U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Digital Geologic Map of the Sandpoint 1- by 2-Degree Quadrangle, Washington, Idaho, and Montana

by

Fred K. Miller[1], Russell F. Burmester[2], David M. Miller[3],
Robert E. Powell[1], and Pamela D. Derkey[1]

Open-File Report 99-144

1999

[1] U.S. Geological Survey, Spokane, WA 99201
[2] Western Washington University, Bellingham, WA 98225
[3] U.S. Geological Survey, Menlo Park, CA 94025

Table of Contents

List of Figures

Introduction

The geology of the Sandpoint 1° x 2° quadrangle, Washington, Idaho and Montana was mapped by Fred K. Miller, Russell F. Burmester, David M. Miller and Robert E. Powell during various periods between 1963 and 1995 and was compiled in 1995. The compilation was made on a 1:250,000-scale greenline mylar of the topographic base map and then scribed. The analog map was then converted to a digital format during 1997 and 1998 for use in a geographic information system (GIS). The resulting digital geologic map GIS can be queried in many ways to produce a variety of geologic maps. Digital base map data files (topography, roads, towns, rivers and lakes, etc.) are not included: they may be obtained from a variety of commercial and government sources. This database is not meant to be used or displayed at any scale larger than 1:250,000 (e.g., 1:100,000 or 1:24,000).

The map area is located in north Idaho (fig. 1). This open-file report describes the geologic map units, the methods used to convert the geologic map data into a digital format, the Arc/Info GIS file structures and relationships, and explains how to download the digital files from the U.S. Geological Survey public access World Wide Web site on the Internet.

Support for all geologic mapping of the quadrangle was provided by the National Cooperative Geologic Mapping Program. Support for all digital preparation was provided by the Mineral Resources Program.

Even though this is an Open-File Report and includes the standard USGS Open-File disclaimer, the authors of the report have tried to closely adhere to the U. S. Geological Survey and IUGS rules for stratigraphic nomenclature.

We wish to thank R.W. Tabor and S.E. Box for reviewing the manuscript and Pamela Cossette for reviewing the digital GIS files.

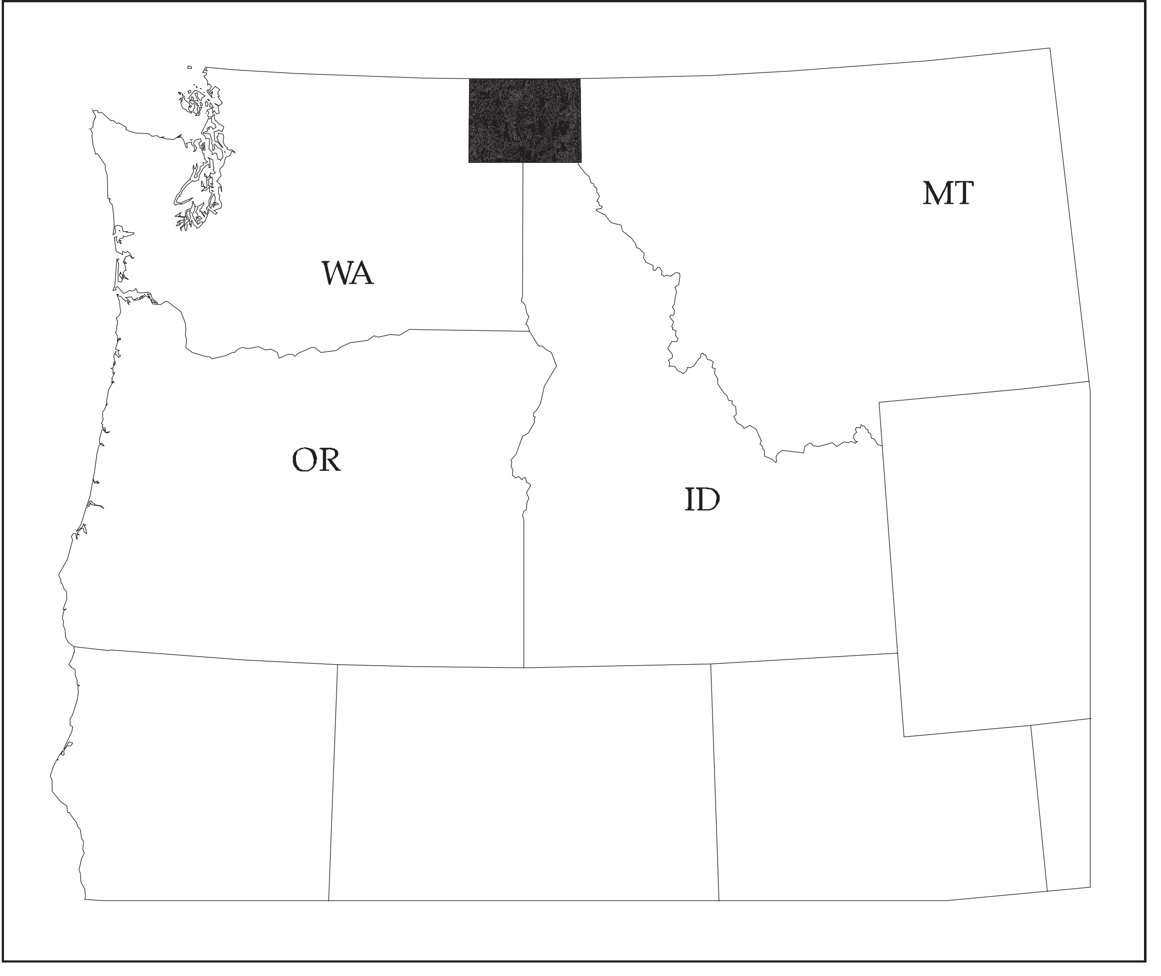

Figure 1. Index map showing the geographic extent of the mapped area (black fill) and the Sandpoint quadrangle with respect to the Pacific Northwest.

Notes on Bedrock Geology

The bedrock geology of the Sandpoint 1° x 2° quadrangle consists of sedimentary, metamorphic, and granitic rocks ranging in age from Middle Proterozoic to Miocene. Bedrock units include rocks of (1) the Middle Proterozoic Belt Supergroup and underlying orthogneiss, (2) the Middle Proterozoic Deer Trail Group, (3) the Late Proterozoic Windermere Group, (4) eugeoclinal, miogeoclinal, and possibly shelf facies lower and middle Paleozoic rocks, (5) eugeoclinal Permian and Triassic rocks, (6) the Jurassic Rossland Group, (7) Mesozoic and Eocene granitic rocks, (8) Cretaceous(?) and Eocene sedimentary and volcanic formations, and (9) the Miocene Columbia River Basalt Group.

Limited exposures of the oldest dated rocks in the area, 1,578-Ma (Middle Proterozoic) orthogneiss (Ylg) (Evans and Fischer, 1986), are found on both sides of the Pend Oreille River near Laclede (fig. 2), about 25 km west of Lake Pend Oreille. The orthogneiss is overlain by highly metamorphosed Prichard Formation, the lowest unit of the Middle Proterozoic Belt Supergroup. Rocks at the contact between the two units are sheared, but it is not clear whether the shearing has significantly detached the Belt Supergroup from its basement.

The Belt Supergroup, a thick section of argillite, siltite, quartzite, and impure carbonate rocks up to 14,000 m thick, forms three non-contiguous sequences in the quadrangle (fig. 3): (1) the Clark Fork-Eastport sequence east of the Purcell trench[4], (2) the Newport sequence north of the town of Newport, and (3) the Chewelah sequence east of the town of Chewelah. Belt rocks of the Clark Fork-Eastport sequence are separated from those of the Chewelah sequence by the Priest River Complex (new name) and an inferred fault in the Purcell trench, and Belt rocks of the Newport sequence are separated from those of the other two sequences by the Newport Fault (fig. 3). Some formations of the Belt Supergroup show differences in thickness and (or) lithofacies from one sequence to another that are greater than those predicted from an empirical depositional model for the distances currently separating the sequences. These anomalous thickness and facies differences suggest that there has been a net contraction along structures separating the sequences despite Eocene extension associated with emplacement of the Priest River Complex. In addition to these three Belt sequences, rocks probably derived from the Belt are present in the Priest River Complex as highly metamorphosed crystalline gneiss and schist.

West of the Chewelah sequence and north of the Newport sequence of the Belt Supergroup is the Deer Trail Group, a distinct Middle Proterozoic sequence of argillite, siltite, quartzite, and carbonate rocks lithostratigraphically similar to the Belt Supergroup, but separated from all Belt rocks by the Jumpoff Joe Fault, at one place by only a few kilometers. Rocks of the Deer Trail Group are pervasively phyllitic and noticeably more deformed than the Belt rocks in any of the three Belt sequences. Lithostratigraphically, the Deer Trail Group is equivalent to part of the upper part of the Belt Supergroup (Miller and Whipple, 1989). Differences in lithostratigraphy and thickness between individual

---

[4] The Purcell trench is a discontinuous geomorphic low that roughly follows the Purcell trench Fault as it is shown in figure 1.

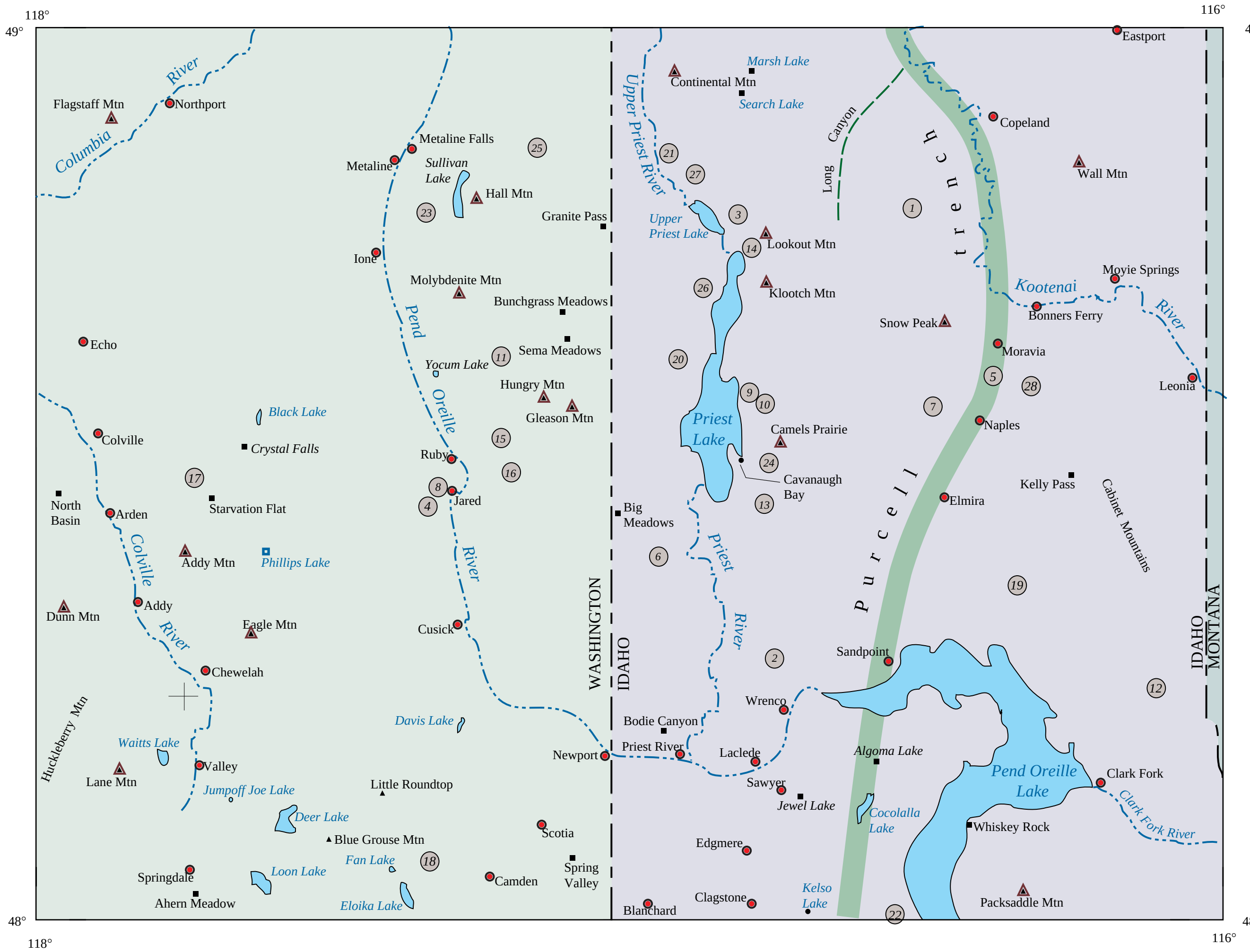

Figure 2. Index map of the Sandpoint 1° X 2° quadrangle showing geographic and cultural features referred to in the text.

Circled numbers show locations of the approximate mid-point of creeks that are mentioned in the text and listed below.

1 Ball Creek
2 Big Creek
3 Caribou Creek
4 Cusick Creek*
5 Deep Creek**
6 Dubius Creek*
7 Fall Creek
8 Gardiner Creek*
9 Horton Creek
10 Hunt Creek*
11 Le Clerc Creek
12 Lightning Creek
13 Lost Creek
14 Lucky Creek*
15 Middle Creek*
16 Mill Creek**
17 Narcisse Creek*
18 Otter Creek*
19 Rapid Lightning Creek
20 Reeder Creek*
21 Ruby Creek**
22 Salee Creek*
23 Sand Creek**
24 Soldier Creek
25 Sullivan Creek
26 Tango Creek*
27 Trapper Creek
28 Twentymile Creek

* Name of these creeks are on 7.5' quadrangle maps, but not on the Sandpoint 1° X 2° quadrangle.

** In addition to the name not appearing on the map, there is more than one creek with this name in the Sandpoint 1° X 2° quadrangle.

EXPLANATION

- Granitic rocks (Tertiary)
- Granitic rocks (Cretaceous, Jurassic, and Triassic)
- Priest River Complex (Cretaceous to Middle Proterozic)
- Granitic and metamorphic rocks (Cretaceous to Middle Proterozic)—May be part of Priest River Complex or Spokane dome (lies south of Sandpoint quadrangle) or may be related to neither feature
- Rocks of Quesnellia Terrane (Jurassic to Carboniferous)
- Rocks west of Huckleberry Range Fault
- Deer Trail Group, Windermere Group, and Paleozoic rocks (Ordovician to Middle Proterozoic)
- Belt Supergroup and Paleozoic rocks (Mississippian to Middle Proterozoic)
- Mylonitized rocks

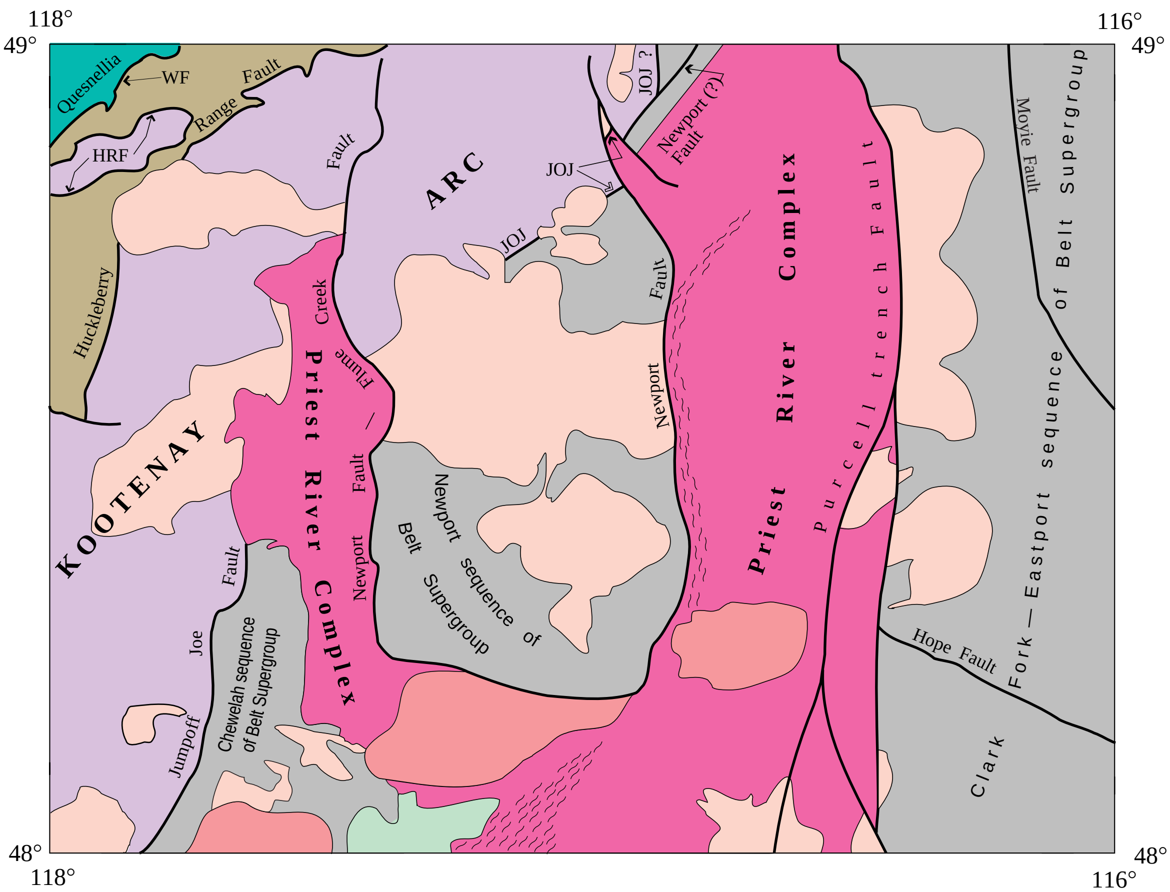

Figure 3. Map showing the location of major structural features and stratigraphic sequences in the Sandpoint 2° quadrangle. The Purcell trench, a discontinuous geomorphically low feature, roughly follows the course of the Purcell trench Fault. JOJ, Jumpoff Joe Fault; HRF, Huckleberry Range Fault; WF, Waneta Fault.

Deer Trail and Belt units and between the Deer Trail Group and Belt Supergroup sequences as a whole indicate that they were probably far apart when they were deposited.

The Windermere Group is a lithologically highly varied sequence of coarse-grained, mostly immature sedimentary and volcanic rocks up to 8,000 m thick. It is characterized by extreme differences in thickness and lithofacies over short distances caused by syndepositional faulting associated with the initial stage of continental rifting in the Late Proterozoic. Strata of the Windermere Group unconformably overlie only the Deer Trail Group, and are nowhere found in depositional contact with rocks of the Belt Supergroup.

Differing sequences of Paleozoic rocks overlie the Windermere Group and each of the three sequences of the Belt Supergroup. West of the Jumpoff Joe Fault, a thick miogeoclinal sequence ranging in age from Early Cambrian to Silurian rests unconformably on Windermere rocks. East of the fault, a much thinner miogeoclinal to shelf sequence ranging in age from Cambrian to Mississippian lies directly on rocks of the Chewelah sequence of the Belt Supergroup. Only thin remnants of Paleozoic rocks are preserved above the Clark Fork-Eastport sequence. East of Lake Pend Oreille on Packsaddle Mountain (fig. 2), areally restricted, Cambrian miogeoclinal or shelf rocks rest unconformably on the Clark Fork-Eastport sequence, and about 8 km northeast of the town of Cusick (fig. 2) a few hundred feet of Late Proterozoic to Cambrian quartzite rests unconformably on the Newport sequence.

Eugeoclinal Paleozoic rocks crop out west of the Huckleberry Range Fault (fig. 3). In the westernmost part of the Sandpoint quadrangle, eugeoclinal strata present between the Huckleberry Range and the Waneta Faults have yielded Devonian fossils at several localities (for references, see Joseph, 1990). Southwest of the quadrangle, eugeoclinal rocks of the Covada Group west of the Huckleberry Range Fault have yielded sparse Early Ordovician fossils (Smith and Gehrels, 1992).

West of the Waneta Fault, limestone pods enclosed within eugeoclinal argillite and wacke have yielded abundant Permian and Triassic fossils (for references, see Joseph, 1990). These Permian and Triassic rocks are unconformably overlain by sedimentary and volcanic rocks of the Jurassic Rossland Group. The upper Paleozoic and Mesozoic strata west of the Waneta Fault have been assigned to the Quesnellia terrane (Cheney and others, 1994).

Voluminous intermediate-composition granitic rocks ranging in age from Triassic to Eocene underlie about half of the Sandpoint quadrangle. About 80 to 90 percent of the granitic rocks are Cretaceous in age, most falling into a narrow age range of 90 to 100 Ma; the rest are Triassic, Triassic or Jurassic, Jurassic, and Eocene in age (Miller and Engels, 1975; Whitehouse and others, 1992). Nearly all of these rocks, irrespective of their ages, belong to either of two broadly defined petrogenetic suites as defined by Miller and Engels (1975): the hornblende-biotite suite or the muscovite-biotite suite. All of the Triassic, Triassic or Jurassic, Jurassic, and Eocene plutons and about half of the Cretaceous rock units fall into the hornblende-biotite suite; all rock units of the muscovite-biotite suite appear to be Cretaceous in age. Volumetrically, most of the muscovite-biotite rock units are part of the Priest River Complex.

In addition to being numerically fewer than the Cretaceous intrusive bodies, the Triassic and Jurassic plutons on average are relatively smaller. The Flowery Trail Granodiorite exposed east of the town of Chewelah is the only granitic rock unit with a well-established Triassic age, but based on compositional similarities to Triassic rock units in other parts of the Cordillera (Miller, 1978), the syenite of Wall Mountain and the monzonite of Long Canyon could also be Triassic. Granitic rock units having well-established Jurassic ages include the quartz monzodiorite of Lane Mountain and the tonalite and trondhjemite of Continental Mountain.

Cretaceous plutons ranging in composition from tonalite to monzogranite are scattered throughout the Sandpoint 1°x 2° quadrangle. They form some of the largest intrusive bodies in the area, such as the Spirit pluton northwest of the town of Ione and the Galena Point Granodiorite southwest of Priest Lake. Relative ages of the Cretaceous granitic rock units are very poorly known primarily because definitive intrusive relationships are rarely exposed. Almost all isotopic ages that have been determined for these rocks fall between roughly 90 and 100 Ma (see Description of Map Units), and within the resolution of the various dating methods, all of these rock units are nearly the same age. Because of this, chiefly to establish their sequence in the Description of Map Units section, most of the Cretaceous rock units are divided into six informal petrogenetic groups: (1) leucocratic rocks, (2) two-mica plutonic rocks, (3) highly evolved plutonic rocks, (4) rocks containing biotite as only characterizing mineral, (5) rocks containing hornblende and biotite as characterizing minerals, and (6) mafic-rich hornblende-biotite plutonic rocks.

The Priest River Complex, underlying much of the central part of the quadrangle, is made up of at least 24 lithodemes of crystalline rocks that are Cretaceous and older in age, variably overprinted by an Eocene deformational fabric. It approximately conforms to the informally named Priest River crystalline complex as defined by Reynolds and others (1981) and Rehrig and others (1987). Individual units of the complex are probably not distinct, sequentially emplaced plutons, but rather, together represent a single, inhomogeneous, composite intrusive mass of predominantly muscovite-biotite granitic rocks that are variably intermixed with metamorphic rocks. The metamorphic rocks are both metasedimentary and metaigneous, probably derived mostly from the Belt Supergroup, but including pre-Belt(?) orthogneiss. All the granitic rocks in the complex, except the Phillips Lake Granodiorite, yield Eocene potassium-argon biotite ages, but all, including the Phillips Lake Granodiorite, are presumably Cretaceous in age.

The eastern part of the Priest River Complex lies between the Purcell trench and the east arm of the Newport Fault (fig. 3), the central part is inferred to extend under the spoon-shaped Newport Fault, and the west part continues for up to 20 km west of the west arm of the Newport Fault. Part or all of the east boundary of the complex lies in the Purcell trench and is inferred to be a detachment fault (Reynolds and others, 1981). Most of the western boundary, and probably the northern boundary, appears to be intrusive. The southern boundary is ill-defined (fig. 3) because the relationship between the Priest River Complex and rocks of the Spokane dome of Cheney (1980) just south of the quadrangle is unclear.

Eocene granitic rocks comprise: (1) the Silver Point Quartz Monzonite and two smaller satellitic plutons west of Loon Lake, (2) the granodiorite of Wrenco west of Lake Pend Oreille, (3) the Coryell plutonic rocks and Sheppard Granite on both sides of the Columbia River, and (4) numerous small hypabyssal bodies throughout the quadrangle, most too small to show on the geologic map. The two non-contiguous plutons of Silver Point Quartz Monzonite together with the granodiorite of Wrenco and an unnamed

Eocene pluton in the Ritzville 1°x 2° quadrangle to the southwest form a prominent west-southwest alignment of Tertiary granitic rocks.

