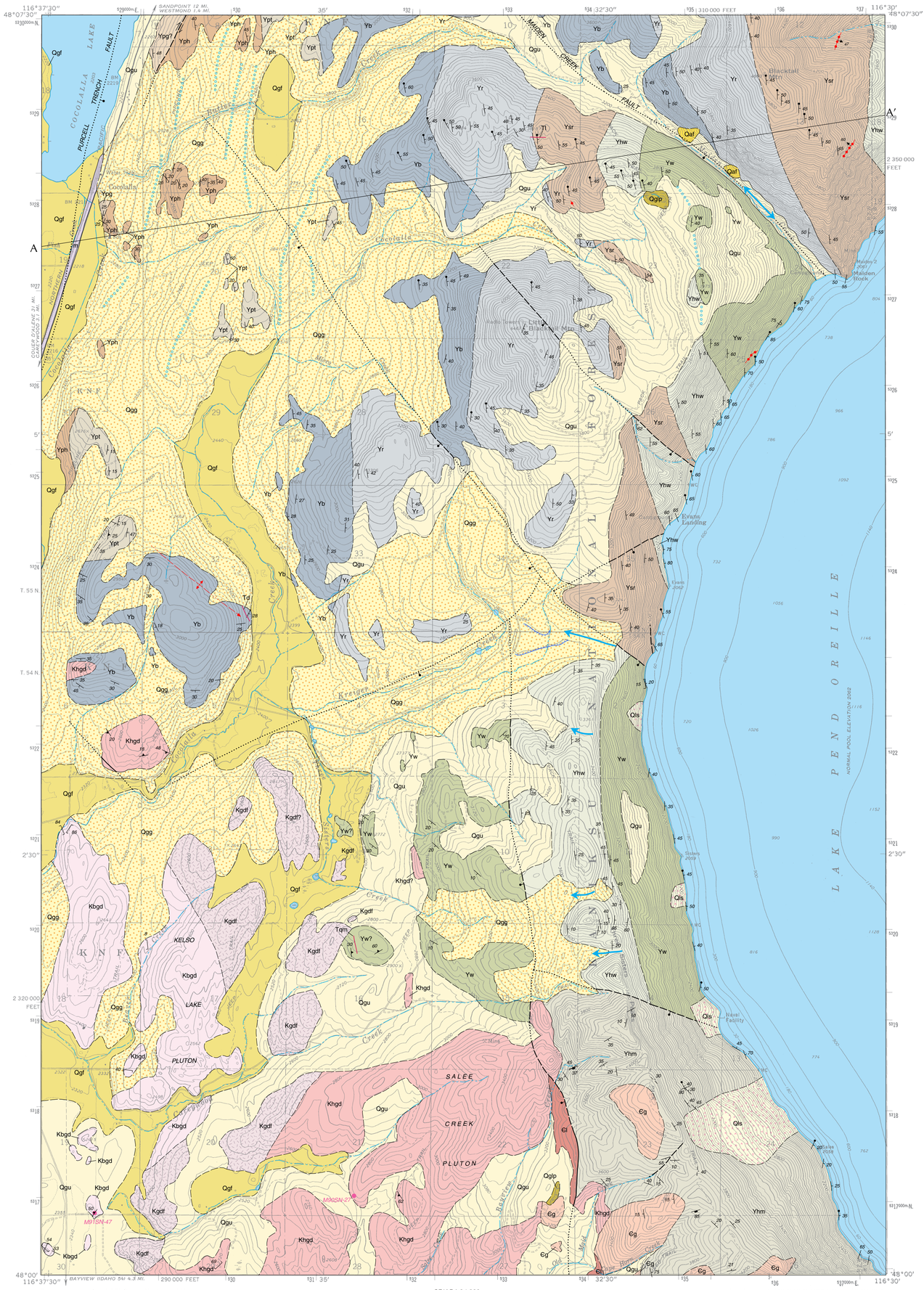
GEOLOGIC MAP OF THE COCOLALLA QUADRANGLE, BONNER COUNTY, IDAHO

Russell F. Burmester, Reed S. Lewis, Mark D. McFaddan,
Roy M. Breckenridge, David M. Miller, and Fred K. Miller

2007



Base map scanned from USGS film-positive base, 1968.
Topography by photogrammetric methods from aerial photographs taken 1966. Field checked 1968.
Transverse Mercator. 1927 North American Datum.
10,000-foot grid ticks based on Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
National geodetic vertical datum of 1929.
Depth curves and soundings in feet. Datum is lake elevation 2,048 feet.

