Preliminary geologic map of the Colville Indian Reservation, Ferry and Okanogan Counties, Washington

Compiled by

Brian F. Atwater and C. Dean Rinehart

With a table of potassium-argon ages compiled by

Robert J. Fleck

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Contents

Introduction ........................................... 1
Portrayal of geologic age on plate 4 .................. 1
Acknowledgements ...................................... 2
Description of map units .............................. 2
  Surficial materials (units 1 and 2) ................... 2
  Younger plutonic rocks and related hypabyssal and volcanic rocks ... 3
    Extrusive rocks (units 3 and 4) ..................... 3
  Hypabyssal intrusive rocks (units 5 and 6) ............ 3
  Plutonic rocks (units 7-17) .......................... 4
  Brecciated rocks (units 18 and 19) ................. 5
Characteristically mylonitic rocks of the gneiss domes (units 20-24) .. 6
Older plutonic rocks .................................. 7
  Hornblende-free rocks (units 25-36) .................. 7
  Hornblende-bearing rocks (units 37-46) .......... ... 9
  Mixed rocks (units 47-50) ......................... 10
Non-mylonitic metamorphosed rocks—sedimentary and mafic igneous (units 51-58) ... 11
References .............................................. 15
Conventional symbols .................................. 16
Additional symbols ..................................... 19

Tables

Table 1. Potassium-argon ages from volcanic and intrusive rocks of the Colville Indian Reservation .............................. 13

Illustrations

Figure 1. 15-minute and 30- by 60-minute quadrangles in the Colville Indian Reservation .................................................. 11
2. Sources of geologic mapping ........................... iii
3. Large-scale geologic map of type area for the hypabyssal intrusive suite of Cody Lake, by Grace McCarley and R. Wade Holder ......................................... iv
Figure 1.—15-minute and 30- by 60-minute quadrangles in the Colville Indian Reservation.
1. Campbell, A. B.—1963–64(?)

2. Campbell, A. B., and Raup, O. B. (1964)


9. Staatz, M. H. (1964)


Figure 2.—Sources of geologic mapping. Numbers 2, 4, 9, and 15b: published maps cited in reference list; date is that of publication. Others: unpublished mapping; dates indicate field work.
Figure 3.--Large-scale geologic map of type area for hypabyssal intrusive suite of Cody Lake, by Grace McCarley and R. Wade Holder. Country rock (the granite of Daisy Trail) is riddled by the Cody Butte. Seventeenmile Mountain quadrangle, about 1 mi south of Twentythree Mile Creek.
The accompanying map presents a generalized view of the bedrock geology of the Colville Indian Reservation, northeastern Washington. The Reservation, covering about 2,175 mi² in Okanogan and Ferry Counties, is bounded on the south and east by the Columbia River, on the west by the Okanogan River, and on the north by a number of lakes (figs. 1, 2). Plutonic rocks predominate but metamorphic, hypabyssal-intrusive, and volcanic rocks also cover large areas. J. T. Pardee (1918), during a two-summer reconnaissance, sketched the distribution of eight of the principal rock types on a primitive 1:250,000-scale base. Subsequent geologic and topographic mapping at scales of 1:62,500 and larger allows delineation of the 72 bedrock units whose distribution and distinguishing character are the subjects of this open-fill report. Nearly all of the bedrock mapping on the reservation since Pardee's reconnaissance, has been done during the past 25 years (figs. 1, 2). During the 1950's and 1960's, U.S. Geological Survey work in the eastern half of the reservation yielded three published 15-minute quadrangles—Bald Knob (Staatz, 1964), Hunters (Campbell and Raup, 1964), and Wilmont (Van Eys, 1965). A reconnaissance of the Inachelm quadrangle (by Arthur B. Campbell), and Twin Lakes quadrangle (by George E. Becraft). To the west, Newcomb (1937) mapped part of the Disautel quadrangle; Snook's (1965) 1:137,000-scale map includes part of the Omak Lake quadrangle; L. G. Fritz (1978) made a reconnaissance of the Okanogan and Bridgeport quadrangles at a scale of 1:62,500; and large-scale maps by Broch (1979) and Gruzius (1982) cover parts of the Alamada Flat quadrangle. Interest in molybdenum deposits led to mining-company mapping during the 1970's in the vicinity of Mount Tolman, near Keller. Some of the Mount Tolman mapping is presented at a scale of 1:6,000 by Cochran and Warlow (1980), and much of the rest is summarized in an unpublished, 1:24,000-scale compilation that was begun by S. A. Mellon and completed in 1980 by William C. Utterbeck. A nearby molybdenum deposit in the Wilbur quadrangle was mapped by R. O. White (1961). The most recent work, which has led to the present map, was carried out during the period 1980-1983 by the Geological Survey at scales of 1:24,000 and 1:62,500. In addition to Atwater and Rinehart, persons primarily responsible for that mapping are Diane H. Carlson, Kenneth F. Fox, Jr., John W. Goodge, Vicki L. Hansen, R. Wade Holder, James P. Minard, Palas J. Noye, and Stephen H. Singer.

The present map was compiled on newly prepared Geological Survey 1:100,000-scale base maps by manually transferring the geology from clear-film photographic reductions made from the larger-scale maps. Only minor generalization of the geology was necessary, mainly for clarity in cluttered areas, and for continuity where compilers prerogative made merging of some units seem appropriate, or necessary. Atwater is primarily responsible for generalization, and also for compiling descriptions of map units, in the Nespelm and Coulee Dam 1:100,000 quadrangles; Rinehart is primarily responsible for these things in the Omak 1:100,000 quadrangle.

Five of the map units were previously given formal names—Columbia River Basalt Group, Sanpoil Volcanics, O'Brien Creek Formation, Tonasket Gneiss, and Colville Group. But none are used herein. Plutonic nomenclature follows that recommended by Streckeisen (1973). Minerals modifying a rock name (for example, biotite-hornblende diorite) are listed in order of increasing abundance; minerals shown in parentheses—for example, (muscovite)-biotite granite—are present only locally. CI denotes color index. The term "aplo-pegmatite" denotes assemblages of aplite, alaskite, and pegmatite. "Miles" rather than "kilometers" are used as standard units of distance because the land net is based on miles.

We use "gneiss dome" as a purely descriptive term for structures defined by mylonitic rock that grades downward into non-mylonitic gneiss and granite. The term was applied to our study area by Fox, Rinehart, Engels, and Stern (1976). We prefer "metamorphic core complex" (Conen, 1980, p. 10, 25-26) or simply "dome" (Cheney, 1980). One of the gneiss domes (Lincoln gneiss dome) has not been recognized previously. All of the gneiss domes in the map area are highly asymmetric: the boundary between mylonite and carapace, shown on the map as a low-angle fault, is exposed only on the west side of the western (Okanogan) gneiss dome and only on the east side of each of the eastern (Kettle and Lincoln) gneiss domes. These gneiss domes may represent but a single gneiss dome, bisected by the Republic and Keller grabens.

PORTRAYAL OF GEOLOGIC AGE ON PLATE 4

Plate 4 shows the known or inferred age of each map unit relative to other units and relative to several divisions of geologic time. A solid-line box shows the age of lithologic features that characterize the unit; a dashed-line box shows age of the protolith (p) of rock that characteristically has been reconstituted (r) by metamorphism, brecciation, or hydrothermal alteration. Lengths of boxes indicate allowable age range; the actual age range may be less. Box length is not necessarily proportional to absolute time.

Potassium-argon ages (for example, 49.4 ± 0.3 m.y.) are given only for samples from the map area. Minerals dated are (b) biotite, (h) hornblende, (m) muscovite, K (K-feldspar), and (s) sericite. Analytical data are presented in table 1; samples are located by coordinates in that table and by circled dots on the map itself (plates 1-3).