Tertiary volcanic rocks in the Sandpoint quadrangle consist of Eocene rocks of intermediate composition and Miocene basalt of the Columbia River Basalt Group, the latter unit being restricted to the southernmost part of the quadrangle. Eocene volcanic rocks are found west and north of the town of Colville and in the Pend Oreille River valley north of the town of Newport. Most appear to be preserved in localized grabens associated with Eocene extensional tectonism. The rocks are chiefly volcanic flows, but include a substantial amount of pyroclastic rocks and volcanic breccia.

Eocene sedimentary rocks, chiefly conglomerate and arkose, are interlayered with volcanic flow rocks at places north of Colville and southwest of the town of Chewelah. The Tiger Formation, an Eocene sedimentary unit in the Pend Oreille River valley, contains no interlayered volcanic flow rocks. Harrison and others (1972; *see also*, Harrison and Schmidt, 1971) considered the Sandpoint Conglomerate, which is restricted to a small area north of the town of Sandpoint, to be Cretaceous in age based on the lack of Cretaceous granitic clasts in the unit. We think that the Sandpoint Conglomerate is lithologically similar to the other extension-related sedimentary units in the quadrangle and that it is Eocene in age.

Major Structural Features

The Sandpoint 1° x 2° quadrangle lies athwart several major tectonic elements (fig. 3) including: (1) the western part of an extensive, nearly contiguous terrane of rocks belonging to the Belt Supergroup, (2) the Priest River Complex, (3) the Kootenay arc, and (4) the eastern edge of the Quesnellia terrane. All these elements are bounded by regionally extensive faults and several elements contain faults within them nearly as large as their bounding faults. For the following discussion, structures within the quadrangle are grouped by the tectonic domains that either contain them or are bounded by them. The structures are described from east to west through the quadrangle; most are shown in Figure 3.

Faults east of the Purcell Trench Fault

The extensive Clark Fork-Eastport sequence of the Belt Supergroup in the Sandpoint 1° x 2° quadrangle east of the Purcell trench Fault is disrupted by two major faults—the Moyie Fault and the Hope Fault (fig. 3). Between the Purcell trench Fault and the Moyie Fault, the Belt rocks form an east-dipping, essentially homoclinal section cut by numerous normal and reverse faults. East of the Moyie Fault, Belt rocks form a west-dipping homocline which is the west limb of the Sylvanite Anticline; the axis of the anticline lies east of the quadrangle. Rocks of this homocline are cut by about the same concentration of second order faults as the rocks west of the Moyie Fault. South of the Hope Fault, the Belt rocks dip dominantly east, but are cut by relatively close-spaced, nearly vertical, mutually intersecting faults. Many of these faults show little apparent offset of other faults because they are vertical or near-vertical, and movement on most of the faults is pure dip-slip (Harrison and Jobin, 1963, 1965).

Moyie Fault— In the Sandpoint 1° x 2° quadrangle, the Moyie Fault is a west-dipping reverse fault, which at the surface is nearly vertical and locally overturned; it probably shallows at depth. At the east edge of the quadrangle, it places the east-dipping Prichard Formation in the hanging wall against west-dipping rocks as young as the Mount Shields Formation in the footwall. In a structure cross-section 37 km along strike to the southeast, Harrison and others (1992) showed the Moyie Fault as having a dip of 60° west at the surface and shallowing to about 20° at a depth of about 8,200 m. They also showed about 3 km of reverse offset, but stated that the offset shown includes some back-slip that occurred during a later period of extension. The fault continues southward, gradually bending to the west, and ends against the Hope Fault a few kilometers east of the quadrangle.

Hope Fault—The Hope Fault is the northernmost fault of the Lewis and Clark line, a series of west-northwest-striking faults that in this region also includes the Osburn and St. Joe Faults south of the quadrangle. It dips steeply south-southwest and extends about 120 km to the east-southeast where it merges with the Ninemile Fault. Harrison and Jobin (1963) interpreted offset contacts and structures across the fault in the Clark Fork area and Libby quadrangle to indicate as much as 13 km of right-lateral strike-slip movement and as much as 6.7 km of normal dip-slip movement, down on the southwest. Yin (1991) interpreted all movement on the fault to be normal dip-slip, down on the southwest. Harrison and Jobin (1963) considered the fault to be part of an ancient zone of crustal weakness; they also considered that the strike-slip movement is probably Precambrian and that the dip-slip movement is Tertiary in age. Yin (1991) considered all movement to be Tertiary.

Faults associated with the Priest River Complex

The Clark Fork-Eastport sequence of the Belt Supergroup is sharply bounded on the west and juxtaposed against the Priest River Complex by an inferred detachment fault, the Purcell Trench Fault (fig. 3), beneath Quaternary deposits in the Purcell trench (fig. 2). Farther west, the Newport fault superposes the Newport sequence of Belt rocks against the Priest River Complex.

Purcell trench Fault—The Purcell trench Fault is nowhere exposed in the Sandpoint 1° x 2° quadrangle, but its existence is inferred based on the metamorphic and deformational contrasts across the Purcell trench. On the west side of the trench, coarse-grained quartz-feldspar-biotite-muscovite schist and numerous amphibolite bodies derived from the Middle Proterozoic Prichard Formation and the mafic sills that intrude it form a kilometers-wide band from the United States-Canada boundary southward for a distance of about 40 km. Large clots of fine-grained muscovite in much of the rocks probably represent retrograded aluminum silicate minerals. Numerous pegmatite, alaskite, and fine-grained two-mica bodies intrude the schist. All the rocks of this unit, including some of the granitic rocks, are tightly folded and faulted, and all the sedimentary features in the rocks are destroyed. Directly across the trench, on the east side, the Prichard Formation that is intruded by thick mafic sills shows only low greenschist-facies burial metamorphism, is mildly or not at all folded, and is cut by relatively few faults. In addition, Cretaceous granitic rocks east of the trench yield Cretaceous potassium-argon ages, but west of the trench yield Eocene cooling ages.

This metamorphic and deformational contrast is present from the United States-Canada boundary to 3 km north of the town of Elmira (fig. 2), at which point the two-mica granitic rocks, and to a lesser degree the metamorphic and deformational conditions, found on the west side of the trench, cross to the east side for a distance of at least 12 km along the fault. Eastward through the rocks along this 12 km stretch, the anomalous metamorphic and deformational conditions gradually diminish and grade into conditions characteristic of the east side of the trench; no fault east of the trench separates the higher rank rocks from the essentially unmetamorphosed rocks that are characteristic of the east side. These higher rank rocks east of the inferred position of the Purcell trench Fault are interpreted as a slice of the uppermost part of the Priest River Complex that was clipped off by the Purcell trench Fault and downdropped with the rest of the relatively unmetamorphosed rocks of the Belt Supergroup that lay above the proto-complex prior to its Eocene unroofing.

Rocks on each side of the trench just north and south of Sandpoint exhibit the metamorphic and deformational contrasts found in the northern part of the quadrangle and continue to do so southward to a point about 2 km south of Cocolalla Lake (fig. 2). From there to the south edge of the quadrangle, some of the rocks just west of the inferred location of the Purcell trench Fault are more characteristic of those normally found east of the fault. Specifically, the Cretaceous granodiorite of Kelso Lake, a sphene-bearing pluton that appears to grade westward into a hornblende-bearing rock, is found on both sides of the fault. The northern contact of the pluton appears to be offset by about 6 km, less than would empirically be expected based on the contrasts across the trench at other places. Immediately south of the quadrangle and continuing for a distance of at least 50 km, rocks on either side of the trench show the metamorphic and deformational contrasts found in the northern part of the Sandpoint 1°x 2° quadrangle.

Newport Fault—The 200-km-long U-shaped Newport Fault (fig. 3) is a spoon-shaped, shallowly dipping listric normal fault that juxtaposes intermediate- to shallow-depth plutonic rocks that intrude low-grade rocks of the Belt Supergroup, Deer Trail Group, and Paleozoic sequences in the hanging wall, against an infrastructure of two-mica granitic rocks, coarsely recrystallized Belt rocks, and pre-Belt(?) basement gneiss of the Priest River Complex that forms the footwall (Harms and Price, 1992). Northward from about the points where the Jumpoff Joe Fault intersects the east limb of the Newport fault and where the projection of the Jumpoff Joe Fault intersects the west limb, the Newport fault is much steeper, more like a conventional normal fault than a listric normal or detachment fault.

A zone of chlorite breccia and chloritized, brittlely deformed rocks, ranging from about 150 to 250 m thick, marks the upper part of the fault zone in the footwall; the zone is thickest along the east-west-oriented southern segment and thins progressively northward. This brittle deformation overprinted ductilely deformed mylonite that extends variable distances away from the fault. Thinner, discontinuous zones of chlorite breccia up to 120 m wide are found in the footwall up to 6 km from the main trace.

Mylonitic foliation east of the east limb of the fault is accompanied by a well-developed stretching lineation. Kinematic indicators in rocks within 1 or 2 km of the east limb of the fault indicate a top-to-the-west sense of movement (Harms and Price, 1992) and appear to be superimposed on a mylonitic fabric at greater distances from the fault that indicates a top-to-the-east sense of movement. This top-to-the-east zone of mylonite may be part of a wide zone of mylonitized rocks just west of longitude 117° in the southernmost part of the quadrangle (McCarthy and others, 1993) and, south of the quadrangle, continuous with extensively mylonitized rocks (Rhodes and Hyndman, 1984) associated with the Spokane dome of Cheney (1980).

Harms and Price (1992) documented unequivocally that the Newport Fault and related bounding structures were produced by extension, and they calculated that between 23 and 30 km of lateral extension occurred on the western limb of the Newport Fault based on separation of the Chewelah and Newport sequences of the Belt Supergroup. There are large lithostratigraphic differences between these two sequences, however, that indicate they probably are not offset parts of a once continuous sequence. Detailed lithostratigraphic comparisons of the two sequences suggest that they were telescoped by late Paleozoic to middle Mesozoic thrust faults that subsequently were obliterated by Cretaceous granitic plutons, and that the amount of telescoping greatly exceeded an undetermined amount of extension in the Eocene.

Faults associated with the Kootenay arc

Much of the western third of the quadrangle is underlain by rocks and structures of the Kootenay arc (fig. 3), which is a broad bend in the regional stratigraphic and structural framework of the Cordillera north and south of the United States-Canada boundary. The arc, concave to the west, extends from the northern margin of the Columbia River Basalt Group, about 25 km south of the quadrangle, through northeastern Washington and northern Idaho, to approximately Revelstoke, British Columbia, a distance of about 400 km. Rocks in the Sandpoint 1°x 2° quadrangle exhibit the characteristics and multiple deformations that Watkinson and Ellis (1987; *also see* Ellis, 1986) pointed out as typical of the Kootenay arc. Within the quadrangle, rocks in the arc that pre-date the Jurassic granitic rocks are highly faulted and folded. The north-northeast strike of these rocks and the structural elements that affect them are characteristic of the trend of the southern part of the Kootenay arc. Beginning at about the U.S.-Canada boundary, the trend of the Kootenay arc curves northward, then north-northwestward.

Rocks of the Kootenay arc were deformed in the Late Proterozoic, in the late Paleozoic to middle Mesozoic, and in the Eocene; probably more than one episode occurred in the late Paleozoic to middle Mesozoic interval. Except for Eocene faults, many faults in the Kootenay arc show evidence of reactivation in one or more periods of deformation. Because of this, it has not been possible to assign many faults to discrete episodes of faulting, nor to date accurately the time(s) during which they were active. This is particularly true for faults of the late Paleozoic to middle Mesozoic episode. In addition to being reactivated, some of these faults were folded or crosscut by younger faults during succeeding episodes of deformation.

Late Proterozoic structures are chiefly normal faults associated with continental-scale rifting and deposition of the Late Proterozoic Windermere Group. Devlin and Bond (1988; *also see* Devlin and others, 1985) convincingly showed that the Windermere strata were deposited in a rift environment in the Late Proterozoic. Differences in thickness, lithology, and distribution of the Windermere units over short distances, in addition to the fact that Windermere units in adjacent fault blocks were deposited on different units of the Deer Trail Group, strongly suggest that there was considerable fault activity in the Late Proterozoic (Miller, 1994, 1995a, and 1995b).

Most of the faults associated with the Kootenay arc are late Paleozoic to middle Mesozoic in age, and probably represent several discrete episodes of faulting within that time interval. Both normal and reverse faults developed, but the few cross-cutting relationships found are conflicting, suggesting that there was more than one period of reverse faulting and possibly more than one period of normal faulting.

Jumpoff Joe Fault—The Jumpoff Joe Fault (fig. 3) places rocks of the Deer Trail Group against Paleozoic rocks and rocks of the Belt Supergroup. It is interpreted to be a west-dipping thrust fault, although the proto-Jumpoff Joe Fault was probably a Late Proterozoic normal fault. The Jumpoff Joe Fault appears to define the eastern limit of the Kootenay arc. It extends at least from near the south boundary of the quadrangle to where it is cut off by the western edge of the Priest River Complex (fig. 3), but reappears east of a large area of granitic rocks in the hanging wall of the Newport Fault, and then again in the footwall east of the fault. On a hill west of Jumpoff Joe Lake (fig. 2) in the southwestern part of the quadrangle and on a small hill 2 km northeast of Chewelah, the Jumpoff Joe Fault appears to have a moderate west dip, but at other places it appears to be near vertical.

Structural and stratigraphic differences across the Jumpoff Joe Fault suggest that it is a complex, multiply reactivated, regional-scale fault with a long movement history. These differences include: (1) intensity and style of rock deformation, (2) regional structural trends, (3) lithostratigraphy of the Deer Trail Group compared to that of the partly coeval Belt Supergroup, (4) lithostratigraphy of Paleozoic rock units, and (5) the fact that the fault is the eastern boundary of the Windermere Group. West of the Jumpoff, Joe Fault the Deer Trail Group is extremely faulted, folded, and cleaved, and most of the rocks are highly phyllitic; east of the fault, partly coeval rocks of the Belt Supergroup are cut by an order-of-magnitude fewer faults, are essentially unfolded, and are rarely phyllitic.

Lithostratigraphically, part of the Deer Trail Group is correlative with part of the upper part of the Belt Supergroup (Miller and Whipple, 1989) . However, stratigraphic differences between the two units indicate that they originated at a considerable distance from one another, implying that they were subsequently juxtaposed by faulting. Paleozoic sequences above the Addy Quartzite west of the Jumpoff Joe Fault differ in thickness and lithostratigraphically from those above the Addy east of the fault.

Rocks of the Windermere Group unconformably overlie the Deer Trail Group and are unconformably overlain by Late Proterozoic and Cambrian quartzite west of the Jumpoff Joe Fault. East of the fault, the Belt Supergroup is everywhere unconformably overlain directly by the Late Proterozoic and Cambrian quartzite, and the Windermere Group is absent. Because the Windermere Group is consistently absent east of the Jumpoff Joe Fault, the fault is thought to have originated as a major Late Proterozoic normal fault that bounded the Windermere sedimentary wedge (Miller, 1994). Large-scale reactivation in late Paleozoic to middle Mesozoic time is thought to have resulted in net contractional movement across the fault.

At the United States-Canada boundary (fig. 3), the Jumpoff Joe Fault is roughly aligned with the St. Mary Fault 55 km to the northeast in Canada, but separated from it by a large area of Cretaceous granitic rocks and the Purcell trench Fault. The Jumpoff Joe and St. Mary Faults may represent disconnected parts of a single structure because of this rough alignment, similar senses of movement, and relationships between the Belt Supergroup and Windermere Group across the two faults. Northwest of the St. Mary Fault 9,000 m of the Windermere Supergroup (lateral equivalent of the Windermere Group in the U.S.) unconformably overlie the Purcell Supergroup (lateral equivalent of the Belt Supergroup in the U.S.) and are unconformably overlain by Late Proterozoic and Cambrian rocks (Rice, 1941). Southeast of the fault, Late Proterozoic and Cambrian rocks unconformably lie directly on the Purcell Supergroup (Lis and Price, 1976).

Huckleberry Range Fault—In the Sandpoint 1° x 2° quadrangle, the Huckleberry Range Fault (fig. 3) is a steeply to moderately dipping fault that reverses dip from westward in the south to eastward in the north. As mapped herein, the fault incorporates parts, but not all, of the Black Canyon and Leadpoint Faults of Yates (1964, 1976; Stoffel and others, 1991) with newly mapped fault segments. The Huckleberry Range Fault juxtaposes a terrane of Middle and Late Proterozoic strata (Deer Trail and Windermere Groups), Late Proterozoic and Cambrian strata (Gypsy or Addy Quartzite), Cambrian and Ordovician strata (Maitlen Phyllite, Metaline Formation, and Ledbetter Slate), and Devonian and Mississippian shelf carbonate rocks to the east against Devonian eugeoclinal rocks to the west. West of the Sandpoint 1° x 2° quadrangle, along the west flank of the Huckleberry Range, this fault juxtaposes the miogeoclinal Paleozoic rocks and underlying Proterozoic rocks against the eugeoclinal Lower Ordovician Covada Group, consisting of the Daisy and Butcher Mountain Formations of Smith and Gehrels (1992), and the Ordovician(?) to Devonian(?) Bradeen Hill assemblage of Smith and Gehrels (1992). The Huckleberry Range Fault is intruded by the Cretaceous Spirit pluton (ca. 100 Ma) in the Sandpoint 1° x 2° quadrangle and by other Cretaceous plutonic rocks west of the quadrangle near the south end of the Huckleberry Range. In British Columbia, the Huckleberry Range Fault continues as the Argillite Fault of Fyles and Hewlett (1959).

Waneta Fault—A fault in the northwesternmost part of the Sandpoint 1° x 2° quadrangle juxtaposes the Devonian eugeoclinal strata to the east against Permian and Triassic eugeoclinal strata overlain by the Rossland Group to the west. Because this fault, incorporating previously and newly mapped fault segments into a single structure, is on trend with the Waneta Fault in British Columbia north of the quadrangle (Fyles and Hewlett, 1959; Parrish and others, 1988; Joseph, 1990), that name is used herein for the fault in Washington as well. In the Sandpoint quadrangle and just west of it, the Waneta Fault appears to be westward dipping, whereas in British Columbia it is eastward dipping. Movement on the Waneta Fault post-dates the Rossland Group. West of the Sandpoint quadrangle, near Kettle Falls, the trend of the Waneta Fault is truncated by the Kettle River Fault, which is the bounding structure along the west margin of the Eocene Kettle dome.

Fault boundary of Columbia River inlier of miogeoclinal rocks—An elongate antiform of miogeoclinal strata—consisting of the Gypsy Quartzite, Maitlen Phyllite, and Metaline Formation—crops out along the Columbia River between Northport (fig. 2) and the west margin of the Sandpoint 1° x 2° quadrangle. The antiform constitutes a structural inlier of

Cambrian and Ordovician miogeoclinal rocks within the belt of Devonian eugeoclinal strata between the Huckleberry Range Fault to the east and the Waneta Fault to the west. The miogeoclinal rocks are everywhere in fault contact with the surrounding Devonian strata, but it is not yet clear whether the bounding fault (or faults) is a folded part of the Huckleberry Range Fault, a folded younger fault that has displaced the Huckleberry Range Fault, or a combination of the two. The bounding fault along the west flank of the antiform is part of the Columbia Fault of Yates (1964, 1971, 1976; Stoffel and others, 1991).

Eocene faults

Rocks and older faults from the Purcell trench westward are broken by numerous Eocene normal faults. Most of these faults are covered by surficial materials in the major river valleys, but where exposed appear to be relatively steeply dipping. Some have stratigraphic separations greater than 3,000 m. All occurrences of Eocene sedimentary and volcanic strata are bounded on at least one side by faults of this group. The faults are probably related to extension associated with uplift and unroofing of the Eocene metamorphic core complexes in the region. By far the greatest number of these faults are developed in the hanging walls of the detachment faults flanking the core complexes.

Description of Map Units

Qag *Glacial and alluvial deposits (Quaternary)*—Till from continental glaciation, glacial flood deposits, and all alluvial material in modern drainages. Also includes some lacustrine deposits in Colville and Pend Oreille River valleys

Qls *Landslide deposits (Quaternary)*—Unconsolidated rubble resulting from slides and land slips. Found mainly around cliffs formed in the Columbia River Basalt Group in the southwestern part of the quadrangle. Identified chiefly by geomorphic forms observed on aerial photographs

Ql *Glacial-lacustrine deposits (Quaternary)*—Silt, sand, gravel, and probably clay; deposited in glacial and possibly post-glacial lakes occupying Kootenay River valley. Most of unit is poorly indurated, finely to massively bedded, fine grained silt. Locally, unit contains gravel, sand, and boulders, some presumably ice-rafted

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; poorly indurated. Restricted to southwestern 15-minute block of quadrangle

Tcr *Columbia River Basalt Group (Miocene)*—Fine-grained tholeiitic basalt flows. Considered to be N_2 flows of Grande Ronde Basalt in Colville River drainage, and Priest

Rapids Member of Wanapum Basalt elsewhere (Swanson and others, 1979). Maximum thickness estimated to be about 180 m; thins northward

Tcg *Conglomerate (Eocene)*—Unit consists of Tiger Formation (Park and Cannon, 1943) in Pend Oreille River valley west of Newport, Sandpoint Conglomerate (originally considered to be Cretaceous in age by Harrison and Schmidt, 1971, and Harrison and others, 1972) north of Sandpoint, and unnamed conglomerate (Miller and Clark, 1975) north of Chewelah. Poorly to moderately-well indurated conglomerate, lithic arkose, and siltstone. Composition and sedimentary characteristics highly variable laterally and vertically. Unconformably overlies a variety of rock units. Tiger Formation considered to be syntectonic basin-fill deposits related to Eocene extensional tectonics (Gager, 1984; Harms and Price, 1992); Sandpoint Conglomerate and unnamed conglomerate probably of similar origin

Tcb *Chlorite breccia and cataclastic rocks associated with Newport Fault zone (Eocene)*—Green to gray brittlely comminuted cataclastic rocks and highly fractured and chloritized rocks formed in footwall of Newport Fault zone. Breccia in upper part of zone is nearly aphanitic; grades downward through decreasing brecciation into unbrecciated, but commonly mylonitized rocks of footwall. Thickness ranges from a few meters along northern parts of both limbs of U-shaped trace to 150 to 250 m along southernmost part

Tcc *Tectonic breccia of Cusick Creek (Eocene)*—Breccia and gouge derived from bounding rock units; materials range in size from powder to house-size blocks. Exposed only on west side of mountain between Jared and Ruby (fig. 2), but may typify unexposed hanging wall rocks immediately adjacent to Newport Fault along much of its trace

Ts *Sanpoil Volcanics (Eocene)*—Volcanic flow rocks, breccia, conglomerate, and lithic arkose. All volcanic rocks fall within compositional range from dacite to andesite; average composition is dacite (Joseph, 1990; Waggoner, 1990). Includes rocks comprising Pend Oreille Andesite of Schroeder (1952), unnamed volcanic flows and sedimentary rocks south of Waitts Lake, flow or intrusive andesite northeast of Waitts Lake, isolated outcrops of flow rocks and sedimentary rocks east of Dunn Mountain, and flows and sedimentary rocks west and north of Colville (Pearson and Obradovich, 1977). Unconformably overlies a variety of rock units.

Tot *Olivine trachybasalt (Eocene)*—Unit of Dings and Whitebread (1965). Olivine, clinopyroxene, and plagioclase in matrix of glass, palagonite, and orthoclase. Dark-gray to black, very fine-grained. Restricted to small area 7 km north of Metaline Falls. Considered to be part of Sanpoil Volcanics on basis of mineralogy and composition by Joseph (1990)

To *O'Brien Creek Formation (Eocene)*—Conglomerate and minor well-bedded tuff. Distinguished from other Eocene conglomerate units by absence of volcanic clasts. Tuff restricted to upper part of formation; both conglomerate and tuff vary greatly in thickness. Biotite from tuff gives potassium-argon age of 53 Ma (Pearson and Obradovich, 1977).

