 2). Phenocrysts average about 4 cm in length. Biotite is only mafic mineral; average color index is 12. Numerous leucocratic dikes in outer part of pluton and in country rocks

Kb **Blickensderfer Quartz Monzonite (Cretaceous)**—Very coarse grained muscovite-biotite monzogranite (fig. 2). Average grain size is about 1 cm. Locally porphyritic, but most of unit is not. Characterized by large smoky-gray quartz crystals. Average color index is 5

Granodiorite of Hall Mountain (Cretaceous)—Forms six noncontiguous plutons; all except Loop Creek pluton of granodiorite of Hall Mountain are north and east of Chewelah quadrangle. Within quadrangle consists of:

Khlc **Loop Creek pluton**—Muscovite-biotite granodiorite (see fig. 1 and modal diagram, fig. 2). Medium to coarse grained in central part; fine grained near margins. Biotite only mafic mineral; average color index is 10. Southern part of pluton cut by numerous, closely spaced quartz veins

Kpl **Phillips Lake Granodiorite (Cretaceous)**—Muscovite-biotite granodiorite; ranges from tonalite to monzogranite (fig. 2). Unit consists of volumetrically large proportion of petrogenetically related dikes, sills, and small stocks of leucocratic monzogranite. Granodiorite, tonalite, and monzogranite are similar in appearance because plagioclase and potassium feldspar are same color. Medium to coarse grained, irregularly porphyritic. Texture of rock is distinctive due to micas interstitial to and, in much of rock, wrapped around felsic minerals. Average color index is 11. In western part of body, average composition is granodiorite to monzogranite. Becomes progressively more tonalitic eastward toward Newport Fault. Inclusions and screens of metamorphic rocks ranging from centimeters to several hundred meters in length are common

Kli **Leucocratic intrusive rocks (Cretaceous)**—Medium- to fine-grained monzogranite; much contains muscovite, some has sparse biotite. Forms small bodies and isolated discontinuous dikes and sills. May include leucocratic rocks associated with more than one large Cretaceous pluton. Texture and grain size variable on outcrop scale. Some bodies contain bipyramidal quartz and garnet

Knb **Two-mica monzogranite of North Basin (Cretaceous)**—Medium- to coarse-grained muscovite-biotite monzogranite and granodiorite. Exposed in only a few deeply weathered outcrops in northwest part of quadrangle, but probably underlies much of area called North Basin (fig. 1). Exposed rock slightly foliated. Color index averages about 12

Knc **Monzogranite of Narcisse Creek (Cretaceous)**—Medium- to coarse-grained biotite monzogranite. Color index about 10, but more variable than most Cretaceous plutons in region. Granitic texture; locally has incipient foliation

Kbm **Monzogranite of Big Meadows (Cretaceous)**—Muscovite-biotite monzogranite and granodiorite. Fine- to coarse-grained, irregularly porphyritic; very heterogeneous texture and composition. Biotite only mafic mineral; average color index 7. Indistinct foliation irregularly developed in much of rock

Koc **Monzogranite of Otter Creek (Cretaceous)**—Sillimanite-bearing muscovite-biotite monzogranite. Medium grained, nonporphyritic; has poorly developed foliation apparent only in thin section; much feldspar is milled and quartz is milled and flattened. Color index ranges from about 5 to 15

Klgs **Leucocratic granitic rocks of Scotia (Cretaceous)**—Alaskite, pegmatite, aplite, and two-mica monzogranite; includes screens of Middle Proterozoic Prichard Formation and mafic sills. All granitic rocks leucocratic and contain muscovite and minor biotite. Fine to very coarse grained. Deformed in eastern part of unit

Ksv **Granodiorite of Spring Valley (Cretaceous)**—Biotite granodiorite; contains very sparse muscovite. Medium to coarse grained, nonfoliate to slightly foliate. Average color index 12. Contains very abundant allanite and opaque minerals

Kbr **Two-mica monzogranite of Blanchard Road (Cretaceous)**—Medium- to coarse-grained, porphyritic muscovite-biotite monzogranite. Distinguished by muscovite phenocrysts 2 to 3 cm long. Biotite is only mafic mineral; average color index 8. Foliate and deformed in southeastern part

KJcc **Hornblende-biotite quartz diorite of Cusick Creek (Cretaceous or Jurassic)**—Medium- to coarse-grained, highly mafic quartz diorite and tonalite. Altered. Color index ranges from 15 to 35

Jlm **Quartz monzodiorite of Lane Mountain (Jurassic)**—Medium- to coarse-grained, highly porphyritic biotite-hornblende quartz monzodiorite (fig. 2). Average color index 18. Almost all potassium feldspar occurs as 1.5- to 9-cm-long phenocrysts of orthoclase. Sphene very abundant. Groundmass has bimodal grain size

MzPzf **Fault-zone rocks (middle Mesozoic to late Paleozoic)**—Highly sheared and deformed argillite, phyllite, carbonate-bearing phyllite, and dolomite. Almost no sedimentary features preserved. Contains abundant fractured quartz veins

JTRft **Flowery Trail Granodiorite (Jurassic or Triassic)**—Biotite-hornblende quartz monzodiorite and quartz monzonite; ranges to granodiorite and monzonite (fig. 2). Fine- to coarse-grained. Average color index 22. Composition and texture variable. East end of pluton metamorphosed

M€u **Carbonate and clastic sedimentary rocks, undivided (Mississippian to Cambrian)**—Limestone, dolomite, and carbonaceous shale. All rocks are either fault bounded or surrounded by alluvium. Much of unit is extremely brecciated; most bedding and sedimentary structures are obliterated