Vertical positions of many unit boxes in plate 4 depend at least partly on one or more of three presumptive datums. (1) Solidification of the hornblende-bearing granitoid rocks of Swimptkin Creek and the diorite of Devils Elbow. Both of these units yield nearly concordant hornblende and biotite K/Ar ages near 49 m.y. (2) Solidification of the porphyritic granite of Coyote Creek, the porphyritic granite of Keller Butte, and the relatively old parts of the granite of Daisy Trail. These rocks appear to be approximately coeval because of similarities in lithology (all are greenish-gray, porphyritic, medium-grained granite) and relative age (all are probably intermediate between the porphyritic granodiorite of Manila Creek and the hypabyssal porphyry of Cody Lake). The discrepancy in biotite K/Ar ages between the Keller Butte (about 60 m.y.) and the Coyote Creek and Daisy Trail (both about 50 m.y.) can be explained by differences in history of cooling and solidification (compare Fox and others, 1977, p. 12-13). (3) Mylonitic deformation associated with formation of the gneiss domes. We presume that the Okanogan, Kettle, and Lincoln gneiss domes underwent mylonitization at about the same time, there being no evidence to the contrary. We further presume that this mylonitization is mostly older than datum (1) and entirely younger than datum (2). The Swimptkin Creek and Devils Elbow [datum (1)] cut (or) contain
inclusions of penetratively mylonitized rock and are themselves scarcely mylonitic. By contrast, gneiss-dome mylonite cuts, but is not cut by, the porphyritic granite of Coyote Creek and relatively old parts of the granite of Daisy Trail [datum (2)]. Possibly the Coyote Creek solidified late in the period of gneiss-dome mylonitization (Fox and others, 1976, p. 1221); mylonitic foliation and sinuation of the Okanogan gneisses die out within the Coyote Creek, south-eastward along the strike of the gneiss-dome border. But this change appears to begin northwest of the Coyote Creek, in the plutonic complex of Boot Mountain, whose non-mylonitic parts are largely or wholly pre-Tertiary and probably predates the gneiss dome. Plate 4 therefore incorporates the view that the mylonitic border of the Okanogan gneiss dome loses definition southeastward with truncation by the porphyritic granite of Coyote Creek.

Dotted lines in Plate 4 group map units that are mylonitic at least locally within the indicated gneiss dome. These lines extend below the presumed age-range of mylonitic deformation in order to enclose the Coyote Creek and the Daisy Trail, predominantly non-mylonitic rocks whose boxes in plate 4 show inferred age of solidification rather than inferred age of mylonitization.

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Sediment and basalt are thinner than 100 m in most areas.

UNCONSOLIDATED DEPOSITS (Quaternary) — Glacial, alluvial, lacustrine, eolian, and landslide deposits conservatively shown as covering about one quarter of the reservation. The glacial deposits are primarily till, the known southern limit of which largely defines the terminal ice margin shown on the map. Erratic boulders known beyond the inferred ice margin lie no higher than altitudes of 200 m, to which they could have been rafted by barges (Atwater, 1983, p. 11). Age of most exposed till probably late Wisconsin; till dating from any earlier glaciation has yet to be reported from the reservation. The alluvial deposits consist mainly of terrace-forming gravel, most of it probably recessional outwash, and fan deposits, mostly rehandled drift. Lacustrine deposits, mainly well-bedded silt and clay, are particularly abundant in the Columbia River Valley, the lower Sappoill River Valley (Keller and Wilbur quadrangles), and in French Valley (Omak Lake and Disautel quadrangles). The lake in the Columbia and Sappoill River valleys (glacial Lake Columbia) formed behind the Okanogan lobe of the Cordilleran ice sheet, which blocked the Columbia as far upstream as Grand Coulee Dam during the last glaciation (Flint, 1935). In the Sappoill River valley, rhythmic interbedding between sandy, normally graded beds and sets of silt-and-clay varves suggests that floods from another ice-dammed lake — probably Lake Missoula, Montana — periodically engulfed Lake Columbia (Atwater, 1983). Deposits of saline post-glacial lakes southeast of Omak consist primarily of calcareous silt but also, at least at White Lake (Omak Lake quadrangle), include coarse vitric-crystal ash of Glacier Peak layer B or C (unpub. correlation by A. M. Sarna-Wojcicki and C. E. Meyer, 1982, based on major-element chemistry of glass; age about 11,200 14C years according to major-element field assistance of A. M. Sarna-Wojcicki and C. E. Meyer (unpub. data, 1982); age between 6000 and 7000 14C years according to Lemke and others, 1975, p. 19-22). Lithologically similar ash is also interbedded with non-glacial alluvium: about 1 m east of the mouth of Wanacut Creek, and in a gravel pit 2.5 mi southwest of St. Mary's Mission (Omak Lake Quadrangle); in a bank of Manila Creek 2.5 mi west-northwest of its mouth, and in banks of Sclome Creek at Sclome Meadow (Keller quadrangle); and in at least two places on the north shore of Franklin D. Roosevelt Lake 0.5-5.0 mi east of Grand Coulee Dam. Additionally, an ash suspected to be Mazama is interbedded with landslide.
deposits at the mouth of Falls Creek (Wilmont Creek quadrangle). Most landslide deposits on the reservation involve glacio-
lacustrine deposits of the Columbia and Sampoil River valleys, and most of these landslide deposits have formed since
construction of Grand Coulee Dam (Jones and others, 1961)

COLUMBIA RIVER BASALT GROUP (Miocene)—Dark-
gray aphric basalt forming extensive flows. Partly covered by drift and locally
interbedded with sedimentary rocks south-west of Omak Lake; partly covered by loess and perhaps also by Miocene (?) alluvial-fan
deposits beside Hellgate Canyon (Wilbur quadrangle)

YOUNGER PLUTONIC ROCKS AND RELATED
HYPABYSSAL AND VOLCANIC ROCKS

This igneous complex, mostly recognized by Pardee (1918), comprises granitoid rocks, some near the
Republic and Keller grabens, others farther west in the Okanogan gneiss dome; hypabyssal intrusive rocks,
widely distributed but also concentrated as dikes swarms flanking the grabens; lava flows and tuff,
found primarily in the grabens; and minor brecciated rocks. Some of the hornblende-bearing flows, dikes,
and plutons in the complex are probably comagmatic (Pardee, 1918, p. 39). Most of the hornblende-free
granitoid rocks that we place in the complex either
are the only hornblende-free rocks known to
underlies Sanpoil Volcanics in northeastern
Washington (Pearson and Obradovich, 1977). Probably correlates with the
Sanpoil Volcanics that apparently rest on the crystalline floor of the southern end of
the Republic graben (Nespelem quadrangle)

O'BRIEN CREEK FORMATION (Eocene)—Light-colored
epiclastic and pyroclastic rocks, mostly
pyroclastic and epiclastic. Underlies but
nowhere overlies typical dark, quartz-poor, hornblende-rich Sanpoil Volcanics. Except
for local presence of hornblende, resembles the O'Brien Creek Formation, which widely

HYPABYSSAL INTRUSIVE SUITE OF CODY LAKE

Hypabyssal intrusive rocks

INTRUSIVE RHYOLITE NEAR WEST FORK (Eocene)—
Forms light-colored dikes and plugs intruding upper unit of Sanpoil Volcanics in eastern part of Republic graben (Seventeen-
mile Mountain quadrangle). Sole phenocryst is fine-grained biotite, set in a glassy groundmass or in a devitrified groundmass of quartz and feldspar. These are the only hornblende-free rocks known to intrude Sanpoil Volcanics in the map area. Probably youngest hypabyssal intrusions in the map area, and possibly comagmatic with the granite of Deadhorse Creek and with splotie dikes (not shown on map) cutting the intrusive suite of Cody Lake. K/Ar age about 50 m.y. (table 1)

HYPABYSSAL INTRUSIVE SUITE OF CODY LAKE

(Eocene)—Porphyritic rocks of intermediate and acidic composition forming dikes and other small or narrow intrusions. Most voluminous as swarms of narrow intrusions flanking Republic and Keller grabens and extending south of these grabens. Shading

Hypabyssal intrusive rocks

Upper unit—Dark-colored rocks, mostly lava
flows, with quartz phenocrysts scarce or absent, and hornblende and(or) augite at least as abundant as biotite. Pyroclastic rocks shown by pattern of ovals, epiclastic rocks by coarse stipple, autoclastic breccia by solid triangles

Lower unit—Light-colored hornblende-quartz-
biotite-plagioclase rocks, largely
pyroclastic and epiclastic. Underlies but
nowhere overlies typical dark, quartz-poor, hornblende-rich Sanpoil Volcanics. Except
for local presence of hornblende, resembles the O'Brien Creek Formation, which widely

Probably correlates with the
Sanpoil Volcanics that apparently rest on the crystalline floor of the southern end of
the Republic graben (Nespelem quadrangle)