Forms discontinuous exposures northwest of Colville and in northwestern part of quadrangle

Thd *Hypabyssal dikes (Eocene)*—Mafic dikes of widely varied mineralogic composition and moderately varied chemical and modal composition. Fine-grained, light- to dark-gray; contain phenocrysts of one or more of following: clinopyroxene, hornblende, biotite, plagioclase, potassium feldspar, quartz, and rarely orthopyroxene and olivine. Found throughout quadrangle, but rare to absent within inner parts of Priest River Complex; most too small to show on map. Hornblende and biotite give potassium-argon ages ranging from 48 Ma (Miller, 1974c) to 53 Ma (Yates and Engels, 1968) (both ages recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Tsp *Silver Point Quartz Monzonite (Eocene)*—Hornblende-biotite monzogranite, granodiorite, quartz monzonite, and quartz monzodiorite; porphyritic with groundmass having distinctive bi-modal grain size. Occurs as two non-contiguous plutons. Extremely homogeneous with respect to composition and texture, except for foliate, mafic zone along north side of largest pluton near Davis Lake. Zircon gives slightly discordant uranium-lead age of 52 Ma (Whitehouse and others, 1992); biotite and hornblende give potassium-argon ages of 49 and 48 Ma, respectively, on one sample, and 52 and 48 Ma, respectively, on another (Miller, 1974c, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Tam *Quartz monzodiorite of Ahern Meadows (Eocene)*—Hornblende-biotite quartz monzodiorite to quartz monzonite; on basis of spatial association and mineralogic similarities, probably genetically related to Silver Point Quartz Monzonite (Tsp). Forms single pluton 8 km west of Loon Lake. Distinguished from other plutons by some hornblende having pyroxene cores, average color index of 28, and extremely abundant sphene. Biotite gives potassium-argon age of 50 Ma (Engels, *in* Miller and Clark, 1975)

Tll *Quartz monzonite of Loon Lake (Eocene)*—Hornblende-biotite quartz monzonite; on basis of spatial association and mineralogic similarities, probably genetically related to Silver Point Quartz Monzonite and quartz monzonite of Ahern Meadows. Forms single pluton northwest of Loon Lake. Distinguished from other plutons by nearly all hornblende having pyroxene cores. Fine-grained, with average color index of 18. Biotite gives potassium-argon age of 51 Ma (Engels, *in* Miller and Clark, 1975)

Tw *Granodiorite of Wrenco (Eocene)*—Medium- to coarse-grained, highly porphyritic hornblende-biotite granodiorite; hornblende distinctly subordinate to biotite. Sphene and xenoliths abundant. Typically has 1- to 8-cm-long orthoclase phenocrysts. Homogeneous composition in southern half of unit except for felsic phase near margin; heterogeneous mixture of magmatically mixed mafic and felsic rocks in northern part. Texture variable; much of pluton has variably developed foliation, and rocks along northwestern margin have fine-grained matrix. Color index averages about 16. Zircon gives uranium-lead age of 51 Ma (Whitehouse and others, 1992); biotite gives potassium-argon age of 46 Ma

(Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Ttp *Quartz monzonite of Trapper Peak (Eocene)*—Quartz monzonite to monzonite. Chilled, fine-grained margin contains olivine, hypersthene, clinopyroxene, hornblende, and biotite phenocrysts; interior is medium-grained and contains clinopyroxene, hornblende, and biotite, but only sparse hypersthene and no olivine. Age assignment based on mineralogical similarities to other Eocene intrusive rocks, as well as absence of fabric found in surrounding Priest River Complex. Forms single pluton 18 km north of Priest Lake

Tcs *Coryell plutonic rocks and Sheppard Granite, undivided (Eocene)*—Fine- to coarse-grained alkalic plutonic rocks that include locally porphyritic syenite, granite, monzonite, monzodiorite, and shonkinite. Form numerous, noncontiguous bodies on both sides of Columbia River in northwest part of quadrangle. Underlies much larger area in Canada. Color index widely variable from 1 to 15. Most of Coryell plutonic rocks fall in compositional range between syenite and monzonite. Sheppard Granite is leucocratic, equigranular granite and syenite containing abundant myrmekite; almost everywhere altered. Sheppard considered by Little (1982) to be a part of Coryell plutonic rocks. Zircon uranium-lead age of Coryell plutonic rocks is 51 Ma (Carr and Parkinson, 1989). Biotite potassium-argon age is 52 Ma (Yates and Engels, 1968, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Ksm *Sophie Mountain Formation (Cretaceous)*—Conglomerate with minor sandstone. Clasts from 2 cm to 1 m across include quartzite, greenstone, and fine-grained granitic rock. Thickness unknown, but at least 100 m (Little, 1982). Unconformably overlies rocks of the Rossland Group. Restricted to northwest side of Columbia River in Sandpoint quadrangle. Cretaceous age assignment inferred on basis of platanoid leaves (Little, 1960)

Kmm *Monzogranite of Midnight mine (Cretaceous)*—Medium- and coarse-grained, leucocratic, quartz-rich, muscovite-biotite monzogranite. Forms large body in southwestern part of quadrangle. Color index averages about 5; muscovite:biotite ratio averages about 1:2. Texture is seriate to hypidiomorphic-granular; much of pluton contains sparse, centimeter-long, microcline phenocrysts. Ludwig and others (1981) reported very slightly discordant U-Pb age of 75 Ma on zircon from lithologically similar pluton at Midnight mine 10 km to southwest

Kbgm *Muscovite monzogranite of Blue Grouse Mountain (Cretaceous)*—Medium- and coarse-grained, locally garnet-bearing muscovite monzogranite. Highly evolved petrologically; contains no mafic minerals, plagioclase composition is an_3. Forms four small, noncontiguous, east-west-aligned plutons east of Deer Lake. Nonporphyritic, hypidiomorphic-granular. Largest pluton partly surrounded by well-developed greisen zone and associated huebnerite-bearing quartz veins. Muscovite gives potassium-argon age of 80 Ma (Engels, *in* Miller and Clark, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Klr *Monzogranite of Little Roundtop (Cretaceous)*—Biotite monzogranite; characterized by very coarse grain size. Average color index of 7. Relatively uniform with respect to composition. Subtlely porphyritic, because 2- to 3-cm-long phenocrysts are only slightly larger than other minerals in rock. Texture variable, caused by ubiquitous, localized concentrations of potassium feldspar phenocrysts. Forms two large plutons east and west of Deer Lake in southwestern part of quadrangle. Rocks indistinguishable from very coarse-grained monzogranite 8 km southwest of quadrangle that gives slightly discordant $^{206}Pb/^{238}U$ age of 91 Ma on zircon (Ludwig and others, 1981)

Kg *Monzogranite of Granite Pass (Cretaceous)*—Medium- to coarse-grained leucocratic muscovite monzogranite. Averages 6 percent muscovite. Forms single pluton 3 km west of Upper Priest Lake. Locally garnet-bearing; contains minor biotite at a few places near margins. Color index 0 to 3. Texture ranges from seriate to hypidiomorphic-granular; locally has fine-grained, chilled border. Muscovite gives potassium-argon age of 98 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Km *Monzogranite of Middle Creek (Cretaceous)*—Leucocratic biotite monzogranite; some parts muscovite-bearing. Forms several tabular bodies 6 km east of Ruby in central part of quadrangle. Characterized by extreme textural variation ranging from fine-grained to pegmatitic. Color index averages 5. Deeply weathered, poorly exposed; could actually be series of dikes related to monzogranite of Gleason Mountain (Kgm) or Galena Point Granodiorite (Kgp) rather than coherent pluton. Age considered Cretaceous based on compositional similarity to nearby leucocratic granitic rocks

Kli *Leucocratic intrusive rocks (Cretaceous)*—Medium- to fine-grained monzogranite in small bodies and isolated discontinuous dikes and sills. Mapped 8 km southwest of Colville, but most too small to show on map. Probably includes leucocratic dike rocks associated with numerous Cretaceous plutons. Texture, grain size, and composition variable; most rocks contain muscovite, some are garnet-bearing, none have more than three percent biotite. Considered Cretaceous in age based on spatial association with, and mineralogical similarity to, dated Cretaceous rocks in map region

Kdc *Granodiorite of Dubius Creek (Cretaceous)*—Medium- to coarse-grained muscovite-biotite monzogranite and granodiorite; more mafic in sparsely exposed eastern part of unit. Forms large two-lobed body 3 km south of Priest Lake (fig. 2). Average color index 10. As mapped, unit could include more than one pluton. Mafic-rich eastern part of northern lobe and muscovite deficient southern lobe could be discrete plutons. Most of unit is even-grained, but locally contains 2- to 4-cm-long microcline phenocrysts. Muscovite and biotite give potassium-argon ages of 102 Ma and 95 Ma respectively, (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kb *Blickensderfer Quartz Monzonite (Cretaceous)*—Very coarse-grained muscovite-biotite monzogranite and granodiorite; locally porphyritic. Forms single pluton 24 km northwest of Newport. Average color index of 5. Muscovite:biotite ratio noticeably higher than most two-mica rocks in region. Hypidiomorphic-granular; where porphyritic, 2- to 3-cm-long phenocrysts are microcline. Very uniform texture and composition, except along fine-grained southern border. Muscovite and biotite give potassium-argon ages of 102 Ma and 100 Ma, respectively (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kmo *Granodiorite of Molybdenite Mountain (Cretaceous)*—Muscovite-biotite granodiorite. Forms single pluton 5 km east of Ione, in central part of quadrangle. Coarse-grained but, locally variable grain size. Some muscovite to 1 cm across. Average color index of 7. Hypidiomorphic-granular, nonporphyritic. Lithologically resembles, and may be genetically related to, Blickensderfer Quartz Monzonite. Muscovite and biotite both give potassium-argon ages of 103 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Ktmc *Two-mica monzogranite of Twentymile Creek (Cretaceous)*—Medium-grained, seriate, two-mica monzogranite and granodiorite. Forms a single pluton 25 km north of Lake Pend Oreille. Rocks in much of pluton characterized by 5- to 8-mm-wide muscovite grains, distinctly larger than other minerals. Color index about 10. Appears to have distinctly chilled margin against granodiorite of Kelly Pass (Kkp). Age considered Cretaceous based on textural and compositional similarities to nearby Cretaceous two-mica rocks

Knb *Two-mica monzogranite of North Basin (Cretaceous)*—Medium- to coarse-grained, seriate, non-porphyritic muscovite-biotite monzogranite or granodiorite. Forms sparse, deeply weathered exposures 8 km southwest of Colville; most of pluton lies west of quadrangle. Color index averages about 12. Assigned Cretaceous age based on textural and compositional similarities to nearby Cretaceous two-mica plutons

Kbm *Monzogranite of Big Meadows (Cretaceous)*—Muscovite-biotite monzogranite and granodiorite. Forms small body 6 km southwest of Priest Lake. Medium-grained; contains sparse, irregularly distributed, potassium feldspar phenocrysts. Internally heterogeneous with respect to texture and composition. Average color index of 7, but ranges from at least 5 to 15. Irregularly foliate. Age considered Cretaceous based on textural and compositional similarities to nearby Cretaceous plutonic rocks

Kbf *Granodiorite of Bonners Ferry (Cretaceous)*—Medium- to coarse-grained muscovite-biotite granodiorite. Color index averages 13, higher than many muscovite-bearing plutons. Characterized by abundant epidote; possibly primary. Has subtle foliation in places. Small, but wide-spread exposures suggest pluton underlies much of valley southwest of Bonners Ferry, extending nearly to Moravia. Cretaceous age based on textural and compositional similarities to nearby Cretaceous two-mica plutons

Ktc *Monzogranite of Tango Creek (Cretaceous)*—Very porphyritic, medium- to coarse-grained biotite monzogranite with ubiquitous trace amounts of muscovite. Forms a single pluton at the north end of Priest Lake Texture and phenocryst concentration variable; pluton may be texturally zoned. Distinguished by pink potassium feldspar phenocrysts up to 10 cm long. Contains trace amounts of sphene. Biotite gives potassium-argon age of 90 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977), which is considered minimum age

Kh *Monzogranite of Hungry Mountain (Cretaceous)*—Medium- to coarse-grained, porphyritic muscovite-biotite monzogranite. Forms a single, large pluton 8 km west of Priest Lake. Three to 7 cm-long white microcline phenocrysts very irregularly distributed throughout pluton; concentrations of phenocrysts make up 50 percent of rock locally. Color index averages 7. Muscovite and biotite give potassium-argon ages of 97 Ma and 93 Ma, respectively (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kgm *Monzogranite of Gleason Mountain (Cretaceous)*—Muscovite-biotite monzogranite. Forms two bodies, one intruding the eastern part of the Hungry Mountain pluton 3 km west of Priest Lake, and another flanking the west side of the Hungry Mountain pluton. Characterized by extreme variations in grain size, even in small exposures. Typical rock is medium grained, but contains pods of aplite or pegmatite from 1 cm to several hundred meters across that have diffuse, gradational borders. Color index averages 7. Grades outward through increasing grain-size and concentration of potassium feldspar phenocrysts into monzogranite of Hungry Mountain (Kh). Age considered Cretaceous based on spatial and probable genetic relationship with monzogranite of Hungry Mountain

Ksc *Monzogranite of Sand Creek (Cretaceous)*—Porphyritic medium- to coarse-grained biotite monzogranite. Forms single pluton 3 km west of Sullivan Lake in northwestern part of quadrangle. Pink orthoclase phenocrysts average 3 cm long, but range to 6 cm. Color index averages 8. Biotite gives potassium-argon age of 99 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Klc *Granodiorite of Lightning Creek (Cretaceous)*—Medium- to coarse-grained biotite granodiorite; contains sparse hornblende. Forms small pluton 6 km east of Lake Pend Oreille. Color index about 15. Even-grained, non-foliate; uniform texture and composition. Contains sparse, but ubiquitous sphene and epidote. Biotite gives potassium-argon age of 72 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977), which is considered minimum age

Kw *Granodiorite of Whiskey Rock (Cretaceous)*—Medium- to coarse-grained biotite granodiorite. Even-grained, non-porphyritic. Color index about 12. Exposed only on eastern shore of Lake Pend Oreille, but aeromagnetic anomaly (Harrison and others, 1972) suggests that it probably underlies much of lake itself. Biotite gives potassium-argon age of 88 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977), which is considered minimum age

Krl *Granodiorite of Rapid Lightning Creek (Cretaceous)*— Porphyritic medium- to coarse-grained hornblende-biotite and biotite granodiorite. Color index 12 to 16. May consist of more than one pluton, especially in westernmost rocks of unit. Biotite gives potassium-argon age of 75 Ma in western part of unit, and 98 Ma in eastern part (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Knc *Monzogranite of Narcisse Creek (Cretaceous)*—Medium- to coarse-grained biotite monzogranite, but includes lesser mixed mafic and leucocratic granitic rocks. Forms irregular shaped body 10 km east of Colville. Average color index of 10, but more variable than most Cretaceous plutons. Locally has slight foliation. As mapped, may include more than one pluton in northeastern part of unit. Biotite from rocks 2.5 km east of Black Lake gives potassium-argon age of 100 Ma. (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kwm *White Mud Lake porphyritic body (Cretaceous)*—Porphyritic, medium- to coarse-grained biotite monzogranite and granodiorite. Forms single pluton 8 km east of Colville. Orthoclase phenocrysts range from 2 to 6 cm, highly concentrated in places. Color index averages 13; contains variable amounts of sphene. May grade into, and be petrogenetically related to, Starvation Flat Quartz Monzonite. Age considered Cretaceous based on compositional similarity to Starvation Flat Quartz Monzonite and other nearby granitic rocks of Cretaceous age

Kgp *Galena Point Granodiorite (Cretaceous)*—Porphyritic medium- to coarse-grained biotite granodiorite and monzogranite. Average color index of 12. Forms large, irregular-shaped mass between Priest Lake and north-south leg of Pend Oreille River. Feldspar phenocrysts range from 2 to 8 cm in length; average 3 cm. Except for phenocryst size, texture and composition very uniform throughout most of pluton. Compositionally similar to, and may grade into, granodiorite of Yocum Lake (Ky), but contact relations poorly exposed and ambiguous. Biotite gives potassium-argon age of 101 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Klcc *Granodiorite of Le Clerc Creek (Cretaceous)*—Fine-grained, irregularly porphyritic biotite granodiorite. Forms single, small, elongate body 21 km west of Priest Lake in Le Clerc Creek drainage (fig. 2). Grain size variable, including very fine-grained chilled-margin phase. Feldspar phenocrysts small and irregularly distributed. Color index about 10. Trace amount of muscovite; possibly secondary. Age considered Cretaceous based on lithologic similarity to nearby granitic rocks of that age

Kbc *Monzogranite porphyry of Bodie Canyon (Cretaceous)*—Fine- to medium-grained, irregularly porphyritic, leucocratic biotite monzogranite. Phenocrysts are potassium feldspar and quartz, some of latter are bipyramidal. Forms small pluton 2 km north of town of Priest River (fig. 2). Grain size, texture, and concentration of phenocrysts highly variable, even at outcrop scale. Deeply weathered and cut by numerous Eocene hypabyssal dikes (Thd). Age considered Cretaceous based on lithologic similarity to nearby granitic rocks of that age

Khm *Granodiorite of Hall Mountain (Cretaceous)*—Fine- to coarse-grained muscovite-bearing biotite granodiorite. Characterized by abundant epidote and allanite. Forms six non-contiguous plutons between north end of Priest Lake and Ione, Washington (fig. 2). Texture and mafic content locally variable; slightly foliate at margins of some plutons. Average color index of 10, but ranges up to 17. Based on petrologic similarities, probably genetically related to granodiorite of Reeder Creek (Krc). Several plutons have tungsten, molybdenum, or gold geochemical anomalies associated with them (Miller and Theodore, 1982; Miller and Frisken, 1984). Biotite and muscovite give potassium-argon ages of 99 Ma and 96 Ma, respectively (Miller and Frisken, 1984)

Krc *Granodiorite of Reeder Creek (Cretaceous)*—Medium- and coarse-grained muscovite-bearing biotite granodiorite; generally contains less than 1 percent muscovite. Forms large irregular-shaped pluton around Priest Lake. Characterized by fairly abundant epidote and allanite and irregularly shaped, poikilitic microcline enclosing randomly distributed euhedral plagioclase. Chemical and petrologic similarities and coarser grain size suggest granodiorite of Reeder Creek could be deep-seated equivalent of granodiorite of Hall Mountain. Biotite gives potassium-argon age of 94 Ma (Miller and Engels, 1975, recalculated using current IUGS constants Steiger and Jaeger, 1977), which is considered minimum age

Kk *Granodiorite of Kelso Lake (Cretaceous)*—Biotite granodiorite and hornblende-biotite granodiorite. Chief rock-type is medium- to coarse-grained; strongly inequigranular, slightly porphyritic biotite granodiorite. Forms large body west of Lake Pend Oreille in southernmost part of quadrangle. Locally contains sparse muscovite *or* acicular hornblende. Color index 8 to 12. Sphene and epidote very abundant. In north and west parts of body, rocks grade into medium- to coarse-grained slightly to moderately foliated hornblende-biotite granodiorite having stubby prismatic hornblende coequal to biotite. In east part, rocks grade into fine-grained hornblende-biotite granodiorite. Hornblende-bearing rocks also carry abundant sphene and epidote and have color index between 15 and 20. Zircon gives uranium-lead age of 88 ±9 Ma, sphene gives 88 ±0.5 Ma (J.L. Wooden, written commun., 1994)

Starvation Flat Quartz Monzonite (Cretaceous)—Hornblende-biotite monzogranite and granodiorite with core of muscovite-bearing monzogranite (Arden pluton). Forms large pluton 16 km north of Chewelah and smaller pluton 13 km west of Chewelah (fig. 2). Consists of:

Ksh *Hornblende-biotite monzogranite and granodiorite*—Medium- to coarse-grained, non-porphyritic monzogranite to granodiorite. Average color index of 15, contains abundant sphene. Very homogeneous with respect to texture and composition, except for local mafic-rich parts near contacts on northeast flank of Addy Mountain, and 6 km north of town of Addy. Hornblende and biotite give potassium-argon ages of 99 Ma and 100 Ma, respectively (Engels *in* Miller and Clark, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977). Includes:

Ksha *Arden pluton*—Leucocratic biotite monzogranite and muscovite-biotite monzogranite genetically related to unit Ksh, but has slightly coarser grain size, lower color index, no hornblende, and it contains muscovite. Presumably evolved from same magma as Starvation Flat Quartz Monzonite. Average color index of 9. Incompletely exposed contact with hornblende-bearing phase (Ksh) suggests that these two rock types are gradational over a few meters

Kgs *Granitic rocks of Spirit pluton (Cretaceous)*—Coarse- to fine-grained hornblende-biotite and biotite granodiorite, monzogranite, and quartz monzonite. Forms large, composite pluton 7 km northwest of Ione (fig. 2). Pluton consists primarily of two concentrically zoned phases: (1) feldspar-porphyritic biotite monzogranite in central part, grading outward through seriate porphyritic monzogranite into (2) non-porphyritic biotite monzogranite and quartz monzonite. Subordinate phases include (3) mafic-rich rocks around eastern part of pluton margin and (4) scattered various-sized bodies of leucocratic rocks, especially in central part of pluton. Biotite gives potassium-argon age of 99 Ma (Yates and Engels, 1968, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kco *Granodiorite of Copeland (Cretaceous)*—Medium- to coarse-grained hornblende-biotite and biotite granodiorite. Forms large pluton east of Copeland (fig. 2). Sphene-bearing. Color index ranges from 13 to 17. Porphyritic in part, containing feldspar phenocrysts 2.5 cm long. Fairly uniform with respect to texture and composition, except in southwestern part of unit. Scattered southwestern exposures devoid of hornblende and may be separate pluton. Hornblende and biotite from northern part of unit give potassium-argon ages of 95 Ma and 90 Ma, respectively (Miller and Engels, 1975; recalculated using current IUGS constants, Steiger and Jaeger, 1977); emplacement age inferred to be about 100 Ma

Kyl *Granodiorite of Yocum Lake (Cretaceous)*—Medium- to coarse-grained hornblende-biotite granodiorite and monzogranite. Forms large pluton northeast of Ruby (fig. 2). Even-grained to seriate, non-porphyritic; uniform with respect to texture and composition. Average color index about 14. Strongly resembles hornblende-biotite monzogranite and granodiorite phase of Starvation Flat Quartz Monzonite. Hornblende and biotite both give potassium-argon ages of 100 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kru *Granodiorite of Ruby Creek (Cretaceous)*—Coarse-grained, porphyritic biotite granodiorite. Forms small pluton 8 km north of Upper Priest Lake. Nearly all potassium feldspar is in 2- to 5-cm-long phenocrysts, almost none in groundmass. Contains abundant sphene. Color index averages 20. Biotite gives potassium-argon age of 68 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977), which is considered to be cooling age. Rock type is texturally and compositionally similar to nearby 100-Ma plutons

Kcu *Granitic rocks of Cabinet Mountains, undivided (Cretaceous)*—Medium- to coarse-grained hornblende-biotite and biotite granodiorite and monzogranite. Form numerous, small, non-contiguous, incompletely mapped bodies in the Cabinet Mountains (fig. 2) that may or may not be genetically related to one another. Age considered Cretaceous based on lithologic similarities to nearby granitic rocks of that age, but could include some Jurassic rocks

Kpm *Granodiorite porphyry of Packsaddle Mountain (Cretaceous)*—Hornblende-biotite granodiorite porphyry. Found only on Packsaddle Mountain east of Lake Pend Oreille. Fine-grained matrix enclosing 1-cm-long phenocrysts of plagioclase, quartz, and locally hornblende. One or both mafic minerals partially altered in most rocks. Biotite potassium-argon age is 98 Ma (J. K. Nakata, U.S. Geological Survey, written commun., 1993)

Kv *Granodiorite of V-78 Road (Cretaceous)*—Hornblende-biotite granodiorite; some parts of unit contain no hornblende. Forms small, isolated exposures from Bonners Ferry to Naples; also flanks southeast margin of granodiorite of Kelly Pass (Kkp). Contains sparse microcline phenocrysts averaging 2 cm in length. Contains abundant sphene and epidote. Color index averages about 16. Medium- to coarse-grained. Rock type has well-developed lineation and irregularly developed foliation. Biotite gives potassium-argon age of 89 Ma (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977), which is considered cooling age, not emplacement age

Kfl *Fan Lake Granodiorite (Cretaceous)*—Hornblende-biotite granodiorite ranging to monzogranite; medium- to coarse-grained. Forms large, sparsely exposed pluton around and east of Eloika Lake (fig. 2); extent south of quadrangle unknown. Characterized by large stubby hornblende crystals, abundant sphene, and color index averaging 19. Hornblende and biotite give potassium-argon ages of 97 Ma and 95 Ma respectively, (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977); emplacement age inferred to be about 100 Ma

Kc *Biotite monzogranite of Camden (Cretaceous)*—Medium-grained biotite monzogranite and granodiorite. Even-grained, non-porphyritic. Forms single, poorly exposed pluton 5 km northeast of Eloika Lake (fig. 2). Biotite is only mafic mineral; average color index of 12. Sphene-bearing, but difficult to see because rocks everywhere deeply weathered. Spatial association and textural similarities suggest genetic relation to Fan Lake Granodiorite (Kfl). Age considered Cretaceous based on relation to Fan Lake Granodiorite

Kse *Granodiorite of Sema Meadows (Cretaceous)*—Porphyritic hornblende-biotite granodiorite. Forms sparsely exposed pluton 22 km east of Ione. Contains 2.5-cm-long potassium feldspar phenocrysts. Average color index of 18. Medium- to coarse-grained, non-foliate. Contains abundant inclusions. Age considered Cretaceous based on lithologic similarities to nearby granitic rocks of that age, especially granodiorite of Priest Lake (Kgpl)

Kbu *Granodiorite of Bunchgrass Meadows (Cretaceous)*—Hornblende-biotite granodiorite. Forms sparsely exposed pluton 17 km east-southeast of Ione. Non-porphyritic, but in all other lithologic aspects similar to, and probably genetically related to, granodiorite of Sema Meadows (Kse). Also lithologically resembles Cretaceous granodiorite of Priest Lake (Kgpl). Age considered Cretaceous based on lithic similarity to nearby granitic rocks of that age, especially granodiorite of Priest Lake

