GEOLOGIC MAP OF THE COCOLALLA QUADRANGLE, BONNER COUNTY, IDAHO

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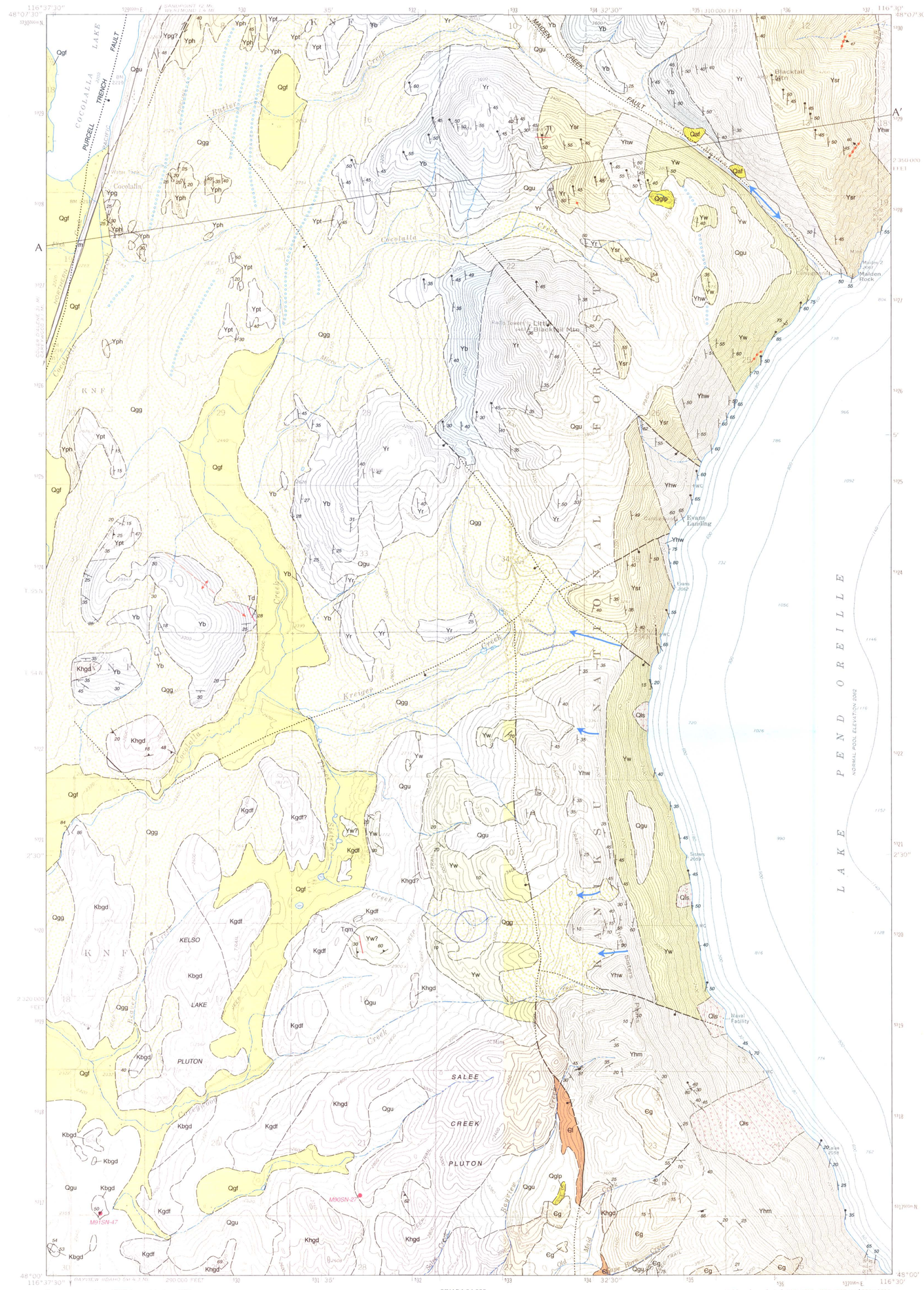
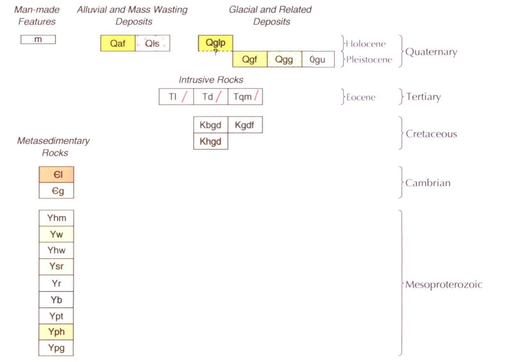


CORRELATION OF MAP UNITS



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 The bedrock mapping built on previous unpublished U. S. Geological Survey 7 ½' mapping by F.K. Miller and D.M. Miller (assisted by Pahdrig McCarthy) from 1992-1995, which was utilized on the Sandpoint 1° x 2°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 M91ISN-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 (*Kbgd 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

