GEOLOGIC MAP OF THE UPPER NORTH FORK OF THE CLEARWATER RIVER AREA, NORTHERN IDAHO

R.S. Lewis, R.F. Burmester, M.D. McFadden, B.A. Eversmeyer, C.A. Wallace, and E.H. Bennett

1992

DESCRIPTION OF MAP UNITS

Qa ALLUVIAL DEPOSITS (HOLOCENE)—Stream deposits in modern drainages.

Ql LANDSLIDE DEPOSITS (HOLOCENE)—Unconsolidated deposits of landslide origin.

Qg GLACIAL DEPOSITS (HOLOCENE AND PLEISTOCENE)—Poorly sorted and poorly stratified, unconsolidated deposits principally of glacial origin. Includes till in lateral and ground moraines as well as outwash and modern stream alluvium.

Ts SEDIMENT (MIOCENE?)—Unconsolidated, poorly sorted, fluvial sediment. Includes beds of boulder and cobble gravel, sand, and clay. Typically deeply weathered and contains decomposed quartzite, calc-silicate, siltite, argillite, and granite boulders in a red or yellow, sandy and clayey matrix.

Tb BASALT DIKES (MIOCENE?)—Black, aphanitic, tabular dikes that consist principally of plagioclase, augite, glass, and opaque oxides. Dikes are typically 1 m thick and intruded along inclined fractures or foliation; some show columnar joints. Most likely related to Columbia River Basalt Group.

Tr RHYOLITE DIKES (EOCENE)—Tan-weathering aphanitic to very fine-grained phaneritic rock that contains variable amounts of bipyramidal quartz and euhedral feldspar phenocrysts.

Trp RHYOLITE PORPHYRY PLUGS AND DIKE SWARMS (EOCENE)—Similar to Tr, but occurs as larger masses that are typically porphyritic. Phenocrysts of quartz, alkali feldspar, and plagioclase compose about 40% of the rock. Includes poorly exposed rhyolite dike swarms in the southeastern part of the area.

Td DACITE DIKES (EOCENE)—Dark to medium gray, aphanitic dikes that contain plagioclase and hornblende phenocrysts up to 1 cm long.

Ta ANDESITE DIKES (EOCENE)—Dark gray, fine-grained dikes characterized by acicular hornblende and lath-shaped plagioclase within aphanitic groundmass. Some dikes have chilled margins and more rarely internal chilled contacts.

Tu UNDIFFERENTIATED DIKES (EOCENE)—May include any of the types of dikes described above, but most are either rhyolite (Tr) or dacite (Td). Mapped primarily from aerial photographs.

Tg GRANITE (EOCENE)—Fine- to coarse-grained, equigranular to slightly porphyritic granite that contains equant to bipyramidal smoky quartz, white to pinkish feldspar, biotite, and sparse amphibole. Contains miarolitic cavities, which are most common in associated aplite dikes. Pegmatites are rare. Contacts sharp and discordant. Weathers to form rounded outcrops and spires. Includes the Bungalow pluton (Hietanen, 1968; Reynolds, 1991), the Horseshoe Lake stock (herein named), and the Lolo Hot Springs batholith (Nold, 1974).

Tqs QUARTZ SYENITE (EOCENE)—Medium- to fine-grained, porphyritic quartz syenite, syenite, and quartz monzonite. Similar to Tg, but quartz poor. Contains hornblende, clinopyroxene cores in hornblende, and biotite. Commonly occurs as resistant, iron-stained stocks and dikes. Locally contains miarolitic cavities. Includes unit mapped as the monzonite of Junction Lake by Childs (1982).

Tdi DIORITE (EOCENE)—Medium- to fine-grained, equigranular pyroxene-hornblende diorite along Rocky Ridge Creek in the southwestern part of the area.

Tv VOLCANIC ROCKS (EOCENE)—Primarily dacitic tuff(?) breccia, but also includes andesite flows, rhyolite tuff(?), and volcaniclastic rocks. Subdivided locally by Simpson (1985), but grouped on this map. All rock types are phenocryst poor. Clasts are angular to subangular dacite and quartzite, mostly 0.5 to 1.0 cm across.

Kp PEGMATITE AND APLITE (CRETACEOUS)—Irregular bodies of intermixed, very coarse-grained biotite- or biotite-muscovite-bearing pegmatite and fine-grained aplite. Generally lacks fabric, but locally occurs as small pygmatic dikes in schist and gneiss.

Kgd BIOTITE GRANODIORITE (CRETACEOUS)—Medium- to fine-grained, equigranular to slightly porphyritic biotite granodiorite. Hornblende-bearing and tonalitic near some contacts with metasedimentary rocks. Associated pegmatite and aplite dikes and sills are common. Similar rocks along the Lochsa River south of the area have yielded U-Pb dates on zircon of 71 ± 9 Ma and 75 ± 5 Ma (Toth and Stacey, 1992). Mass along the lower part of Cayuse Creek is atypical in that it contains perthitic alkali feldspar and has chemical compositions intermediate between Tg and Kgd.