Kcl *Tonalite of Clagstone (Cretaceous)*—Highly mafic biotite-hornblende tonalite. Forms single pluton just east of Clagstone (fig. 2). Color index about 30. Coarse-grained, moderately to weakly foliate. Contains abundant sphene and epidote, and minor microcline. Compositionally gradational into hornblende-bearing phase of granodiorite of Kelso Lake, but because of age difference, the two bodies are considered distinctly different plutons. Zircon gives uranium-lead age of 90 to 100 Ma; sphene gives age of 94 ±0.5 Ma (J.L. Wooden, written commun., 1994)

Kgpl *Granodiorite of Priest Lake (Cretaceous)*—Medium- to coarse-grained hornblende-biotite granodiorite. Forms sparsely exposed pluton in and west of Priest Lake. Hornblende almost as abundant as biotite. Average color index of 17. Very abundant sphene. Even-grained, non-porphyritic, non-foliate. Very uniform with respect to texture and composition. Zircon gives uranium-lead age of 96 to 103 Ma; sphene gives age of 101 ±0.5 Ma (J.L. Wooden, written commun., 1994)

Kmc *Granodiorite of Mill Creek (Cretaceous)*—Non-porphyritic medium-grained biotite-hornblende granodiorite. Forms small pluton exposed on both sides of Pend Oreille River 19 km north of town of Cusick. Distinguished from most other granitic units by average color index of 23 and by hornblende more abundant than biotite. Mafic content and grain-size highly variable in some parts of pluton. Abundant mafic inclusions. Hornblende and biotite gives potassium-argon ages of 104 Ma and 100 Ma respectively, (R.J. Fleck, written commun., 1989)

Kkp *Granodiorite of Kelly Pass (Cretaceous)*—Highly porphyritic, very coarse-grained biotite-hornblende and hornblende monzogranite and granodiorite. Forms single pluton concentrically enclosing two-mica monzogranite of Twentymile Creek (Ktmc) 1 km east of Naples (fig. 2). Blocky microcline phenocrysts from 3 to 10 cm long make up 25 percent of rock volume in much of body. Color index about 16. Very abundant sphene. Hornblende potassium-argon age is 99 Ma (J. K. Nakata, U.S. Geological Survey, written commun., 1993)

Kslc *Granodiorite of Salee Creek (Cretaceous)*—Biotite-hornblende granodiorite. Forms two bodies divided by granodiorite of Kelso Lake (Kk) on west side of Lake Pend Oreille. Medium- to coarse-grained; non-foliated to well-foliated. Color index 15 to 20. Characterized by hornblende-biotite ratio greater than one. Contains abundant sphene, epidote, and allanite. Feldspars are commonly gray. Zircon gives U-Pb age of 94 ±5 Ma (J.L. Wooden, written commun., 1994). Biotite and hornblende give potassium-argon ages of 83 Ma and 137 Ma, respectively (R. Fleck, written commun., 1993); biotite age considered a cooling age; hornblende age probably reflects excess argon

Priest River Complex—Unit is defined on basis of combined intrusive, metamorphic, and structural characteristics. Consists predominantly of muscovite-biotite granitoid rocks and lesser metasedimentary and metaigneous rocks; these latter rock types are probably derived mostly from Belt Supergroup. Priest River Complex is here formally named following usage of Reynolds and others (1981), and Rehrig and others (1987) for their informally named Priest River crystalline complex. Name is here shortened to Priest River Complex and adopted as a formal geologic unit; named for Priest River valley, northern Idaho. Note that this unit should not be confused with herein abandoned Priest River Group (whose rocks are now considered part of Deer Trail Group). T. 58 N., R. 3 W. (Happy Fork Gap, Mount Casey, Coolin, and Prater Mountain 7.5-minute quadrangles) is here designated as the type area for the complex. Heterogeneity of such large complex precludes accurate designation of specific type area, but rocks in designated township are at least representative. Rocks of complex are Cretaceous and older in age, and may possibly include Eocene granitoids in places. Granitic rocks range in composition from tonalite to granite, commonly over very short distances with almost no change in macroscopic appearance. Metamorphic rocks include micaceous schist, quartzo-feldspathic gneiss, quartzite, calc-silicate hornfels, and amphibolite; south and east of Newport Fault, they are metamorphosed as high as orthoclase-sillimanite zone of amphibolite facies. Metamorphic rocks typically have a strong crystaloblastic foliation, and mylonitic fabric is irregularly developed locally in both granitic and metamorphic rocks. Best exposures of variety of rocks characterizing complex are found in mountains east of Priest Lake. Eastern part of Priest River Complex lies between Purcell trench and east arm of Newport Fault, central part is inferred to extend under spoon shaped Newport Fault and may extend south of the fault, west part continues for up to 20 km west of west arm of Newport Fault. Part or all of east boundary in Purcell trench is inferred to be a detachment fault concealed beneath Quaternary sedimentary deposits in trench. Northern and most of western boundary appears to be intrusive but where sheared, contact-metamorphosed sedimentary rocks are in contact with granitic rocks, they are included in Priest River Complex. Northern and most of western boundary placed at point where primary sedimentary features are recognizable in metasedimentary rocks. Southern boundary is ill-defined, because relationship between Priest River Complex and Spokane dome of Cheney (1980) to south is unclear. Granitoid bodies making up complex differ from one another in texture, mineralogy, and, to lesser degree, bulk composition. In any particular unit, dikes, pods, or small bodies of other units occur as small intrusions or inclusions. Nearly all units have wide, gradational boundaries and are probably not distinct sequentially emplaced plutons, but rather, collectively represent a single inhomogeneous, composite intrusive mass. All granitic bodies of complex are presumed Cretaceous in age, except for one of two older included bodies (JTRpl). Cross-cutting relationships are ambiguous and of little value to determine relative ages of constituent units, due to composite nature of complex. Priest River Complex is largely coextensive with Cretaceous batholithic rocks in region. Although no two-mica body in the complex has been identified as Eocene in age, possibility of Eocene rocks in complex cannot be excluded. Except along northwestern margin, nearly all granitic rocks in complex gives biotite potassium-argon cooling ages of roughly 50 Ma. Complex consists of:

Kpl *Phillips Lake Granodiorite (Cretaceous)*—Muscovite-biotite granodiorite that forms a large mass west of Pend Oreille River in west-central part of quadrangle. Ranges in composition from tonalite to monzogranite, more potassic in western part. Medium- to coarse-grained, irregularly porphyritic, with poorly formed, small, white phenocrysts of microcline and orthoclase. Color index averages 11. Includes abundant metamorphic rocks; some screens several hundred meters in length. Unit contains very abundant dikes, pods, and small bodies of pegmatite, alaskite, and fine-grained leucocratic two-mica monzogranite. Phillips Lake Granodiorite makes up western part of Priest River Complex. Biotite gives potassium-argon age of 94 Ma, and muscovite from related pegmatite gives age of 101 Ma (Yates and Engels, 1968, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Kptc *Granodiorite of Trapper Creek (Cretaceous)*—Medium-grained muscovite-biotite granodiorite. Forms single body north of Upper Priest Lake. Even-grained, non-porphyritic, except for poorly formed 2-cm-long phenocrysts locally. Color index averages 9. Abundant pegmatite and leucocratic dike rocks, but otherwise slightly more uniform than most other units of Priest River Complex

Kplm *Mixed granitic and metamorphic rocks of Lookout Mountain (Cretaceous)*—Two-mica granitic rocks with about 5 percent gneiss and amphibolite. Widespread north of Priest Lake. Some granitic rocks contain no muscovite. Highly irregular distribution of metamorphic rocks in unit. Granitic rocks extremely variable with respect to texture, composition, and grain-size. Most rocks in unit are leucocratic, but some are highly mafic; latter probably represent incompletely mixed residue of partial anatectic melt derived from mafic sills in Middle Proterozoic Prichard Formation. Very abundant pegmatite and leucocratic dike rocks

Kpgb *Garnet-bearing granodiorite (Cretaceous)*—Medium-grained two-mica granodiorite, ranging to tonalite. Forms small pluton 10 km north of Upper Priest Lake. Foliate near margins. Characterized by pale tan garnet and abundant epidote. Unlike most other units of Priest River Complex, contains anhedral, embayed sphene. Mineralogy could result from incompletely mixed partial anatectic melt derived from Middle Proterozoic Prichard Formation and mafic sills in that unit

Kpcc *Granodiorite of Caribou Creek (Cretaceous)*—Medium- to coarse-grained muscovite-biotite granodiorite, but ranges from tonalite to monzogranite. Forms single pluton in Caribou Creek drainage 1 km northeast of Upper Priest Lake (fig. 2). Locally contains sparse potassium feldspar phenocrysts. Color index ranges from 4 to 10. Overall, much more uniform in appearance than most other units of Priest River Complex, but contains discrete areas of pronounced textural and compositional inhomogeneity

Kpml *Biotite-rich granodiorite of Marsh Lake (Cretaceous)*—Medium- and fine-grained biotite granodiorite; ranges to tonalite. Forms small pluton 10 km northeast of Upper Priest Lake (fig. 2). Slightly foliate. Characterized by euhedral allanite with epidote overgrowths. Average color index of 15

Kpsl *Granodiorite of Search Lake (Cretaceous)*—Medium- and locally coarse-grained muscovite-biotite granodiorite. Forms moderate-size pluton 11 km northeast of Upper Priest Lake (fig. 2). Average color index 11. Slightly foliate in northeast part. More uniform in composition and contains lower proportion of leucocratic dike rocks than most other units of Priest River Complex

Kplc *Biotite-rich granodiorite of Lucky Creek (Cretaceous)*—Biotite granodiorite, but ranges from tonalite to monzogranite. Forms moderate-size pluton at north end of Upper Priest Lake. Distinguished by relatively high color index for unit of Priest River Complex; ranges from 5 to 20, averages 13. Contains large, irregularly shaped mafic inclusions. Texture, composition, and concentration of inclusions extremely variable throughout body

Kpkm *Monzogranite of Klootch Mountain (Cretaceous)*—Medium- to coarse-grained two-mica monzogranite and granodiorite. Forms large pluton east of Priest Lake. Characterized by relatively well-formed, 2.5- to 4-cm-long potassium feldspar phenocrysts that have well-defined crystal shapes. Composition and texture very uniform compared to other units of Priest River Complex. Locally foliate, and shows ductile grain-size reduction within 2 km of Newport Fault. Color index averages about 6

Kph *Two-mica granitic rocks of Horton Creek (Cretaceous)*—Heterogeneous, mostly leucocratic, two-mica monzogranite and granodiorite; includes abundant pegmatite, alaskite, and leucocratic dike rocks. Forms moderate-size pluton on east side of Priest Lake (fig. 2). Average color index of 6. Very similar to rock types found in mixed granitic rocks of Camels Prairie (Kpcp) unit. Lineate, foliate, and shows ductile grain-size reduction in western part

Kpcb *Biotite-rich granodiorite of Cavanaugh Bay (Cretaceous)*—Biotite granodiorite. Forms moderate-size body east of the southern part of Priest Lake. Fine- to coarse-grained; moderately heterogeneous with respect to texture, very heterogeneous with respect to composition. Color index averages about 14, but ranges to over 20. Lineate, foliate, and shows ductile grain-size reduction in western part

Kpcp *Mixed granitic rocks of Camels Prairie (Cretaceous)*—Mixed leucocratic two-mica granitoid rocks, amphibolite, gneiss, and schist. Forms large, irregularly shaped body between Naples and Priest Lake (fig. 2). About 90 percent of unit is heterogeneous granitic rocks; most abundant rock type is even-grained, leucocratic two-mica monzogranite. Large proportion of granitic rocks are dikes, pods and irregular masses of pegmatite and alaskite

Kpms *Mixed granitic and metamorphic rocks of Soldier Creek (Cretaceous)*—Leucocratic two-mica granitic rocks, schist, amphibolite, and minor gneiss. Forms two large masses, one between Sandpoint and south end of Priest Lake, other 6 km southwest of Sandpoint (fig. 2). About 55 to 75 percent of unit consists of extremely heterogeneous granitic rocks ranging in composition from tonalite to monzogranite; color index between 5 and 10. Differs from unit Kpcp chiefly in proportion of metamorphic rocks. Ratio of metamorphic to granitic rock varies greatly over short distances, but generally is greater south of granodiorite of Wrenco (Tw). Most metamorphic rocks appear to be derived from Middle Proterozoic Prichard Formation and mafic sills in that unit

Kpll *Mixed leucocratic granitic rocks of Lost Creek (Cretaceous)*—Even-grained leucocratic two-mica granitic rocks, abundant dikes of pegmatite and alaskite, and minor metamorphic rocks. Forms two small bodies, 3 and 11 km southeast of Priest Lake. Granitic rocks similar in composition to those in surrounding mixed granitic and metamorphic rocks of Soldier Creek (Kpms) unit, but consistently contains less than 10 percent metamorphic rocks. Extreme textural and compositional variety in granitic rocks

Kpbi *Granitic rocks of Big Creek (Cretaceous)*—Slightly foliate, porphyritic biotite granodiorite; minor muscovite and garnet. Forms two small bodies 12 km northwest of Sandpoint (fig. 2). Color index about 8. Composition and texture noticeably more uniform than granitic rocks of bounding mixed granitic and metamorphic rocks of Soldier Creek (Kpms) unit, and concentration of pegmatite and alaskite dikes noticeably less

Kpsh *Monzogranite of Shorty Peak (Cretaceous)*—Slightly porphyritic, two-mica, monzogranite and granodiorite. Forms large irregularly shaped body 19 km west of Copeland (fig. 2). Characterized by equant 1- to 2-cm-square potassium feldspar phenocrysts. Color index variable, averaging 10. Mostly medium-grained, but ranges from fine- to coarse-grained. Texture and composition uniform over large areas, and variable over large areas

Kpbc *Mixed two-mica rocks of Ball Creek (Cretaceous)*—Mostly muscovite-biotite granodiorite, but includes some tonalite and monzogranite. Forms large north-south-elongated body 15 km west of Bonners Ferry (fig. 2). Unlike some two-mica units, muscovite easily visible in almost all parts of unit, locally megacrystic. Medium- to coarse-grained. Average color index of 7. Composition and texture generally more variable than bounding units, but not nearly as variable as mixed rocks units

Kpfc *Granodiorite of Falls Creek (Cretaceous)*—Chiefly granodiorite, but includes some monzogranite and minor tonalite. Forms large north-south-elongated body 5 km west of Naples (fig. 2). Medium- to coarse-grained, but contains very abundant fine- to coarse-grained leucocratic dikes and pods. Biotite only mafic mineral; minor muscovite in western part of unit. Contains sparse to moderately abundant epidote. Composition, texture, and concentration of included leucocratic rocks variable in much of unit

Kpsp *Tonalite of Snow Peak (Cretaceous)*—Tonalite to granodiorite; average composition tonalite. Forms large north-south-elongated body 9 km west of Bonners Ferry (fig. 2). Medium- and coarse-grained; seriate in much of unit. Biotite only mafic mineral; color index higher than most other units in Priest River Complex, ranges from 11 to 17. Muscovite absent, except very locally. Unit characterized by very abundant pale-green epidote with allanite cores and abundant irregularly shaped mafic inclusions ranging from 1 cm to tens of meters across. Composition and texture uniform in much of unit, but variable in places

Kpdc *Mixed granitic and metamorphic rocks of Deep Creek (Cretaceous)*—Heterogeneous, mafic to leucocratic granitic rocks with screens and inclusions of metamorphic rocks, chiefly schist. Mapped as two small bodies, one 5 km north of Moravia, other 8 km south of Moravia (fig. 2). Unlike most other units of Priest River

Complex, some granitic rocks in unit contain hornblende and sphene, and are highly porphyritic locally. As mapped, may include some rocks belonging to granodiorite of Kelly Pass and granodiorite of Bonners Ferry

Koc *Monzogranite of Otter Creek (Cretaceous)*—Sillimanite-bearing muscovite-biotite monzogranite. Forms small body 2 km northeast of Eloika Lake (fig. 2). Medium-grained with weakly developed foliation. Color index variable from 5 to 15, but overall texture and composition fairly uniform. Sillimanite forms acicular crystals in biotite and may be restricted to numerous sub-centimeter-size inclusions distributed throughout unit. Some distributed zones of ductile grain-size reduction. Considered to be Cretaceous in age based on compositional similarity to Cretaceous plutonic rocks in quadrangle

Klgs *Leucocratic granitic rocks of Scotia (Cretaceous)*—Heterogeneous mixture of alaskite, pegmatite, aplite, and two-mica monzogranite; includes metamorphic rocks derived from Middle Proterozoic Prichard Formation and mafic sills in that unit. Forms scattered bodies east and southwest of Scotia (fig. 2). Foliation, lineation, and ductile deformation common in eastern part of unit. Considered Cretaceous in age, based on compositional similarity to Cretaceous leucocratic two-mica rocks associated with Phillips Lake Granodiorite

Ksv *Granodiorite of Spring Valley (Cretaceous)*—Biotite granodiorite; contains sparse muscovite that may not be primary. Forms a small elongate pluton 3 km southeast of Scotia (fig. 2). Medium- to coarse-grained; nonfoliate to slightly foliate. Relatively uniform with respect to texture and composition; contains fewer leucocratic dike rocks than surrounding units. Considered Cretaceous in age based on compositional similarity to Cretaceous plutonic rocks in quadrangle

Kbr *Monzogranite of Blanchard Road (Cretaceous)*—Medium- to coarse-grained megacrystic muscovite-biotite monzogranite. Forms large body 8 km northwest of Blanchard (fig. 2). Distinguished by muscovite megacrysts 2 to 3 cm across. Average color index of 8. Southeastern part has well-developed mylonitic foliation and lineation caused by ductile deformation related to early stage of development of Eocene core complex(es) in region. Relatively uniform with respect to texture and composition; composition and texture strongly resembles those of monzogranite of Long Mountain (Klm). Age considered Cretaceous based on lithologic similarity to nearby Cretaceous two-mica rocks

Klm *Monzogranite of Long Mountain (Cretaceous)*—Biotite-muscovite monzogranite bearing megacrysts of muscovite and potassium feldspar. Forms large body west of Cocolalla Lake and small body 7 km north of Cocolalla Lake (fig. 2). Megacrysts range from 0 to 20 percent of rock volume; muscovite averages 2 cm across, potassium feldspar 3 cm long. Strongly foliated on northwest, moderately foliated to unfoliated on southeast; variably mylonitic. Pegmatite and aplite dikes abundant. Grades into and intrudes muscovite-biotite monzogranite (Kmg). Relatively uniform with respect to texture and composition; strongly resembles monzogranite of Blanchard Road. Age considered Cretaceous based on lithologic similarity to nearby Cretaceous two-mica rocks

Kag *Granitic rocks of Algoma Lake (Cretaceous)*—Foliate and lineate muscovite-biotite monzogranite containing sparse microcline porphyroblasts up to 1 cm long. Forms moderate-size body 3 km north of Cocolalla Lake (fig. 2). Color index about 8; rocks contain about 3 percent muscovite. Includes abundant pegmatitic rocks

Ksg *Granodiorite of Sawyer (Cretaceous)*—Biotite granodiorite. Forms small body near Sawyer (fig. 2). Medium-grained; slightly to moderately foliate. Color index ranges from 15 to 25; hornblende locally abundant in mafic parts; muscovite in rocks with lower color index. Contains sphene, epidote, and allanite. Hornblende paleobarometry indicates crystallization at 6.7 Kb (T.D. Hoisch, written commun., 1993). U-Pb isotopic data on zircon inconclusive, but suggests that 90-100 Ma is most probable age. Sphene gives U-Pb age of 65 ±0.5 Ma (J.L. Wooden, written commun., 1994); considered cooling age because of depth of crystallization

Kjl *Granitic rocks of Jewel Lake (Cretaceous)*—Fine- to medium-grained, leucocratic, gneissic granite. Forms small mass east of Sawyer (fig. 2). Unit comprises several small bodies, all with biotite, most with muscovite, one with megacrystic microcline. Highly foliated throughout. Age considered Cretaceous based on lithologic similarity to nearby Cretaceous two-mica rocks

Kmg *Muscovite-biotite monzogranite (Cretaceous)*—Medium-grained, subequigranular to equigranular muscovite-biotite monzogranite. Forms small body 3 km east of Edgmere (fig. 2). Micas about equal in amount. Locally has anhedral cm-long potassium feldspar phenocrysts. Slightly to moderately foliated. Gradational into and cut by dikes of monzogranite of Long Mountain (Klm). Age considered Cretaceous based on lithologic similarity to nearby Cretaceous two-mica rocks

Kphc *Monzogranite of Hunt Creek (Cretaceous)*—Porphyritic, medium- to coarse-grained, sphene-bearing biotite monzogranite and granodiorite. Forms an elongated series of noncontiguous bodies from 20 km northwest of Copeland (fig. 2) to within 3 km of the southern part of Priest Lake. Color index as high as 20 in northern part of body; progressively more leucocratic and sphene-deficient southward. In southern part of unit, rock has color index between 8 and 14, and contains no sphene. Almost everywhere rock is slightly gneissic, and displays incipient to strong ductile grain-size reduction in thin section. Appears to be older than most other granitoid bodies of Priest River Complex, caught up within, and strung out between, various units of the complex. Discordant zircon indicates age between 90 and 100 Ma (J.L. Wooden, written commun., 1994); Archibald and others (1984) report 94-Ma uranium-lead age on zircon from equivalent(?) unit in Canada

Jcm *Tonalite and trondhjemite of Continental Mountain (Jurassic)*—Medium- to coarse-grained biotite tonalite, granodiorite, and trondhjemite. Trondhjemite contains a few percent muscovite and forms small appendage along eastern edge of much larger tonalite and granodiorite pluton. Rocks of larger tonalite and granodiorite body contain trace muscovite. Biotite and some muscovite is interstitial to felsic minerals. Average color index of tonalite 17, of trondhjemite 9. Both rock types have abundant epidote and trace amounts of garnet and hornblende. Most muscovite and epidote is contained within water-clear plagioclase. Texture and mineralogy indicate pluton has been metamorphosed. Zircon gives U-Pb age of 120 Ma; sphene gives 160 ±1.0 Ma (J.L. Wooden, written commun., 1994). Biotite from tonalite gives K-Ar age of 107 Ma; biotite and muscovite from trondhjemite give ages of 101 Ma and 96 Ma, respectively (Miller and Engels, 1975, recalculated using current IUGS constants, Steiger and Jaeger, 1977)

Jlm *Quartz monzodiorite of Lane Mountain (Jurassic)*—Medium- to coarse-grained highly porphyritic biotite-hornblende quartz monzodiorite and granodiorite. Forms moderate-size pluton south of Waitts Lake (fig. 2). Potassium feldspar phenocrysts to 9 cm long; concentration variable. Groundmass has bi-modal grain size. Average color index 18. Characterized by hornblende-biotite ratio greater than one, very abundant sphene, large phenocrysts, and bi-modal grain size. Hornblende and biotite give potassium-argon ages of 161 Ma and 162 Ma respectively, (R. Fleck, U.S. Geological Survey, written comm., 1988)

MzPzf *Fault-zone rocks on Eagle Mountain (middle Mesozoic to late Paleozoic)*—Highly sheared phyllite, carbonate-bearing phyllite, and brecciated carbonate rocks. Found only on Eagle Mountain 6 km northeast of town of Chewelah (fig. 2). All probably derived from Middle Proterozoic Togo, Chamokane Creek, and Wabash Detroit Formations. Abundant brecciated quartz veins found in this unit, some gold-bearing

Rossland Group—Volcanic flow rocks ranging in composition from basalt to trachyandesite, volcaniclastic rocks, and metasedimentary rocks. In Sandpoint 1° x 2° quadrangle, group is restricted to area northwest of Columbia River. Age is Early Jurassic based on marine macrofossils. Consists of:

Jrg *Greenstone (Early Jurassic)*—Metamorphosed basalt, basaltic andesite, trachyandesite, flow breccia, and tuff. Mineralogy characteristic of greenschist-facies metamorphism. Lesser amounts of interlayered siltite and conglomerate; highly schistose locally (Beddoe-Stephens, 1982; Little, 1982; Höy and Andrew, 1988; Joseph, 1990). Unit depositionally overlies metasedimentary and metavolcanic rocks (Jrs) unit

Jrs *Metasedimentary and metavolcanic rocks (Early Jurassic)*—Conglomerate, greenschist, argillite, chert, quartzite, wacke, limestone, and minor flow rock and flow breccia (Joseph, 1990); conglomerate and conglomeratic wacke most abundant. Metamorphosed to greenschist facies. West of quadrangle, unconformably overlies Permian Mount Roberts Formation (Roback, 1989). Thickness probably exceeds 400 m

JTRpl *Monzonite of Long Canyon (Jurassic or Triassic)*—Pyroxene-hornblende monzonite to quartz monzonite. Forms north-south-elongated pluton 12 km west of Copeland (fig. 2). Extremely heterogeneous with respect to composition, color index, and texture. Pyroxene is hedenbergite; hornblende is ferrohastingsite. Color index ranges from 6 to 20, averaging 8. Very abundant sphene, allanite, and inclusions. Fine- to coarse-grained. Appears to be pre-existing pluton caught-up within younger rocks of Priest River Complex, but is here considered to be part of Priest River Complex. Triassic or Jurassic age based on compositional similarity of pluton to other alkalic bodies of this age, and to compositional dissimilarity with Cretaceous and to Tertiary rocks in region