UTM Grid and 1968 Magnetic North Declination at Center of Map

SCALE 1:24,000

1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 KILOMETER

Contour interval 40 feet.
Supplemental contour interval 20 feet.

IDAHO
QUADRANGLE LOCATION

Field work conducted 1988-1989, 1992-1995, and 2004-2006.

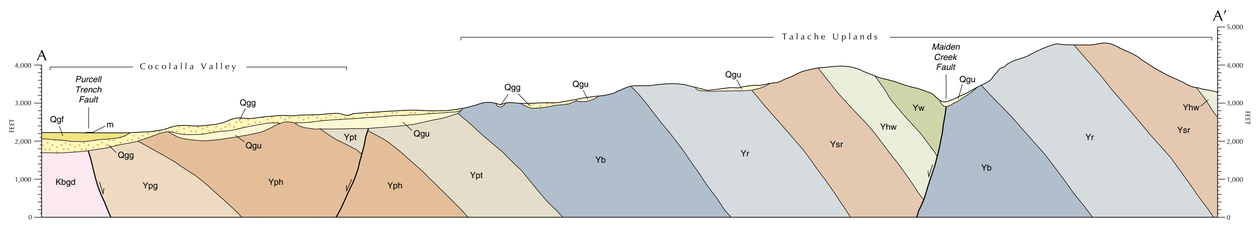
This geologic map was funded in part by the U.S. Geological Survey National Cooperative Geologic Mapping Program, USGS Award No. 06HQAG0020.

Digital cartography by Jesse S. Bird and Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.

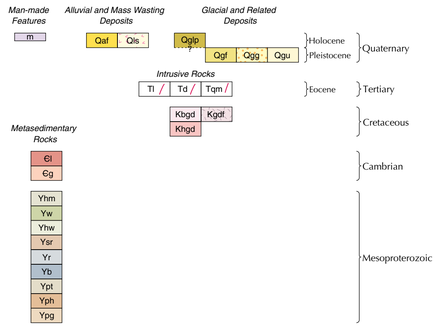
Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run and fading but will deteriorate with long-term exposure to light.

PDF map (Acrobat Reader) may be viewed at www.idahogeology.org.

Map version 10-4-2007.



CORRELATION OF MAP UNITS



INTRODUCTION

Quaternary deposits on this 1:24,000-scale Cocolalla quadrangle were mapped in 1988-1989 and 2004-2006 by R.M. Breckenridge. Bedrock was mapped in 2006 by R.F. Burmester, R.S. Lewis and M.D. McFaddan. The bedrock mapping built on previous unpublished U. S. Geological Survey 7 ½′ mapping by F.K. Miller and D.M. Miller (assisted by Pahdrig McCarthy) from 1992-1995, which was utilized on the Sandpoint 1° x 2° quadrangle map (Miller and others, 1999). Michael Wells and John Nakata provided D.M. Miller with $^{40}Ar/^{39}Ar$ and K-Ar analyses. Vein locations and faults in the northeast part of the map were modified from Green (1976).

Low metamorphic grade metasedimentary rocks of the Belt-Purcell Supergroup, Precambrian in age, occupy the northern and most of the eastern parts of the Cocolalla quadrangle. Dominantly granitic rocks of Cretaceous age occupy the southwestern part. Sediments in the topographically low areas in the west-central part of the quadrangle date primarily from Pleistocene glaciation and catastrophic floods from glacial Lake Missoula.

The geomorphic subsections of the quadrangle are mostly the Talache Uplands bordered on the west by small parts of the Cocolalla Valley and on the east by the Pend Oreille Lake Basin (Savage, 1967). During Pleistocene glaciation, a lobe of the Cordilleran Ice repeatedly advanced southward along the Purcell Trench from Canada. The lobe filled the Pend Oreille Lake basin, blocked the Clark Fork River, and formed Glacial Lake Missoula. Ice overflowed into the Cocolalla Valley and mostly protected the valley from the effects of the flood outbursts that mainly passed down the Pend Oreille Lake basin. The floods ended about 15,000 years ago with the retreat of the ice lobe. Post glacial Holocene alluvium, colluvium, and lacustrine sediments are mostly reworked glacial deposits.