Sano poil Volcanics elsewhere in northeastern
Washington (Pearson and Obradovich, 1977,
p. 23, 40). In most of Republic graben
(Bald Knob and Nespelem quadrangles), shown as a single unit, interstitially stippled in Nespelem quadrangle where abundantly tuffaceous. In Keller graben (Keller quadrangle), and in an eastern part of Republic graben (Seventeenmile Mountain quadrangle, east of dotted meridian),
Phenocrysts of plagioclase along with a few percent phenocrysts of biotite; some also contain phenocrysts of quartz. Dark-colored, hornblende-bearing, quartz-poor or quartz-free intrusions cut across light-colored, hornblende-free, quartz-bearing intrusions and also cut both the O'Brien Creek Formation and Sampol Volcanics. Hornblende-free intrusions, in contrast, cut the O'Brien Creek but not the Sampol despite a great abundance of hornblende-free porphyry in dikes swarms flanking the eastern sides of the Republic and Keller grabens. These age relationships, together with petrologic similarities between intrusive and extrusive sequences, suggest that hornblende-free porphyry is an intrusive equivalent of the O'Brien Creek Formation, and that much of the hornblende-bearing porphyry is an intrusive equivalent of the Sampol Volcanics. All hypabyssal porphyry contains hornblende where known to cut the porphyritic granodiorite of Mission Creek, the diorite of Devil's Elbow, the granodiorite of Joe Moses Creek, the granite of west of Armstrong Mountain, and the plutonic complex of Johnny George Mountain. All porphyry known to cut Reed Creek quartz diorite gneiss lacks hornblende and contains phenocrysts of quartz. Excepting these occurrences, and excepting porphyry cutting Sampol Volcanics, rock units shown as cut by hypabyssal porphyry are cut by both hornblende-free and hornblende-bearing varieties, commonly but not always in the same area. Age of hornblende-bearing porphyry about 47-50 m.y. Judging from K/Ar dates on three dikes in Republic graben (table 1).

Plutonic rocks

**Tvg**

**VARIED GRAINNEAR STEPHSTONE CREEK (Eocene)—**

Massive, fine- to medium-grained leucocratic (CI 5) granite that shows marked textural variations at outcrop scale. Forms mapped and unmapped bodies, along and near Stepstone Creek between Moses Mountain and Little Moses Mountain, that cut the main phase of the granite of Moses Mountain and also cut local mapped and unmapped bodies of the diorite of Little Moses Mountain. Also includes, for convenience, a plug of fine-grained biotite granite that crosses Stepstone Creek 3 mi northwest of Gold Lake.

**Tg**

**GRANITE OF DEADHORSE CREEK (Eocene)—**Biotite granite forming stocks scattered near eastern margin of Republic graben. Fine-grained, equigranular, and light gray to light brown where intruded into the quartz monzonite of Seventeenmile Mountain and into the granite of Daisy Trail; but medium-grained, and commonly seriate and pink where intruded into the diorite of Devils Elbow. K/Ar biotite age (table 1) about 50 m.y. May be plutonic equivalent of the intrusive rhyolite near West Fork.

**Td1**

**DIORITE OF LITTLE MOSES MOUNTAIN (Eocene)—**

Massive, fine- to medium-grained hornblende diorite exposed primarily in mapped and unmapped bodies along the valley of Stepstone Creek between Moses Mountain and Little Moses Mountain. These bodies are in the same general area as the varied granite of Stepstone Creek; some are known to intrude the main phase of the granite of Moses Mountain and(or) to be cut by dikes of the Stepstone Creek. Also included in unit is a narrow body of diorite that cuts the Moses Mountain north of Looney Creek (Bald Knob quadrangle).

**Tgd 10**

**GRANODIORITE OF JOE MOSES CREEK (Cretaceous)—**Fine- to medium-grained inequigranular hornblende-biotite granodiorite forming a stock that cuts the porphyritic granite of Keller Butte (near Sherman fault, Nespelem quadrangle) and forming several nearby pods cutting the diorite of Devils Elbow. Also present, but not shown on map, as small masses among hypabyssal-porphyry dikes east of Keller graben between John Tom Creek and Columbia River (Keller and Wilbur quadrangles). Cut by hornblende-bearing dikes of the hypabyssal intrusive suite of Cody Lake. Distinguished from diorite of Devils Elbow by low color index (typically less than 5) and presence of fine-grained groundmass.

**Tqm 11**

**QUARTZ MONZONITE OF SEVENTEENMILE MOUNTAIN (Eocene)—**Inequigranular, medium-grained, hornblende-biotite quartz monzonite intruded into diorite of Devils Elbow near Seventeenmile Mountain. Also shown as border to the granite of Deadhorse Creek in stocks intruding the granite of Daisy Trail. Commonly pink to brown.

**Tgs 12**

**HORNBLende-BEARING GRANITOID ROCKS OF SWIMPTKIN CREEK (Cretaceous)—**Medium-grained equigranular hornblende-biotite quartz monzonodiorite to granodiorite (CI 10-25) forming a large pluton that extends southward from the northern border of the map about 14 mi east of the Okanogan River. Accessory sphene is generally present. Inclusions of hornblende gabbro, diorite, and paragneissic country rocks are common, the latter composing numerous roof pendants that are widely distributed across the west-central part of the pluton. Metamorphic grade in the inclusions and roof pendants is as high as the sillimanite zone of the amphibolite facies; some of the inclusions resemble mylonitic rocks of the Okanogan gneiss dome (Fox and others, 1976, p. 1221). Grain size is locally very coarse in some of the inclusions and roof-pendant rocks, and the pluton itself shows a wide variety of coarse and unusual textures and compositions near metamorphic rocks. Little is exposed of the pluton's southeastern lobe, which underlies the topographic basin of Moses Meadow, but contacts observed there dip gently outward or are horizontal. The rocks in the southeastern lobe also appear to be somewhat more homogeneous and slightly finer grained. Throughout most of the pluton the rocks are massive but both flow foliation and mylonitic fabric of the Okanogan gneiss dome are locally present in the westernmost parts. Near the southwestern contact with the Clark Creek phase of the granite of Moses Mountain, the latter clearly cuts the Swimptkin Creek, but along and near Mackey Ridge, bordering Moses Meadow on the northeast, excellent exposures of the contact with the main phase of the granite of Moses Mountain show age relations that are equivocal. K-Ar dates on biotite and hornblende are...
about 49 m.y. except for a hornblende age of 45 m.y. that is probably erroneous (table 1)

GRANITE OF MOSES MOUNTAIN (Eocene)---Large composite pluton of (muscovite)-biotite granite that lies northwest of Nespelem and extends to the northern boundary of the reservation. Nears the unit, undivided granitic rocks near Gold Creek, along the common boundary of the Disautel and Bald Knob quadrangles, from Steptoe Creek to North Star Creek. This is the result of an attempt in 1980-1983 to distinguish individual plutons within granitic terrane referred to as "Colville batholith" by earlier workers. Much of that terrane in the Bald Knob quadrangle was not examined by USGS mappers in 1980-1983

Tgm 13 Main phase---Coarse (3 mm av), leucocratic (CI 5), in places seriately porphyritic with 1-2 cm subhedral K-feldspar phenocrysts. Quartz is dark gray. Generally massive, the rocks are locally deformed by weak to moderate mylonitic fabric with lineation parallel to that of the Okanogan gneiss dome. Biotite is the only dark mineral, excluding sparse, dispersed aggregates of magnetite. Muscovite is not uncommon but is sparse; some is secondary but some may be primary

Tgmc 14 Clark Creek phase---Distinguishable from main phase only by finer average grain size (2 mm) of the Clark Creek. Contacts with main phase typically gradational over 0.01-0.2 mi; zone of gradation even broader southeast of Moses Mountain and in the Lost Creek area. Massive except locally and in westernmost parts where the rocks show weak mylonitic fabric that becomes increasingly well developed westward. Thin dikes of probable Clark Creek phase cut and include rocks of the Swilmpkin Creek pluton near the eastern part of their mutual contact. K-Ar biotite age about 49 m.y. (table 1)