Kpgd PORPHYRITIC BIOTITE GRANODIORITE (CRETACEOUS)—Medium-grained biotite granodiorite and granite that contains subhedral phenocrysts of alkali feldspar 1-3 cm long. Contains foliated mafic inclusions at Bald Mountain.

Kbgd BIOTITE-RICH GRANODIORITE (CRETACEOUS)—Medium- to coarse-grained, equigranular to slightly porphyritic hornblende-biotite granodiorite. Contains conspicuous books of euhedral biotite as thick as 4 mm and subhedral hornblende up to 6 mm long. Weathers to a coarse-grained grus. Mafic inclusions are common north of Blacklead Mountain.

Kt TONALITE (CRETACEOUS)—Medium-grained, equigranular, massive to well-foliated hornblende-biotite tonalite and quartz diorite. Distinguished by stubby hornblende crystals that locally define a linear fabric parallel to that in the host rocks. Locally contains inclusions of fine-grained hornblende diorite. Includes unit mapped as the quartz diorite of Junction Mountain by Childs (1982).

Kfg FOLIATED GRANITE (CRETACEOUS)—Small bodies of foliated and lineated, fine- to medium-grained muscovite-biotite granite, quartz monzonite, and leucocratic biotite quartz diorite. Present only in the central part of the map area. Characteristically iron-stained and pegmatite-rich. May be anatectic in origin (R.E. Kell, pers. commun., 1990).

Kfgd FOLIATED GRANODIORITE (CRETACEOUS)—Foliated, medium- to coarse-grained granodiorite and tonalite in the lower part of Black Canyon and in the upper part of Collins Creek. Includes units mapped as quartz dioritic orthogneiss by Childs (1982) and tonalite orthogneiss by R.E. Kell (pers. commun., 1990).

Kmig MIGMATITE (CRETACEOUS)—Areas of nearly equal amounts of metamorphic and granitic rocks, contorted and intermixed. Migmatitic rock in the drainages of Hemlock Creek, Middle Creek, and Beaver Dam Creek in the southwestern part of the area was not delineated. Despite an abundance of injected granitic material in that area, preexisting metasedimentary units could still be distinguished.

um ULTRAMAFIC ROCK (CRETACEOUS?)—Small dike- and sill-like bodies of medium- to coarse-grained pyroxenite that are in places altered to amphibole. Present on Little Moose Ridge and Hanson Ridge in the east-central part of the map area and on Green Point in the west-central part of the area.

am AMPHIBOLITE (CRETACEOUS? OR PROTEROZOIC?)—Fine- to medium-grained plagioclase-hornblende rock. Contains garnet on Flat Mountain. Typically lineated, but interiors of some larger masses (e.g., on Indian Henry Ridge) are equigranular. Interpreted to have an igneous protolith on the basis of uniform composition and texture and apparent cross-cutting relations at many places. May include some Proterozoic mafic bodies, but a Cretaceous age is probable for most. One dike cross-cuts the Kfg pluton along Kelly Creek, but no dikes cross-cut presumed younger (less deformed) Cretaceous plutons. Includes biotite-rich rock that occurs both as dikes and as thin borders on amphibolite dikes near pegmatitic intrusions. Biotite may result from replacement of hornblende.

Pzm MARBLE (PALEOZOIC)—Small roof pendant of marble in southeast corner of map north of Blacklead Mountain. Ranges from magnetite-epidote skarn near its margins to interbedded gray limestone marble and pure white dolomite marble in core. Marble is too pure to be part of the Wallace Formation. Probable correlative units are the Hasmark Formation (nearest exposure near Alberton, Montana) or the Jefferson Formation (exposed in western Montana; Wells, 1974; Wallace and others, 1986).

Ymg MISSOULA GROUP, UNDIVIDED (MIDDLE PROTEROZOIC)—Dominantly siltite and argillite over much of the area, but contains quartzitic portions as well. Correlates with rocks to the north assigned to the upper member of the Wallace Formation (Reid and others, 1981) and with schist of the Wallace Formation to the west (Hietanen, 1968). Unit is likely correlative with the Snowslip Formation and part of the Shepard Formation in the western part of the area and may include part of the overlying Mount Shields Formation in the eastern part of the area along the Idaho-Montana border. Assignment to the Missoula Group is based on similarity with parts of the Snowslip, Shepard, and Mount Shields Formations of the Missoula Group as mapped southwest of Missoula in western Montana by Harrison and others (1986).