DESCRIPTION OF MAP UNITS

Intrusive rocks are classified according to IUGS nomenclature using normalized values of modal quartz (Q), alkali feldspar (A) and plagioclase (P) on a ternary diagram (Streckeisen, 1976). Mineral modifiers are listed in order of increasing abundance for both igneous and metamorphic rocks. Grain size classification of unconsolidated and consolidated sediment is based on the Wentworth scale (Lane, 1947). Bedding thicknesses and lamination type are after McKee and Weir (1963), and Winston (1986). Thicknesses and distances are given in abbreviation of metric units (e.g., dm=decimeter). Multiple lithologies within a rock unit description are listed in order of decreasing abundance. Soil series are from Weisel and others (1982).

MAN-MADE DEPOSITS

m — **Made land (Historical)**—US 95 Highway and railway fills in the Cocolalla valley.

ALLUVIAL AND MASS WASTING DEPOSITS

Qaf — **Alluvial fan deposits (Holocene)**—Mixed pebble to cobble gravel deposited as fans at the mouths of local drainages. Mostly subangular to angular clasts derived locally from colluvium and glacial deposits on steep slopes. Unified Classification is GM and SM. Soils mainly of the Colburn, Pend Oreille, and Bonners series. Thickness 1-10 m (3-33 feet).

Qls — **Landslide deposits (Holocene)**—Poorly sorted and poorly stratified sandy cobble and boulder gravel mixed with sand. Mass-movements mainly associated with till, outwash, and glaciolacustrine sediments deposited on steep glaciated slopes above Lake Pend Oreille but involve bedrock. Subsurface lake profiles show extensive landslide and turbidite deposits in the deep lake basin. Soils of the Bonner and Dufort series. Varied thickness as much as 10-30 m (30-100 feet).

GLACIAL AND RELATED DEPOSITS

Qglp — **Lake and peat deposits (Pleistocene to Holocene)**—Organic muck, mud and peat bogs in poorly drained paleoglacial outwash channels and kettles of the Selle Lowland. Interbedded with thin layers of fine sand, silt and clay. Soils of the Pywell series and Pt in the Unified Soil System. Thickness varies 1-5 m.

Qgu — **Glacial deposits, undivided (Pleistocene)**—Mostly loose cobbly silty sand with a silty fine sand matrix; pebble-to boulder-sized gravel; includes deposits of till and associated proglacial outwash and glacial sediments. Scattered large boulders on bedrock and in till. Unstratified to poorly bedded, unsorted to moderately sorted. In tributary drainages and on slopes composed of discontinuous remnants of till and kame terraces, on steeper unstable slopes may take the form of mass movements. May include some interbedded lake sediments. Soils mainly silt loam of the Pend Oreille series. Thickness varies from several to tens of meters.

Qgg — **Deposits of glacial outwash gravels (Pleistocene)**—Sandy cobble boulder gravel mostly preserved as terrace deposits from valley glaciers. Soils of the Bonner — Kootenai series. SP-SM and ML classes in the Unified Soil Classification. Thickness varies; may exceed 50 m (160 feet).

Qgf — **Glaciofluvial deposits (Pleistocene)**—coarse silt, sand, and gravel deposits mostly of glacial outwash. Mostly stratified sands and rounded gravels. Commonly occurs in channels within and interbedded with *Qgg*. Soils are gravelly silt loam to gravelly sand loam of Bonner —Kootenai series. Unified Soil Classification GM, GP, and SM. Thickness a meter to over tens of meters.

INTRUSIVE ROCKS

Tl — **Lamprophyre dike (Eocene)**—Dike exposed in north-central part of map. Contains biotite phenocrysts in a fine-grained dark green groundmass.

Tqm — **Quartz monzonite dike (Eocene)**—Dike exposed in central part of map. Fine-grained biotite-hornblende quartz monzonite. Acicular hornblende.

Td — **Dacite dike (Eocene)**—Porphyritic dacite dike exposed on the west side of Cocolalla Creek in the west-central part of the map. Phenocrysts of plagioclase, hornblende, and biotite in a fine-grained gray groundmass.