JTRw *Syenite of Wall Mountain (Jurassic or Triassic)*—Hornblende quartz syenite. Forms small pluton 10 km east-southeast of Copeland (fig. 2). Fine- to coarse-grained; equigranular to porphyritic. Color index averages 18. Abundant epidote and sphene. Hornblende gives potassium argon age of 131 Ma (R. Fleck, U.S. Geological Survey, written commun., 1988), which is considered to be cooling age because pluton located in area where potassium-argon ages of mineral pairs from other plutons are discordant (Miller and Engels, 1975). Emplacement age inferred to be Triassic or Jurassic based on compositional similarities to other alkalic rocks of this age in region

TRft *Flowery Trail Granodiorite (Triassic)*—Fine- to coarse-grained hornblende-biotite quartz monzodiorite and quartz monzonite, but ranges to granodiorite. Forms elongate pluton east of Chewelah (fig. 2). Composition and texture highly variable throughout body. Average color index greater than 20. Hornblende and biotite give potassium-argon ages of 198 Ma and 100 Ma, respectively (Engels *in* Miller and Clark, 1975; recalculated using current IUGS constants, Steiger and Jaeger, 1977). Amount of discordance suggests emplacement age older than 205 Ma; thus age of Flowery Trail is considered to be Triassic in this report

TRs *Metasedimentary rocks (Triassic)*—Metamorphosed interbedded siliciclastic and carbonate rocks. Found only in few fault-bounded exposures near Huckleberry Range Fault on northwest side of Columbia River. Thin-bedded to massively bedded limestone and dolomite, argillaceous limestone, phyllite, and minor quartzite. These rocks were originally mapped as part of Flagstaff Mountain sequence of Carboniferous(?) age (Yates, 1971). Triassic age based on conodonts (Joseph, 1990)

Ps *Metasedimentary rocks (Permian)*—Lithic sandstone and wacke with lesser siltstone and chert-bearing fossiliferous limestone, conglomerate, and metavolcanic rocks. Restricted to northwestern part of quadrangle, west of Huckleberry Range Fault. Includes Mount Roberts Formation as defined by Yates (1971). West of Echo, include siliceous and calcareous argillite interbedded with fine- to medium-grained wacke and pods of fossiliferous limestone which are of uncertain affinities, and may or may not be Mount Roberts Formation. Unconformably overlain by Early Jurassic greenstone (Jrv) and Early Jurassic metasedimentary and metavolcanic rocks (Jrs) units. Age based on macrofossils (Roback, 1989) and conodonts (Joseph, 1990)

MꞒu *Sedimentary rocks, undivided (Mississippian to Cambrian)*—Limestone, dolomite, and carbonaceous shale. Probably includes parts of Metaline Formation, Ledbetter

Formation, and unnamed Devonian and Mississippian units. Mapped 4 km northeast of Springdale, and 7 km west-southwest of Arden (fig. 2). Most rocks assigned to this unit are fault-bounded and brecciated; bedding features obliterated

Ml *Limestone (Mississippian)*—Limestone with lesser dolomitic limestone and dolomite. Found in limited areas north and southwest of town of Springdale. Medium- to pale-gray; thick- to thin-bedded with irregularly discontinuous chert bands. Thickness about 200 m, but upper and lower contacts not exposed and section could be internally faulted. Mississippian age assignment based on conodonts *Bactrognathus* sp., *Hindeodus* aff. *H. cristulus* (Youngquist and Miller), *Hindeodus* aff. *H. crassidentatus* (Branson and Mehl), *Kladognathus* sp. indet., *Ozarkodina* sp. indet. (Waggoner, 1990) contained in unit

MDs *Dolomite and slate (Mississippian and Devonian)*—Upper 170 m of unit is light-gray dolomite interbedded with maroon and pale-green argillite, which conformably overlies 175 m of pale-gray, coarse-grained, bedded dolomite. Lower 200 m is medium-grained, mottled dark-gray, sparsely sandy dolomite. Found in limited areas on east side of Colville Valley south of town of Chewelah. Age assignment inferred on presumed stratigraphic position below fossiliferous Mississippian limestone (Ml) unit and above fossiliferous Devonian dolomite and limestone (Ddl) unit

Ddl *Dolomite and limestone (Devonian)*—Light-gray and cream-colored dolomite interbedded with medium-gray argillaceous or carbonaceous limestone. Stratigraphic relationships and thickness uncertain. Found only in limited outcrops northwest of town of Metaline and on single hill 3 km east of town of Valley. Near Valley, unit contains Late Devonian brachiopods *Cytrospirifer* sp., and *Tenticospirifer* (Miller and Clark, 1975) and Late Devonian conodonts *Plamatolepsis quadrantinodosa inflexa* Muller, *Pelekysgnathus* ? sp. indet., *Polyngathus semicostatus* Branson and Mehl, *Polygnathus* sp. indet (Waggoner, 1990)

Ds *Metasedimentary rocks (Devonian)*—Argillite, phyllite, and slate, much of it carbonaceous, calcareous, and siliceous; interbedded with minor greenstone, metawacke, and quartzite; grades southwestward into metawacke, quartzite, metaconglomerate, and lesser phyllite, argillite, and slate. Forms 10-km-wide belt straddling Columbia River and continuing southward to near Colville. Both fine- and coarse-grained facies contain numerous pods and beds of limestone, some barite-bearing and some fossiliferous (Yates, 1964; Yates, 1971; Joseph, 1990). Interbedded metavolcanic rocks include metaflow rocks and metatuff. Interlayered metavolcanic rocks, which are locally shown as separate unit (Dv), are more abundant southwestward. Unit assigned Devonian(?) and Carboniferous(?) ages by Yates (1964; 1971), and Devonian(?) and Carboniferous(?) and Ordovician(?) to Carboniferous ages by Joseph (1990). Considered Devonian in age here because all contained fossils, chiefly conodonts, indicate Devonian age for both facies of unit, but may possibly include some Ordovician rocks

Dv *Metavolcanic rocks (Devonian)*—Greenstone and chloritic phyllite of probable volcanic origin. Mapped chiefly north and south of Echo (fig. 2) and northwest of

Columbia River. Composed of albite, chlorite, actinolite, epidote, and carbonate minerals (Yates, 1971; Joseph, 1990). Part of unit may be pyroclastic. Assigned to Devonian because unit bounded by fossiliferous Devonian metasedimentary rocks (Ds) unit, but may possibly include some Ordovician rocks

Sc *Quartz-granule conglomerate (Silurian)*—Conglomerate and minor slate. Found only in a restricted area 6 km north of Metaline Falls (fig. 2). Angular to well-rounded quartz- and chert-bearing conglomerate; contains clasts of mudstone in fine-grained matrix. Interbedded slate contains graptolites (Joseph, 1990)

Sms *Metasedimentary rocks (Silurian)*—Thin-bedded sandy, calcareous siltstone, argillite, limestone, and fossiliferous packstone. Found only in a restricted area 6 km north of Metaline Falls (fig. 2). Argillite contains monograptids and limestone conodonts. Sharply overlain by quartz-granule conglomerate (Sc) unit (Joseph, 1990)

Ol *Ledbetter Formation (Ordovician)*—Dark-gray carbonaceous shale, slate, and limestone; minor quartzite and chert interbeds. Massively bedded to thinly laminated; most lamination inconspicuous. At most places, highly deformed internally, including single and multiple cleavage(s), small-scale folds, and faults with unknown sense and amount of offset. Thickness estimated to be between 670 m and 760 m (Dings and Whitebread, 1965). Ordovician age based on abundant graptolites contained in unit (Park and Cannon, 1943; Carter, 1989a, 1989b), conodonts (Hogge, 1982), and trilobites, (Schuster, 1976)

OЄgc *Phyllite and quartzite of Gardiner Creek (Ordovician or Cambrian)*—Medium- to dark-gray phyllite, white to brown vitreous quartzite, and minor interbeds of sandy, dark-brown dolomite. Mapped only in a small area 4 km northwest of Jared (fig. 2). Unit is about 60 percent phyllite and 40 percent quartzite. Correlation with other units in quadrangle questionable, Lithologically, unit most closely resembles Cambrian upper part of Late Proterozoic and Cambrian Addy Quartzite, but it may, in fact, overlie Metaline Formation(OFm), and be Ordovician in age

OЄm *Metaline Formation (Ordovician and Cambrian)*—Limestone, dolomite, shaly limestone, limestone conglomerate, and carbonate-bearing quartzite. Internal stratigraphy of formation in Metaline area differs markedly from that of unit in area west of Addy. In Metaline area, upper part of formation consists of 0 to 600 m of massively bedded, fine-grained, gray limestone; middle 1200 to 1400 m is dominantly light gray and white, fine to medium grained, bedded dolomite; and lower 300 to 900 m is thin bedded, dark-gray limestone interbedded with lesser black shale (Joseph, 1990). In Addy area, upper 600 m of unit is similar to lower thin-bedded part in Metaline area; middle part of formation is dolomite similar to middle part in Metaline area, but is only about 800 m thick; lower part of formation is about 830 m of alternating zones of thin-bedded, fine-grained limestone, and thick-bedded, coarse-grained limestone and limestone conglomerate. Included in lower part of unit is 210-m-thick zone of dark-gray, coarse-grained dolomite and dolomite breccia and 150 m of sandy limestone, carbonate-bearing quartzite, pebble conglomerate, and argillite making up the lower part of formation. Age assignment based on contained trilobites (Park and Cannon, 1942), conodonts (Repetski and others, 1989), and graptolites (Carter, 1989a)

Ꞓsu *Sedimentary rocks, undivided (Cambrian)*—Limestone, dolomite, quartzite, and shale. Probably includes parts of (Middle Cambrian) undivided, Rennie Shale and Lakeview Limestone (Flr) and (Middle? Cambrian) Gold Creek Quartzite (Fgc). Mapped only in southernmost part of quadrangle west of Lake Pend Oreille

Ꞓlr *Rennie Shale and Lakeview Limestone, undivided (Middle Cambrian)*—Fossiliferous greenish-gray fissile shale and light- to dark-gray well-bedded to massive limestone and dolomite. Shale and limestone contain Middle Cambrian trilobites and brachiopods. Shale about 30 m thick; limestone at least 610 m thick (Harrison and Jobin, 1963). Found only in Packsaddle Mountain area on east side of Lake Pend Oreille and in thin fault slice 7 km north-northeast of Moyie Springs (fig. 2)

Ꞓgc *Gold Creek Quartzite (Middle? Cambrian)*—White, pink, tan, and purple, slightly feldspathic, medium- to coarse-grained quartzite; locally conglomeratic. Bedding ranges from massive to thin bedded; most is thick bedded. Thickness of unit about 120 m (Harrison and Jobin, 1963). Found only in Packsaddle Mountain area on east side of Lake Pend Oreille

Maitlen Phyllite (Early Cambrian)—Interbedded phyllite, quartzite, and carbonate rocks. Thickness as calculated from outcrop width, is about 2650 m in Metaline area, but unit is internally deformed. Maitlen Phyllite is not present between the Metaline Formation and Late Proterozoic and Cambrian Addy Quartzite (CZq) in the southwestern part of quadrangle; about 100 m of Maitlen-like argillite west of Dunn Mountain is lithologically indistinguishable from upper part of Addy Quartzite, and is included with unit CZq. Consists of:

Ꞓmp *Phyllite*—Gray phyllite; quartzitic in lower part, calcareous in upper part. Thin bedded to laminated, but bedding poorly preserved in most of unit except where quartzite beds or lenses are present

Ꞓmc *Carbonate rocks*—Early Cambrian archaeocyathid-bearing limestone at base (Reeves Limestone Member; Yates, 1964) at base of Maitlen Phyllite and zones of probably discontinuous limestone beds distributed irregularly throughout formation

ꞒZq *Quartzite (Cambrian and Late Proterozoic)*—White, purple, pink, gray, and tan, vitreous quartzite with interbedded siltite and argillite. Includes Gypsy Quartzite in northern part of quadrangle, and Addy Quartzite everywhere else (Lindsey and others, 1990). Addy averages about 1,400 m thick west of Jumpoff Joe Fault, but probably less east of fault. Gypsy ranges from 1,350 to 1,855 m in thickness east of Newport-Flume Creek Fault; is about 30 percent thinner west of fault. Upper part of Addy contains Early Cambrian trilobite *Nevadella addyensis* and brachiopod *Kutorgina* sp (Okulitch, 1951). Lindsey and others (1990) note abundant body and trace fossils in roughly same part of formation

Windermere Group—In northern part of quadrangle, Windermere Group consists of (from youngest to oldest) Three Sisters Formation, Monk Formation, Leola Volcanics, and Shedroof Conglomerate; in southern part of quadrangle, group consists of Monk Formation and Huckleberry Formation; latter unit is divided into (upper) greenstone member and (lower) conglomerate member (Campbell and Loofbourow, 1962). From southwestern edge to northern edge of quadrangle, units of Windermere Group form a north-northwest-trending belt west of Jumpoff Joe Fault; no Windermere rocks are found east of Jumpoff Joe Fault. Unconformities bound Windermere Group at its top and base. All Windermere units have been subjected to greenschist-facies metamorphism. Consists of:

Zt *Three Sisters Formation (Late Proterozoic)*—Quartzite, conglomeratic quartzite, conglomerate, and phyllite. Lower part consists of phyllite with scattered quartzite and grit beds; upper part is quartzite, conglomeratic quartzite, and conglomerate. Clast types include quartzite, argillite, chert, vein quartz, and rare volcanic rock. Most appear to be derived from formations of Deer Trail Group, but there is a conspicuous absence of carbonate clasts. Thickness about 2,000 m east of Newport-Flume Creek Fault, about 1,000 m west of fault. Not found south of Ione either because of non-deposition or removal by Late Proterozoic erosion

Zm *Monk Formation (Late Proterozoic)*—Conglomerate, megabreccia, diamictite, limestone, feldspathic and lithic quartzite, siltite, argillite, carbonaceous argillite, and locally, greenstone. Clast types in conglomerate, megabreccia, and diamictite include quartzite, dolomite, argillite, chert, vein quartz, and volcanic rock; most clast lithologies recognizable from formations of Deer Trail Group. Extremely variable lithostratigraphy and thickness over short distances, probably due to highly varied depositional conditions caused by syndepositional faulting

Zl *Leola Volcanics (Late Proterozoic)*—Greenstone, derived from lava flows, tuff, volcanic breccia, and volcaniclastic rocks; much is phyllitic. Composition is tholeiitic basalt (Miller, 1983a). Thickness of flows range from a few meters to several tens of meters. Pillow structure present, but subtle and difficult to recognize. Maximum thickness 1,850 m

Huckleberry Formation (Late Proterozoic)—Conglomerate, diamictite, and greenstone. Greenstone derived from extrusive, intrusive, and pyroclastic rocks of basaltic composition. Informally subdivided into greenstone member (upper) and conglomerate member (lower) (Campbell and Loofbourow, 1962). Consists of:

Zhg *Greenstone member*—Greenstone, derived from lava flows, tuff, volcanic breccia, and volcaniclastic rocks; much is phyllitic. Composition is tholeiitic basalt (Miller and Clark, 1975). Thickness of flows range from a few meters to several tens of meters; separated by flow breccia consisting of light-green angular clasts averaging 5 mm to 5 cm across in dark-green matrix. Pillow structure fairly abundant, especially in lower part of member, but pillows subtle and difficult to recognize. Thickness averages 975 m. Includes intrusive rocks that are similar to massive flow rocks but coarser grained; some is gabbroic

Zhc *Conglomerate member*—Diamictite, conglomerate, sandy siltite and argillite, and lithic quartzite. Clasts in diamictite and conglomerate appear to be derived almost totally from formations of Deer Trail Group. Pale-green and pale-gray matrix-supported diamictite and conglomerate are most common lithologies. Maximum thickness in Huckleberry Mountain area (fig. 2), 480 m; thins and pinches out eastward and northeastward

Shedroof Conglomerate (Late Proterozoic)—Diamictite, conglomerate, sandy siltite and phyllite, lithic quartzite, sandy limestone, and greenstone. Maximum thickness 3,250 m as calculated from outcrop width; may be thickened by unrecognized faults. Clasts in diamictite and conglomerate appear to be derived from formations of Deer Trail Group, but in places include boulders of medium- and coarse-grained two-mica granitic rock of unknown provenance. Thickness of formation differs by order of magnitude across some syn-depositional faults Miller, 1994). Consists of:

Zsc *Conglomerate member*—Phyllitic, matrix-supported diamictite and conglomerate and minor lithic quartzite; most of lower part is pale-tan and most of upper part is pale-green. Concentration of clasts ranges from only a few percent of rock volume to about 70 percent. Clast size ranges from centimeters to meters across; shape ranges from angular to moderately well rounded. Bedding in member is readily apparent only where lithic quartzite is interbedded

Zsp *Phyllite member*—Pale-gray, pale-green, and pale-tan phyllite. Contains very sparse lithic clasts to 1 cm in length and nearly ubiquitous, mm-size, round quartz grains. Bedding indistinct or unrecognizable in most of member. Northeast of Sullivan Lake, forms thick, northeastward-thinning sedimentary wedge bounded by conglomerate

Zsl *Sandy limestone member*—Brownish-gray to pale-gray, slightly dolomitic limestone containing numerous, round, millimeter-size quartz grains and a moderate, but variable, amount of argillaceous material. Medium to thick bedded. Thickness estimated to be about 150 m

Zsg *Greenstone member*—Massive and phyllitic greenstone; numerous 1- to 10-m-thick bodies too small to show at scale of map. No diagnostic primary features preserved; greenstone bodies could represent intrusive sills, flow rocks, or pyroclastic rocks

ZYmi *Mafic intrusive rocks in upper part of Belt Supergroup (Late and Middle Proterozoic)*—Medium- to fine-grained mafic-rich sills; intrude Wallace Formation and along Wallace Formation-Snowslip Formation contact. Lithologically indistinguishable from 1,433-Ma mafic intrusive rocks (Ymi) that are restricted to Prichard Formation, but considered by Harrison and others (1992) to be 1,100 or 800 Ma in age. Sills found only two places in quadrangle, 6 km north-northeast of Leonia and 6 km east-northeast of Moyie Springs; at both places they intrude Wallace Formation of Middle Proterozoic Belt Supergroup

Deer Trail Group—Deer Trail Group consists of, from youngest to oldest: Buffalo Hump Formation, Stensgar Dolomite, McHale Slate, Wabash Detroit Formation, Chamokane Creek Formation, and Togo Formation (Campbell and Loofbourow, 1962; Miller, 1995a).

Base of Togo Formation not exposed. In north-central part of 1° x 2° quadrangle, rocks that are assigned to Deer Trail Group were previously referred to as Priest River Group. These rocks are demonstrably Deer Trail Group formations, so the name Priest River Group is here formally abandoned. Deer Trail Group is lithostratigraphically correlative (in part) with upper part of Middle Proterozoic Belt Supergroup (Miller and Whipple, 1989), is separated from all Belt rocks by Jumpoff Joe Fault. Unconformably overlain by Windermere Group. Near Idaho-Washington border, all Deer Trail formations are much more deformed than they are southwest of town of Chewelah. Consists of:

Ydtu *Undivided part (Middle Proterozoic)*—Argillite, phyllite, and quartzite. Rocks of Deer Trail Group lacking distinguishing characteristics needed to assign them to individual formations because of poor exposure, metamorphism, or deformation

Yb *Buffalo Hump Formation (Middle Proterozoic)*—Interbedded vitreous quartzite and dark-gray to greenish-gray, massively bedded to faintly laminated argillite. Much of quartzite is coarse grained and cross bedded; some contains thin quartzite-pebble beds. East of Sullivan Creek, thickness and proportion of quartzite in unit may be greater than it is southwest of Chewelah. Unit southwest of Chewelah contains maroon, argillaceous, fine-grained quartzite in lower part that strongly resembles quartzite of Bonner Formation of Belt Supergroup. Maximum thickness of unit about 550 m

Ys *Stensgar Dolomite (Middle Proterozoic)*—Southwest of Chewelah, formation consists of tan, pink, gray, and maroon dolomite with minor interbedded maroon and gray argillite. About ninety percent of formation is dolomite that contains relatively little non-carbonate material; relative purity is basis to distinguish unit from Wabash Detroit Formation. Near Idaho-Washington border, formation is white, tan, and gray dolomite containing much higher proportion of silt and argillaceous material and much higher proportion of interbedded gray phyllite. Fault-bounded Stensgar Dolomite in this area difficult to distinguish from undivided Wabash Detroit Formation and Chamokane Creek Formation (Ywcu). Formation is host to large deposits of magnesite, probably of remobilized syngenetic origin (Campbell and Loofbourow, 1962; Miller and Whipple, 1989). Thickness of Stensgar southwest of Chewelah averages 250 m; near Idaho-Washington border, appears to be about 300 m

Ym *McHale Slate (Middle Proterozoic)*—Formation is almost entirely argillite. West of Chewelah, lower third of unit is medium- to dark-gray argillite; upper two-thirds is pale-greenish-gray and lavender-gray argillite or phyllitic argillite. Thickness averages 370 m. Near Idaho-Washington border, unit is entirely dark-gray phyllite. Thickness appears to be about 300 m, but unit here is everywhere faulted or internally deformed by intense cleavage

Ywd *Wabash Detroit Formation (Middle Proterozoic)*—Thin- to thick-bedded, gray and white, impure dolomite with abundant thin interbeds of pale-green and gray argillite and carbonate-bearing siltite; locally, unit contains altered greenstone in upper part that may be volcanic flow rocks. Near Idaho-Washington border, rocks of unit are included with Chamokane Creek Formation because deformation and homogenization by faulting and multiple cleavages have destroyed sedimentary features used to distinguish the two units. Thickness southwest of Chewelah averages 240 m

Ywcu *Wabash Detroit Formation and Chamokane Creek Formation, undivided (Middle Proterozoic)*—Highly sheared and faulted dolomite, dolomitic quartzite, argillite, and quartzite. Close-spaced faults and multiple cleavages, especially in Idaho-Washington border area, have destroyed sedimentary and lithologic features used to distinguish Wabash Detroit Formation from Chamokane Creek Formation. Thickness unknown

Yc *Chamokane Creek Formation (Middle Proterozoic)*—Carbonate-bearing quartzite and siltite, interbedded with dolomite, and argillite. West of Chewelah, contains a 150-m-thick zone of interbedded vitreous quartzite and argillite. Vitreous quartzite zone present in section near Idaho-Washington border, but thickness uncertain. Very poorly exposed. Thickness of composite sections in both areas about 600 m

Yt *Togo Formation (Middle Proterozoic)*—Medium- and dark-gray argillite with subordinate green argillite and green and gray siltite. Also contains rare, thin, beds of quartzite and dolomite in lower part of unit. West of Chewelah, minimum thickness about 800 m, but unit highly deformed internally and base of formation everywhere faulted. In section near Idaho-Washington border, Togo Formation is found mostly in extremely deformed fault-bounded blocks

Belt Supergroup—Belt Supergroup forms three thick sequences composed of quartzite, siltite, argillite, dolomite, and mixtures of these rock types in all proportions. Sequence east of Purcell trench (referred to as Clark Fork-Eastport sequence) separated from other two by Priest River Complex and possible buried fault(s) in Purcell trench. Sequence north of Newport (referred to as Newport sequence) in hanging wall of Newport Fault, and sequence east of Chewelah (referred to as Chewelah sequence) in footwall. Latter two sequences also separated by part of Priest River Complex. Some differences in lithofacies of individual units between three sequences. Belt is not found west of Jumpoff Joe Fault. Consists of:

Yl *Libby Formation (Middle Proterozoic)*—Laminated black argillite and white siltite in lower part of unit, green cherty argillite, siltite, and silty limestone and dolomite in upper part. About 550 m thick, but unknown thickness removed by erosion (Harrison and Jobin, 1963). Found only in Clark Fork-Eastport sequence

Ybmh *Bonner Formation, Mount Shields Formation, and argillite of Half Moon Lake, undivided (Middle Proterozoic)*—Altered and bleached argillite, siltite, and lesser quartzite. Mapped as undivided unit only on one ridge east of Pend Oreille River in Newport sequence, where alteration and poor preservation of sedimentary features preclude assignment of rocks to specific formations

Ybo *Bonner Formation (Middle Proterozoic)*—Maroon, pale-purple, and pale-green siltite, argillite, and quartzite. As mapped, unit in southern part of Clark Fork-Eastport sequence includes quartzite member of Striped Peak Formation (Harrison and Jobin, 1963). Unit mostly quartzite there; about 80 percent thin-bedded, coarse siltite in Newport sequence. In Clark Fork area, about 210 m thick; in Newport sequence, about 190 m thick; not present in Chewelah sequence

Yms *Mount Shields Formation (Middle Proterozoic)*—Argillite, siltite, quartzite, dolomite, and dolomitic siltite. As mapped, unit in southern part of Clark Fork-Eastport sequence includes lower three members of Striped Peak Formation (Harrison and Jobin, 1963); thickness about 400 m. In northern part of sequence, thickness is about 620 m. In Newport sequence, thickness about 420 m; not present in Chewelah sequence