In the northwestern part of the map area, from Pole Mountain to Five Lakes Butte, this unit typically consists of parallel microlaminated and laminated black to dark gray siltite and argillite with abundant argillite couplets. Some sections expose 10- to 30-cm-thick tabular siltite layers and dark gray siltite and argillite as pinch-and-swell couplets with rare cross-lamination and rippled surfaces. Small, silt-filled desiccation cracks are pygmatically folded; larger ones are straight sided. Scapolite is present in some black argillite, and rare diopside gneiss (calc-silicate hornfels) occurs in beds as much as 3 m thick. Grain size and metamorphic grade increase to the west, as indicated by chloritoid, garnet, and staurolite porphyroblasts and by the formation of uniform, fine-grained muscovite-biotite schist. Foliation is parallel to bedding in the lowest-grade rocks; a micaceous cleavage is axial planar to upright folds at intermediate grade; and schistosity is generally at some small angle to compositional layering in the highest grade rocks. Previously mapped as schist within the Wallace Formation by Hietanen (1968) in the Pole Mountain area.

In the north, in the Chamberlain Mountain-Gospel Hill area, the uppermost part of the unit is sparsely calcareous, cross-laminated white quartzite with vertical extension fractures and interbedded subordinate siltite and argillite. Beds are a few centimeters to decimeters thick, commonly with ripple surfaces, and have abundant soft-sediment deformational structures including loaded bases and ball-and-pillow structures. Grades downward into lenticular couplets and microlaminae of dark green siltite and light green argillite but contains fining-upward planar-laminated quartzite and siltite beds 1-20 cm thick. Straight-sided desiccation cracks in argillite filled with the dark siltite are common. Appears to grade downward into an interval of chloritoid-bearing, parallel laminated, black argillite near the base of the exposed section. Metamorphic grade increases to the southwest where garnet-mica schist is assigned to the unit.

In the eastern part of the area along the Idaho-Montana border, the uppermost exposures consist of unevenly laminated and microlaminated siltite and argillite and of subordinate fine-grained quartzite. Biotite-grade metamorphism and magnetite impart a characteristic gray color, although some red and green coloration is preserved locally. Siltite and quartzite beds are normally graded and usually capped by argillaceous layers. Intervals containing ripple cross-lamination, mud chips, and water-expulsion structures commonly alternate with intervals containing more planar lamination and microlamination. Argillaceous beds commonly contain grayish white, oval-shaped scapolite(?) crystals. In this part of the area the unit is interpreted as member 3 of the Mount Shields Formation by C.A. Wallace (pers. commun., 1990) and as Shepard Formation by D. Winston (pers. commun., 1991). Grades downward into light gray, fine- to very fine-grained quartzite in decimeter-scale beds. Graded quartzite beds are capped by blackish green to blackish gray silty argillite. Ripples, small-scale planar cross-bedding, ripple cross-lamination, and planar lamination are well preserved. These lithologies are interpreted as member 2 of the Mount Shields Formation by C.A. Wallace (pers. commun., 1990) and as the upper part of the Snowslip Formation by D. Winston (pers. commun., 1991).

Yms2 MOUNT SHIELDS FORMATION, MEMBER 2 (MIDDLE PROTEROZOIC)—Gray to pale red, fine-grained quartzite in tabular, decimeter- to meter-thick beds with green siltite and argillite along partings. Planar-laminated and ripple cross-laminated. Simpson (1985) reports about 10% feldspar, most of which is potassium feldspar. Correlation is based on similarities with member 2 of the Mount Shields Formation in the Missoula area to the northeast (Winston, 1984).

Yw WALLACE FORMATION, UNDIVIDED (MIDDLE PROTEROZOIC)—Areas where exposure or degree of metamorphism prevented subdivision into middle and lower members.

Ywm WALLACE FORMATION, MIDDLE MEMBER (MIDDLE PROTEROZOIC)—Tan-weathering, grayish white, dolomitic siltite and fine-grained quartzite overlain by black argillite ("black and tan" rock type), brownish orange-weathering carbonate-bearing white quartzite, greenish gray siltite and argillite, and syndepositional breccia that weathers brownish orange. The siltite and fine-grained quartzite layers of the "black and tan" are mostly 1 to 3 cm thick, and the argillite drapes range from less than 1 mm to 5 cm in thickness. Siltite and fine-grained quartzite beds are uneven and continuous or uneven and discontinuous (pinch-and-swell structure). Sedimentary structures are planar lamination, microlamination, ripple cross-lamination, small-scale cross-bedding, shallow channels, water-expulsion structures, mudcracks, and load casts. Where more highly metamorphosed, quartzite contains actinolite and diopside, and argillite contains scapolite. However, calcite persists in the highest grades mapped.