Tgmv 15 Whitelaw Creek phase---Varied in both texture and composition probably owing to contamination by metamorphic rocks that are moderately abundant but are generally too small to map. Ubiquitously associated with abundant pegmatite as dikes and masses of irregular shape, and with alaskite whose textures range from aplitic to pegmatitic, and which is commonly host to swarms of tiny pink to red garnet crystals. Contacts with the Clark Creek phase are gradational over tens of meters, but are typically abrupt with the porphyritic granite of Coyote Creek, which at one locality, is cut by a thin dike of the Whitelaw Creek. North and east of Strawberry Mountain (Bald Knob quadrangle), lacks metamorphic xenoliths and consists partly of fine-grained biotite-muscovite granite

Tge GRANITE WEST OF ARMSTRONG MOUNTAIN (Eocene)---Biotite-granite and granodiorite, medium-grained (2 mm av), equigranular, homogeneous, and leucocratic (CI 5), contains sparse but widespread sphenes and a trace of hornblende; forms a small pluton about 8 mi northwest of Nespelem. Probably younger than the porphyritic granite of Coyote Creek which encloses the entire pluton and which is cut in Coyote Canyon by granite dikes petrographically indistinguishable from the Armstrong Mountain. Cut by dikes of biotite-hornblende hypabyssal porphyry similar to rocks that are components of the nearby intrusive complex north of Grant Lake. K-Ar biotite age about 52 m.y. (table 1)

Tdd 17 DIORITE OF DEVILS ELBOW (Eocene)---Medium-grained, mostly equigranular (agite)-biotite-hornblende plutonic rocks ranging from diorite to tonalite, granodiorite, and granite. CI mostly 10-20 but locally up to 50. Typically contains accessory sphene. Forms Devils Elbow pluton, between Republic and Keller grabens; Ball Creek pluton, east of Republic; granite near Seventeenmile Mountain; Friedlander pluton, east of Keller graben beside Brody Creek fault; small intrusions north of Klondyke Creek in Seventeenmile Mountain quadrangle; and small intrusions cutting the plutonic complex of Johnny George Mountain along the shores of Franklin D. Roosevelt Lake in the Lincoln quadrangle. Near Devils Elbow and south of Republic, granite appears to grade into hornblende-bearing parts of the hypabyssal-intrusive complex of Cody Lake. Cut by granodiorite of Joe Moses Creek, granite of Deadhorse Creek, a few hornblende-bearing dikes of hypabyssal porphyry, and aplite containing mafic microlitic cavities. Yields K/Ar ages between 44 and 51 m.y. (table 1). For convenience, also includes a small (0.2 mi²) body of diorite along the southwestern margin of the Republic graben about 2 mi southwest of Gold Lake, although that rock may be older than others included here, inasmuch as it is intruded by adjacent granitoid rocks (Staats, 1964, p. 23)

Brecelated rocks

Tic INTRUSIVE COMPLEX NORTH OF GRANT LAKE (Eocene)---Crops out as a small ellipsoidal body about 6 mi west of Nespelem. Consists mainly of hornblende-bearing and hornblende-free hypabyssal porphyry resembling the hypabyssal intrusive suite of Cody Lake; medium-grained (2 mm av) biotite-hornblende diorite, and medium-grained (1-2 mm) biotite granite. Some of the granite resembles the granite west of Armstrong Mountain. The diorite and perhaps also the granite locally contain partly digested pieces of hornblende-bearing hypabyssal porphyry; additionally the diorite contains sparse granitic inclusions referable to the Coyote Creek pluton. All rock types are commonly cut by a network of closely spaced faults of diverse orientations. Most or all of the faults post-date emplacement of the unit.

Bfs BRECCIA WEST OF FORT SPOKANE (Eocene)---Weakly consolidated tectonic breccia composed of granitic and volcanic rocks in generally heterogeneous distribution, but with local suggestion of subtle gently east-dipping layers showing crude alternating abundance of granitic and volcanic fragments. Limited to a narrow zone of discontinuous exposures 4 mi long along the western shore of Roosevelt Lake (Lincoln quadrangle). Fragment size ranges from less than a millimeter to about a meter. Varied degree
of clayey alteration commonly obscures identity of parent rock. Volcanic lithologies are similar to those exposed, undeformed, in nearby outcrops of Sanpoil Volcanics and hypabyssal equivalents. Most identifiable granitic fragments from the southernmost exposure are strongly lineated, resembling similar rocks to the west in the plutonic complex of Johnny George Moutain. Age range shown on correlation chart is that inferred for the brecciation.

CHARACTERISTICALLY MYLONITIC ROCKS OF THE GNEISS DOMES

tg
TONASKET GNEISS—High-grade gneiss and schist that form the southernmost part of a large body, west of the Okanogan River, that extends about 30 mi north of Omak (Fox and others, 1976). Includes hornblende-biotite gneiss, biotite-gneiss, K-feldspar augen gneiss, sillimanite-garnet-muscovite-biotite schist, biotite quartzite, amphibolite, pyroxene calc-silicate gneiss, and garnet-bearing alaskite gneiss. Fine-grained mafic rocks show pronounced mineral lineation and schistocity. Penetrative mylonitic foliation and lineation dominate the internal structure of the rocks in the western part of the unit. These structures, which intensify westward, are sparse east of the scalled line, and appear to postdate a high-grade dynamothermal metamorphism of the rock (Snook, 1965; Goodge, 1983). Intruded by porphyritic granodiorite of Mission Creek and by granodiorite of French Valley, probably before mylonitization.

hgg
GNEISSIC PORPHYRTIC GRANODIORITE OF MISSION CREEK—Extensive plutonic body lying east of Omak and north of Omak Lake. Light- to medium-gray, homogeneous, foliated, coarsely porphyritic rock of which 1-5 percent is composed of gray to pink K-feldspar megacrysts (2-8 cm), the remainder composed of an equigranular, medium-grained (0.5-5 mm) matrix of quartz, plagioclase, biotite, and minor K-feldspar, spherne, and iron oxides (CI=5-7). Contains numerous thin (0.5 m) dikes of aplite pegmatite and granite and tabular, rounded, dark inclusions of amphibolite and biotite schist (1m long). Penetrative mylonitic foliation and lineation become progressively less pronounced northeastward. Megacrysts locally show effects of mylonitic deformation as “tails” in plane of foliation. Contact with the plutonic complex of Boot Mountain is abrupt (<10 m); intrudes Tonasket Gneiss, and is intruded by hypabyssal dikes provisionally assigned to the hypabyssal intrusive suite of Cody Mountain. K-Ar biotite age about 47 m.y. (table 1)

hbg
Granitic gneiss—Biotite gneiss with or without muscovite, more homogeneous and probably older than granitic gneiss in the northeastern part of the Daisy Trail.

hbg
Orthogneiss of Onion Creek—Biotite gneiss restricted to a small band between Onion and Barnaby Creeks. Protolith possibly the granodiorite of Barnaby Creek or the granite and granodiorite near Meteor.

hp
Mafic gneiss—Contains biotite and hornblende; locally includes marble. Adjoins orthogneiss of Onion Creek.

hms
Metasedimentary gneiss—Biotite schist or quartzite, locally interlayered with (muscovite)-biotite granitic gneiss. Divided into:

hq
Quartzite—Unlayered to thinly layered

hgs
Quartzite and schist

hi
Interlayered quartzite, schist, and granitic gneiss

hp
Phyllite—Forms easternmost part of the Hall Creek at several places north and south of Hall Creek. Weakly lineated.

pcj
PLUTONIC COMPLEX OF JOHNNY GEORGE MOUNTAIN—Granitoid rocks characterized by marked variation in texture, grain size, and composition, occupy about 80 mi2 in the southeastern corner of the reservation. The rocks, most of which are light-colored (CI less than 5) and many of which are lineated, range from fine-grained aplite and alaskite, through equigranular and porphyritic (muscovite)-biotite granite (some of which resembles the granite of Swampia Basin), to pegmatite; also they include medium-grained sphenite-biotite-hornblende diorite whose principal occurrences are shown by stipple; and locally they are migmatitic. Large areas of relatively homogeneous granite are shown by crosses (rock mostly medium-grained and equigranular to seriate) and open.
Diverse granitoid rocks, mainly hornblende-free, make up most of what Pardee (1918) mapped as Colville batholith. Many of the rocks are known or suspected from field relations to predate Eocene rocks in the map area; some are known or suspected to postdate by location and relative age; in the following description they are grouped mainly by lithology.