Kbgd — **Biotite granodiorite (Cretaceous)**—Biotite granodiorite grading to granite. Strongly inequigranular to seriate; most minerals medium to coarse grained. Color index 8 to 12. Quartz is distinctive pale lavender to pale gray; globular and up to 10 mm across. Potassium feldspar is interstitial and exhibits grid twins. Biotite in books 2-5 mm thick. Abundant epidote and sphene. High magnetite content (magnetic susceptibility about 18 x 10^{-3} SI units). Minor hornblende noted at one locality north of Careywood Creek in the south-central part of map. Equivalent to the granodiorite of Kelso Lake described by Miller and others (1999). U-Pb ages are 88 ± 9 Ma for zircon and 88 ± 0.5 Ma for sphene (J.L. Wooden, written communication, 1994, in Miller and others,). Potassium-argon age of 80.7 ± 2 Ma obtained for biotite from sample M91SN-47 (on map) dates cooling below 300°- 350° C.

Kgdf — **Fine-grained granodiorite (Cretaceous)**—Hornblende-biotite granodiorite. Fine-grained, but contains medium to coarse grains typical of the biotite granodiorite unit (*Kbgd*). Hornblende abundant to rare; sphene and epidote abundant and conspicuous. High magnetite content (magnetic susceptibility about 28 x 10^{-3} SI units). Unit forms eastern part of Kelso Lake pluton, where locally it is unusually fine grained in contact with the Salee Creek pluton (*Khgd unit*). Fine-grained rocks could represent a chilled margin against that unit.

Khgd — **Biotite-hornblende granodiorite (Cretaceous)**—Medium- to coarse-grained biotite-hornblende granodiorite containing about 15-20 percent mafic minerals. Plagioclase, quartz, and potassium feldspar are anhedral; hornblende is euhedral in prismatic crystals up to 4 mm by 12 mm; biotite forms 4 mm to 5 mm-wide hexagonal books. Potassium feldspar is interstitial. Plagioclase and potassium feldspar commonly are gray. Sphene, epidote, and allanite are accessory minerals. Varied magnetite content (magnetic susceptibility 0.3-11 x 10^{-3} SI units). Unfoliated to well foliated. Pluton develops narrow contact aureoles in Belt Supergroup rocks. Equivalent to the granodiorite of Salee Creek described by Miller and others (1999). A U-Pb zircon age of 94 ± 5 Ma was obtained from this unit (J.L. Wooden, written commun., 1994, in Miller and others, 1999). A $^{40}Ar/^{39}Ar$ weighted mean age on hornblende of 99.55 ± 0.16 Ma (steps 9 to 13, 87.8 percent gas; sample number M90SN-27 on map) does not support protracted cooling.

PALEOZOIC STRATA

Gl — **Lakeview Limestone (Cambrian)**—Light gray to white weathering recrystallized limestone exposed in a down-faulted block east of the Salee Creek pluton. Locally forms semi-resistant, rounded outcrops on steep slopes in southeastern part of map area. Near intrusive contacts with igneous rocks, occurs as coarsely crystalline white marble. Contains minor, varied content of fine to medium siliciclastic grains and traces of sub-mm black magnetite grains. The thin (30 m²), non-resistant Rennie Shale presumably underlies the Lakeview in the map area, but we did not observe this unit. Outcrops of the highly resistant Gold Creek quartzite are the best indicators of approximate lower contact. Internal stratigraphy and thickness indeterminate in map area. Estimated to be at least 2000 ft (610 m) thick east of Pend Oreille Lake on Packsaddle Mountain (Harrison and Jobin, 1965).

Gg — **Gold Creek Quartzite (Cambrian)**—Medium to thick bedded quartzite; some is thinly banded but all banding may not represent sedimentary layering. White, commonly stained yellow or orange. Medium to coarse grained, locally conglomeratic; much is poorly sorted. Much is of unit is semi-friable, apparently due to chemical alteration. Metamorphosed near plutonic rocks to coarse quartzite with accessory muscovite and magnetite. Internal stratigraphy and thickness indeterminate in map area. Estimated to be 400 ft (120 m) thick east of Pend Oreille Lake on Packsaddle Mountain (Harrison and Jobin, 1965).