Beds of breccia and layers of nonstratified breccia (shown as hollow triangles on map) occur in the middle member. The breccia is composed of clasts of black and tan-weathering argillite and siltite of the middle member, white- and brownish orange-weathering quartzite, and rusty-weathering dolomite in a carbonate-rich, brownish orange matrix. Clasts are angular to rounded and pebble to boulder sized; some large clasts are deformed internally, and soft-sediment folds occur in bedded rocks below breccia zones. Sparry calcite fills some interstitial spaces and fractures, and pseudomorphs after shortite(?) (J.E. Harrison, pers. commun., 1990) occur locally. Where higher grade in the extreme southeast, orange coloration from weathering of carbonate is absent, actinolite and diopside are common, and the breccia is green and white. Stratification of unit is parallel with enclosing rocks, which suggests deposition by multiple debris flows. East-west folds in the northwestern part of the area are recognized only in the breccia unit, so they may record northward down-slope movement rather than tectonic deformation. Thickness of breccia zones ranges from 1 m to more than 200 m.

Ywl WALLACE FORMATION, LOWER MEMBER (MIDDLE PROTEROZOIC)—Consists of eight principal rock types that occur randomly distributed in intervals 1 to 30 m thick: (1) gray, laminated or massive-weathering limestone that contains abundant molar-tooth structure; (2) tan or dark gray, orange-weathering, crinkly dolomitic siltite; (3) noncalcareous and calcareous, ripple cross-laminated and planar-laminated, tan siltite and fine-grained quartzite; (4) fine-grained, planar-laminated, ripple cross-laminated and low-angle cross-bedded, white to light gray quartzite with extension fractures normal to layering; (5) noncalcareous, microlaminated couplets of light green siltite and medium green argillite; (6) massive-weathering dark green siltite that contains dark gray limestone pods both parallel and perpendicular to bedding; (7) wavy-bedded, tan-weathering, dolomitic siltite and rhythmically interbedded black argillite ("black and tan" rock type) that forms most of the middle member of the Wallace Formation; and (8) white quartzite beds, 2 to 30 cm thick, interbedded with dark green dolomitic siltite, green argillite, or silty dolomite that weathers brownish orange. The Hoodoo Pass area contains most of these rock types; many areas are dominated by relatively few rock types.

To the south and west where metamorphic grade is high, argillaceous rocks are muscovite-biotite schist, and dolomitic and calcareous rocks are calc-silicate hornfels and actinolite (or hornblende)-diopside gneiss. Diopside gneiss locally contains relicts of pod and ribbon structures.

sg SCHIST AND GNEISS (MIDDLE PROTEROZOIC)—Muscovite-biotite schist that grades into schistose biotite gneiss. Commonly contains sillimanite and as much as 60% quartz and feldspar. Unit is spatially associated with calc-silicate gneiss (cs) in the southwestern part of the map area. Mapped as Wallace Formation by Hietanen (1963). Because of folding and metamorphism, the stratigraphic relationship with cs is uncertain. All or part of the unit may be equivalent to the lower part of the Ymg unit that is itself equivalent to the argillitic upper Wallace Formation.

cs CALC-SILICATE GNEISS (MIDDLE PROTEROZOIC)—Includes centimeter-scale layered hornblende-diopside-quartz-plagioclase gneiss, diopside quartzite, amphibolite, quartzite with more than 5% garnet, and minor amounts of garnet-biotite schist and gneiss. Compositional layering or range in grain size of amphibolite distinguishes it from the more homogeneous rock of the metaigneous amphibolite (am). Unit probably was derived from carbonate-bearing lower and middle members of the Wallace Formation, but is too recrystallized to apply a formational name.

qi IMPURE QUARTZITE (MIDDLE PROTEROZOIC)—Generally medium- to coarse-grained, impure, thin-bedded quartzite that contains abundant feldspar and biotite. Grades into quartz-rich biotite gneiss where migmatized; also contains as much as 5% diopside, hornblende, or garnet and grades into calc-silicate gneiss. Quartzite with sparse flattened quartz pebbles as much as 6 cm long occurs along the Lolo "motorway" on the west end of Rocky Ridge in the southwest corner of the map area. Smaller quartz pebbles (1 cm long) are present along Cayuse Creek 1 km east of the mouth of Cayuse Creek. Unit probably represents quartzite-rich portions of the Wallace Formation. Hietanen (1963) mapped the qi and cs units as gneiss of the Wallace Formation, and Childs (1982) mapped the qi unit as quartz gneiss of the Wallace Formation.

qrv QUARTZITE OF RAVALLI(?) GROUP (MIDDLE PROTEROZOIC)—Consists of light gray quartzite in beds several cm to 1 m thick and interbedded subordinate phyllite or schist. Unit is too highly metamorphosed to be unambiguously assigned to a single group or formation.