Hornblende-free rocks

PORPHYRITIC GRANITE OF COYOTE CREEK—Forms a large pluton in the west-central part of the reservation that consists of coarse-grained and porphyritic granite. Typically contains large (11 cm) blocky K-feldspar megacrysts, abundant sutured quartz, fairly commonly as rounded crystals or aggregates 3-10 mm across, in a medium-grained equigranular matrix. A subordinate facies distinguished by rounded quartz phenocrysts and a finer, dark-colored granite. Forms large bodies in highlands (Nespelem, Grand Coulee Dam, and Keller quadrangles), also small bodies east of Sanpoil River near Hellgate Canyon (Wilbur quadrangle). Contains subequal amounts of plagioclase, orthoclase, and quartz, and less than 5 percent biotite. Closely resembles much of the granite of Moses Mountain cut by the Coyote Creek east of Omak Lake. K-Ar biotite age about 51 m.y. (table 1)
GRANITE OF SWAVILLA BASIN—Medium-grained, mostly equigranular, medium-grained, and porphyritic granite along Columbia River in southeasternmost part of reservation. Overlain, probably partially overlain, by Sanpoil Volcanics. Lack of lineation and foliation distinguishes this rock from nearby plutonic complex of Johnny George Mountain.

GRANITE OF DAISY TRAIL—Forms a large pluton, centered about 20 mi northeast of Keller, and ranges from relatively old, light-colored biotite granite, exposed mostly in the southwest, to well-linеated (muscovite)-biotite gneiss with relatively young aplo-pegmatite as its dominant protolith, exposed to the northeast in the Kettle gneiss dome. The Daisy Trail is also mapped as a fault-bounded aliver 7 mi north of Keller and as a stock 8 mi east of Keller; both of these bodies consist of medium-grained biotite granite that closely resembles the relatively old part of the large pluton northeast of Keller. Northeastern edge of this pluton grades into the Kettle gneiss dome: aplo-pegmatitic rocks of the Daisy Trail variously transect and interweave with mylonitic gneiss, quartzite, and schist in the gneiss dome; and light-colored biotite granite in the Daisy Trail is the probable protolith of (muscovite)-biotite gneiss in the gneiss dome. Western part of the pluton teems with dikes of the hypabyssal suite of Cody Lake (fig. 3), and south-central part hosts small intrusive masses of diorite, granodiorite, and quartz monzonite believed approximately coeval with the Cody Lake. Southern edge of the pluton intrudes Covada Group, and southeastern edge near Twin Lakes appears faulted against the Meteor pluton. In Seventeenmile Mountain quadrangle, metamorphic inclusions too small to delineate are shown by three-dot symbol. Relatively structureless and homogeneous parts of the pluton are dominated by medium- to coarse-grained, locally porphyritic granite containing roughly equal amounts of quartz, oligoclase, and orthoclase; this kind of rock closely resembles the porphyritic granites of Keller Butte and Coyote Creek. K/Ar biotite age, from medium-grained granite in south-central part of pluton, is 50 m.y. (table 1); but most of the pluton must have solidified before emplacement of the intrusive suite of Cody Lake, whose early dikes may be as old as 524 m.y. if the Cody Lake pluton is coeval with the Sanpoil Volcanics and O'Brien Creek Formation (see descriptions for the Cody Lake, Sanpoil, and O'Brien Creek).

GRANITE OF FELIX CREEK—Forming an elliptical pluton 3 mi wide and 5 mi long due south of Okanogan, the Felix Creek is composed of medium-grained, foliated granite with a varied Cretaceous fossil record. Identification is defined by biotite-rich schlieren that range from thin, wispy streaks to pronounced layers several feet thick. Large inclusions of Salmon Creek schist and gneiss occur, especially in the eastern part, with foliation around them particularly well developed. Contact with the porphyritic granite of Cook Lake is...
gradational and indistinct suggesting that the units are co-magmatic. The contact with the Salmon Creek is drawn at the approximate 30 percent volumetric limit of Salmon Creek in the Felix Creek.

EQUIGRANULAR GRANITE OF VIRGINIA LAKE—Four separate plutons of biotite granite lie on a slightly curved line about 25 mi long that extends east-southeastward from just east of Malott, on the Okanogan River, to the Columbia River at Hopkins Canyon. These plutons are correlated mainly on the basis of mutual petrographic similarity and relative-age data that at least allow the possibility of mutual contemporaneity. The rocks are massive, leucocratic, coarse grained to the east, medium and fine grained to the west. Eastern parts contain mafic inclusions that are probably from the plutonic complex of Boot Mountain, but in places, felsic rocks of the Boot Mountain appear to be gradational into the Virginia Lake. The body south of Omak Lake contains numerous inclusions of hornblende gabbro and hybrid derivatives; also it intrudes the Reed Creek quartz diorite gneiss of Menzer (1983). A property typical of all the rocks is their tendency toward mechanical disintegration. The westernmost body called ega, is fine-grained highly leucocratic rock intruding an opaline phase of the parent equigranular granite. The Virginia Lake is likely correlative with the Pogue Mountain quartz monzonite of Menzer (1983).

PORPHYRITIC GRANODIORITE OF MANILA CREEK—Medium- to coarse-grained biotite granodiorite and granite. It extends extensively but discontinuously in the southern part of the reservation between Hudnut Canyon on the west (Alameda Flat quadrangle) and Ninemile Creek on the east (Keller and Wilmont Creek quadrangles). In general, potassium feldspar present only as megacrysts, these mostly subequant, subhedral, and 3-5 cm long except near Ninemile Creek, where tabular. Locally abounds in meta-sedimentary xenoliths, the largest of which show on the map; also, west of Nespelem River, contains many aligned, disc-shaped mafic inclusions up to 1 m in diameter (Broch, 1979), some of which closely resemble fine-grained, sphere-bearing parts of the plutonic complex of Boot Mountain. Near Ninemile Creek, well-developed foliation and lineation are parallel with structures in the adjacent Cowda Group, but nearly perpendicular to overall strike of the Manila Creek's intrusive contact with the Cowda; elsewhere the Manila Creek is massive or weakly foliated. Color index 7-15; typical Manila Creek is darker than the granites of Daisy Trail and Swawilla Basin and also darker than the porphyritic granitoids of Keller Butte and Copper Creek. Near Mica Mountain (Grand Coulee Dam quadrangle) and Mount Tolman (Keller quadrangle), abundantly cut by aplopegmatite that may have come from Swawilla Basin and(or) the Keller Butte; similarly, aplopegmatite abounds in the Manila Creek near its contact with the Daisy Trail west of Ninemile Creek; the Manila Creek is also cut, about 1 mile north-northwest of Grand Coulee Dam, by a dike of fine-grained granodiorite that conceivably came from the granite of Swawilla Basin. These dikes, together with the relatively great abundance of metasomatic xenoliths in the Manila Creek, suggest that the Manila Creek predates the Swawilla Basin, the Keller Butte, and Daisy Trail. No K/Ar ages available; tonalitic inclusion containing datable biotite and hornblende is exposed 0.40 mi south of Mount Iams (Alameda Flat quadrangle).

PORPHYRITIC GRANODIORITE NEAR GOLD LAKE—Quartz-anadean porphyry that forms two east-trending dikes, combined on this map, cutting quartz-mica schist about 1.5 mi southwest of Gold Lake (Bald Knob quadrangle). The andesine phenocrysts are euhedral, 3 by 4 mm on average, and contain inclusions of orthoclase, muscovite, and quartz. Dominant mafic mineral is chlorite. Weak foliation in the Gold Lake dikes is parallel to foliation in the country rock but discordant to the trend of the dikes.

Hornblende-bearing rocks

PORPHYRITIC GRANODIORITE AND GRANODIORITE OF COOK LAKE—From northermost exposures 5 mi west of Omak Lake, unit forms a belt of widely discontinuous exposures extending 17 mi south-southeast to the Columbia River. The rock is medium-grained (2-3 mm), light-colored (CI 3-7), and characterized by elongate gray K-feldspar megacrysts, except in the north-central part where they are sparse, by 0.5-2 cm phenocrysts and subrounded agglomerates of quartz, and by the co-occurrence of fuchsite and red garnet. In its northermost part, the rock shows varied development of foliation near contacts where it becomes contaminate by, and locally grades into, Felix Creek pluton and Salmon Creek schist and gneiss. Probable primary foliation parallels the Cook Lake's intrusive contact with the Reed Creek quartz diorite gneiss of Menzer (1983) southwest of Rat Lake. Sugary tourmaline and epidote are common, especially in the northern part. Hornblende is widely distributed but not abundant. Biotite is bimodal in size in the north and forms worm-shaped books in the south. Garnet-bearing plagioclase megacrysts are common.