Ml **Limestone (Mississippian)**—Limestone and lesser amounts of dolomitic limestone and dolomite. Medium to fine grained, medium to pale gray on fresh surface; weathers medium gray. Thin to thick bedded; sparsely cherty. All rock extremely fetid. Thickness about 200 m, but upper and lower contacts not exposed. Fossiliferous

MD_3 **Dolomite and slate (Mississippian or Devonian)**—Light-gray and cream-colored dolomite interbedded with maroon and pale-green argillite. Thin to thick bedded. Thickness poorly constrained, appears to be about 170 m. Unfossiliferous

MD_2 **White and pale-gray dolomite (Mississippian or Devonian)**— Dolomite; thick- to thin-bedded. Oolitic in lower part. White and pale gray. Most of unit is coarse grained. Unfossiliferous, except for sparse nondefinitive algae. Unit appears to be 150 to 200 m thick

MD_1 **Dark-gray dolomite (Mississippian or Devonian)**—Medium- to fine-grained, dark-gray dolomite; locally mottled light gray. Contains sparse quartz sand grains throughout. Thick to thin bedded; has oolites and matrix-supported dolomite conglomerate. Thickness estimated to be 180 to 210 m. Unfossiliferous

Ddl **Dolomite and limestone (Devonian)**—Light-gray and cream-colored dolomite interbedded with medium-gray limestone. Very poorly exposed; thickness and stratigraphic relations to other units uncertain. Fossiliferous

Ol **Ledbetter Formation (Ordovician)**—Dark-gray carbonaceous shale and slate and minor carbonaceous limestone and chert interbeds. Massive to very faintly laminated; nearly all of unit is highly cleaved. Limestone beds range from 1 cm to 1 m thick; all are medium to dark gray and carbonaceous. Large chert masses lacking internal stratification occur as fault-bounded pods. Extreme internal deformation. Apparent thickness is 550 m as calculated from outcrop width, but upper contact faulted. Graptolitic

O€gc **Phyllite and quartzite of Gardiner Creek (Ordovician or Cambrian)**—Medium- to dark-gray phyllite, white to brown vitreous quartzite, and minor interbeds of dark-brown, sandy dolomite. Unit is about 60 percent phyllite and 40 percent quartzite. Sandy dolomite is restricted to quartzite zones. Correlation with other units in quadrangle questionable. Resembles upper member of Late Proterozoic and Cambrian Addy Quartzite; however, unit may overlie Metaline Formation and be Ordovician in age

Metaline Formation (Ordovician and Cambrian)—Limestone, dolomite, shaly limestone, and carbonate-bearing quartzite. Metaline Formation forms a pure and impure carbonate rock sequence lying between Ledbetter Formation and Late Proterozoic and Cambrian Addy Quartzite. Highly variable from place to place, suggesting thrust faulting or abrupt lateral changes in lithofacies. In quadrangle, subdivided into four informal members, but internal stratigraphy of members and formation is poorly understood. Sparsely and locally fossiliferous. Consists of:

O€mu **Undivided part**—Limestone and shaly limestone. Large area south of Dunn Mountain (fig. 1) that is mapped as undivided is gray shaly limestone and subordinate pure limestone having parallel-planar and irregular bedding, respectively. Shaly limestone resembles shaly limestone member (O€ms). Pure limestone beds are unlike limestone beds of informal members. Southeast of Springdale (fig. 1), undivided Metaline overlies Cambrian upper member of Addy Quartzite (€au) and consists of thick- to thin-bedded blue-gray limestone that has irregularly shaped, yellow-brown-weathering argillaceous seams interwoven through rock. North of Jared, rocks mapped as undivided are gray, thick-bedded, brecciated, and recemented dolomite and dolomitic limestone

O€ms **Shaly limestone member**—Thin-bedded, extremely fine-grained, shaly limestone and calcareous shale. Ranges from pure limestone to nearly pure shale. Many beds, especially in upper part of unit, are distinctly carbonaceous. Most bedding is parallel planar, ranging from 5 cm to submillimeter laminations. Commonly fissile; argillaceous rocks slightly phyllitic. Gray, weathering pale gray or pale grayish-tan. In most places unit is highly cleaved and folded

O€md **Thick-bedded dolomite member**—Coarse-grained, relatively pure dolomite in beds up to 5 m thick; average bed thickness about 2 m. Bedding indistinct in much of member. White to pale gray, commonly containing diffuse, discontinuous, dark-gray streaks. Most of unit is coarse to very coarse grained. Tremolitic dolomite-marble near intrusive rocks. Apparent thickness, calculated from outcrop width, is about 800 m, but upper contact is fault

O€ml **Thick- and thin-bedded limestone member**—Interlayered fine-grained limestone, coarse-grained limestone; and limestone conglomerate. Medium gray, blue gray, and dark gray, weathering pale blue gray. Typically 1- to 3-m-thick intervals of centimeter-thick, parallel-planar limestone beds separated by 1- to 10-m-thick intervals of limestone conglomerate. Conglomerate is rounded and angular pebbles to boulders of limestone in matrix of fine- to coarse-grained, gray limestone. Conglomerate both clast and matrix supported; some beds of edgewise conglomerate. Member may be as thick as 680 m (including dolomite beds of unit O€mld). Locally, includes:

O€mld **Dark-gray dolomite beds**—Dolomite and dolomite breccia, very coarse-grained, dark gray. One- to 3-cm-thick, parallel-planar-bedded dolomite intervals as much as 2 m thick. Parallel-planar-bedded intervals separated by dolomite sedimentary breccia. Breccia clasts are sharp-edged tabular fragments up to 6 cm; most are matrix supported. Maximum thickness as calculated from outcrop width is about 210 m, but may be thickened by faulting