In the upper part of Black Canyon the unit consists of decimeter- to rare meter-thick beds of light gray quartzite and thin interbeds of phyllite or schist. The quartzite is typically fine grained and friable and forms talus with internal planar and cross lamination. Plagioclase feldspar predominates over potassium feldspar. As metamorphic grade increases toward the batholith, feldspar content and grain size increase, and quartz-muscovite-biotite schist is interbedded with the quartzite. Unit includes rocks correlated with Ravalli Group (Day, 1975; R.E. Kell, pers. commun., 1990). Alternatively, unit may correlate with member 2 of the Mount Shields Formation (C.A. Wallace, pers. commun., 1990).

In the middle part of Black Canyon the unit consists of medium-grained quartzite in decimeter- to meter-thick beds with lesser amounts of biotite schist. Sedimentary structures include large channels, dune bedforms, and much more prominent lenticular bedding than the flat, aggradational bedding of the quartzite of upper Black Canyon but similar to exposures along Rawhide Creek. Plagioclase is the predominant feldspar. This portion of unit has been correlated with the Ravalli Group (Childs, 1982; R.E. Kell, pers. commun., 1990).

To the west, in the Snow Creek area, the unit consists of quartzite beds 1 m thick that occur at the base of upward fining and thinning cycles. Apparent coarsening downward of the quartzite may be an artifact of increased recrystallization southward. Plagioclase is the predominant feldspar. The section west of Snow Creek is about 2,500 m thick.

sp SCHIST OF THE PRICHARD(?) FORMATION (MIDDLE PROTEROZOIC?)—Quartz-muscovite-biotite schist, quartz-biotite-muscovite schist, muscovite-biotite gneiss and coarsely recrystallized micaceous quartzite. Schist grades into biotite gneiss and locally contains sillimanite. Generally coarse-grained and has crenulated or multiply crenulated foliation. Some coarse schist has compositional layering at angles to foliation; more commonly centimeter-scale compositional layering is preserved by fine-grained biotite quartzite and schist. Most layers are parallel to foliation but are probably transposed bedding as indicated by rare isoclinal fold hinges to which foliation is axial planar. Schist is variably garnetiferous; garnets in the northwest part of map are 1 to 2 cm in diameter, but elsewhere are less than 1 cm in diameter. Unit includes some bodies of coarse-grained quartzite and rare calc-silicate quartzite that were not mapped separately. Contains small, discontinuous sulfide-bearing quartz veins. Present tentative correlation with the Prichard Formation is based on an apparently gradational contact with qp and on previous correlations (Childs, 1982; R.E. Kell, pers. commun., 1990). Some or all of the unit may also correlate with schist in the Boehls Butte Formation, exposed to the west of the map area, which is assumed by some workers to be pre-Belt in age (Hietanen, 1984).

qp QUARTZITE OF THE PRICHARD(?) FORMATION (MIDDLE PROTEROZOIC?)—Coarsely recrystallized quartzite that occurs as small bodies in sp unit and as larger bodies to the west. Ranges from laminated dark and light gray to uniform white to dark gray. Includes muscovite, or biotite, or both, and rarely magnetite. Parting typically 5 to 30 cm thick, rarely over 1 m. Some quartzite in the northwestern part of the area has garnet on parting surfaces, apparently associated with thin argillaceous interlayers. Internal lamination and schist interlayers commonly tightly folded or discontinuous due to inhomogeneous strain. Unit includes rocks previously correlated with Revett, Burke, and Prichard Formations (Hietanen, 1968; Childs, 1982), but intense deformation and lack of preservation of sedimentary features in most places make correlations uncertain. Present tentative correlation with Prichard Formation is based on spatial association with sp unit.

FAULTS

Faults in the map area can be divided into two groups based on attitude: those that are inferred to have been originally at a low angle and those that are at a high angle and have straight traces. Most of the low-angle faults are folded and therefore are older than the steep faults that cut the folds.

Low-angle faults

Several low- to moderate-angle faults are present in the northern part of the map area. All are mapped as thrust faults, and some show older over younger relationships characteristic of thrust faults. Notable exceptions are the fault at the base of the Wallace Formation (Ywl) in the north-central part of the area and the fault at the base of the Missoula Group (Ymg) in the eastern part of the area along the Idaho-Montana border. Both of these faults show younger over older relationships.

The section of Ymg along the Idaho-Montana border is truncated across bedding at its base along a fault that is nearly horizontal. Bleached and cleaved rocks of the upper plate overlie sedimentary breccia of the middle Wallace Formation (Ywm) in the lower plate. Although this fault is mapped as a thrust, an alternate explanation is that it is a low-angle normal fault (D. Winston, pers. commun., 1991).

The fault at the base of Ywl is best exposed along the upper part of the North Fork of the Clearwater River, 5 km west of Hoodoo Pass. Bedding of both plates is truncated there, and topographic expression clearly indicates that Ywl is in the upper plate. If the quartzite in the lower plate (qrv) is part of the Ravalli Group (a tentative correlation), then this fault also places younger rocks over older. To the south near Trap Point, the contact relationships between Ywl and qrv are less certain, but this contact is interpreted to be the same younger over older fault. Southward, this fault becomes much more tightly folded and overturned to the west. R.E. Kell (pers. commun., 1990) has interpreted this fault to be part of a nappe structure.