GRANODIORITE OF SOAP LAKE MOUNTAIN—Comprises two bodies, the larger east of the Okanogan River near Malott, the smaller 2 mi farther east, both composed of fairly equigranular, medium-grained granodiorite; CI 10-12. Contains minor hornblende and fuchsite. Shows steeply dipping flow foliation near margins. Contains recognizable inclusions of the orthogneiss near Wakefield, and abundant cognate inclusions, as well as inclusions of metasomatic and mafic plutonic rocks. Is cut by numerous mafic dikes. Gradational contact with the equigranular granite of Virginia Lake suggests that the Virginia Lake and Soap Lake Mountain may be co-magmatic.

PORPHYRITIC GRANODIORITE SOUTHWEST OF OMAK LAKE—Coarse-grained (3-10 mm), mostly coarse grained porphyritic biotite granodiorite containing pink to gray K-feldspar.
megacrysts (1-6 cm) that commonly enclose conspicuous biotite and plagioclase crystals. In the porphyritic rock, all the K-feldspar is phenocrystic. In addition to K-feldspar, contains fuchited and along geocr keeps; normally zoned plagioclase; biotite; and minor hornblende, sphene, allanite, epidote, and iron oxides. The Omak Lake is characterized by flow foliation defined by elongate quartz and plagioclase, and aligned biotite and megacrysts of K-feldspar. Inclusions of hornblende-biotite amphibolite, stretched parallel to the foliation, make up as much as two percent of the rock; some and hornblende content increases near the inclusions. Medium-grained (3-5 mm) assemblages, generally genetically related to the granodiorite, cuts the latter mainly near and along the Omak Lake’s contact with Salmon Creek schist and gneiss of Menzer (1983). Both granodiorite and assemblages are cut by pegmatite characterized by graphic texture, coarse (2-4 cm) biotite, and sparse red garnet. The granodiorite is also cut by fine-grained mafic and felsic dikes and hornblende-biotite-feldspar porphyritic dikes. Generally similar rocks, exposed west of this major fault and lying northeast of the body described, are tentatively considered to be correlative and are queried on the map. K-Ar biotite age about 53 m.y. (table 1)

gbc GRANODIORITE OF BARNABY CREEK—Forms small, isolated intrusions into Covada Group in northeastern corner of map area. Hornblende mostly altered to chlorite

ggm GRANITE AND GRANODIORITE NEAR METEOR—Centered in the mutual corner of Twin Lakes, Inchelium, Hunters, and Wilmont Creek quadrangles, the pluton comprises medium-grained, equigranular to moderately porphyritic hornblende-biotite granite and granodiorite (CI 5-20); the more mafic, nonporphyritic variety separately mappable, locally. K-feldspar phenocrysts (1 cm) common pink. Hornblende sparse to moderately abundant in nonporphyritic variety; biotite observed to pseudomorph hornblende locally. The two varieties commonly intergrade but gradation locally abrupt. K-Ar biotite age about 55 m.y. (table 1)

gac GABBRO NEAR STRANGER CREEK—Forms a small body east-southeast of Twin Lakes that consists of generally massive, equigranular, coarse-grained (av. 5 mm) hornblende gabbro; fairly homogeneous except highly varied near exposed contact with metamorphic rocks at northeastern margin; locally contains abundant fresh, unaltered, randomly oriented inclusions of metamorphic rocks along southwestern margin

ptow ORTHOGNEISS NEAR WAKEFIELD (pre-Tertiary)—Medium- to coarse-grained orthogneiss of varied texture and composition forms a southward-trending belt east of the Okanogan River extending southward from Malott to about the latitude of None. Compositional types include quartz diorite, tonalite, leucocratic trondjemitic, and some amphibolitic schist

pTrc RED CREEK QUARTZ DIORITE GNEISS OF MENZER (1983) (pre-Tertiary) Varied, medium- to coarse-grained orthogneiss (CI 15-25) in its northwesternmost outcrop area south of Omak Lake, where it contains undeformed inclusions of gabbro. Exposures there, are a little more than a mile southeast of exposures mapped by Menzer (1983). Progressively southeastward the rocks are markedly varied, medium-grained (3-5 mm), massive to foliated, locally migmatic granite grading southward to granodiorite. Commonly contains sphene; color index 5-30, increasing in southern half of unit with concomitant increase in amount of hornblende. Contains xenoliths of paragneisses, probably Salmon Creek schist and gneiss of Menzer (1983); and is cut by the porphyritic granite of Cook Lake and by the equigranular granite of Virginia Lake, 3 mi west of Boot Mountain. Also locally cut by red-garnet-bearing felsic dikes perhaps satellitic to the Cook Lake. In westernmost exposures, locally grades into gabbro. Definitely pre-Tertiary in age, the Reed Creek is probably the oldest granitoid rock in this part of reservation. K-Ar ages discordant: biotite, 57 m.y. hornblende, 75 m.y. (table 1)

pTrb GRANODIORITE OF ROGERS BAR (pre-Tertiary)—Medium-grained, equigranular, spinel-biotite hornblende granodiorite intruding the Covada Group along the Columbia River near the mouth of Wilmont Creek. K-Ar hornblende age about 70 m.y. (table 1)

pTmd METADIORITE OF NORTH STAR CREEK (pre-Tertiary)—Dark green, structureless to schistose, fine- to coarse-grained rock that sparsely intrudes metasedimentary rocks along the western margin of the Republic graben. Shown only in Bald Knob quadrangle but present also to the south in Alameda Flat quadrangle, where seen in reconnaissance and lumped with the metamorphic and granitoid rocks of Squaw Mountain. Mafic minerals principally hornblende and (or) chlorite, locally with abundant clinzoisite and epidote (Staatz, 1964, p. 19)

plc Mixed rocks

pcs PLUTONIC COMPLEX WEST OF STEVENS LAKE—Varied migmatic granitoid rocks that crop out near the southwestern margin of the reservation east of the Soap Lake fault, and which also form numerous small unmapped roof pendants in the granodiorite of Soap Lake Mountain. Consists mainly of equigranular, intermediate to mafic plutonic rocks that include abundant diabase and pegmatite intermixed with granodiorite of Soap Lake Mountain. Fossilization between component rock types is locally more pronounced than fossilization within an individual lithologic type

plc PLUTONIC COMPLEX OF BOOT MOUNTAIN—Large, wedge-shaped body extending and widening southeastward from Omak Lake. Varied, commonly migmatic, mostly medium grained (0.5-5 mm), equigranular in more homogeneous parts. Ranges from tonalite, especially common in northern part, to granite. Darker rocks (CI 10-20) commonly
Moses Mountain, along this segment of the boundary, were not examined by USGS mappers in 1980-1983

NON-MYlonITic Metamorphosed RoccS---Sedimentary AND Mafic Igneous

Eugeoclinal rocks are widely distributed in the map area but extensive only east of the Sanpoil River and along the western side of the Republic graben. Pardee (1918) assigned most of the rocks to the Covada Group. We retain this name in most areas east of the Sanpoil River but apply other names farther west wherever correlation with the type Covada is doubtful.

P Tac SALMON CREEK SCHIST AND GNEISS OF MENZER (1983) (pre-Tertiary)--Extensively exposed southeast of Okanogan, generally along the projected strike of similar rocks to the northwest, the Salmon Creek comprises high-grade, compositionally layered, mostly metasedimentary rocks, and subordinate metavolcanic gneiss and schist. Rock types include hornblende-biotite gneiss, feldspar-augen gneiss, biotite gneiss, sillimanite-muscovite-biotite schist, biotite-quartzofeldspathic schist, amphibolite, quartzite, biotite quartzite, marble, garnet-pyroxene calc-silicate gneiss, coarse hornblendite. A well-developed metamorphic foliation, commonly with mineral lineation, parallels compositional layers. Mesoscopic tight to isoclinal, similar folds are present locally, especially in the schistose rocks. Axial planes parallel metamorphic foliation and layering; fold axes parallel mineral lineations. Assemblage is regionally metamorphosed to sillimanite zone of amphibolite facies. Mobilized granitic material is present locally, especially in westernmost body where the Salmon Creek is in part, migmatite. Rock labelled "d" is dunite, which forms a small metamorphosed mass in center of elongate body of the Salmon Creek a mile southwest of Omak Lake.