O€mq **Limestone and carbonate-bearing quartzite member**—Limestone, sandy limestone, carbonate-bearing quartzite, pebble conglomerate, and argillite. Lower part of member includes at least two 10-m-thick intervals of white, carbonate-cemented quartzite, separated by brownish-gray argillite. Carbonate cement in quartzite commonly leached, producing friable or porous, yellow-stained quartzite. Quartzite intervals overlain by thick argillite zone, part of which has thin, wavy, discontinuous lenses of quartzite. In Dunn Mountain area (fig. 1), argillite zone overlain by distinctive, 2-m-thick bed of carbonate-cemented quartz-pebble conglomerate. Pale-gray limestone containing lensoidal trains of matrix-supported, coarse-grained quartz sand forms upper part of member. Thickness of member as calculated from outcrop width is about 150 m

Addy Quartzite (Cambrian and Late Proterozoic)—Vitreous quartzite and lesser interbedded siltite and argillite. In parts of quadrangle, subdivided into four informal members following usage of Miller (1983), modified by Lindsey and others (1990). Unconformably overlies Late Proterozoic Windermere Group with very slight angularity detectable only on regional scale. Unconformity cuts through Windermere Group into Middle Proterozoic Deer Trail Group about 35 km southwest of quadrangle. Thickness of Addy as calculated from outcrop width averages about 1,400 m west of Jumpoff Joe Fault, but may be much less east of fault. Consists of:

€Zau **Undivided part (Cambrian and Late Proterozoic)**—White, purple, pink, gray, and tan vitreous quartzite interbedded with lesser amounts of gray, greenish-gray, purplish-gray, and brownish-gray argillite and siltite. Lower and middle parts relatively pure, white, purple, and pink quartzite. Upper part is white and gray quartzite interlayered with argillite and siltite. Moderately to highly recrystallized on hill south of Springdale, in Fan Lake area, in Leslie Creek area east of Addy Mountain, and on mountain north of Jared (fig. 1)

€au **Upper member (Cambrian)**—Interbedded vitreous quartzite and argillite and minor siltite. Argillite zones average 5 m thick and separate quartzite zones of equal or greater thickness. Discontinuous lenses of siltite and fine-grained, wavy-bedded quartzite common in argillite. Argillite is purplish gray and greenish gray. Quartzite is medium grained, white and gray, planar and wavy bedded; some are cross bedded. Thickness about 425 m on Dunn Mountain. Contains Early Cambrian trilobite *Nevadella addyensis* and brachiopod *Kutorgina* sp. (Okulitch, 1951). Lindsey and others (1990) note body and trace fossils in lower part of upper member

€ac **Coarse-grained member (Cambrian)**—White, gray, and pink, medium- and coarse-grained quartzite. Unit defined by Lindsey and others (1990). Contains matrix-supported pebbles throughout and lenses as much as 5 cm thick of clast-supported pebbles locally. Pebbles and coarseness decrease upward in member. Sparse, interbeds of pale-greenish-gray, brownish-gray, and purplish-gray argillite or siltite. Beds from 10 cm to 2 m thick; form blocky-weathering outcrops. Crossbedding fairly abundant. Thickness on Dunn Mountain about 370 m

€Zap **Purple member (Cambrian and Late Proterozoic)**—Purple, pink, gray, and white medium-grained quartzite and minor thin siltite and argillite beds. Quartzite marked by distinctive black stripes and reddish hues. Stripes both parallel and crosscut bedding; most are trains of disseminated hematite and hematite-coated quartz grains. In Iron Mountains (fig. 1), lower part of member contains several half-meter-thick beds that are 30 percent hematite. Bed thickness of member ranges from 2 cm to about 1 m. Abundant crossbedding, typically highlighted by dark stripes. Thickness of member on Dunn Mountain about 460 m

Zal **Lower member (Late Proterozoic)**—Vitreous quartzite and minor interbedded argillite. Quartzite is white, medium to fine grained, and thick to massively bedded. Member thickens to the northeast (Miller, 1983; Groffman, 1986) and thins to the southeast (Miller and Clark, 1975). On Dunn Mountain, average thickness is 150 m. Not subdivided east of Jumpoff Joe Fault, where member is only a few meters thick

Windermere Group—Consists of Monk Formation and Huckleberry Formation; latter divided into upper greenstone member and lower conglomerate member (Campbell and Loofbourow, 1962). Unconformities bound Windermere Group at top and bottom. Conglomerate and greenstone members of Huckleberry Formation laterally equivalent to Shedroof Conglomerate and Leola Volcanics, respectively, in Metaline area 70 km to northeast (Park and Cannon, 1943) and to Toby Conglomerate and Irene Volcanics, respectively, in southern British Columbia (Reesor, 1957; Miller and others, 1973). Windermere is not found east of Jumpoff Joe Fault. Consists of:

Monk Formation (Late Proterozoic)—Conglomerate, megabreccia, diamictite, feldspathic and lithic quartzite, siltite, and argillite. Extremely variable from place to place. Formation on Empey Mountain (fig. 1) informally subdivided into three members; other places mapped as undivided part (Zmu) or as conglomerate member (Zmc). Consists of:

Zmu **Undivided part**—Argillite, siltite, dolomite, and conglomerate. In Iron Mountains, lower 15 m is dark greenish-gray conglomerate containing nearly spherical 6 cm-wide clasts of andesitic-looking volcanic rock. Conglomerate rests directly on greenstone member of Huckleberry Formation; probably thins to north and south. Overlain by dolomite, carbonate-bearing siltite interlayered with argillite, and fine-grained quartzite. Upper part of formation is finely laminated, multicolored siltite and argillite. Same rock types found in partial sections near Bayley Creek and southwest of Chewelah, but conglomerate clasts are quartzite, dolomite, and argillite derived from Middle Proterozoic Deer Trail Group. Unconformably overlain by Addy Quartzite. Thickness variable owing to depth of pre-Addy erosion and possibly to syndepositional faulting

Zma **Argillite member**—On Empey Mountain (fig. 1), occurs as two distinct argillite zones separated by greenstone (Zmg) and conglomerate (Zmc). Upper zone is gray argillite and siltite having indistinct parallel-planar laminations. Some argillite has sparse, 1-mm, matrix-supported quartz grains. Lower zone is gray, parallel-planar argillite and siltite containing thin quartzite interbeds in multiple fining-upward sequences. Upper contact of argillite member is unconformity; up to 250 m preserved on Empey Mountain

Zmg Zmc **Conglomerate member** (Zmc)—Conglomerate, megabreccia, diamictite, and feldspathic and lithic quartzite and siltite; on Empy Mountain contains band of greenstone (Zmg). West-northwest of Waitts Lake, unit is dolomite megabreccia. Blocks ranging from centimeters to 200 m enclosed in matrix of conglomeratic siltite, argillite, and lithic quartzite. Cobble-sized clasts in matrix are mixed lithologies and well rounded. On Lane Mountain clasts are sparse and matrix is tan siltite and argillite. On Empey Mountain, below greenstone, unit is interbedded conglomerate, lithic arkose, and siltite in multiple, fining-upward beds; above greenstone, unit is green, matrix-supported diamictite. Thickness is variable due to syndepositional faulting, Mesozoic faulting, pronounced facies changes, and pre-Paleozoic erosion. **Greenstone** (Zmc)—Altered basalt flow-rocks and minor volcanic breccia. Rocks indistinguishable from greenstone (Zhg) in underlying Huckleberry Formation. Collapsed vesicles abundant at some localities. Appears to grade into conglomerate member (Zmc) of Monk Formation, which lies above and below. Thins southward; not recognized in Monk sections north of Empey Mountain

Huckleberry Formation (Late Proterozoic)—Extrusive and intrusive rocks of basaltic composition, conglomerate, and diamictite; all basaltic rocks metamorphosed to greenstone. Informally subdivided into greenstone member (upper) and conglomerate member (lower) (Campbell and Loofbourow, 1962). Intrusive greenstone related to flows of greenstone member. Thin discontinuous zones of conglomerate are present in greenstone member. Consists of:

Zhgc Zhi Zhg **Greenstone member** (Zhg)—Greenstone derived from basaltic lava flows, tuff, volcanic breccia, and volcaniclastic rocks; includes intrusive greenstone and minor conglomerate. Thicknesses of flows range from meters to several tens of meters. Individual flows poorly defined due to lack of lithologic contrast across flow boundaries. Flow breccia consisting of light-green, angular clasts in dark-green matrix common north of Chewelah. Indistinct pillow structures in lower part. Composition is tholeiitic basalt (Miller and Clark, 1975) containing pyroxene and plagioclase in microcrystalline groundmass altered to chlorite, quartz, albite, calcite, epidote, and opaque minerals. Typically phyllitic. On Gold Hill (fig. 1) and south flank of Deer Mountain, member is thin and includes conglomerate and diamictite. Thickness calculated from outcrop width averages 975 m. Thins eastward; not present east of Jumpoff Joe Fault. **Volcanic conglomerate** (Zhgc)—Poorly rounded to well-rounded clasts of volcanic rocks in matrix of medium- to fine-grained volcaniclastic material. Mapped only west of Waitts Lake and northeast of Stensgar Mountain. **Intrusive greenstone** (Zhi)—Lithologically similar to massive flow rocks of greenstone member, but most is coarser grained; some is gabbroic. Forms several large masses in Huckleberry Creek and Service Creek drainages (fig. 1)

Zhc **Conglomerate member**—Diamictite, conglomerate, sandy siltite and argillite, and lithic quartzite. Green and gray, matrix-supported diamictite and conglomerate are most common lithologies. Clasts typically sparse or nearly absent; clast types include dolomite, argillite, siltite, quartzite, and milky quartz derived from Deer Trail Group. Matrix is quartz, feldspar, sericite, chlorite, and abundant carbonate minerals and lithic material. Characterized by sparse, round, matrix-supported quartz grains throughout rock. Typically phyllitic; foliation commonly oriented 10° or 20° from bedding. Bedding apparent only where rare lithic quartzite beds are found. Thickness about 480 m; thins eastward and northeastward

Deer Trail Group—Deer Trail Group crops out exclusively in north-northeast-striking, highly deformed belt known as magnesite belt (Campbell and Loofbourow, 1962). Northern two-thirds of magnesite belt lies within Chewelah quadrangle. Base of Deer Trail Group not exposed; upper contact is faulted everywhere except south of Chewelah, where rocks of Windermere Group unconformably overlie middle part, and north of Chewelah where Windermere rocks lie on middle to lower part. Deer Trail Group is lithostratigraphic equivalent of part of upper part of Belt Supergroup (Miller and Whipple, 1989). Consists of:

Ydtu **Undivided part (Middle Proterozoic)**—Argillite, phyllite, and quartzite. Includes five small outcrop areas of sheared and deformed rocks near Empey Mountain and highly recrystallized schist west of Bayley Lake (fig. 1). Rocks are nondistinctive and cannot be assigned to specific formations of Deer Trail Group