High-angle faults

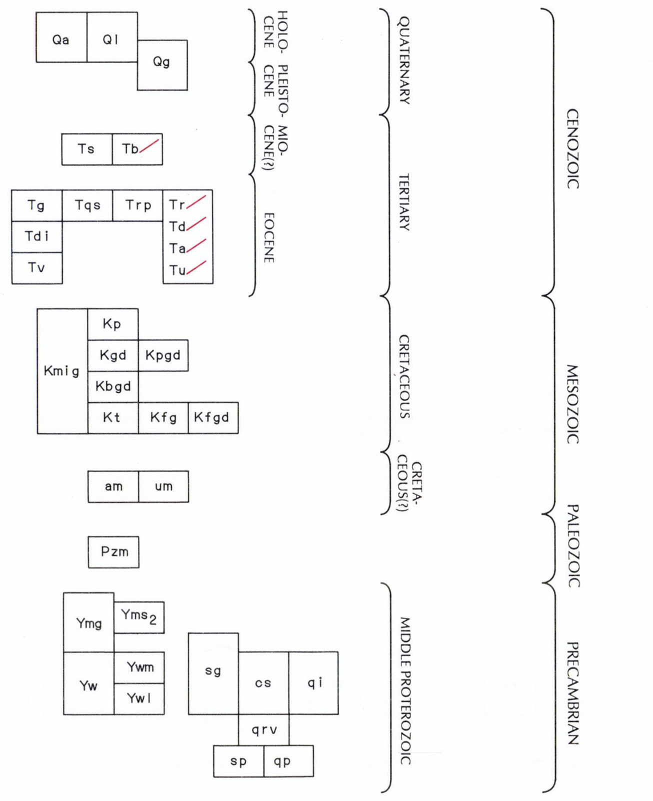
The most significant high-angle structure is the Kelly Forks fault, which trends northwest-southeast across the map area. Its strike is parallel to that of the Lewis and Clark line mapped to the north (Harrison and others, 1986). Childs (1982) and R.E. Kell (pers. commun., 1990) have postulated that left-lateral motion was followed by minor right-lateral motion along this structure. Complex dip-slip motion may also have occurred. The presence of younger metasedimentary rocks (equivalent to Wallace Formation) south of the fault compared with the dominance of rocks inferred to be Prichard Formation immediately north of the fault suggests south side down, yet the abundance of batholithic rocks on the south side suggests the opposite sense of motion.

The Collins Creek fault is one of several high-angle faults in the western part of the area that have north-south trends. The increase in metamorphic effect (grain size) west of the fault suggests that motion was east side down.

East- to west-trending faults that occur in the area include the Cayuse Creek fault in the southeast and an unnamed fault to the west, north of Cook Mountain. The Cayuse Creek fault separates Ymg from Yw, much like the low-angle structure near the Idaho-Montana line. However, its relatively straight trace suggests its dip is steeper, so it is shown as a normal fault. Bedding is truncated, but at a low angle. The western extension of Cayuse Creek fault is obscured by the intrusion of Tqs. It may connect to the Kelly Forks fault or continue (unmapped) to the west toward the fault north of Cook Mountain. A third east-west fault is now occupied by Tqs from Hanson Ridge eastward to the Lolo Hot Springs batholith.

Several northeast-trending high-angle faults, including the Shale Mountain fault, are present in the southeastern part of the area. These faults controlled emplacement of Eocene dikes and dike swarms and formed grabens in which Eocene volcanic rocks are preserved.

CORRELATION OF MAP UNITS



MAP SYMBOLS

Contact: approximately located; queried where uncertain

High-angle fault: approximately located; dotted where concealed; queried where uncertain; ball and bar on downthrown side

Thrust fault: approximately located; dotted where concealed; queried where uncertain; teeth on upper plate

Overturned thrust fault: approximately located; teeth in direction of dip; bar on side of tectonically higher plate

Fold axis: approximately located; dotted where concealed; queried where uncertain; arrow indicates plunge direction

Syncline

Anticline

Overturned anticline

Dikes

Areas of mylonitized rock

Strike and dip of compositional layering interpreted as bedding: ball indicates top direction was determined

Vertical bedding

Overturned bedding

Strike and dip of foliation: includes compositional layering of gneisses

Vertical foliation

Strike and dip of foliation variable

Bearing and plunge of mineral lineation

Bearing and plunge of small fold axis

Bearing and plunge of crenulation lineation

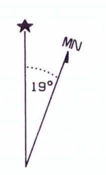
Bearing and plunge of asymmetrical small fold showing counterclockwise rotation viewed down plunge