Yhm *Argillite of Half Moon Lake (Middle Proterozoic)*—Dark- to medium-gray, laminated argillite, thin-bedded siltite, and thick- to thin-bedded quartzite. As mapped, unit includes laminated argillite and siltite member of Wallace Formation at Clark Fork, Idaho (Harrison and Jobin, 1963); about 120 m thick there. About 155 m thick northeast of Bonners Ferry; about 350 m thick north of Newport; and about 650 m thick at Chewelah

Yshs *Shepard Formation and Snowslip Formation, undivided (Middle Proterozoic)*—Schist, calc-silicate rock, dolomitic marble, argillite, siltite, and dolomite. Sequence may contain unrecognized faults. Thickness unknown. Found only on mountain 16 km due north of town of Cusick

Ysh *Shepard Formation (Middle Proterozoic)*—Pale green, white, tan, pale-gray, and maroon, stromatolitic and oolitic dolomite, dolomitic siltite, and siltite. North of Newport, contains some dark, chlorite-green siltite beds. As mapped, unit in Clark Fork area includes upper calcareous member of Wallace Formation (Harrison and Jobin,1963). Thickness in Clark Fork area, about 300 m; northeast of Bonners Ferry, about 380 m; north of Newport, about 360 m; east of Chewelah, about 430 m

Yssw *Shepard Formation, Snowslip Formation, and Wallace Formation, undivided (Middle Proterozoic)*—Argillite, siltite, and porous quartzite. West of Fan Lake, all rocks hydrothermally altered, bleached, and deeply weathered. Sedimentary features used to distinguish formations are destroyed. East of Packsaddle Mountain, poor exposure and complex structure preclude specific formational assignment (Harrison and Jobin 1965). Thickness unknown

Yss *Snowslip Formation (Middle Proterozoic)*—Green, and medium- and dark-gray, argillite and siltite, and minor quartzite; locally, all rock-types may contain carbonate minerals. In Clark Fork area, lower part of formation contains limestone and calcareous argillite and siltite. As mapped, formation there is most of argillite member and all of argillite, siltite, and limestone member of Wallace Formation as defined by Harrison and Jobin (1963). Thickness at Clark Fork, about 1,920 m; northeast of Bonners Ferry, about 880 m; north of Newport, about 380 m; east of Chewelah, about 1,400 m thick. Clark Fork and Chewelah sections may be thickened by faults

Ywr *Wallace Formation and Ravalli Group, undivided (Middle Proterozoic)*—Quartz-feldspar-muscovite-biotite schist and calc-silicate rock. No primary sedimentary features preserved; thickness unknown. Mapped only in area south of Calispell Peak, 24 km northeast of Chewelah

Yw *Wallace Formation (Middle Proterozoic)*—Dolomite, dolomitic limestone, and carbonate-bearing siltite and quartzite with abundant thin interbeds of dark-gray argillite. In Clark Fork area, includes lower calcareous member and lower part of argillite member of Wallace Formation as defined by Harrison and Jobin (1963). Thickness in Clark Fork area, about 760 m; northeast of Bonners Ferry, about 1400 m; north of Newport, about 730 m; and east of Chewelah, about 800 m

Ye *Empire Formation (Middle Proterozoic)*—Pale-green siltite, quartzite, argillite, dolomite, and carbonate-bearing siltite. Thickness northeast of Bonners Ferry, between 200 m and 580 m; north of Newport, 320 m. Included with St. Regis Formation east of Chewelah, and with Wallace Formation at Clark Fork

Ravalli Group—In Sandpoint 1° x 2° quadrangle, group consists of:

Yru *Undivided part (Middle Proterozoic)*—Siltite, quartzite, and argillite. Mapped as undivided only between Lake Pend Oreille and Cocolalla Lake (fig. 2). Probably includes part or all of each formation of Ravalli Group (St. Regis, Revett, and Burke Formations). Moderately metamorphosed close to plutons. Thickness unknown, but probably cut by more faults than shown on map

Ysr *St. Regis Formation (Middle Proterozoic)*—Maroon to purple siltite, argillite, and lesser quartzite. Unit characterized by ripple marks, mud cracks, mud-chip breccia, cross lamination, and fluid-escape structures. Thickness in Clark Fork area, from 180 to 335 m; northeast of Bonners Ferry, from 250 to 470 m; north of Newport, about 275 m; east of Chewelah, about 450 m as mapped (including Empire Formation)

Yr *Revett Formation (Middle Proterozoic)*—Quartzite and minor siltite; white, tan, light-gray, pink, and maroon. Formation northeast of Bonners Ferry and east of Chewelah contains larger proportion of finer grained rocks than formation in Clark Fork area. At Newport, much of formation is fine grained, maroon quartzite Thickness in Clark Fork area, about 610 m; northeast of Bonners Ferry, from 570 m to 750 m; north of Newport, about 750 m; and east of Chewelah, 950

Ybk *Burke Formation (Middle Proterozoic)*—Siltite with minor argillite and quartzite. Most of formation is uniform, medium- to pale-gray siltite in even beds ranging in thickness from a few centimeters to about 20 cm. Upper part of formation contains zone, up to 150 m thick, of lavender siltite and argillite containing abundant ripple marks and mud-chip breccia; strongly resembles strata of typical St. Regis Formation (Ysr). Thickness in Clark Fork area, about 975 m; northeast of Bonners Ferry, about 1360 m; north of Newport, about 850m, and east of Chewelah, about 1,100 m

Ymi *Mafic intrusive rocks (Middle Proterozoic)*—Medium- to fine-grained sills and dikes of diabase composition intruding Prichard Formation. Composed of hornblende, biotite, plagioclase, quartz, and opaque minerals. Most bodies are sills, but discordance of intrusions appears to increase progressively with depth in Prichard Formation. Zircon from sill near Bonners Ferry, Idaho gives uranium-lead age of 1,433 Ma (Zartman and others, 1982). Sills and dikes are lithologically indistinguishable from sills and dikes (ZYmi) in Wallace Formation, which represent younger periods of intrusion at 1,100 and 800 Ma (Harrison and others, 1992). Some sills in Prichard Formation could belong to the two younger sill groups

Yp *Prichard Formation (Middle Proterozoic)*—Interbedded quartzite, siltite, and argillite; color ranges from white and pale-gray for quartzite, pale- to medium-gray for siltite, and medium- to dark-gray for argillite. Entire formation contains pyrite, highest concentration in argillites; oxidation of pyrite causes almost all rock surfaces in Prichard Formation to be iron-stained. Thickness in Clark Fork area, about 6,000 m (Cressman, 1989); northeast of Bonners Ferry, about 5,500 m; north of Newport, about 5,200 m; and east of Chewelah, about 4,100 m; all thicknesses include mafic sills. Undetected faults are probably present in all sections

Ypm *Prichard Formation, metamorphosed (Middle Proterozoic)*—Medium- to coarse-grained feldspar-quartz-muscovite-biotite schist and hornfels, locally containing aluminosilicates, intruded by two-mica granitic rocks of Priest River Complex. Contains bodies of medium- to coarse-grained amphibolite and garnet amphibolite derived from mafic intrusive rocks in Prichard Formation. East of Chewelah, contact with relatively unmetamorphosed Prichard Formation is gradational zone several hundred meters wide; generally placed where bedding in Prichard cannot be distinguished from metamorphic foliation. Much of unit within 4 km of Newport Fault shows incipient to strong mylonitization

Ynl *Newman Lake Gneiss (Middle Proterozoic?)*—Biotite-quartz-plagioclase-potassium feldspar orthogneiss. Contains traces of muscovite. Fine- to coarse-grained; much of unit is megacrystic. Foliation, lineation, grain-size-reduction, and tectonic rounding of megacrysts present in most of unit; caused by intense ductile deformation. Numerous pods composed of metamorphosed Prichard Formation and associated amphibolite are distributed throughout easternmost 300 to 500 m of unit. Possible age for Newman Lake Gneiss ranges from Proterozoic to Eocene; older age is preferred because of regional association of gneiss with metamorphosed Prichard Formation, and lithologically similar orthogneiss (gneiss of Leclede, Ylg) of known Middle Proterozoic age to north

Ylg *Gneiss of Laclede (Middle Proterozoic)*—Medium- to coarse-grained, megacrystic biotite orthogneiss. Composition ranges from monzogranite to granodiorite. Color index ranges from 8 to 13. Highly foliate and lineate throughout. Includes small areas of extremely heterogeneous gneiss, possibly paragneiss, on south side of Pend Oreille River and 5 km east of Priest River (fig. 2). Zircon from typical orthogneiss gives uranium-lead age of 1,578 Ma (Evans and Fischer, 1986)

sgg *Schist, gneiss, and leucocratic granitic rocks (age unknown)*—Coarse-grained quartz-feldspar-muscovite-biotite schist and gneissic rocks that include minor amphibolite bands and pods. Mapped only around Davis Lake (fig. 2). Intruded by texturally and compositionally heterogeneous leucocratic granitic rocks. Schist and gneiss could be metamorphosed Middle Proterozoic Belt Supergroup, but appear to be more thoroughly recrystallized, contain a higher proportion of granitic material, and are uniformly, strongly deformed; unit could be pre-Belt crystalline rocks

Data Sources, Processing, and Accuracy

Mapping by F.K. Miller, R.F. Burmester, D.M. Miller and R.E. Powell (this report), in addition to Yates (1964 and 1971) for the Deep Creek and Northport areas; Joseph (1990) for the southwest quadrant of the Colville 1:100,000 quadrangle; Harrison and Schmidt (1971) for the Elmira quadrangle; Harrison and Jobin (1965 and 1963) for the Packsaddle Mountain and Clark Fork quadrangles, respectively; and Bennett and others (1975) for the Mount Pend Oreille quadrangle, were the sources of geologic data used to create the digital map. A stable-base clear film blackline of the geologic map linework was electronically scanned to create a digital raster image. This raster image was then converted to vector and polygon GIS layers and minimally attributed by Optronics Specialty Co., Inc., Northridge, CA. This initial product was remitted to the U.S. Geological Survey in an Arc/Info interchange format in scanner units with only two tic points for registration purposes. A new set of tic points was created based on intersections of geologic contacts and faults with topographic contours. These tic points were then used to transform the digital files to calculated latitude-longitude points for a Universal Transverse Mercator (zone 11, with a -5,000,000 m y-offset) map projection. The RMS error[5] resulting from the file transformation was moderate (24.177 meters, see Appendix A). The digital files were then augmented with an interim geologic map data model (or data base), further attributed and edited, and then plotted and compared to the original stable-base geologic map to check for digitizing and attributing errors. All processing by the U.S. Geological Survey was done in Arc/Info version 7.1.1 installed on a Sun Ultra workstation.

The accuracy of the lines in the digital geologic map (Figs. 4 and 5) with respect to the lines on the scanned stable-base map is generally better than +/- 70 meters on the ground. This digital database is not meant to be used or displayed at any scale larger than 1:250,000 (e.g., 1:100,000 or 1:24,000).

[5] The root mean square error (RMS error) describes the deviation between the tic locations in the input file and those in the output file. It is an indication of the quality of the derived transformation and is a measure of the quality of the original scanned materials. The transformation report of errors for each tic point is given in Appendix A.

- Qag - Glacial and alluvial deposits (Quaternary)
- Qls - Landslide deposits (Quaternary)
- Ql - Glacial-lacustrine deposits (Quaternary)
- QTs - Consolidated alluvial and (or) glacial deposits (Quaternary and (or) Tertiary)
- Tcr - Columbia River Basalt Group (Miocene)
- Tcg - Conglomerate (Eocene)
- Tcb - Chlorite breccia and cataclastic rocks associated with Newport Fault zone (Eocene)
- Tcc - Tectonic breccia of Cusick Creek (Eocene)
- Ts - Sanpoil Volcanics (Eocene)
- Tot - Olivine trachybasalt flows (Eocene)
- To - O'Brien Creek Formation (Eocene)
- Thd - Hypabyssal dikes (Eocene)
- Tsp - Silver Point Quartz Monzonite (Eocene)
- Tam - Quartz monzondiorite of Ahern Meadows (Eocene)
- Tll - Quartz monzonite of Loon Lake (Eocene)
- Tw - Granodiorite of Wrenco (Eocene)
- Ttp - Quartz monzonite of Trapper Peak (Eocene)
- Tcs - Coryell plutonic rocks and Sheppard Granite, undivided (Eocene)
- Ksm - Sophie Mountain Formation (Cretaceous)
- Kmm - Monzogranite of Midnight Mine (Cretaceous)
- Kbgm - Muscovite monzogranite of Blue Grouse Mountain (Cretaceous)
- Klr - Monzogranite of Little Roundtop (Cretaceous)
- Kg - Monzogranite of Granite Pass (Cretaceous)
- Km - Monzogranite of Middle Creek (Cretaceous)
- Kli - Leucocratic intrusive rocks (Cretaceous)
- Kdc - Granodiorite of Dubius Creek (Cretaceous)
- Kb - Blickensderfer Quartz Monzonite (Cretaceous)
- Kmo - Granodiorite of Molybdenite Mountain (Cretaceous)
- Ktmc - Two-mica monzogranite of Twentymile Creek (Cretaceous)
- Knb - Two-mica monzogranite of North Basin (Cretaceous)
- Kbm - Monzogranite of Big Meadows (Cretaceous?)
- Kbf - Granodiorite of Bonners Ferry (Cretaceous)
- Ktc - Monzogranite of Tango Creek (Cretaceous)
- Kh - Monzogranite of Hungry Mountain (Cretaceous)
- Kgm - Monzogranite of Gleason Mountain (Cretaceous)
- Ksc - Monzogranite of Sand Creek (Cretaceous)
- Klc - Granodiorite of Lightning Creek (Cretaceous)
- Kw - Granodiorite of Whiskey Rock (Cretaceous)
- Krl - Granodiorite of Rapid Lightning Creek (Cretaceous)
- Knc - Monzogranite of Narcisse Creek (Cretaceous)
- Kwm - White Mud Lake porphyritic body (Cretaceous)
- Kgp - Galena Point Granodiorite (Cretaceous)
- Klcc - Granodiorite of Le Clerc Creek (Cretaceous)
- Kbc - Monzogranite porphyry of Bodie Canyon (Cretaceous)
- Khm - Granodiorite of Hall Mountain (Cretaceous)
- Krc - Granodiorite of Reeder Creek (Cretaceous)
- Kk - Granodiorite of Kelso Lake (Cretaceous)

Starvation Flat Quartz Monzonite (Cretaceous) - consists of the following:

- Ksh - Hornblende-biotite monzogranite and granodiorite
- Ksha - Arden pluton

- Kgs - Granitic rocks of Spirit pluton (Cretaceous)
- Kco - Granodiorite of Copeland (Cretaceous)
- Kyl - Granodiorite of Yocum Lake (Cretaceous)
- Kru - Granodiorite of Ruby Creek (Cretaceous)
- Kcu - Granitic rocks of Cabinet Mountains, undivided (Cretaceous)
- Kpm - Granodiorite porphyry of Packsaddle Mountain (Cretaceous)
- Kv - Granodiorite of Road V-78 (Cretaceous)
- Kfl - Fan Lake Granodiorite (Cretaceous)
- Kc - Biotite monzogranite of Camden (Cretaceous)
- Kse - Granodiorite of Sema Meadows (Cretaceous)
- Kbu - Granodiorite of Bunchgrass Meadows (Cretaceous)
- Kcl - Tonalite of Clagstone (Cretaceous)
- Kgpl - Granodiorite of Priest Lake (Cretaceous)
- Kmc - Granodiorite of Mill Creek (Cretaceous)
- Kkp - Granodiorite of Kelly Pass (Cretaceous)
- Kslc - Granodiorite of Salee Creek (Cretaceous)

Priest River Complex (Cretaceous) - consists of the following units:

- Kpl - Phillips Lake Granodiorite
- Kptc - Granodiorite of Trapper Creek
- Kplm - mixed granitic and metamorphic rocks of Lookout Mountain
- Kpgb - Garnet-bearing granodiorite
- Kpcc - Granodiorite of Caribou Creek
- Kpml - Biotite-rich granodiorite of Marsh Lake
- Kpsl - Granodiorite of Search Lake
- Kplc - Biotite-rich granodiorite of Lucky Creek
- Kpkm - Monzogranite of Klootch Mountain
- Kph - Two-mica granitic rocks of Horton Creek
- Kpcb - Biotite-rich granodiorite of Cavanaugh Bay
- Kpcp - mixed granitic rocks of Camels Prairie
- Kpms - mixed granitic and metamorphic rocks of Soldier Creek
- Kpll - Mixed leucocratic granitic rocks of Lost Creek
- Kpbi - Granitic rocks of Big Creek
- Kpsh - Monzogranite of Shorty Peak
- Kpbc - mixed two-mica rocks of Ball Creek
- Kpfc - Granodiorite of Falls Creek
- Kpsp - Tonalite of Snow Peak

Figure 4. Explanation for the Digital Geologic Map of the Sandpoint 1:250,000 quadrangle, WA, ID, and MT

Kpdc - Mixed granitic and metamorphic rocks of Deep Creek

Koc - Monzogranite of Otter Creek (Cretaceous)

Klgs - Leucocratic granitic rocks of Scotia (Cretaceous)

Ksv - Granodiorite of Spring Valley (Cretaceous)

Kbr - Monzogranite of Blanchard Road (Cretaceous)

Klm - Monzogranite of Long Mountain (Cretaceous)

Kag - Granitic rocks of Algoma (Cretaceous)

Ksg - Granodiorite of Sawyer (Cretaceous)

Kjl - Granitic rocks of Jewel Lake (Cretaceous)

Kmg - Muscovite-biotite monzogranite (Cretaceous)

Kphc - Monzogranite of Hunt Creek (Cretaceous)

Jcm - Tonalite and trondhjemite of Continental Mountain (Jurassic)

Jlm - Quartz monzodiorite of Lane Mountain (Jurassic)

MZPZf - Fault-zone rocks on Eagle Mountain (middle Mesozoic to late Paleozoic)

Rossland Group (Early Jurassic) - consists of the following two units:

Jrg - Greenstone

Jrs - Metasedimentary and metavolcanic rocks

JTRpl - Monzonite of Long Canyon (Jurassic or Triassic)

JTRw - Syenite of Wall Mountain (Jurassic or Triassic)

TRft - Flowery Trail Granodiorite (Triassic)

TRs - Metasedimentary rocks (Triassic)

Ps - Metasedimentary rocks (Permian)

MCu - Carbonate and clastic sedimentary rocks, undivided (Mississippian to Cambrian)

Ml - Limestone (Mississippian)

MDs - Dolomite and slate (Mississippian and Devonian)

Ddl - Dolomite and limestone (Devonian)

Ds - Metasedimentary rocks (Devonian)

Dv - Metavolcanic rocks (Devonian)

Sc - Quartz-granule conglomerate (Silurian)

Sms - Metasedimentary rocks (Silurian)

Ol - Ledbetter Formation (Ordovician)

OCgc - Phyllite and quartzite of Gardiner Creek (Ordovician or Cambrian)

OCm - Metaline Formation (Ordovician and Cambrian)

Csu - Sedimentary rocks, undivided (Cambrian)

Clr - Rennie Shale and Lakeview Limestone, undivided (Middle Cambrian)

Cgc - Gold Creek Quartzite (Middle? Cambrian)

Maitlen Phyllite (Early Cambrian) - consists of the following units:

Cmp - Phyllite

Cmc - Carbonate rocks

CZq - Quartzite (Cambrian and Late Proterozoic)

Windermere Group (Late Proterozoic) - consists of the following units:

Zt - Three Sisters Formation

Zm - Monk Formation

Zl - Leola Volcanics

Huckleberry Formation - consists of the following two members:

Zhg - Greenstone member

Zhc - Conglomerate member

Shedroof Conglomerate (Late Proterozoic) - consists of the following four members:

Zsc - Conglomerate member

Zsp - Phyllite member

Zsl - Sandy limestone member

Zsg - Greenstone member

ZYmi - Mafic intrusive rocks in upper part of Belt Supergroup (Late and Middle Proterozoic)

Deer Trail Group (Middle Proterozoic) - consists of the following units:

Ydtu - Undivided part

Yb - Buffalo Hump Formation

Ys - Stensgar Dolomite

Ym - McHale Slate

Ywd - Wabash Detroit Formation

Ywcu - Wabash Detroit Formation and Chamokane Creek Formation, undivided

Yc - Chamokane Creek Formation

Yt - Togo Formation

Belt Supergroup (Middle Proterozoic) - consists of the following units:

Yl - Libby Formation

Ybmh - Bonner Formation, Mount Shields Formation, and argillite of Half Moon Lake, undivided

Ybo - Bonner Formation

Yms - Mount Shields Formation

Yhm - Argillite of Half Moon Lake

Yshs - Shepard Formation and Snowslip Formation, undivided

Ysh - Shepard Formation

Yssw - Shepard Formation, Snowslip Formation, and Wallace Formation, undivided

Yss - Snowslip Formation

Ywr - Wallace Formation and Ravalli Group, undivided

Yw - Wallace Formation

Ye - Empire Formation

Ravalli Group - consists of the following units:

Yru - Undivided part

Ysr - St. Regis Formation

Yr - Revett Formation

Ybk - Burke Formation

Ymi - Mafic intrusive rocks

Yp - Prichard Formation

Ypm - Metamorphosed part of the Prichard Formation (Middle Proterozoic)

Ynl - Newman Lake Gneiss (Middle Proterozoic?)

Ylg - Gneiss of Laclede (Middle Proterozoic)

sgg - Schist, gneiss, and leucocratic granitic rocks (age unknown)

contact

fault

hypabyssal dikes (unit Thd)

Figure 4 (continued). Explanation for the Digital Geologic Map of the Sandpoint 1:250,000 quadrangle, WA, ID, and MT

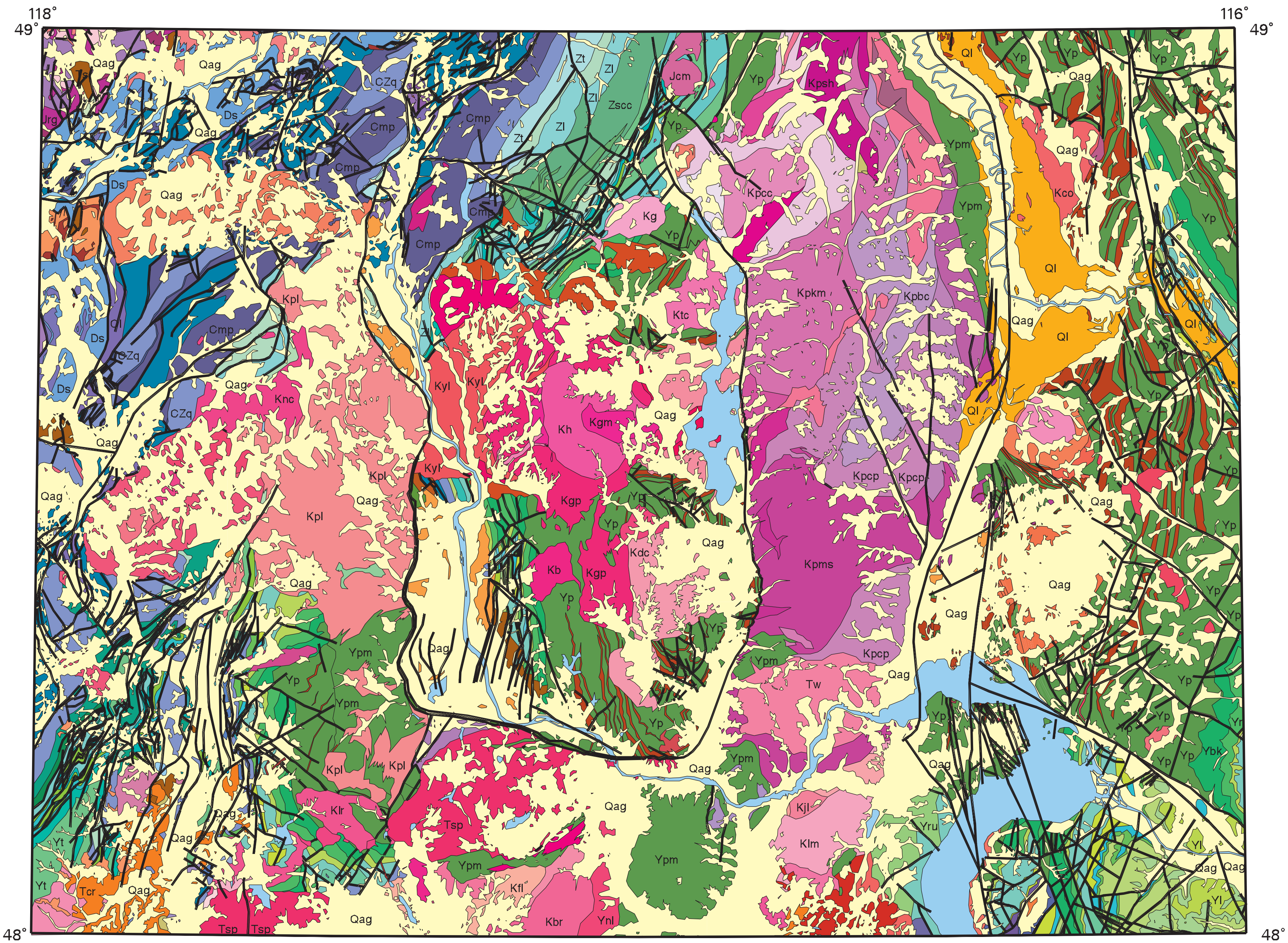

Figure 5. Digital Geologic Map of the Sandpoint 1:250,000 quadrangle, WA, ID, and MT

GIS Documentation

The digital geologic map of the Sandpoint 1° x 2° quadrangle includes a geologic linework arc attribute table, SAND250K.AAT, that relates to the SAND250K.CON, SAND250K.STR, SAND250K.LGU and SAND250K.SR* files; and a rock unit polygon attribute table, SAND250K.PAT, that relates to the SAND250K.RU and SAND250K.SR* files (see fig. 6). These data files are described below.