BELT-PURCELL SUPERGROUP

Yhm — **Argillite of Howe Mountain (Mesoproterozoic)**—Gray siltite and darker gray argillite couplets, subordinate pale siltite and fine-grained quartzite, and minor carbonate. Typical pattern is 2-5 cm siltite interlayered with multiple siltite and argillite micromlaminae. Uneven or wavy layering more common than planar. Includes some mud chips and cracks. Commonly contact metamorphosed, with undiagnosed spots to 1 cm increasing to the south. Corresponds to upper Wallace member 1 to the south (Lewis and others, 2002) and Snowslip Formation elsewhere; see Burmester and others (2004b) for details. Named after Howe Mountain, northwest of Clark Fork, Idaho. Subdivided into three units in the Clark Fork quadrangle to the east but undivided here because of contact metamorphism, faulting and discontinuous exposure. Top not exposed.

Yw — **Wallace Formation (Mesoproterozoic)**—Pinch and swell couplets and couples of light gray, tan-weathering calcitic to dolomitic, very fine-grained quartzite or siltite and black argillite, and lesser amounts of calcareous and non-calcareous white quartzite and dolomitic siltite. In the pinch and swell sediment type of Winston (1986), scours and loads of quartzite cut or deform subjacent black argillite. Black argillite caps generally mm-scale commonly contain ptygmatically folded siltite- or quartzite-filled cracks that taper downward. On bedding plane surfaces, the cracks are generally discontinuous and sinuous, occurring as isolated parallel or three-pointed star "birdsfoot" cracks. Some dolomitic siltite to 30 cm has distinct "molar-tooth" structure in which non-resistant, irregular, vertical calcite ribbons have been removed by weathering. Minor light green siltite/argillite couplets in lower part of unit, as well as rare 10 cm beds of elongate, cm-scale dolomitic siltite rip-up clasts. Poorly exposed on eastern end of ridge south of Maiden Creek in northern part of quadrangle; poorly exposed and contact metamorphosed in south-central part of map area. Where metamorphosed, pinch and swell beds are mauve. Top not exposed in area. Zircons from a tuff in the upper Helena about 170 km ENE yielded a U/Pb date of 1.454 Ga (Evans and others, 2000), which may be close to the age of the upper part of the Wallace here. Unit is upper part of the lower calcareous member (Wallace 1) of Harrison and Jobin (1965). Equivalent to the middle member of Wallace as mapped by Harrison and others (1986, 1992) and Lewis and others (2002).

Yhw — **Helena Formation, western facies (Mesoproterozoic)**—Cyclic couplets and couples of white quartzite to tan-weathering dolomite or dolomitic siltite, with associated massive green siltite and thinly laminated uneven green siltite and argillite couplets containing various amounts of carbonate (dolomite and calcite) pods. Lower part predominately thin, flaggy weathering wavy laminae to uneven couplets of calcitic green siltite and pale green argillite. Contains thin, mm lenticular white calcitic siltite that weathers recessively to brown. Mudcracks are common, although mudchips are rare and scattered in occurrence. Upper part dominated by siliciclastic to carbonate cycles. White calcitic quartzite, commonly 10-20 cm thick, overlain by tan-weathering, green silty dolostone or dolomitic siltstone. Brown-weathering, gray, conchoidally-fracturing dolostone scattered throughout; gray dm limestone with characteristic vertical "molar-tooth" structures more common in upper part. High in unit, oblong horizontal carbonate "pods" are common within silty dolostone that contains scattered ripple cross-laminations. Best exposed south of Maiden Creek where map pattern suggests thickness of 280 m (850 ft). Contact metamorphosed along the crest of the Three Sisters ridge where green color of quartzite and siltite is due to potassic alteration, not diopside. Upper contact placed at lowest occurrence of pinch and swell couplets of overlying Wallace Formation.