Cl **Lakeview Limestone (Cambrian)**—Light gray to white we limestone exposed in a down-faulted block east of th Locally forms semi-resistant, rounded outcrops on steep part of map area. Near intrusive contacts with ign coarsely crystalline white marble. Contains minor, va medium siliciclastic grains and traces of sub-mm bi The thin (30 m?), non-resistant Rennie Shale pres Lakeview in the map area, but we did not observe thi highly resistant Gold Creek quartzite are the best ind lower contact. Internal stratigraphy and thickness inde Estimated to be at least 2000 ft (610 m) thick east of Packsaddle Mountain (Harrison and Jobin, 1965).

Cg **Gold Creek Quartzite (Cambrian)**—Medium to thick be is thinly banded but all banding may not represent White, commonly stained yellow or orange. Media locally conglomeratic; much is poorly sorted. Much is apparently due to chemical alteration. Metamorphos to coarse quartzite with accessory muscovite an stratigraphy and thickness indeterminate in map area ft (120 m) thick east of Pend Oreille Lake on Packsadd and Jobin, 1965).

BELT-PURCELL SUPERGRO

Yhm **Argillite of Howe Mountain (Mesoproterozoic)**—Gray argillite couplets, subordinate pale siltite and fine- minor carbonate. Typical pattern is 2-5 cm siltite inte siltite and argillite micromlaminae. Uneven or wavy l than planar. Includes some mud chips and crack metamorphosed, with undiagnosed spots to 1 cm i Corresponds to upper Wallace member 1 to the sou 2002)and Snowslip Formation elsewhere; see Burme for details. Named after Howe Mountain, northwest Subdivided into three units in the Clark Fork quad undivided here because of contact metamorphism, fau exposure. Top not exposed.

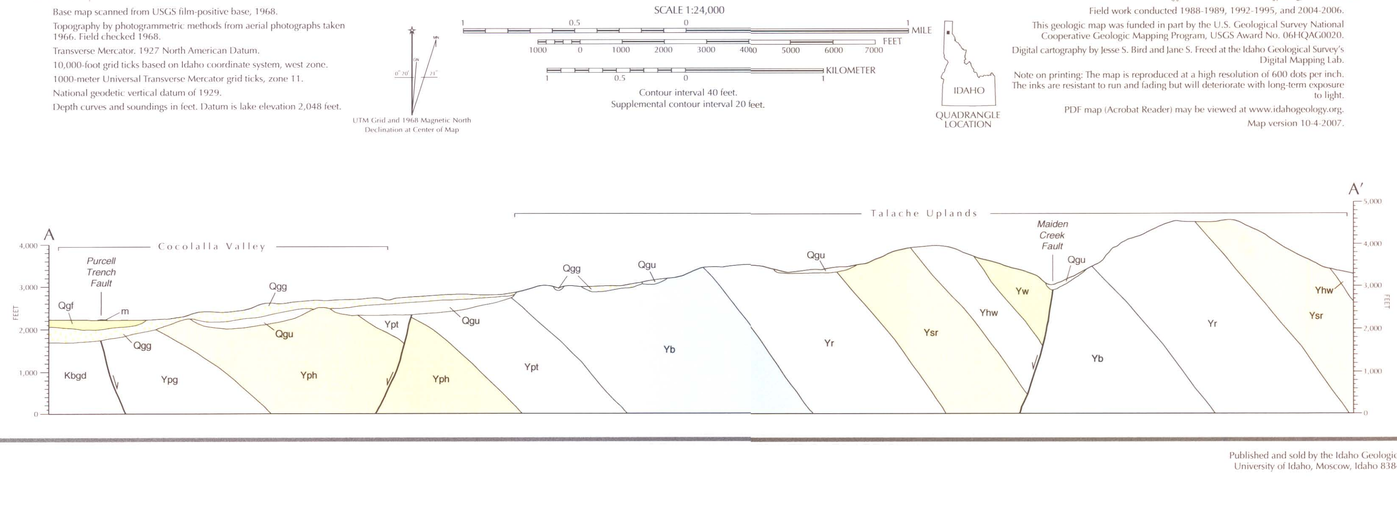
Yw **Wallace formation (Mesoproterozoic)**—Pinch and swell of light gray, tan-weathering calcitic to dolomitic, very or siltite and black argillite, and lesser amounts of calcareous white quartzite and dolomitic siltite. In sediment type of Winston (1986), scours and loads of subjacent black argillite. Black argillite caps generally contain ptygmatically folded siltite- or quartzite-fi downward. On bedding plane surfaces, the cracks are s and sinuous, occurring as isolated parallel or three-p cracks. Some dolomitic siltite to 30 cm has distinct " in which non-resistant, irregular, vertical calcite ribbo by weathering. Minor light green siltite/argillite cou unit, as well as rare 10 cm beds of elongate, cm-sca up clasts. Poorly exposed on eastern end of ridge sou northern part of quadrangle; poorly exposed and co in south-central part of map area. Where metamorph beds are mauve. Top not exposed in area. Zircons fr Helera about 170 km ENE yielded a U/Pb date of others 2000), which may be close to the age of the up here. Unit is upper part of the lower calcareous m Harrison and Jobin (1965). Equivalent to the middle mapped by Harrison and others (1986, 1992) and Le