Linear Features

Descriptions of the items identifying linear features such as contacts, boundaries (e.g., lines of latitude and longitude) and structures in the arc (or line) attribute table, SAND250K.AAT, are as follows:

SAND250K.AAT			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
linecode	integer	3	Numeric code used to identify type of linear feature. Linecodes < 100 are used for contacts and boundaries which are described in the SAND250K.CON file. Linecodes > 100 and < 600 represent structural features which are described in the SAND250K.STR file. Linecodes > 800 represent linear geologic units (e.g., dikes) which are described in the SAND250K.LGU file.
name	character	30	Name given to structural feature.
source	integer	4	Numeric code used to identify the data source for the linear feature. Complete references for the sources are listed in the SAND250K.SR* files.

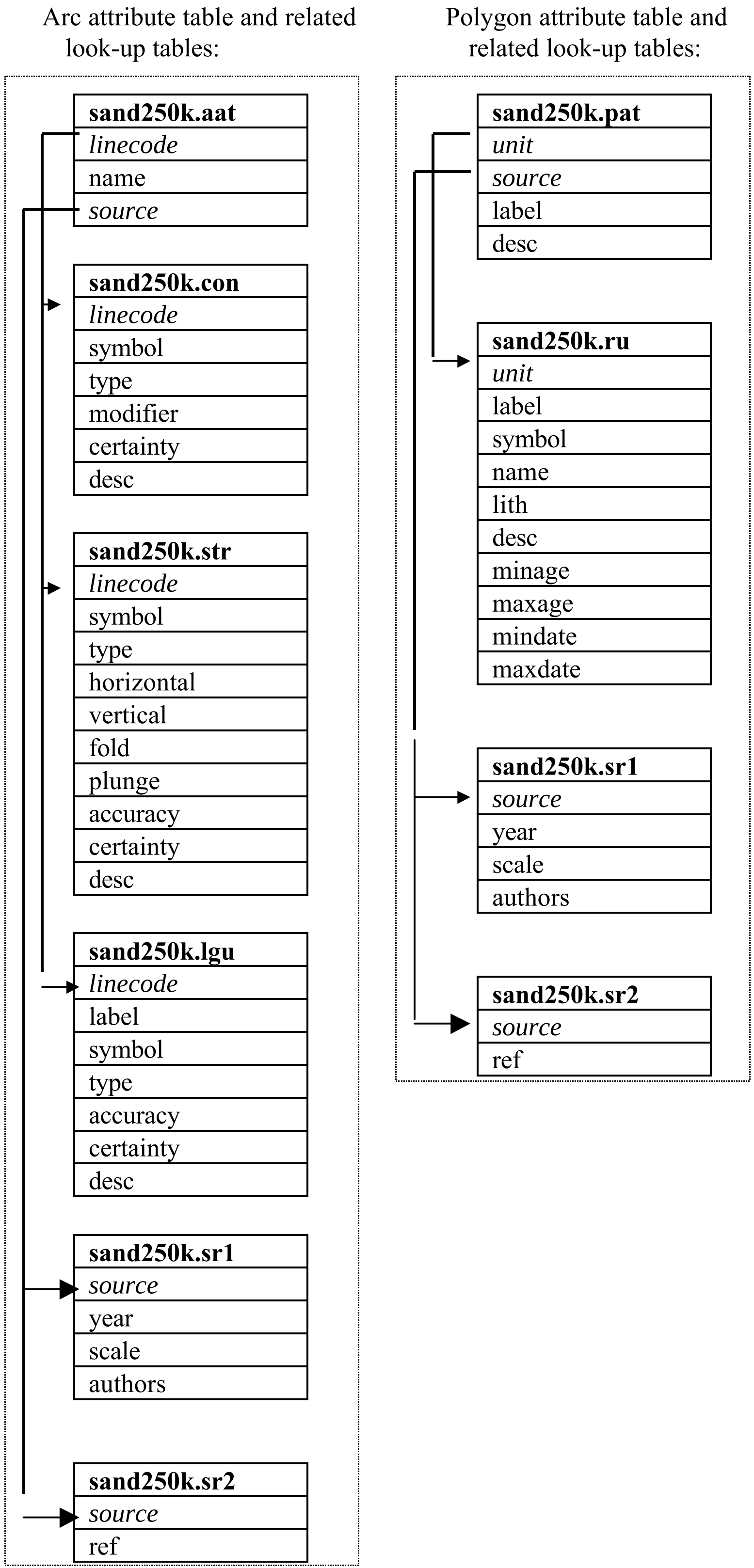

Figure 6. Relationships between feature attribute tables and look-up tables

Attribute descriptions for items in the contact (and boundary) look-up table, SAND250K.CON (for use with the PLOTTER.LIN lineset), are as follows:

SAND250K.CON			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
linecode	integer	3	Numeric code (a value < 100) used to identify type of contact or boundary. (This item also occurs in SAND250K.AAT.)
symbol	integer	3	Line symbol number used by Arc/Info to plot arc (line). Symbol numbers refer to the **PLOTTER.LIN lineset**.
type	character	10	Major type of line, e.g., contact, shoreline, lines of latitude and longitude used for neatlines.
modifier	character	20	Line type modifier, i.e., approximate, concealed, gradational. No entry implies 'known.'
certainty	character	15	Degree of certainty of contact or boundary, i.e., inferred, uncertain. No entry implies 'certain.'
desc	character	100	Written description or explanation of contact or boundary.

Attribute descriptions for items in the structure look-up table, SAND250K.STR [for use with the GEOLOGY.LIN lineset (Fitzgibbon and Wentworth, 1991)], are as follows:

SAND250K.STR			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
linecode	integer	3	Numeric code (a value > 100 and < 600) used to identify type of structural feature. (This item also occurs in SAND250K.AAT.)
symbol	integer	3	Line symbol number used by Arc/Info to plot arc (line). Symbol numbers refer to the **GEOLOGY.LIN lineset** (Fitzgibbon and Wentworth, 1991).
type	character	10	Major type of structure, i.e., fault, fracture, fold, other.
horizontal	character	20	Type of horizontal fault movement, e.g., left-lateral, right-lateral. No entry implies 'unknown.'
vertical	character	20	Type of vertical fault movement, e.g., normal. No entry implies 'unknown.'
fold	character	15	Type of fold, e.g., anticline, syncline.
plunge	character	15	Type of plunge on fold, i.e., horizontal, plunging, plunging in, plunging out.
accuracy	character	15	Line type modifier indicating degree of accuracy, i.e., approximately located, concealed, gradational.. No entry implies 'known.'
certainty	character	15	Degree of certainty of contact or boundary, i.e., inferred, uncertain. No entry implies 'certain.'
desc	character	100	Written description or explanation of structural feature.

Attribute descriptions for items in the linear geologic units (e.g., dikes and rock units that can only be mapped as linear features at a scale of 1:250,000) look-up table, SAND250K.LGU, [for use with the GEOLOGY.LIN lineset (Fitzgibbon and Wentworth, 1991)], are as follows:

SAND250K.LGU			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
linecode	integer	3	Numeric code (a value > 800) used to identify type of linear geologic unit. (This item also occurs in SAND250K.AAT.)
label	character	10	Map label used in the map proper to identify rock unit.
symbol	integer	3	Line symbol number used by Arc/Info to plot linear geologic unit. Symbol numbers refer to **GEOLOGY.LIN lineset**. (Fitzgibbon and Wentworth, 1991).
type	character	10	Major type of linear geologic unit, e.g., dike or formation.
accuracy	character	15	Line type modifier indicating degree of accuracy, i.e., approximate, concealed, gradational. No entry implies 'known.'
certainty	character	15	Degree of line type certainty, i.e., inferred, uncertain. No entry implies 'certain.'
desc	character	100	Written description or explanation of linear geologic unit.

Areal Features

Descriptions of the items identifying geologic units in the polygon attribute table, SAND250K.PAT, are as follows:

SAND250K.PAT			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
unit	integer	4	Numeric code used to identify the rock unit which is described in the SAND250K.RU look-up table. (This item also occurs in SAND250K.RU.)
source	integer	4	Numeric code used to identify the data source for the rock unit. Complete references for the sources are listed in the SAND250K.SR* files.
label	character	10	Rock unit label (abbreviation) used to label unit on map.
desc	character	100	Formal or informal unit name

Attribute descriptions for items in the lithology (rock unit) look-up table, SAND250K.RU (for use with the CALCOMP1.SHD shadeset), are as follows:

SAND250K.RU			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
unit	integer	4	Numeric code used to identify rock unit. (This item also occurs in SAND250K.PAT.)
label	character	10	Rock unit label (abbreviation) used to label unit on map.
symbol	integer	3	Shadeset symbol number used by Arc/Info to plot a filled/shaded polygon. (The symbol numbers used in this file refer to the **CALCOMP1.SHD shadeset**.)
name	character	7	The prefix portion of the geologic unit label that does not include subscripts. (If no subscripts are used in the label, then the 'name' entry is the same as the 'label' entry.)
lith	character	20	Major type of lithostratigraphic unit, i.e., unconsolidated sediments, sedimentary rocks, metasedimentary rocks, intrusive rocks, extrusive rocks, metamorphic rocks, water, ice.
desc	character	100	Formal or informal unit name
minage	character	7	Minimum stratigraphic age of lithologic unit, i.e., CRET, TERT, PCY.
maxage	character	7	Maximum stratigraphic age of lithologic unit
mindate	integer	4	Minimum radiometric age (in millions of years) if determined.
maxdate	integer	4	Maximum radiometric age (in millions of years) if determined.

Source Attributes

Descriptive source or reference information for the SAND250K coverage is stored in the SAND250K.SR1 and SAND250K.SR2 files. Attribute descriptions for items in each of the data source filed are as follows:

SAND250K.SR1			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
source	integer	4	Numeric code used to identify the data source. (This item also occurs in the SAND250K.AAT and SAND250K.PAT files.)
year	integer	4	Source (map) publication date
scale	integer	8	Scale of source map. (This value is the denominator of the proportional fraction that identifies the scale of the map that was digitized or scanned to produce the digital map.)
authors	character	200	Author(s) or compiler(s) of source map.

SAND250K.SR2			
ITEM NAME	ITEM TYPE	ITEM WIDTH	ATTRIBUTE DESCRIPTION
source	integer	4	Numeric code used to identify the data source. (This item also occurs in the SAND250K.AAT and SAND250K.PAT files.)
ref	character	250	Remainder of reference in USGS reference format.

Obtaining Digital Data

The complete digital version of the geologic map is available in Arc/Info interchange format with associated data files. These data and map images are maintained in a Universal Transverse Mercator (UTM) map projection:

Projection: UTM
Zone: 11
Y-offset (false northing): -5,000,000 meters
Units: meters

To obtain copies of the digital data, do the following:
Download the digital files from the USGS public access World Wide Web site on the Internet: **URL = http://pubs.usgs.gov/of/1999/0144/**

The Internet sites contain the digital geologic map of the Sandpoint 1° x 2° quadrangle both as an Arc/Info interchange-format file (sand250k.e00) and as an HPGL2 plot file (sand250k.hp), as well as the associated data files and Arc/Info macro programs which are used to plot the map at a scale of 1:250,000.

To manipulate this data in a geographic information system (GIS), you must have a GIS that is capable of reading Arc/Info interchange-format files (files with a .E00 file extension).

Obtaining Paper Maps

Paper copies of the digital geologic map are not available from the USGS. However, with access to the Internet and access to a large-format color plotter that can interpret HPGL2 (Hewlett-Packard Graphics Language), a 1:250,000-scale paper copy of the map can be made, as follows:
Download the plot file of the map, **sand250k.hp**, from the USGS public access World Wide Web site on the Internet using the
URL = http://pubs.usgs.gov/of/1999/0144/

These files can be plotted by any large-format color plotter that can interpret HPGL2. The finished plot is about 28 inches by 44 inches.

Paper copies of a customized geologic map can also be created by obtaining the digital data files as described above and then creating a custom plot file in a GIS.

References Cited

Archibald, D.A., Krogh, T.E., Armstrong, R.L., and Farrar, E., 1984, Geochronology and tectonic implications of magmatism and metamorphism, southern Kootenay arc and neighbouring regions, southeastern British Columbia. Part II: mid Cretaceous to Eocene: Canadian Journal of Earth Science, v. 21, p. 567-583.

Beddoe-Stephens, B., 1982, The petrology of the Rossland volcanic rocks, southern British Columbia: Geological Society of America Bulletin, v. 93, no. 7, p. 585-594.

Bennett, E.H., Kopp, R.S., and Galbraith, J.H., 1975, Reconnaissance geology and geochemistry of the Mt. Pend Oreille quadrangle and surrounding areas: Idaho Bureau of Mines and Geology Pamphlet No. 163, 83 p., scale 1:62,500.

Burmester, R.F., 1985, Preliminary geologic map of the Eastport area, Idaho and Montana: U.S. Geological Survey Open-File Report OF-85-517, 10 p., scale 1:48,000.

Burmester, R.F., 1986, Preliminary geologic map of the Leonia area, Idaho and Montana: U.S. Geological Survey Open-File Report OF-86-554, scale 1:48,000, 13 p.

Burmester, R.F., and Miller, F.K., 1983, Preliminary geologic map of the Abercrombie Mountain area: U.S. Geological Survey Open-File Report OF-83-600, 10 p., scale 1:48,000.

Campbell, I., and Loofbourow, J.S., 1962, Geology of the magnesite belt of Stevens County, Washington: U.S. Geological Survey Bulletin 1142-F, p. F1-F53, scale 1:36,000.

Carr, S.D., and Parkinson, D.L., 1989, Eocene stratigraphy, age of the Coryell batholith and extensional faults in the Granby Valley southern British Columbia: Geological Survey of Canada Paper 89-1E, p. 79-87.

Carter, C., 1989a, A Middle Ordovician graptolite fauna from near the contact between the Ledbetter Slate and the Metaline Limestone in the Pend Oreille Mine, northeastern Washington state: U.S. Geological Survey Bull. 1860-A, p. A1-A23.

Carter, C., 1989b, Ordovician-Silurian graptolites from the Ledbetter Slate, northeastern Washington state: U.S. Geological Survey Bull. 1860-B, p. B1-B29.

Cheney, E.S., 1980, Kettle dome and related structures of northeastern Washington *in* Crittenden, M.D., Jr., Coney, P.J., Davis, G.H., editors, Cordilleran metamorphic core complexes: Geological Society of America Memoir 153, p. 463-483.

Cheney, E.S., Rasmussen, M.G., and Miller, M.G., 1994, Major faults, stratigraphy, and identity of Quesnellia in Washington and adjacent British Colombia: Washington Division of Geology and Earth Resources Bulletin 80, p. 49-71.

Cressman, E.R., 1989, Reconnaissance stratigraphy of the Prichard Formation (Middle Proterozoic) and the early development of the Belt Basin, Washington, Idaho, and Montana: U.S. Geological Survey Professional Paper 1490, 80 p.

Devlin, W.J., and Bond, G.C., 1988, The initiation of the early Paleozoic miogeocline—Evidence from the uppermost Proterozoic-Lower Cambrian Hamil Group of southeastern British Columbia: Canadian Journal of Earth Sciences, v. 25, no. 1, p. 1-19.

Devlin, W.J., Bond G.C., and Brueckner, H.K., 1985, An assessment of age and tectonic setting of volcanics near the base of the Windermere Supergroup in northeastern Washington—implications for latest Proterozoic-earliest Cambrian continental separation: Canadian Journal of Earth Sciences, v. 22, p. 829-837.

Dings, M.G, and Whitebread, D.H., 1965, Geology and ore deposits of the Metaline zinc-lead district, Pend Oreille County, Washington: U.S. Geological Survey Professional Paper 489, 109 p.

Ellis, M.A., 1986, Structural morphology and associated strain in the central Cordillera (British Columbia and Washington): evidence of oblique tectonics: Geology, v. 14, p. 647-650.

Evans, K. V., and Fischer, L.B., 1986, U-Pb geochronology of two augen gneiss terranes, Idaho—New data and tectonic implications: Canadian Journal of Earth Sciences, v. 23, no. 12, p. 1919-1927.

Fitzgibbon, Todd T. and Wentworth, Carl M., 1991, ALACART user interface - executable AML code and demonstration maps: U.S. Geological Survey Open-File Report 91-587A (as updated October 17, 1996 for version 3.1).

Fyles, J.T., and Hewlett, C.G., 1959, Stratigraphy and structure of the Salmo lead-zinc area: British Columbia Department of Mines Bulletin 41, 162 p.

Gager, B.R., 1984, The Tiger Formation: Paleogene fluvial sediments deposited adjacent to a deforming Cordilleran metamorphic core-complex, northeastern Washington: Sedimentary Geology, v. 38, p. 393-420.

Harms, T.A., and Price, R.A., 1992, The Newport fault: Eocene listric normal faulting, mylonitization, and crustal extension in northeast Washington and northwest Idaho: Geological Society of America Bulletin, v. 104, p. 745-761.

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

Harrison, J.A., and Jobin, D.A., 1963, Geology of the Clark Fork quadrangle, Idaho-Montana: U.S. Geological Survey Bulletin 1141-K, 38 p.

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

Harrison, J.A., and Schmidt, P.W., 1971, Geologic map of the Elmira quadrangle, Idaho: U.S. Geological Survey Geologic Quadrangle Map GQ-953, scale 1:62,500.

Harrison, J.A., Kleinkopf, M.D., and Obradovich, J.D., 1972, Tectonic events at the intersection between the Hope fault and the Purcell trench, northern Idaho: U.S. Geological Survey Professional Paper 719, 24 p.

Hogge, C.E., 1982, Geology of the Paleozoic black shale sequence, Moberg Hill, Stevens County, Washington: Pullman, Washington State University, M.S. dissertation, 80 p.
Höy, Trygve and Andrew, K.P.E., 1988, Preliminary geology and geochemistry of the Elise Formation, Rossland Group, between Nelson and Ymir, southern British Columbia (82F/06). *In* British Columbia Ministry of Energy, Mines, and Petroleum Resources, 1988, Geological fieldwork 1987— A summary of field activities and current research: British Columbia Ministry of Energy, Mines, and Petroleum Resources Paper 1988-1, p. 19-30.
Joseph, N.L., 1990, Geologic map of the Colville 1:100,000 quadrangle, Washington-Idaho: Washington Division of Geology and Earth Resources Open-File Report 90-13, 78 p., scale 1:100,000.
Lindsey, K.A., Gaylord, D.R., and Groffman, L.H., 1990, Geology of the Upper Proterozoic to Lower Cambrian Three Sisters Formation, Gypsy Quartzite, and Addy Quartzite, Stevens and Pend Oreille Counties, northeastern Washington: Washington Division of Geology and Earth Resources, Report of Investigations 30, 37 p.
Lis, M.G. and Price, R.A., 1976, Large-scale block faulting during deposition of the Windermere Supergroup (Hadrynian) in southeastern British Columbia: *in* Report of activities, part A, Geological Survey of Canada, Paper 76-1A, p. 135-136.
Little, H.W., 1960, Nelson map-area, west half, British Columbia: Geological Survey of Canada Memoir 308, 205 p.
Little, H.W., 1982, Geology of the Rossland-Trail map-area, British Columbia: Geological Survey of Canada Paper 79-26, 38 p., 1 pl., scale 1:50,000.
Ludwig, K.R., Nash, J.T., and Naeser, C.W., 1981, U-Pb isotope systematics and age of uranium mineralization, Midnight mine, Washington: Economic Geology, v. 25, no.4, p. 514-519.
McCarthy, P.T., Miller, D.M., Nakata, J.K., and Hoisch, T.D., 1993, Structures adjacent to the Purcell trench south of Sandpoint, Idaho: Geological Society of America Abstracts with Programs, vol. 25, no. 5, p. 117.
Miller, C.F., 1978, An early Mesozoic alkalic magmatic belt in western North America, *in* Howell, D.G., and McDougall K.A., eds., Mesozoic paleogeography of the western United States: Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium 2, p. 163-173.
Miller, F.K., 1974a, Preliminary geologic map of the Newport number 1 quadrangle, Pend Oreille County Washington, and Bonner County, Idaho: Washington Division of Geology and Earth Resources Geologic Map GM-7, 6 p., 1 pl., scale 1:62,500.
_________1974b, Preliminary geologic map of the Newport number 2 quadrangle, Pend Oreille and Stevens Counties, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-8, 6 p., 1 pl., scale 1:62,500.
_________1974c, Preliminary geologic map of the Newport number 3 quadrangle, Pend Oreille, Stevens, and Spokane Counties, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-9, 7 p., 1 pl., scale 1:62,500.
_________1974d, Preliminary geologic map of the Newport number 4 quadrangle, Pend Oreille, Stevens, and Spokane Counties, Washington, and Bonner County, Idaho: Washington Division of Geology and Earth Resources Geologic Map GM-10, 6 p., 1 pl., scale 1:62,500.

_________1982a, Preliminary geologic map of the Coolin area: U.S. Geological Survey Open-File Report OF-82-1061, scale 1:48,000, 20 p.
_________1982b, Preliminary geologic map of the Continental Mountain area: U.S. Geological Survey Open-File Report OF-82-1062, scale 1:48,000, 32 p.
_________1982c, Preliminary geologic map of the Priest Lake area: U.S. Geological Survey Open-File Report OF-82-1063, scale 1:48,000, 25 p.
_________1983a, Preliminary geologic map of the Gypsy Peak area: U.S. Geological Survey Open-File Report OF-83-601, scale 1:48,000, 28 p.
_________1983b, Preliminary geologic map of the Smith Peak area: U.S. Geological Survey Open-File Report OF-83-602, scale 1:48,000, 17 p.
_________1991a, Preliminary geologic map of the Orwig Hump area: U.S. Geological Survey Open-File Report OF-91-24, scale 1:48,000, 20 p.
_________1991b, Preliminary geologic map of the Wigwams area: U.S. Geological Survey Open-File Report OF-91-25, scale 1:48,000, 14 p.
_________1994, The Windermere Group and Late Proterozoic tectonics of northeastern Washington and northern Idaho: *in* Lasmanis, R. and Cheney, E.S., eds., Selected papers on the geology of Washington: Washington Division of Geology and Earth Resources Bulletin 80, p. 1-19.
_________1995a, Geologic map of the Empey Mountain area, Stevens County, Washington: U.S. Geological Survey Miscellaneous Investigation Series Map I-2493, scale 1:48,000.
_________1995b, Geologic map of the Addy area, Stevens County, Washington: U.S. Geological Survey Miscellaneous Investigation Series Map I-2492, scale 1:48,000.
Miller, F.K., and Clark, L.C., 1975, Geology of the Chewelah-Loon Lake area, Stevens and Spokane Counties, Washington: U.S. Geological Survey Professional Paper 806, 74 p., scale 1:62,500
Miller, F.K., and Engels, J.C., 1975, Distribution and trends of discordant ages of the plutonic rocks of northeastern Washington and northern Idaho: Geological Society of America Bulletin, v. 86, no. 4, p. 517-528.
Miller, F.K., and Frisken, J.G., 1984, W-Mo-Au-Ag geochemical anomalies associated with the granodiorite of Hall Mountain, northeastern Washington: U.S. Geological Survey Open-File Report 84-365, 14 p.
Miller, F.K., and Theodore T.G., 1982, Molybdenum and tungsten mineralization associated with two stocks in the Harvey Creek area, northeastern Washington: U.S. Geological Survey Open-File Report 82-295, 31 p.
Miller, F.K., and Whipple, J.W., 1989, The Deer Trail Group: is it part of the Belt Supergroup? *in* Joseph, N.L., and others, ed., 1989, Geologic guidebook for Washington and adjacent areas: Washington Division of Geology and Earth Resources Information Circular 86, p. 1-21.
Okulitch, V.J., 1951, A Lower Cambrian fossil locality near Addy, Washington: Journal of Paleontology, v. 25, no. 3, p. 405-407.
Park, C.F., Jr., and Cannon, R.S., Jr., 1943, Geology and ore deposits of the Metaline quadrangle, Washington: U.S. Geological Survey Professional Paper 202, 81p.

Parrish, R.R., Carr, S.D., and Parkinson, D.L., 1988, Eocene extensional tectonics and geochronology of the southern Omineca belt, British Columbia and Washington: Tectonics, v. 7, p. 181-212.