Ysr — **St. Regis Formation (Mesoproterozoic)**—Red to pale purple siltite, argillite and quartzite, light green siltite and darker green argillite or dark green siltite and light green argillite couplets. Lower part of unit dominated by pale purple siltite/purple argillite; intervals of greens increase toward top where purples are minor. Shallow, mm-scale scours and loads are common at siltite bases. Siltite and argillite couplets typically mudcracked; quartzite typically fine grained in very thin (2-5 cm) and rarer thin (10-20 cm) tabular, ripple crested beds with thin argillite caps. Tabular quartzite beds more abundant near base. Conspicuous layers of mudchips to 5 cm thickness ubiquitous; chips more abundant in purple siltite and argillite couplets. Brown-weathering dolomitic silts appear higher in section than in Sagle quadrangle to the north, and increase upward. A few dm beds of waxy green argillite are present very near the top of the unit. Upper contact placed above the highest cracked and mudchip-bearing purple siltite and argillite. Thickness based on map pattern on ridge south of Maiden Creek of about 520 m (1800 ft) is greater than in the Clark Fork quadrangle to the east, where thickness was estimated at 240-290 m (Burmester and others, 2004b).

Yr — **Revett Formation (Mesoproterozoic)**—Resistant white to pale purple or rarer light green quartzite with green siltite and argillite commonly as mm to cm caps. Quartzite weathers from white to common light orange; fresh colors are more commonly pale grayish-purple upsection. Most beds tabular, with rare wedge-shaped or discontinuous beds. Some quartzite vitreous or sericitic; most feldspathic with subequal potassium feldspar and plagioclase, each comprising 15-20 percent of the rock. Sub-millimeter orange-brown spots common, as are vitreous, quartz-cemented weathering rinds. Rippled tops and tabular planar cross-laminations more common than trough cross lamination; much is flat laminated. Quartzite is commonly of the discontinuous sediment type, containing irregular internal agillite wisps (Winston, 1986). Mudcracks and mudchips common in argillite tops throughout unit. Lower part consists of multiple beds of feldspathic quartzite from 50 cm to 2 m thick (cosets of thick sets). Bases of most lower beds are planar, although some beds exhibit load casts to 40 cm wide and 20 cm deep. A less-resistant interval with lower concentration of quartzite and more uneven mudcracked couplets of pale purple or green siltite and mm dark purple argillite occurs well toward the top. Upper part consists of more cosets of thick sets of resistant quartzite, with thin cracked green argillite caps. Large load casts to 20 cm deep and 30 cm across and small ball and pillow structures are especially abundant in the upper part, although present at the bases of some quartzite beds throughout. Exposed well if discontinuously north of Maiden Creek in the northeast corner of the map. Top is placed at the top of meter thick, orange-weathering quartzite. Transition to overlying thinner, purple quartzite and argillite NNW of Blacktail Mtn includes white quartzite interpreted as apparent lag deposits of anomalously coarse and well rounded quartz grains. Thickness based on map pattern south of Maiden Creek of about 730 m (2400 ft) and measured section north of Maiden Creek (785 m; 2580 ft) is greater than in the Clark Fork quadrangle to the east, where thickness was estimated at 550-590 m (Burmester and others, 2004b).

Yb — **Burke Formation (Mesoproterozoic)**—Burke Formation (Middle Proterozoic)—Green siltite and argillite, gray to white quartzite, purple quartzite and argillite. Siltite beds typically 10-20 cm with magnetite, some as macroscopic octahedra. Argillite partings commonly dark green, some lighter green in lower part, dark purple in upper. Colors lost and argillitic parts schistose where contact metamorphosed in the west-central part of the map. Mudcracks and chips present throughout. Fine-grained quartzite in 20-50 cm beds, some with rippled tops and cross lamination including climbing ripples, increase upward. Uppermost part of unit characterized by fining-upward, cyclical packages of decimeter thick pale purple, flat to convolute laminated, very fine-grained quartzite with diffuse grading into unevenly laminated to lenticular cm pale purple siltite/mm dark purple argillite. Quartzite beds in upper part display soft sediment deformation features including irregular loaded bases with common ball and pillow structures and contorted bedding, emphasized by purple layering. "Clear gray", light or vitreous weathering rinds are common on both siltite and quartzite outcrops throughout the Burke. Upper contact generally poorly exposed; placed at base of first thick sets of m quartzite beds or at abundant dm float of white quartzite of Yr. Best exposures are discontinuous outcrops on west end of ridge south of Maiden Creek in northern part of quadrangle and on lower western slopes of Little Blacktail Mountain. Thickness based on map pattern in Sagle quadrangle to the north (Lewis and others, 2006) approximately 1000 m (3400 feet).