Bearing and plunge of asymmetrical small fold showing clockwise rotation viewed down plunge

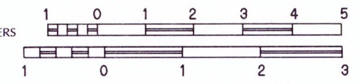
Strike and dip of fracture cleavage

Sedimentary breccia

Breccia of uncertain origin

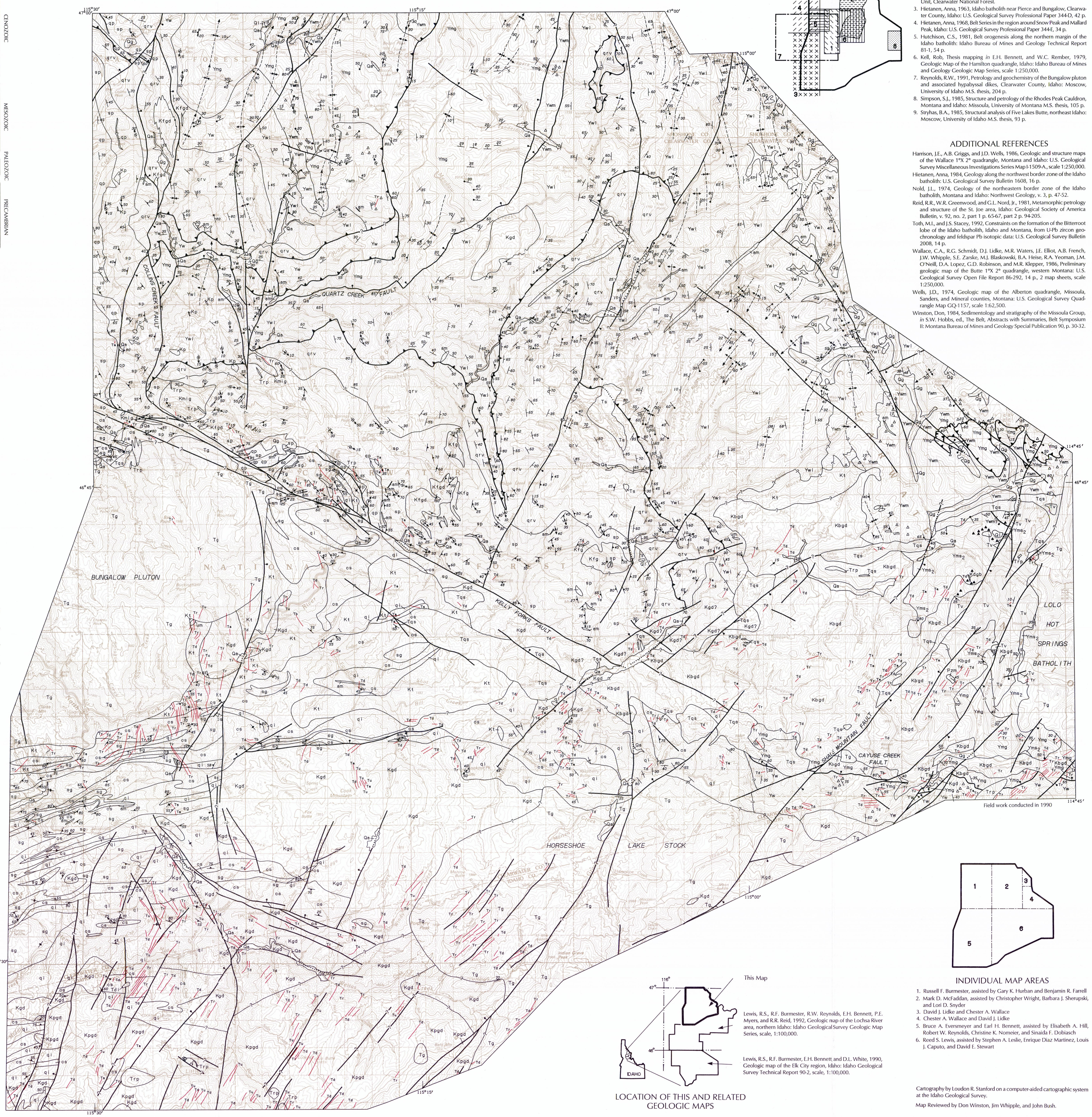


SCALE 1:100,000



CONTOUR INTERVAL 50 METERS

U.S.G.S. 1:100,000 topographic base
Projection and 10,000 meter grid, zone 11,
Universal Transverse Mercator