Pearson, R.C., and Obradovich, J.D., 1977, Eocene rocks in northeastern Washington—Radiometric ages and correlation: U.S. Geological Survey Bulletin 1433, 41 p.

Repetski, J.E., Dutro, J.T., Jr., and Schuster, J.E., 1989, Upper Metaline Limestone is Ordovician: Geological Society of America Abstracts with Programs, v. 21, no.5, p. 133.

Rehrig, W.A., Reynolds, S.J., and Armstrong, R.L., 1987, A tectonic and gechronologic overview of the Priest River crystalline complex, northeastern Washington and northern Idaho: Washington Division of Geology and Earth Resources Bulletin 77, p. 1-14.

Reynolds, S.J., Rehrig, W.A., and Armstrong, R.L., 1981, Reconnaissance Rb-Sr geochronology and tectonic evolution of the Priest River crystalline complex of northern Idaho and northeastern Washington: Geological Society of America Abstracts with Programs, v. 13, p. 103.

Rhodes, B.P., and Hyndman, 1984, Kinematics of mylonites in the Priest River "metamorphic core complex," northern Idaho and northeastern Washington: Canadian Journal of Earth Sciences, vol. 21, no. 10, p. 1161-1170

Roback, R.C., 1989, Lithology, stratigraphy, and geochronology of late Paleozoic and Mesozoic rocks in a part of Stevens County, Washington: Division of Geology and Earth Resources unpublished report, 17 p., 1 pl.

Schroeder, M.C., 1952, Geology of the Bead Lake district, Pend Oreille County, Washington: Washington Division of Mines and Geology Bulletin 40, 57 p.

Schuster, J.E., 1976, Geology of the Clugston Creek area, Stevens County, Washington: Washington Division Geology and Earth Resources Open-File Report 76-8, 26 p.

Smith, M.T., and Gehrels, G.E., 1992, Stratigraphy and tectonic significance of lower Paleozoic continental margin in northeastern Washington: Tectonics, v. 11, p. 607-620.

Steiger, R.H., and Jaeger, E., 1977, Subcommission on geochronology-- Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, no. 3, p. 359-362.

Stoffel, K.L., Joseph, N.L., Waggoner, S.Z., Gulick, C.W., Korosec, M.A., and Bunning, B.B., 1991, Geologic map of Washington—Northeast quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-39, 3 sheets, scale 1:250,000, with 36 p. of text.

Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1979, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457G, 59 p.

Waggoner, S.Z., 1990, Geologic map of the Chewelah 1:100,000 quadrangle, Washington-Idaho: Washington Division of Geology and Earth Resources Open-File Report 90-14, 63 p.

Watkinson, A.J., and Ellis, M.A., 1987, Recent structural analysis of the Kootenay arc in northeastern Washington, *in* Schuster, J.E., editor, Selected papers on the geology of

Washington: Washington Division of Geology and Earth Resources Bulletin 77, p. 41-53
Whitehouse, M.J., Stacey, J.S., and Miller, F.K., 1992, Age and nature of the basement in northeastern Washington and northern Idaho: isotopic evidence from Mesozoic and Cenozoic granitoids: Journal of Geology, v.100, p. 691-701.
Yates, R.G., 1964, Geologic map and sections of the Deep Creek area, Stevens and Pend Oreille counties, Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-412, scale 1:31,680.
Yates, R.G., 1971, Geologic map of the Northport area, Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-603, scale 1:31,680.
Yates, R.G., 1976, Geology of the Deep Creek area, Washington, and its regional significance: U.S. Geological Survey, Open-file Report 76-537.
Yates, R.G., and Engels, J.C., 1968, Potassium-argon ages of some igneous rocks in northern Stevens County, Washington, in Geological Survey research 1968: U.S. Geological Survey Professional Paper 600-D, p. D242-D247.
Yin, An, 1991, Kinematics of the Hope-Ninemile Fault and its tectonic implications, northern Idaho and northwestern Montana: Geological Society of America Abstracts with Programs, v. 23, no. 2, p. 111.
Zartman, R.E., Peterman, Z.E., Obradovich, J.D., Gallego, M.D., and Bishop, D.T., 1982, Age of the Crossport C sill near Eastport, Idaho, *in* Reed, R.R., and others, eds., Society of Economic Geologists, Coeur d'Alene Field Conference: Idaho Bureau of Mines and Geology Bulletin 24, p. 61-69.

Appendix A - Transformation report for Sandpoint GIS

One Arc/Info file was remitted to the USGS from the contractor, and it was transformed to a UTM map projection (zone 11, y-shift = -5,000,000 meters). The errors for each latitude and longitude tic used in the transformation are given below. The report identifies a root mean square (RMS) error of 24.177 meters.

Arc: transform spgeo2 spgeo3 affine|
Transforming coordinates for coverage spgeo2

Scale (X,Y) = (6350.334,6346.368) Skew (degrees) = (0.026)
Rotation (degrees) = (0.026) Translation = (414951.270,307481.279)
RMS Error (input,output) = (0.004,24.177)

Affine X = Ax + By + C
Y = Dx + Ey + F

A =	6350.333	B =	-0.013	C =	414951.270
D =	2.884	E =	6346.368	F =	307481.279

tic id	input x output x	input y output y	x error	y error
1	2.260	18.727		
	429327.469	426343.906	-23.428	-6.401
2	7.596	18.588		
	463167.594	425455.375	21.189	14.102
3	13.324	18.798		
	499549.344	426827.531	10.968	-9.435
4	19.446	18.775		
	538444.000	426676.281	-6.946	12.239
5	24.404	18.196		
	569911.438	423020.500	13.750	10.941
6	2.079	10.582		
	428142.750	374599.219	9.450	42.788
7	8.499	12.640		
	468930.844	387744.031	-8.267	-20.779
8	15.475	12.934		
	513251.125	389640.781	-31.168	-34.119
9	19.086	11.778		
	536143.750	382274.813	7.275	7.131
10	24.105	11.811		
	568026.188	382526.656	1.609	-15.735
11	2.453	2.833		
	430525.438	325478.625	3.796	-9.106
12	6.961	2.231		

	459149.844	321654.938	6.699	3.894
13	14.978	2.882		
	510062.094	325843.500	3.786	-26.891
14	20.395	1.567		
	544466.438	317486.906	-1.418	0.484
15	25.092	1.720		
	574299.188	318440.406	-7.295	30.888

Appendix B - List of digital files in the Sandpoint GIS

--Use the '00import.aml' to IMPORT all of the *.E00 files for use in Arc/Info.
--Use the Arc/Info 'DRAW' command to plot the *.GRA file to your screen. (Make sure the display is set with the Arc/Info 'DISPLAY 9999 3' command.)
--Use the Arc/Info 'HPGL2' command to create a HPGL2 file from the *.GRA file.
--Use the UNIX 'lpr -P<plotter_name> sand250k.hp' command to send the sand250k.hp file to a large-format color plotter that can interpret Hewlett-Packard Graphics Language.
--To re-create the *.GRA file, open the ArcPlot module, enter 'display 1040', enter a filename for the graphics file, enter '&run sand250k (and enter 'quit' to exit the ArcPlot module).

Primary Arc/Info interchange-format files (*.e00) for the digital geology:

- sand250k.e00

Plot files in Encapsulated PostScript (*.eps), Arc/Info graphics (*.gra) and HPGL2 map plot (*.hp) formats for the geologic map plate:

- sand250k.eps /.gra /.hp

Additional Arc/Info interchange-format files (*.e00) necessary to re-create the geologic map plate:

- calcomp1.shd.e00 - shadeset
- sandu11.e00 - exterior boundary of the Sandpoint quadrangle

AML, graphics, key, symbolset and text files necessary to re-create the geologic map plate:

- scale2a.aml - plots scale bar on plate
- sand250k.aml - program that creates a graphics file of the geologic map of the Sandpoint quadrangle, Idaho.

- index_sd.gra - index map graphic displayed on map plate (showing location of the Sandpoint quadrangle with respect to the Pacific Northwest).
- sd_line.key - lineset symbol values and descriptive text for lines on the map plate
- sd_pol.key - shadeset symbol values and descriptive text for geologic map units on the map plate
- geology.lin - lineset
- geo.prj - a text file used to identify real-world (geographic) coordinates - for use in adding latitude and longitude notation around the margins of the map quadrangle
- u11.prj - a text file to identify UTM, zone 11 map projection - for use in adding latitude and longitude notation around the margins of the map quadrangle
- sandcrd.txt - text file listing map credits on the map plate
- sanddisc.txt - disclaimer statement
- sandref.txt - text file listing map references on the map plate
- sand250k.met - formal metadata file

Appendix C - Arc/Info Macro Language program (sand250k.aml) used to plot the geologic map of the Sandpoint quadrangle

```
/*  sand250k.aml, 3/3/99, pd
/*  to plot the digital geologic map of the
Sandpoint 1- by 2-degree quadrangle in color
for USGS Open-File Report 99-144.
/************************
/*  This Arc/Info Macro Language (AML)
program will plot the geologic map plate for the
Sandpoint 1- by 2-degree quadrangle.

/*  To run this AML:
/*     1. Type 'ap' at the 'Arc:' prompt to enter the
ArcPlot module,
/*     2. Type 'display 1040' at the 'Arcplot:'
prompt to create a GRA file,
/*     3. Type 'sand250k' (or a filename of your
own choosing, but be sure to edit the draw
command at the end of the file with your new
name) at the 'Enter ARC/INFO Graphics
filename :' prompt for the GRA to be created,
/*     4. Type '&run sand250k' at the 'Arc:'
prompt to start the program,
/*     5. Run the Arc/Info HPGL2 command to
convert the GRA file to an HPGL2 file, i.e.,
hpgl2 sand250k sand250k.hp # 1.0 opaque # 0 #
# # cal.dat
/*     6. Execute the UNIX 'lpr' command to
print the 1:250,000-scale geologic map plot on
your plotter, i.e., lpr -Ppicasso sand250k.hp
/**************************

clear
clearselect

pagesize 43.0 28.0
pageunits inches
mapunits meters
mapscale 250000
mapposition ll 0.75 6.0
mapangle 0.2

&set cover sand250k
&set rut sand250k.ru
&set quad sandu11
&set key1 sd_pol.key
&set key2 sd_line.key
&s credits sandcrd.txt
&s disclaimer sanddisc.txt
/* -->where 'cover' contains contacts and
structures and rock units; rut contains rock unit
labels; and 'quad' is the quadrangle boundary.

mape %quad%
maplimits 0.0 2.4 26 26

/*draw outside box
linesymbol 9
linecolor 1
box 0.5 0.5 42.5 27.5
/*
textquality proportional
textfont 94021
linedelete all

/* cut marks
markerset plotter
markersymbol 1
markersize 0.1
marker 0 0
marker 0 28
marker 43.0 0
marker 43.0 28

&label shadepolys
/* color polygons for geologic rock units
shadedelete all
shadeset calcomp1
polygonshade %cover% unit %rut%

&label contacts
/* plot contacts and boundaries
linedelete all
lineset geology.lin
res %cover% arcs linecode gt 0 and linecode lt
40
arclines %cover% linecode %cover%.con
asel %cover% arcs
linedelete all
lineset carto.lin
res %cover% arcs linecode gt 40 and linecode lt
100
arclines %cover% linecode %cover%.con
asel %cover% arcs

&label structure
/* plot faults with line patterns
linedelete all
```

```
lineset geology.lin
res %cover% arcs linecode gt 100 and linecode
lt 600
arclines %cover% linecode %cover%.str
asel %cover% arcs

&label lgu
/* plot linear geologic units with line pattern
linedelete all
lineset geology.lin
res %cover% arcs linecode gt 800
arclines %cover% linecode %cover%.lgu
asel %cover% arcs

&label mapquad
/* plot quadrangle boundary
linedelete all
lineset plotter
linesymbol 5
arcs %quad%

&label geolabels
textsize 0.10
res %cover% poly area gt 750000
labeltext %cover% unit %rut% cc
asel %cover% poly

&label titles
textfont 93715
textquality kern
textsize 0.5
move 1.2 26.5
text 'U.S. DEPARTMENT OF THE INTERIOR'
move 1.2 25.9
text 'U.S. GEOLOGICAL SURVEY'
move 41.5 26.5
text 'Open-File Report 99-144' lr
move 41.5 25.9
text 'Plate 1' lr
textfont 93711
textsize 0.6
move 13.75 5.5
text 'Digital Geologic Map of the Sandpoint 1-
by 2-degree quadrangle,' lc
move 13.75 4.8
text 'Washington, Idaho and Montana' lc
textsize 0.4
move 13.75 4.0
text 'by' lc
move 13.75 3.5
text 'Fred K. Miller, Russell F. Burmester,
David M. Miller,  Robert E. Powell and Pamela
D. Derkey' lc
move 13.75 3.0
text '1999' lc

&label explan
/* plot explanation - geologic units
shadedelete all
shadeset calcomp1
textfont 93711
textsize 0.25
move 25.75 25.0
text 'Explanation'
textsize 0.12
textquality proportional
textfont 94021
keyarea 25.75 2.8 43.5 24.5
keybox 0.6 0.35
keyseparation 0.2 0.2
keyshade %key1%

&label linekey
/*  plot explanation - line key
linedelete all
lineset geology.lin
/*keyarea 25.75 2.8 31.0 21.0
keybox 0.6 0.0
keyline %key2% nobox

&label disclaimer
textfont 93713
textquality proportional
textsize 0.12
move 38.9 2.2
textfile %disclaimer%

&label credits
/*list credits
textfont 93713
textquality proportional
textsize 0.12
move 21.75 7.1
textfile sandcrd.txt

&label proj
/*plot map projection notes
textfont 93713
textquality proportional
textsize 0.12
move 2.0 7.0
text 'map projection: UTM, zone 11'

&label scale
/* plot scale bars
linedelete all
lineset plotter
textfont 94021
```

```
textsize 0.12
&r scale2a 13.75 2.55 other 250000

&label references
/* list references
textfont 93711
textsize 0.25
textcolor 1
move 38.9 10.5
text 'References'
move 38.9 10.25
textsize 0.12
textquality proportional
textfont 94021
textfile sandref.txt

&label index-map
plot index_sd.gra box 38.9 3.25 41.9 5.25
textfont 93713
textquality proportional
textsize 0.12
move 38.9 3.125
text 'Index map showing Sandpoint quadrangle'

&label lat-long
/* plot neat line labels (latitude and longitude)
mape %quad%
linecolor 1
mapprojection geo.prj u11.prj
neatline -118 48.0 -116 49.0 geo.prj
neatlinehatch 0.25 0.25 0.2 0 geo.prj
textset font.txt
textsymbol 1
textsize 8 pt
textstyle typeset
textoffset -0.35 0.15
neatlinelabels 0.25 top all geo.prj dms
'%1%!pat1857; %2%!pat1727; %3%!pat1728'
textoffset -0.75 0.0
neatlinelabels 0.25 left all geo.prj dms
'%1%!pat1857; %2%!pat1727; %3%!pat1728'

&label done
quit
display 9999 3
draw sand250k
&return
```

Appendix D - Metadata file (sand250k.met) for the Sandpoint GIS

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Fred K. Miller
      Originator: Russell F. Burmester
      Originator: David M. Miller
      Originator: Robert E. Powell
      Originator: Pamela D. Derkey
      Publication_Date: 1999
      Title:
        Digital geologic map of the Sandpoint 1- by 2-degree quadrangle,
        Washington, Idaho, and Montana
      Edition: version 1.0
      Geospatial_Data_Presentation_Form: map
      Series_Information:
        Series_Name: Open-File Report 99-144
        Issue_Identification: sand250k.e00
      Publication_Information:
        Publication_Place: Spokane WA
        Publisher: U.S. Geological Survey

      Online_Linkage: URL = http://pubs.usgs.gov/of/1999/0144/
  Description:
    Abstract:
      The geology of the Sandpoint 1:250,000 quadrangle, Washington, Idaho, and Montana was mapped by F.K. Miller, R.F. Burmester, D.M. Miller, and R.E. Powell between 1963 and 1995 onto a scale-stable 1:250,000 topographic map base and subsequently input into an Arc/Info geographic information system (GIS) by P.D. Derkey. The digital geologic map database can be queried in many ways to produce a variety of derivative geologic maps.

    Purpose:
      This dataset was developed to provide geologic map GIS of the Sandpoint 1:250,000 quadrangle for use in future spatial analysis by a variety of users.

      This database is not meant to be used or displayed at any scale larger than 1:250,000 (e.g., 1:100,000 or 1:24,000).

    Supplemental_Information:
      This GIS consists of one major Arc/Info dataset: a line and polygon file (sand250k) containing geologic contacts and structures (lines) and geologic map rock units (polygons and lines).

  Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 1999
    Currentness_Reference: publication date

```
Status:
  Progress: In progress
  Maintenance_and_Update_Frequency:
    Will update with new geologic map data
    model, perhaps in 1999.

Spatial_Domain:
  Bounding_Coordinates:
    West_Bounding_Coordinate: -118.0
    East_Bounding_Coordinate: -116.0
    North_Bounding_Coordinate: 49.0
    South_Bounding_Coordinate: 48.0

Keywords:
  Theme:
    Theme_Keyword_Thesaurus: none
    Theme_Keyword: geology
    Theme_Keyword: geologic map
  Place:
    Place_Keyword_Thesaurus: none
    Place_Keyword: Idaho
    Place_Keyword: Washington
    Place_Keyword: Montana
    Place_Keyword: Sandpoint
    Place_Keyword: Pacific Northwest
    Place_Keyword: USA

Access_Constraints:

Use_Constraints:
  This digital database is not meant to be used or displayed at
  any scale larger than 1:250,000 (e.g., 1:100,000 or 1:24,000).

  Any hardcopies utilizing this data set shall clearly indicate
  its source.  If the user has modified the data in any way
  they are obligated to describe the types of modifications they
  have performed on the hardcopy map.  User specifically agrees
  not to misrepresent these data, nor to imply that changes they
  made were approved by the U.S. Geological Survey.

Point_of_Contact:
  Contact_Information:
    Contact_Person_Primary:
      Contact_Person: Fred K. Miller
      Contact_Organization: U.S. Geological Survey
    Contact_Position: geologist
    Contact_Address:
      Address_Type: mailing and physical address
      Address: 904 W. Riverside Ave., Rm. 202
      City: Spokane
      State_or_Province: WA
      Postal_Code: 99201
      Country: USA
```

Contact_Voice_Telephone: 1-509-368-3121
Contact_Facsimile_Telephone: 1-509-368-3199
Contact_Electronic_Mail_Address: fmiller@usgs.gov

Data_Set_Credit:
F.K. Miller, R.F. Burmester, D.M. Miller and R.E. Powell mapped the geology onto stable-base material;
Optronics Specialty Co., Inc. scanned the geologic map and provided minimally attributed Arc/Info interchange-format files to the USGS;
Pamela D. Derkey (USGS) imported the files in Arc/Info, transformed them to UTM zone 11 (with a y-shift) and attached and attributed an interim geologic map data model.

Native_Data_Set_Environment:
SunOS, 5.5.1, sun4u UNIX
ARC/INFO version 7.1.1

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
Attribute accuracy was verified by manual comparison of the source with hard copy printouts and plots.

Logical_Consistency_Report:
Polygon and chain-node topology present.
Polygons intersecting the neatline are closed along the border.
Segments making up the outer and inner boundaries of a polygon tie end-to-end to completely enclose the area. Line segments are a set of sequentially numbered coordinate pairs. No duplicate features exist nor duplicate points in a data string. Intersecting lines are separated into individual line segments at the point of intersection. Point data are represented by two sets of coordinate pairs, each with the same coordinate values. All nodes are represented by a single coordinate pair which indicates the beginning or end of a line segment. The neatline was generated by mathematically generating the four sides of the quadrangle, densifying the lines of latitude and projecting the file to UTM zone 11 (with a y-shift).

Completeness_Report:
All geologic units were mapped in the field at scales ranging from 1:24,000 to 1:62,500 and compiled at a scale of 1:250,000.
In general, the minimum mapping unit is from 1 to 3 acres.
Some small units and those obscured by dense forest cover may not be included in this dataset.

Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
The horizontal positional accuracy for the digital data is no better than +/- 24 meters based on the transformation RMS error.
It was tested by visual comparison of the source with hard copy

plots.

Lineage:
Process_Step:
Process_Description:
Geologic map information was compiled from field sheets
on to a stable-base copy of the USGS Sandpoint 1:250,000-scale
topographic quadrangle map and manually labeled.
Process_Description:
Stable-base map was scanned and converted from
a raster to a vector format (in scanner units).
Process_Description:
Digital files were transformed to UTM zone 11 (meters),
with a RMS error (input,output) = (0.004, 24.177), and
attributed using an interim geologic map data model.
The data were checked for position by comparing plots
of the digital data to the source.
Process_Date: 1997-1998

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Point
Point_and_Vector_Object_Count: 6929
SDTS_Point_and_Vector_Object_Type: String
Point_and_Vector_Object_Count: 16801
SDTS_Point_and_Vector_Object_Type: GT-polygon composed of chains
Point_and_Vector_Object_Count: 6930

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 11
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: implied
Longitude_of_Central_Meridian: implied
Latitude_of_Projection_Origin: implied
False_Easting: 0.000
False_Northing: -5,000,000 meters
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: not determined
Ordinate_Resolution: not determined
Planar_Distance_Units: METERS
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1927
Ellipsoid_Name: Clarke 1866
Semi-major_Axis: 6378206.4
Denominator_of_Flattening_Ratio: 294.98

Entity_and_Attribute_Information:
  Overview_Description:
    Entity_and_Attribute_Overview:
      The 'Digital geologic map of the Sandpoint 1:250,000 quadrangle,
      Washington, Idaho, and Montana' Open-File Report 99-xxx text contains
      a detailed description of each attribute code and a reference to
      the associated map symbols on the map source materials.
      The GIS includes a geologic linework arc attribute table,
      sand250k.aat, that relates to the sand250k.con (contact look-up
      table), sand250k.str (structure look-up table), sand250k.lgu
      (linear geologic unit look-up table) and sand250k.sr1 and
      sand250k.sr2 (source reference look-up tables) files; a rock unit
      polygon attribute table, sand250k.pat, that relates to the
      sand250k.ru (rock unit look-up table) and the sand250k.sr1 and
      sand250k.sr2 (source reference look-up tables) files.
    Entity_and_Attribute_Detail_Citation:
      Please see the Open-File Report text for a complete
      description of entities and attributes.

Distribution_Information:
  Distributor:
    Contact_Information:
      Contact_Organization_Primary:
        Contact_Organization: U.S. Geological Survey Information Services
      Contact_Address:
        Address_Type: mailing and physical address
        Address: Open-File Reports, Box 25286
        City: Denver
        State_or_Province: CO
        Postal_Code: 80225
        Country: USA
      Contact_Voice_Telephone: 1-303-202-4200
      Contact_Facsimile_Telephone: 1-303-202-4693

    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Pamela D. Derkey
        Contact_Organization: U.S. Geological Survey
      Contact_Position: Database Administrator
      Contact_Address:
        Address_Type: mailing and physical address
        Address: 904 West Riverside, Rm. 202
        City: Spokane
        State_or_Province: WA
        Postal_Code: 99201
        Country: USA
      Contact_Voice_Telephone: 1-509-368-3114
      Contact_Facsimile_Telephone: 1-509-368-3199
      Contact_Electronic_Mail_Address: pderkey@usgs.gov

Distribution_Liability:
The U.S. Geological Survey (USGS) provides these geographic data "as is." The USGS makes no guarantee or warranty concerning the accuracy of information contained in the geographic data. The USGS further makes no warranties, either expressed or implied as to any other matter whatsoever, including, without limitation, the condition of the product, or its fitness for any particular purpose. The burden for determining fitness for use lies entirely with the user. Although these data have been processed successfully on computers at the USGS, no warranty, expressed or implied, is made by the USGS regarding the use of these data on any other system, nor does the fact of distribution constitute or imply any such warranty.

In no event shall the USGS have any liability whatsoever for payment of any consequential, incidental, indirect, special, or tort damages of any kind, including, but not limited to, any loss of profits arising out of use of or reliance on the geographic data or arising out of the delivery, installation, operation, or support by USGS.

This digital geologic map GIS of the Sandpoint 1:250,000 quadrangle, Washington, Idaho, and Montana is not meant to be used or displayed at any scale larger than 1:250,000 (e.g., 1:100,000 or 1:24,000).

Metadata_Reference_Information:
Metadata_Date: 19990303
Metadata_Review_Date:
Metadata_Future_Review_Date:
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey
Contact_Person: Pamela D. Derkey
Contact_Position: geologist
Contact_Address:
Address_Type: mailing and physical address
Address: 520 N. Park Avenue, Room 355
City: Tucson
State_or_Province: AZ
Postal_Code: 85719-5035
Country: USA
Contact_Voice_Telephone: 1-520-670-5573
Contact_Facsimile_Telephone: 1-520-670-5571
Contact_Electronic_Mail_Address: pderkey@usgs.gov

Metadata_Standard_Name:
  FGDC Content Standards for Digital Geospatial
  Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Access_Constraints: none
Metadata_Use_Constraints: none