Prichard Formation (Mesoproterozoic)—White to gray siltite, white to gray to black argillite and white to gray fine feldspathic to coarser feldspar-poor quartzite. Siltite typically rusty weathering and planar laminated with black argillite tops, some with white argillite tops. Rusty nature comes from abundant sulfides, commonly pyrrhotite. Only the upper part recognized in map area. Nomenclature based on Cressman (1985). Members defined where more completely exposed in the Scotchman Peak 7.5′ quadrangle (Burmester and others, 2004c).

Ypt — **Prichard Formation, transition member (Mesoproterozoic)**—Gray to greenish gray to white siltite and dark gray argillite. Bedding uneven, with loading or channeling at bed or couplet bases common. Dark argillite tops have siltite-filled, ptygmatically-folded birdsfoot cracks. Abundance of magnetite-bearing, green siltite layers increases toward the top and rusty weathering decreases, although magnetite versus sulfide abundance does not vary smoothly. White quartzite beds 10-50 cm present near the bottom and at top are very fine grained and characterized by dark mm-thick horizontal planar laminations. Manganese carbonate content indicated by brown weathering spots or cavities. Where contact metamorphosed in the west-central part of the map, argillitic parts are phyllitic with incipient growth of porphyroblasts. Upper contact placed above uppermost recognized dark gray argillite tops or white quartzite. Thickness (450 m, 1600 feet) based on map pattern in Sagle quadrangle to the north (Lewis and others, 2006).

Yph — **Prichard Formation, member h (Mesoproterozoic)**—Laminated gray siltite and black argillite couplets to microlaminated black and white argillite. Laminae and microlaminae characteristically very even and continuous. Weathers with a distinct rusty veneer. Uppermost contact placed at the lowest occurrence of wavy or uneven siltite and argillite couplets or quartzite of overlying *Ypt*. Base is covered near Cocolalla, thickness is about 580-700 m (1900-2300 feet) in the Scotchman Peak area. This is nicknamed the "lined unit" of the Prichard Formation.

Ypg — **Prichard Formation, member g (Mesoproterozoic)**—Gray to white feldspathic quartzite and dark gray argillite. Exposed poorly only near western edge of map.

STRUCTURE

MAIDEN CREEK FAULT

Apparent right offset of contacts across Maiden Creek is attributed to down-to-the-south normal faulting on a southwest dipping surface, parallel to that inferred for the Mirror Lake fault in the Talache quadrangle to the northeast (Burmester and others, 2006) and smaller displacement faults to the south. These are seen as similar in origin and timing to the Hope fault farther northeast (Burmester and others, 2004a).

SYMBOLS

- Contact: line showing the boundary between one map unit and another; dashed where approximate. The location accuracy of contact is 80 feet or more on the ground.
- High-angle fault: ball and bar indicates downthrown side of a normal fault; dashed where approximately located; dotted where concealed.
- Indicates sense of strike-slip fault.
- Anticline.
- Fold axis, approximately located; dotted where concealed; arrow indicates direction of plunge.
- Ice cross over divide.
- Terrace scarp.
- Crest of lateral or end moraine or debris flow levee.
- Quartz vein: Arrow indicates dip.
- Strike and dip of bedding.
- Strike and dip of bedding, ball indicates bedding known to be upright.
- Estimated strike and dip of bedding.
- Strike and dip of bedding known to be overturned.
- Strike and dip of joint.
- Strike and dip of cleavage.
- Strike and dip of foliation.
- Sample location and number.

REFERENCES

Burmester, R.F., R.M. Breckenridge, R.S. Lewis, and M.D. McFaddan, 2004a, Geologic Map of the Hope Quadrangle, Bonner County, Idaho, Idaho Geologic Survey Digital Web Map 26, scale 1:24,000.

Burmester, R.F., R. M. Breckenridge, R.S. Lewis, and M.D. McFaddan, 2004b, Geologic Map of the Clark Fork quadrangle, Bonner County, Idaho, Idaho Geologic Survey Digital Web Map 25, scale 1:24,000.