Buffalo Hump Formation (Middle Proterozoic)—Formation subdivided into quartzite and argillite units; appears to have two distinct zones of each: lower white quartzite zone overlain by two argillite zones that are separated by thinner quartzite zone. Both rock types are variable in appearance and probably vary in relative abundance. Quartzite most abundant at each end of magnesite belt (fig. 1); argillite predominates in central part (Miller and Whipple, 1989). Mapped variations in quartzite to argillite ratio are due largely to faulting, folding, and poor exposure. Maximum thickness of Buffalo Hump Formation about 550 m. Windermere Group unconformably overlies unit. Consists of:

Ybu **Undivided part**—Chiefly laminated argillite and siltite. Even-parallel to nonparallel bedding and lamination; soft-sediment deformation abundant. Mapped as undivided rocks only on The Island (fig. 1), south of town of Valley

Yba **Argillite**—Pale, greenish-gray, massive argillite; minor amount laminated. Almost all is highly deformed and phyllitic. Unit is probably two distinct argillite zones separated by quartzite zone about 50 m thick (included in unit Yba). Upper part of upper argillite zone contains dark-gray laminated argillite. Thickness of upper argillite zone about 180 m; thickness of lower argillite zone at least 50 m

Ybq **Quartzite**—Vitreous quartzite, subordinate argillite, and minor siltite and conglomerate. Chiefly white, coarse-grained, medium- to thick-bedded quartzite; argillite beds scattered through section, and green and red feldspathic quartzite near base. Upper 50 meters of quartzite separated from lower part of unit by at least 50 m of argillite. Thick-bedded quartzite typically very coarse grained, some is pebble bearing

Ys **Stensgar Dolomite (Middle Proterozoic)**—Dolomite; contains minor interbedded argillite. Most dolomite pink or maroon, white, and tan. Maroon argillite beds in sequences up to 3 m thick restricted chiefly to sharply defined intervals in upper and middle parts of formation; lower part contains thin beds and bedding-plane partings of argillite. Maroon coloration diminishes southwestward. Section near Jim McGraff Quarry (fig. 1) includes about 50 m of gray-weathering, medium- to thin-bedded dolomite and chert; no other carbonate rocks of Deer Trail Group weather gray. Upper part of Jim McGraff Quarry section contains sparse algal structures, oolites, and beds containing nodular chert. About 50 to 75 m below inferred top of unit, about 3 m of argillite contains abundant casts of evaporite minerals. All magnesite deposits in magnesite belt are restricted to Stensgar Dolomite

Ym **McHale Slate (Middle Proterozoic)**—Formation almost entirely argillite. Lower third is medium- to dark-gray argillite having tan, pale-gray, and white laminae. Beds range from laminations to fining-upward couplets as much as 3 cm thick. Parallel-planar to wavy-nonparallel lamination common but extensively disrupted by soft-sediment deformation. Gray argillite of lower third of formation grades upward into pale-greenish-gray and pale-lavender-gray argillite, which characterize upper part of formation. Bedding indistinct in upper two-thirds of formation. Throughout extent, McHale is phyllitic and folded. Thickness about 370 m

Ywdg Ywd **Wabash Detroit Formation** (Ywd) **(Middle Proterozoic)**—Dolomite and subordinate argillite, quartzite, and carbonate-bearing quartzite and siltite; greenstone in upper part. Formation is chiefly thin- to thick-bedded, tan-weathering, gray and white impure dolomite having abundant thin interbeds of pale-green and gray argillite and carbonate-bearing siltite. Beds average between 5 and 15 cm. Stromatolitic beds common. Most rocks, especially argillitic and siltitic strata, are extremely cleaved and sheared. Zones of vitreous quartzite in upper and lower part. Unit forms very poor outcrops. Grades upward into argillite of McHale Slate; at some places, vitreous quartzite interval appears to directly underlie McHale, and at other places greenstone does. Thickness about 240 m. **Greenstone** (Ywdg)—Altered flows or sills of basaltic composition; matrix chloritized and plagioclase altered to albite. Contains abundant calcite. Persistent between Wabash Detroit Formation and McHale Slate, more so than shown on geologic map. Persistence of greenstone at one interval suggests it is extrusive, but no extrusive features are preserved; could also represent sills related to greenstone member (Zhg) of Huckleberry Formation. Thickness ranges from 0 to 15 m

Ywcu **Wabash Detroit Formation and Chamokane Creek Formation, undivided (Middle Proterozoic)**—Highly sheared and faulted dolomite, dolomitic quartzite, argillite, and quartzite. Mapped as undivided unit in Eagle Mountain area because bedding characteristics and other sedimentary features used to distinguish specific formations are destroyed, and because lithologies are homogenized by faulting

Chamokane Creek Formation (Middle Proterozoic)—Carbonate-bearing quartzite, vitreous quartzite, and siltite; interbedded with dolomite and argillite. Formation is most poorly exposed unit of Deer Trail Group; commonly identified by red-orange soil developed on unit and by aligned swamps and bogs. Thickness about 600 m as calculated from outcrop width of composite section. Consists of:

Ycc **Carbonate-bearing rocks**—Pale-tan, carbonate-bearing quartzite and siltite interbedded with lesser pale-gray, pale-green, and dark-gray argillite. Unit lithologically identical above and below 150-m-thick zone of carbonate-free vitreous quartzite and argillite (Yccq) in upper middle part of Formation. Upper and lower part of unit contains zones of tan impure dolomite up to 3 m thick. Except for dolomite, beds range from 1 to 10 cm thick and are chiefly wavy nonparallel. Pyrite ubiquitous but sparse, especially in dolomite. Carbonate minerals leached from most of carbonate-bearing quartzite and siltite. Thickness, including Yccq, about 600 m as calculated from outcrop width of composite section. Includes:

Yccq **Vitreous quartzite and argillite**—Medium- to fine-grained vitreous quartzite and interbedded dark-gray argillite. Upper and lower contacts are bed-by-bed gradation from carbonate-bearing quartzite and siltite (Ycc). Quartzite beds are quartz cemented and contain almost no other minerals. Beds range from even parallel to wavy nonparallel. Some quartzite crossbedded; much of unit shows extensive soft-sediment deformation and compaction features. Syneresis cracks and fluid-escape structures abundant

Yt **Togo Formation (Middle Proterozoic)**—Medium- and dark-gray argillite containing subordinate beds and intervals of green argillite and green and gray siltite. Beds range from wavy nonparallel to even parallel. Bed thickness ranges from submillimeter laminae to about 10 cm; beds thicker than about 2 cm generally show even-parallel bedding. Laminations defined by light-gray siltite that weathers orange, reflecting minor carbonate content. Soft-sediment deformation common throughout unit. Almost all argillite highly deformed and slightly to highly phyllitic. Minimum thickness about 800 m; unusually broad outcrop is largely due to extreme internal deformation. Base of formation everywhere faulted

Belt Supergroup—Found in two thick sequences of quartzite, siltite, argillite, and dolomite; one north of Newport in hanging wall of Newport Fault, other east of Chewelah in footwall. Sequences separated by part of (informal) Priest River complex. All Belt units are present in both sequences, except Bonner Formation and most of Mount Shields Formation, which are absent in Chewelah sequence. Lithofacies of some units differ between two sequences; units are generally thicker in Chewelah sequence. Thickness of formations calculated from outcrop width are approximate because of incomplete exposure and hidden faults. Consists of:

Ybmh **Bonner Formation, Mount Shields Formation, and argillite of Half Moon Lake, undivided (Middle Proterozoic)**—Argillite, siltite, and lesser amounts of quartzite. Mapped as undivided only on ridge between Skookum and Browns Creeks (fig. 1), where much of rock is altered and bleached, but some sedimentary features are preserved. Unit poorly exposed and probably contains hidden faults. Thickness unknown

Ybo **Bonner Formation (Middle Proterozoic)**—Maroon, pale-purple, and pale-green siltite, argillite, and quartzite. Beds range from less than 1 cm to about 1 m thick. Unit about 80 percent thin-bedded, coarse siltite, 10 percent thick bedded quartzite, and 10 percent thin beds and bedding-plane films of argillite. Mud cracks, mud-chip breccia, and ripple marks common. Thickness is about 190 m

Mount Shields Formation (Middle Proterozoic)—Argillite, siltite, dolomite, and dolomitic siltite. Consists of:

Yms$_5$ **Member 5**—Dark-gray, parallel-planar, micro-laminated argillite. Lithologically uniform except for dolomitic gradational zone into underlying unit. Upper contact is bed-by-bed gradation over 2 meters. Thickness between 70 and 80 m

Yms$_4$ **Member 4**—Dolomite, chert, and minor argillite. Gray, tan, and white; weathers tan, brown, and gray. Bed thickness from 1 cm to 1 m; uneven to parallel planar. Surfaces typically hematite stained. Stromatolites fairly common. Chert occurs as nodular and irregular masses. Has massive sedimentary breccia in lower part. Member about 160 m thick

Yms$_3$ **Member 3**—Siltite, argillite, dolomite, and quartzite. Pale green and tan weathering; surfaces hematite stained. Bedding wavy parallel and nonparallel; graded couplets common. Detrital mica throughout. Fluid-escape structures, mud cracks, mud-chip breccia, ripple marks, and salt casts in most of unit. Stromatolitic dolomite beds range from centimeters to 1 m thick; abundant in upper part. North of Newport, member about 180 m thick. On Quartzite Mountain and along Grouse Creek (fig. 1), few meters of unit preserved beneath Late Proterozoic unconformity

Yhm **Argillite of Half Moon Lake (Middle Proterozoic)**—Gray, laminated argillite, thin-bedded siltite, and thick- to thin-bedded quartzite. Lower third is parallel-planer-laminated argillite. Middle 75 m is thin-bedded siltite interlayered with laminated argillite. North of Newport, siltite interval contains several 3- to 50-cm-thick, fine-grained quartzite beds. East of Chewelah, middle part of unit is much more quartzitic and contains detrital mica. Above siltite zone in both areas, unit is argillite similar to that in lower part. Unit characterized by localized areas of soft-sediment deformation. About 350 m thick north of Newport; thickens westward to about 650 m near Chewelah

Yssh **Shepard Formation and Snowslip Formation, undivided (Middle Proterozoic)**—Schist, calc-silicate rock, dolomitic marble, argillite, siltite, and dolomite. Mapped as undivided unit only west of Pend Oreille River at north edge of quadrangle, where rocks are contact metamorphosed. Most sedimentary features destroyed. Very abundant sulfide minerals. Thickness unknown due to faulting

Yssw **Shepard Formation, Snowslip Formation, and Wallace Formation, undivided (Middle Proterozoic)**—Argillite, siltite, and porous quartzite. Very poorly exposed. Hydrothermally altered and bleached; carbonate minerals leached from quartzite and siltite. Characteristic sedimentary features poorly preserved in limited areas. Mapped between Fan Lake and Loon Lake Mountain. Thickness unknown