P Tm METASEDIMENTARY ROCKS BETWEEN OKA Lake AND SOUTH SEVENTEENMILE MOUNTAIN (pre-Tertiary)--Low- to high-grade rocks forming a belt averaging 3 mi in width on west side of Republic graben, and small isolated bodies elsewhere in central part of reservation. The belt along the Republic graben contains graywacke, phyllite, black shale, quartzite, quartz-mica schist, and minor limestone. Bodies elsewhere are mostly fine- to coarse-grained pelitic and psammitic granofels, schist, and gneiss, locally accompanied by calcareous and meta-volcanic rocks. Ortho-quartzite is a noteworthy constituent southeast of Moses Mountain and is associated at one locality with sharpstone conglomerate, a rock type common in metasedimentary assemblages of the Permian.
Anarchist Group several tens of miles northwest of the locality. Other rocks in the unit, particularly those east of the Republic graben and K-feldspar-rich greywacke west of that graben, may belong to the nearby Covada Group, whose age is Ordovician, at least in part (Snook and others, 1981)

pTg GREENSTONE OF ROARING CREEK (pre-Tertiary)—Fine-grained rock, locally with pillow structures, located west of the Republic graben near the north edge of the map area. Chiefly hornblende and plagioclase. Protolith probably extrusive andesite according to Staatz (1964, p. 17)

pTs SERPENTINITE NEAR PARMENTER CREEK (pre-Tertiary)—Serpentinite and talc-magnesite rock forming small bodies near bounding faults of the Republic graben. The largest body is located 8.5 mi north of Nespelem; other smaller bodies lie nearby and also about 10 mi to the southeast. The bodies north of Nespelem cut pre-Tertiary quartzite, and two of them are cut by dikes of the hypabyssal-intrusive suite of Cody Lake; otherwise the age of emplacement of the serpentinite is unconstrained (Staatz, 1964, p. 31)

pTum ULTRAMAFIC AND MAFIC ROCKS NEAR BRIDGE CREEK (pre-Tertiary)—Talc-carbonate rock, greenschist, and minor serpentinite and meta-tuff (?) northeast of the Keller graben; also forms a small fault-bounded sliver 5 mi east of graben. northeast of the graben, owes much of its east-west extent to cross-cutting dikes of the hypabyssal intrusive suite of Cody Lake. Much of the greenstone may have originated as diabase and gabbro because it commonly preserves laths of plagioclase and a subophitic texture. Possibly the Bridge Creek represents oceanic crust and mantle on which adjacent parts of the Covada Group accumulated; alternatively, the Bridge Creek and the Covada were brought together tectonically from widely separated areas

pTml MAFIC INTRUSIVE ROCKS NEAR TWIN LAKES (pre-Tertiary)—Metamorphosed mafic rocks some of which are known to be intrusive into the Covada Group. The unit comprises meta-gabbro, which forms a small body between the North and South Forks of Hall Creek, 9 mi north-northeast of Twin Lakes, and greenschist, which forms a dike between Ninemile and Wilmont Creeks, 14 mi south of Twin Lakes. Additional mafic rocks known or believed to intrude the Covada Group form small bodies (not shown on map) in the Wilbur quadrangle, 1 mi south-southeast of the mouth of Dick Creek and also in section 35, T. 29 N., R. 33 E.

COVADA GROUP (Ordovician)—Low- to medium-grade metasedimentary and minor meta-volcanic rocks abundantly exposed between the lower Sampoil River valley and the northeastern corner of the reservation. As mapped by Pardee (1918), the Covada embraces nearly all metasedimentary rocks in the reservation east of Omak Lake; but following Fox and Rinehart (1974), we restrict the term to rocks whose coarse-clastic facies locally contain granitic detritus, particularly K-feldspar. Internal stratigraphic sequence unknown. Age Pennsylvanian (?) according to David White (Bancroft, 1914, p. 14-15), who described plant fossils in limestone near Silver Leaf mine (Inchelium quadrangle); but more probably Early Ordovician according to Snook and others (1981) who cite conodonts and other animal fossils indentified by John Repetski and Peter Ward from localities just off the reservation, about 4 mi east-northeast of the mouth of Little Jim Creek (Inchelium quadrangle). Shown undivided (Oc) in a small strip north of Barnaby Creek (Inchelium quadrangle); elsewhere divided into:

Pelitic and psammitic rocks—Greywacke, locally conglomeratic; impure quartzite; slate; and minor pods of limestone and greenstone. Locally upgraded to hornfels, phyllite, or quartz-mica schist. Beds as thick as 4 m, some of them graded from granule conglomerate at base to argillite at top. Stipple in Twin Lakes quadrangle denotes blue quartzite. Phyllite commonly spotted with chlorite; schists near the porphyritic granodiorite of Manilla Creek contains andalusite in some places and sillimanite in a few others

Carbonate and argillaceous rocks—Limestone and dolomite, mostly impure and locally upgraded to marble, that are commonly interlayered with slate, phyllite, and greywacke. Large body in Keller quadrangle near Ninemile Creek owes much of its east-west extent to crosscutting swarms of aplo-pegmatite dikes (in area patterned with X's) and hypabyssal-porphyry dikes. The northeastern part of this body appears to grade, through interlayered limestone and phylitic slate, into the adjoining pelitic and psammitic rocks. The northwestern part of the body was either deposited on or faulted against the ultramafic and mafic rocks of Bridge Creek. An elongate, fault-bounded body between Wilmont and Nez Perce Creeks consists largely of greywacke and lesser greenstone

Greenstone—Metamorphosed subaqueous basalt flows containing many calcite-filled amygdules, few pillow structures, and interbeds of argillite, limestone, basaltic sandstone, and pyroclastic rocks. Widely but sparsely distributed among pelitic and psammitic parts of the Covada north of Nez Perce Creek
Table 1.—Potassium-argon ages from volcanic and intrusive rocks of the Colville Indian Reservation, compiled by Robert J. Fleck