Burmester, R.F., R.M. Breckenridge, R.S. Lewis, and M.D. McFaddan, 2004c, Geologic Map of the Scotchman Peak quadrangle, Bonner County, Idaho, Idaho Geologic Survey Digital Web Map 24, scale 1:24,000.

Burmester, R.F., M.D. McFaddan, R.M. Breckenridge, and R.S. Lewis, 2006, Geologic Map of the Talache quadrangle, Bonner County, Idaho, Idaho Geologic Survey Digital Web Map 75, scale 1:24,000.

Cressman, E.R., 1985, The Prichard Formation of the lower part of the Belt Supergroup, Proterozoic Y, near Plains, Sanders County, Montana: U.S. Geological Survey Bulletin 1553, 64 p.

Evans, K.V., J.N. Aleinikoff, J.D. Obradovich, and C.M. Fanning, 2000, SHRIMP U-Pb geochronology of volcanic rocks, Belt Supergroup, western Montana; evidence for rapid deposition of sedimentary strata: Canadian Journal of Earth Sciences, v. 37, no.9, p. 1287-1300.

Green, W.R., 1976, Geology and mineral resources of the Blacktail Mountain area, Bonner County, Idaho: M.S. thesis, University of Idaho, 108 p.

Harrison, J.E., E.R. Cressman, and J.W. Whipple, 1992, Geologic and structural maps of the Kalispell 1°x 2° quadrangle, Montana, and Alberta and British Columbia: U.S. Geological Survey Miscellaneous Investigations Series Map I-2267, scale 1:250,000.

Harrison, J.E., A.B. Griggs, and J.D. Wells, 1986, Geologic and structure maps of the Wallace 1°x 2° quadrangle, Montana and Idaho: U.S. Geological Survey Miscellaneous Investigations Series Map I-1509-A, scale 1:250,000.

Harrison, J.E., and D.A. Jobin, 1965, Geologic map of the Packsaddle Mtn. quadrangle, Idaho: U. S. Geological Survey Geological Quadrangle Map GQ-375, scale 1:62,500.

Lane, E.W., 1947, Report of the subcommittee on sediment terminology; Transactions of the American Geophysical Union, v. 28, no. 6, p. 936-938.

Lewis, R.S., R.F. Burmester, R.M. Breckenridge, M.D. McFaddan, and J.D. Kauffman, 2002, Geologic map of the Coeur d'Alene 30 x 60 minute quadrangle, Idaho: Idaho Geological Survey Geologic Map 33, scale :100,000.

Lewis, R.S., R.F. Burmester, R.M. Breckenridge, D.M. Miller, and Mark D. McFaddan, 2006, Geologic Map of the Sagle quadrangle, Bonner County, Idaho, Idaho Geologic Survey Digital Web Map 74, scale: 1:24,000.

McKee, E.D., and G.W. Weir, 1963, Terminology for stratification and cross-stratification in sedimentary rocks; Geological Society of America Bulletin, v. 64, p. 381-390.

Miller, F.K., R.F. Burmester, R.E. Powell, D.M. Miller, and P.D. Derkey, 1999, Digital geologic map of the Sandpoint 1- by 2-degree quadrangle, Washington, Idaho, and Montana: USGS Open-File Report 99-0144.

Savage, C. N., 1967, Geology and Mineral Resources of Bonner County, Idaho: Idaho Bureau of Mines and Geology County Report No. 6, 131 p.

Streckeisen, A.L., 1976, To each plutonic rock its proper name: Earth-Science Reviews, v. 12, p. 1-33.

Weisel, C.J., P.M. Hartwig, S.D. Keirn, and B.J. Turner, 1982, Soil Survey of Bonner County Area, Idaho, Parts of Bonner and Boundary Counties, United States Department of Agriculture Soil Conservation Service, 201 p.

Winston, Don, 1986, Sedimentology of the Ravalli Group, middle Belt carbonate, and Missoula Group, Middle Proterozoic Belt Supergroup, Montana, Idaho and Washington, in S.M. Roberts, ed., Belt Supergroup: A Guide to Proterozoic Rocks of Western Montana and Adjacent Areas: Montana Bureau of Mines and Geology Special Publication 94, p. 85-124.

Published and sold by the Idaho Geological Survey
University of Idaho, Moscow, Idaho 83844-3014