Yhw **Helena Formation, western facies (Mesoproterozoic)** couplets of white quartzite to tan-weathering dolomi with associated massive green siltite and thinly lam siltite and argillite couplets containing various amounts and calcite) pods. Lower part predominately thin, fla laminae to uneven couplets of calcitic green siltite a Contains thin, mm lenticular white calcitic siltite tha to brown. Mudcracks are common, although mudchip in occurrence. Upper part dominated by siliciclasti White calcitic quartzite, commonly 10-20 cm th weathering, green silty dolostone or dolomitic siltsto gray, ;onchoidally-fracturing dolostone scattered limestone with characteristic vertical "molar-tooth" str in upper part. High in unit, oblong horizontal carbona within silty dolostone that contains scattered ripple c exposed south of Maiden Creek where map pattern 280 m (850 ft). Contact metamorphosed along the cr ridge where green color of quartzite and siltite is due not dipside. Upper contact placed at lowest occurre couplets of overlying Wallace Formation.

Ysr **St. Regis formation (Mesoproterozoic)**—Red to pale pur quartzite, light green siltite and darker green argilli and light green argillite couplets. Lower part of un purple siltite/purple argillite; intervals of greens incr purples are minor. Shallow, mm-scale scours and load bases. Siltite and argillite couplets typically mudcrack fine gained in very thin (2-5 cm) and rarer thin (10- crested beds with thin argillite caps. Tabular quartzite near base. Conspicuous layers of mudchips to 5 cm chips more abundant in purple siltite and argillite coup dolomitic silts appear higher in section than in Sagle q and increase upward. A few dm beds of waxy green very near the top of the unit. Upper contact placed ab and mudchip-bearing purple siltite and argillite. Thi pattern on ridge south of Maiden Creek of about 520 than in the Clark Fork quadrangle to the east, where th at 246-290 m (Burmester and others, 2004b).

Yr **Revett Formation (Mesoproterozoic)**—Resistant white light green quartzite with green siltite and argillite c caps. Quartzite weathers from white to common lig are more commonly pale grayish-purple upsection. N rare wedge-shaped or discontinuous beds. Some quartz most eldspathic with subequal potassium feldspar comprising 15-20 percent of the rock. Sub-millimete common, as are vitreous, quartz-cemented weatheri and tabular planar cross-lamination more comm lamination; much is flat laminated. Quartzite is comm sediment type, containing irregular internal agillite w Mudcracks and mudchips common in argillite tops t part consists of multiple beds of feldspathic quartz thick cosets of thick sets). Bases of most lower bed some beds exhibit load casts to 40 cm wide and 20 c interval with lower concentration of quartzite and mo couplets of pale purple or green siltite and mm dark well toward the top. Upper part consists of more resistnt quartzite, with thin cracked green argillite to 20 cm deep and 30 cm across and small ball an especially abundant in the upper part, although prese quartzite beds throughout. Exposed well if discontinu Creek in the northeast corner of the map. Top is plac thick, orange-weathering quartzite. Transition to ove quartzite and argillite NNW of Blacktail Mtn incl interpreted as apparent lag deposits of anomalously co quartz grains. Thickness based on map pattern sou about 730 m (2400 ft) and measured section north m; 2580 ft) is greater than in the Clark Fork quadran thickness was estimated at 550-590 m (Burmester an

Yb **Burke Formation (Mesoproterozoic)**—Burke Formation Green siltite and argillite, gray to white quartzite, argillite. Siltite beds typically 10-20 cm with magnetite octahedra. Argillite partings commonly dark green, lower part, dark purple in upper. Colors lost and a where contact metamorphosed in the west-central part and chips present throughout. Fine-grained quartz some with rippled tops and cross lamination inclu increase upward. Uppermost part of unit characteri cyclical packages of decimeter thick pale purple, flat t very fine-grained quartzite with diffuse grading into lenticular cm pale purple siltite/mm dark purple argi upper part display soft sediment deformation featur loaded bases with common ball and pillow structures emphasized by purple layering. "Clear gray", light rinds are common on both siltite and quartzite ou



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.

SCALE 1:24,000
1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER
Contour interval 40 feet.
Supplemental contour interval 20 feet.

UTM Grid and 1968 Magnetic North Declination at Center of Map

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.
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