Field work conducted in 1990

INDEX TO PREVIOUS MAPPING

1. Childs, J.F., 1982, Geology of the Precambrian Belt Supergroup and the the northern margin of the Idaho batholith, Clearwater County, Idaho: Berkeley, University of California Ph.D. dissertation, 491 p.
2. Day, Norm, 1975, Unpublished U.S. Forest Service map, Cedars Planning Unit, Clearwater National Forest.
3. Hietanen, Anna, 1963, Idaho batholith near Pierce and Bungalow, Clearwater County, Idaho: U.S. Geological Survey Professional Paper 344-D, 42 p.
4. Hietanen, Anna, 1968, Belt Series in the region around Snow Peak and Mallard Peak, Idaho: U.S. Geological Survey Professional Paper 344-E, 34 p.
5. Hutchison, C.S., 1981, Belt orogenesis along the northern margin of the Idaho batholith: Idaho Bureau of Mines and Geology Technical Report 81-1, 54 p.
6. Kell, Rob, Thesis mapping *in* E.H. Bennett, and W.C. Rember, 1979, Geologic Map of the Hamilton quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map Series, scale 1:250,000.
7. Reynolds, R.W., 1991, Petrology and geochemistry of the Bungalow pluton and associated hypabyssal dikes, Clearwater County, Idaho: Moscow, University of Idaho M.S. thesis, 204 p.
8. Simpson, S.J., 1985, Structure and petrology of the Rhodes Peak Cauldron, Montana and Idaho: Missoula, University of Montana M.S. thesis, 105 p.
9. Stryhas, B.A., 1985, Structural analysis of Five Lakes Butte, northeast Idaho: Moscow, University of Idaho M.S. thesis, 93 p.

ADDITIONAL REFERENCES

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.

Hietanen, Anna, 1984, Geology along the northwest border zone of the Idaho batholith: U.S. Geological Survey Bulletin 1608, 16 p.

Nold, J.L., 1974, Geology of the northeastern border zone of the Idaho batholith, Montana and Idaho: Northwest Geology, v. 3, p. 47-52.

Reid, R.R., W.R. Greenwood, and G.L. Nord, Jr., 1981, Metamorphic petrology and structure of the St. Joe area, Idaho: Geological Society of America Bulletin, v. 92, no. 2, part 1 p. 65-67, part 2 p. 94-205.

Toth, M.I., and J.S. Stacey, 1992, Constraints on the formation of the Bitterroot lobe of the Idaho batholith, Idaho and Montana, from U-Pb zircon geochronology and feldspar Pb isotopic data: U.S. Geological Survey Bulletin 2008, 14 p.

Wallace, C.A., R.G. Schmidt, D.J. Lidke, M.R. Waters, J.E. Elliot, A.B. French, J.W. Whipple, S.E. Zarske, M.J. Blaskowski, B.A. Heise, R.A. Yeoman, J.M. O'Neill, D.A. Lopez, G.D. Robinson, and M.R. Klepper, 1986, Preliminary geologic map of the Butte 1°X 2° quadrangle, western Montana: U.S. Geological Survey Open File Report 86-292, 14 p., 2 map sheets, scale 1:250,000.

Wells, J.D., 1974, Geologic map of the Alberton quadrangle, Missoula, Sanders, and Mineral counties, Montana: U.S. Geological Survey Quadrangle Map GQ-1157, scale 1:62,500.

Winston, Don, 1984, Sedimentology and stratigraphy of the Missoula Group, *in* S.W. Hobbs, ed., The Belt, Abstracts with Summaries, Belt Symposium II: Montana Bureau of Mines and Geology Special Publication 90, p. 30-32.

Lewis, R.S., R.F. Burmester, R.W. Reynolds, E.H. Bennett, P.E. Myers, and R.R. Reid, 1992, Geologic map of the Lochsa River area, northern Idaho: Idaho Geological Survey Geologic Map Series, scale, 1:100,000.

Lewis, R.S., R.F. Burmester, E.H. Bennett and D.L. White, 1990, Geologic map of the Elk City region, Idaho: Idaho Geological Survey Technical Report 90-2, scale, 1:100,000.

LOCATION OF THIS AND RELATED GEOLOGIC MAPS

INDIVIDUAL MAP AREAS

1. Russell F. Burmester, assisted by Gary K. Hurban and Benjamin R. Farrell
2. Mark D. McFadden, assisted by Christopher Wright, Barbara J. Sherupski, and Lori D. Snyder
3. David J. Lidke and Chester A. Wallace
4. Chester A. Wallace and David J. Lidke
5. Bruce A. Eversmeyer and Earl H. Bennett, assisted by Elisabeth A. Hill, Robert W. Reynolds, Christine K. Nomeier, and Sinaida F. Dobiasch
6. Reed S. Lewis, assisted by Stephen A. Leslie, Enrique Diaz Martinez, Louis J. Caputo, and David E. Stewart

Cartography by Loudon R. Stanford on a computer-aided cartographic system at the Idaho Geological Survey.

Map Reviewed by Don Winston, Jim Whipple, and John Bush.

Printed by Pikes Peak Litho, Colorado Springs, Colorado

Published and sold by the Idaho Geological Survey
University of Idaho, Moscow, Idaho 83843