Ysh **Shepard Formation (Middle Proterozoic)**—Dolomite, dolomitic siltite, and siltite. White, tan, maroon, and pale-gray; tan-weathering. Stromatolitic and oolitic. Interbedded with dark, chlorite-green siltite beds in lower 60 m; siltite may be volcaniclastic (Miller and Whipple, 1989). Siltite beds lacking in Chewelah sequence. About 360 m thick at Newport; 430 m thick at Chewelah

Ywr **Wallace Formation and Ravalli Group, undivided (Middle Proterozoic)**—Schist and calc-silicate rocks; medium- to coarse-grained. Most calc-silicate rocks found between Calispell and Little Calispell Peaks (fig. 1); occurs as far north as Calispell Peak. Most common assemblage is quartz-plagioclase-actinolite-diopside, but locally scapolite, vesuvianite, epidote, and clinozoisite are abundant. Nearly all schist is plagioclase-muscovite-biotite-quartz schist. Clots of muscovite suggest retrograded aluminum silicate minerals. Thickness unknown

Yss **Snowslip Formation (Middle Proterozoic)**—Gray argillite and siltite and minor quartzite. Wavy, nonparallel to near-parallel beds in fining-upward couplets and 2- to 50-cm-thick siltite intervals. In upper two-thirds of formation 1- to 20-m-thick intervals of gray-green siltite alternate with dark-gray argillite. Fluid-escape, syneresis, and soft-sediment deformation common. May contain carbonate rocks in covered intervals. Thickness north of Newport about 380 m; east of Chewelah, about 1,400 m thick

Yw **Wallace Formation (Middle Proterozoic)**—Carbonate-bearing siltite and quartzite and abundant thin interbeds of dark-gray argillite. Thick beds of relatively pure dolomite most abundant in lower part. Bedding mostly wavy nonparallel. Unit characterized by tan, carbonate-bearing quartzite and siltite beds that show extreme pinch and swell laterally, separated by thin, black, phyllitic argillite beds and bedding-plane partings. Argillite cut by numerous syneresis cracks. Soft-sediment deformation, load features, and fluid-escape structures are abundant. North of Newport, thickness about 730 m; east of Chewelah, about 800 m

Ye **Empire Formation (Middle Proterozoic)**—Siltite, quartzite, argillite, dolomite, and carbonate-bearing siltite; pale-green. Thin, uneven, wavy bedding, but some parallel-planar beds of quartzite. Contains sparsely disseminated sulfide minerals. Lower 30 m contains dolomite-bearing purple siltite. Average thickness about 320 m near Newport, 100 m near Chewelah. In Chewelah section, unit not subdivided, mapped as upper part of St. Regis Formation (Ysr)

Ysr **St. Regis Formation (Middle Proterozoic)**—Maroon to purple siltite, argillite, and lesser amounts of quartzite. Bedding characteristically wavy nonparallel. Bed thickness averages about 6 cm. Ripple marks, mud cracks, mud-chip breccia, cross lamination, and fluid-escape structures common throughout formation. South of Chewelah, includes pale-green beds of Empire Formation. Average thickness north of Newport 275 m; south of Chewelah 450 m (including pale-green Empire strata)

Yr **Revett Formation (Middle Proterozoic)**—Quartzite and minor siltite. Average bed thickness 0.5 m. Large- and small-scale crossbedding and ripplemarks common, but not obvious. Most of formation is white, tan, or gray fine-grained quartzite. North of Newport, upper 200 m is pink or maroon; color similar to St. Regis Formation, but lithology typical of Revett. In Chewelah section, 200 m near middle of formation is mostly siltite. North of Newport averages 750 m thick and, south of Chewelah, 950 m thick

Ybk **Burke Formation (Middle Proterozoic)**—Siltite and minor argillite and quartzite. Most of formation extremely uniform medium- to pale-gray siltite; characteristically has weathering rind that is distinctly lighter gray. Quartzite beds sparsely scattered throughout formation. Bed thickness averages 20 cm Bedding mostly parallel planar to slightly wavy even. Oscillation and current ripple marks common; much siltite is finely cross-laminated. Upper part contains about 100 m of maroon siltite, argillite, and quartzite similar to St. Regis Formation. North of Newport average thickness about 850 m; south of Chewelah, about 1,100 m

Yd **Mafic sills (Middle Proterozoic)**—Medium- to fine-grained sills of diabase intruding Prichard Formation. All are recrystallized; composed of hornblende, biotite, plagioclase, quartz, and opaque minerals. Hornblende forms over 50 percent of most rocks. Sills range in thickness from about 1 m to 460 m. North of Newport, sills are thick, thinning northward. East of Chewelah, sills are sparse and thin. Some intrusions discordant, especially in lower part of Prichard Formation. Zircon uranium-lead age is 1,433 Ma (Zartman and others, 1982)

Yp **Prichard Formation (Middle Proterozoic)**—Interbedded quartzite, siltite, and argillite; white and pale-gray quartzite, pale- to medium-gray siltite, and medium- to dark-gray argillite. Entire formation contains pyrite, but highest concentration is in argillites; oxidation of pyrite causes almost all rock surfaces in Prichard to be iron-oxide stained. Bedding and lamination characteristically parallel planar and graded. Upper 500 to 1,500 m mainly dark-gray argillite and some interbedded quartzite. Below that, quartzite, siltite, and argillite vary in relative proportion. Near Newport sequence is about 5,200 m thick; near Chewelah about 4,100 m thick. Base of formation nowhere exposed in quadrangle. In Chewelah sequence, metamorphism of Prichard Formation increases progressively eastward. Includes:

Ypm **Metamorphosed part (Middle Proterozoic)**—Medium- and coarse-grained schist and hornfels intruded by muscovite-biotite granitic rocks; proportion of igneous rocks in unit generally increases eastward. Schist locally contains sillimanite±kyanite±andalusite. Transition from metamorphosed to unmetamorphosed Prichard is gradational zone several hundred meters wide, generally placed where bedding in Prichard cannot be distinguished from metamorphic foliation. Most of unit within 4 km of Newport Fault is mylonitized

Ynl **Newman Lake Gneiss (Proterozoic?)**—Biotite-quartz-plagioclase-potassium feldspar gneiss. Contains traces of muscovite. Foliation and lineation caused by intense ductile deformation, which decreases westward. Numerous pods of highly recrystallized Prichard Formation (Yp) and mafic sill rocks (Yd) found enclosed within easternmost 300 to 500 m of unit

sgg **Schist, gneiss, and leucocratic granitic rocks (age unknown)**—Coarse-grained quartz-feldspar-muscovite-biotite schist and gneissic rocks that include amphibolite bands and pods. Intruded by concordant and discordant, texturally and compositionally heterogeneous leucocratic granitic rocks. Schist and gneiss could be either metamorphosed rocks of Belt Supergroup, or could be pre-Belt crystalline rock

Contact—Solid where located within 50 m; most located within ±25 m

Faults

High-angle—Solid where located within ±25 m; dashed where located within ±50 m; dotted where concealed; queried where location uncertain

Thrust, younger over older—Dashed where located within ±50 m; dotted where concealed; quiried where location uncertain

Low-angle normal (detachment)—Solid where located within ±25 m; dashed where located within ±50 m;

Strike and dip of bedding*
Horizontal
70 **Inclined**
Vertical
70 **Overturned**
70 **Overturned more than 180°**
70 **Wavy or crinkled**

Strike and dip of foliation, primary igneous*
70 **Inclined**
Vertical

Strike and dip of foliation, metamorphic*
70 **Inclined**
Vertical

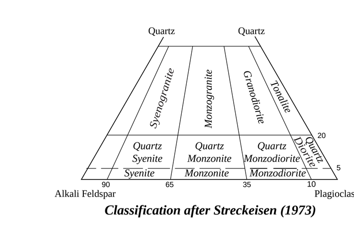
Strike and dip of cleavage*
70 **Inclined**
Vertical

Bearing and plunge of lineation, stretching*
Horizontal
70 **Inclined**

Bearing and plunge of lineation, minor fold axes*
70 **Inclined**

Direction of relative movement on faults—Cross sections only
Single movement
Multiple movements (reactivated faults)—Sequence of directions is not known

*Symbols may be used in combination



Classification after Streckeisen (1973)

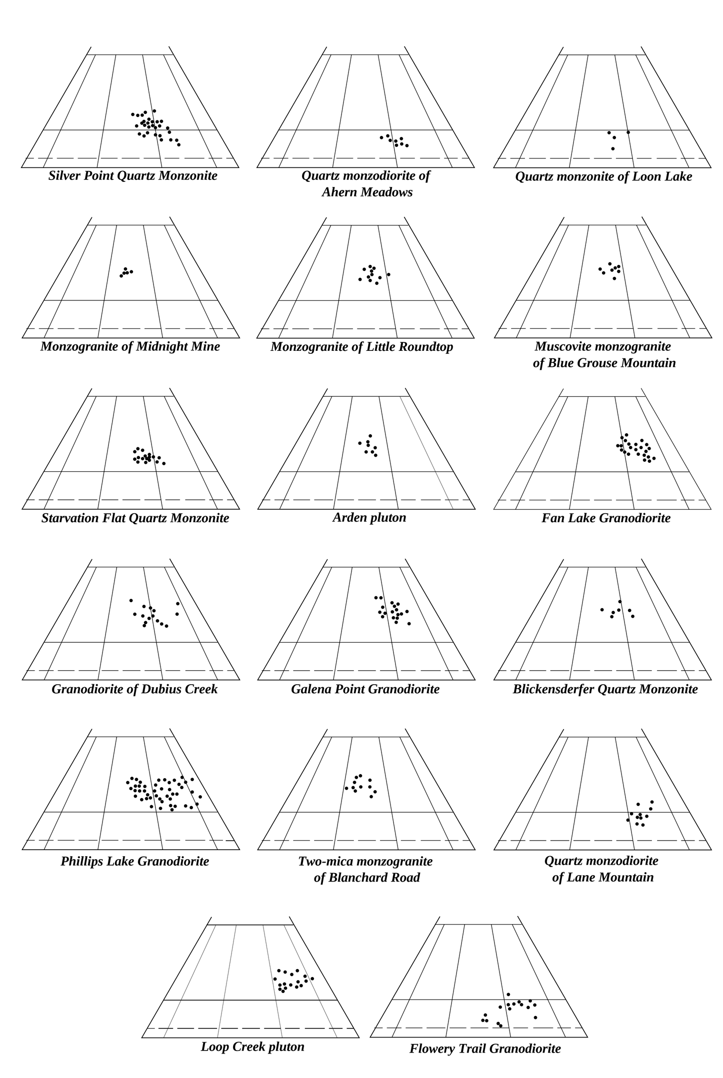


Figure 2. Modal diagrams showing composition of granitic rocks in Chewelah quadrangle.

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GEOLOGIC MAP OF THE CHEWELAH 30' X 60' QUADRANGLE, WASHINGTON AND IDAHO

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