<table>
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<th>Field Number</th>
<th>Collector</th>
<th>Quadrangle</th>
<th>Latitude North</th>
<th>Longitude West</th>
<th>Mineral</th>
<th>K3O (percent)</th>
<th>(10^-10)</th>
<th>Percent or total (^{40}Ar)</th>
<th>1Age (m.y.)</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>FM9480-1</td>
<td>F. J. Hoya</td>
<td>Seventeenmile Mountain</td>
<td>48°25.61'</td>
<td>118°43.47'</td>
<td>Biotite</td>
<td>n.a.</td>
<td>n.a.</td>
<td>48.2±0.3</td>
<td>Lava flow probably near top of Sanpoil section in this part of Republic graben</td>
<td></td>
</tr>
<tr>
<td>78KP28L-3</td>
<td>K. F. Fox, Jr.</td>
<td>Keller</td>
<td>48°13.99'</td>
<td>118°40.17'</td>
<td>Biotite</td>
<td>8.13</td>
<td>5.97</td>
<td>82.8</td>
<td>50.3±0.4</td>
<td>Vitrophylic lava flow underlain by about 150 m of ash-flow tuff</td>
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<td>FM9480-1</td>
<td>F. J. Hoya</td>
<td>Seventeenmile Mountain</td>
<td>48°28.03'</td>
<td>118°42.47'</td>
<td>Biotite</td>
<td>8.38</td>
<td>6.20</td>
<td>92.8</td>
<td>49.5±0.3</td>
<td>Unit intrudes part of upper unit of Sanpoil Volcanics</td>
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<tr>
<td>FM9268L-2</td>
<td>F. J. Hoya</td>
<td>Seventeenmile Mountain</td>
<td>48°15.95'</td>
<td>118°41.07'</td>
<td>Biotite</td>
<td>n.a.</td>
<td>n.a.</td>
<td>46.7±0.4</td>
<td>Dike probably comagmatic with the adjacent diorite of Devils Elbow. Age spurious!</td>
<td></td>
</tr>
<tr>
<td>FM91780-3</td>
<td>do.</td>
<td>do.</td>
<td>48°27.68'</td>
<td>118°38.63'</td>
<td>Hornblende</td>
<td>0.966</td>
<td>0.696</td>
<td>70.4</td>
<td>49.4±0.3</td>
<td>Dike intrudes part of upper unit of Sanpoil Volcanics</td>
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<tr>
<td>FM92890-10</td>
<td>do.</td>
<td>do.</td>
<td>48°27.23'</td>
<td>118°38.04'</td>
<td>Biotite</td>
<td>7.02</td>
<td>5.16</td>
<td>64.6</td>
<td>50.3±0.3</td>
<td>do.</td>
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<tr>
<td>FM91780-2</td>
<td>F. J. Hoya</td>
<td>Seventeenmile Mountain</td>
<td>48°16.43'</td>
<td>118°41.65'</td>
<td>Biotite</td>
<td>9.38</td>
<td>6.79</td>
<td>82.9</td>
<td>49.6±0.3</td>
<td>Unit intrudes diorite of Devils Elbow</td>
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<tr>
<td>EN-5-19</td>
<td>K. F. Fox, Jr.</td>
<td>Disautel</td>
<td>48°25.65'</td>
<td>119°09.15'</td>
<td>Biotite</td>
<td>8.89</td>
<td>6.39</td>
<td>77.7</td>
<td>49.2±1.5</td>
<td>Reported by Fox, Rinshart, Engels, and Stern (1976, p. 1220)</td>
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<tr>
<td>SS-340</td>
<td>S. H. Singer</td>
<td>Disautel</td>
<td>48°24.80'</td>
<td>119°10.58'</td>
<td>Biotite</td>
<td>8.60</td>
<td>6.21</td>
<td>53</td>
<td>49.5±1.2</td>
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<tr>
<td>SS-341</td>
<td>S. H. Singer</td>
<td>Disautel</td>
<td>48°24.20'</td>
<td>119°10.84'</td>
<td>Biotite</td>
<td>8.73</td>
<td>6.29</td>
<td>56</td>
<td>49.4±1.2</td>
<td>Unit intrudes diorite of Swinftkin Creek</td>
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<tr>
<td>SS-351</td>
<td>S. H. Singer</td>
<td>Disautel</td>
<td>48°15.40'</td>
<td>119°08.37'</td>
<td>Biotite</td>
<td>8.15</td>
<td>6.26</td>
<td>44</td>
<td>52.5±1.3</td>
<td>Unit probably intrudes granite of Coyote Creek</td>
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<tr>
<td>EWS-34455</td>
<td>R. V. Holder</td>
<td>Seventeenmile Mountain</td>
<td>48°28.61'</td>
<td>118°32.37'</td>
<td>Biotite</td>
<td>8.93</td>
<td>5.91</td>
<td>57</td>
<td>45.2±1.1</td>
<td>Hall Creek pluton</td>
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<tr>
<td>N-51C</td>
<td>C. D. Rinshart</td>
<td>Nespelem</td>
<td>48°09.99'</td>
<td>118°46.08'</td>
<td>Biotite</td>
<td>8.62</td>
<td>6.24</td>
<td>55</td>
<td>49.6±1.2</td>
<td>Devils Elbow pluton</td>
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<td>PM91780-1</td>
<td>F. J. Hoya</td>
<td>Seventeenmile Mountain</td>
<td>48°16.28'</td>
<td>118°42.50'</td>
<td>Biotite</td>
<td>8.29</td>
<td>6.04</td>
<td>78.0</td>
<td>49.9±0.3</td>
<td>do.</td>
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<td>GNEISSIC PORPHYRITIC GRANODIORITE OF MISSION CREEK (21)</td>
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<td>O-425</td>
<td>K. F. Fox, Jr.</td>
<td>Omak Lake</td>
<td>48°23.45'</td>
<td>119°26.52'</td>
<td>Biotite</td>
<td>9.45</td>
<td>6.50</td>
<td>82.9</td>
<td>47.2±1.4</td>
<td>Reported by Fox, Rinshart, Engels, and Stern (1976, p. 1220)</td>
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<tr>
<td>O-426</td>
<td>K. F. Fox, Jr.</td>
<td>Disautel</td>
<td>48°16.85'</td>
<td>119°08.42'</td>
<td>Biotite</td>
<td>9.02</td>
<td>6.63</td>
<td>77.8</td>
<td>50.4±1.5</td>
<td>Reported by Fox, Rinshart, Engels, and Stern (1976, p. 1220)</td>
</tr>
<tr>
<td>RA-82-54E</td>
<td>B. F. Atwater</td>
<td>Alameda Flat</td>
<td>48°01.16'</td>
<td>119°08.11'</td>
<td>Biotite</td>
<td>8.96</td>
<td>6.69</td>
<td>68</td>
<td>51.4±1.3</td>
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13
<table>
<thead>
<tr>
<th>A65677</th>
<th>W. C. Utterback and R. Badley</th>
<th>Grand Coulee Dam</th>
<th>47°59.67' N 118°50.30' W</th>
<th>Biotite</th>
<th>n.a.</th>
<th>n.a.</th>
<th>61.3±2.3</th>
<th>Biotite weathered</th>
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<tbody>
<tr>
<td><strong>KELLER</strong></td>
<td>n.a.</td>
<td>Keller</td>
<td>48°03.58' N 118°41.53' W</td>
<td>K-feldspar</td>
<td>11.46</td>
<td>10.33</td>
<td>89.6</td>
<td>51.2±1.8</td>
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<tr>
<td>A-56471</td>
<td>W. C. Utterback and C. Dykeman</td>
<td>Keller</td>
<td>48°03.39' N 118°42.20' W</td>
<td>Sericite</td>
<td>n.a.</td>
<td>n.a.</td>
<td>55.7±2.0</td>
<td>From AMAX core DH-6. State coordinates: N391.653; W2,512,050</td>
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<tr>
<td>A-56470</td>
<td>do.</td>
<td>do.</td>
<td>48°03.24' N 118°42.14' W</td>
<td>Muscovite</td>
<td>n.a.</td>
<td>n.a.</td>
<td>57.7±2.1</td>
<td>From AMAX core DH-24. State coordinates: N391.787; W2,512,000</td>
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<tr>
<td>A65679</td>
<td>W. C. Utterback and R. Badley</td>
<td>Nespelem</td>
<td>48°00.47' N 118°48.43' W</td>
<td>Biotite</td>
<td>n.a.</td>
<td>n.a.</td>
<td>58.8±2.2</td>
<td>Unit probably intruded by porphyritic granite of Keller Butte.</td>
</tr>
<tr>
<td>A65695C</td>
<td>R. W. Holder</td>
<td>Seventeenmile Mountain</td>
<td>48°15.00' N 118°31.57' W</td>
<td>Biotite</td>
<td>9.03</td>
<td>6.57</td>
<td>73.3</td>
<td>48.9±0.3</td>
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<td>MOL-39</td>
<td>V. L. Hansen</td>
<td>Omak Lake</td>
<td>48°17.63' N 119°26.39' W</td>
<td>Biotite</td>
<td>9.53</td>
<td>7.44</td>
<td>75</td>
<td>53.4±1.3</td>
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<tr>
<td>R-516</td>
<td>K. F. Fox, Jr.</td>
<td>Twin Lakes</td>
<td>48°15.32' N 118°22.52' W</td>
<td>Biotite</td>
<td>8.40</td>
<td>6.68</td>
<td>92.8</td>
<td>54.5±0.4</td>
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<tr>
<td>ROL-276</td>
<td>V. L. Hansen</td>
<td>Omak Lake</td>
<td>48°16.68' N 119°26.91' W</td>
<td>Biotite</td>
<td>9.22</td>
<td>7.77</td>
<td>80</td>
<td>57.4±1.4</td>
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<td>Hornblende</td>
<td>1.35</td>
<td>1.50</td>
<td>57</td>
<td>75.2±1.9</td>
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<td><strong>GRANODIORITE NEAR ROGERS BAR (45)</strong></td>
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<tr>
<td>R-528</td>
<td>K. F. Fox, Jr.</td>
<td>Wilmont Creek</td>
<td>48°03.51' N 118°17.54' W</td>
<td>Hornblende</td>
<td>0.980</td>
<td>1.04</td>
<td>16.6</td>
<td>71.1±2.0</td>
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<td><strong>PLUTONIC COMPLEX OF BOOT MOUNTAIN, EQUIGRANULAR PHASE (48)</strong></td>
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<tr>
<td>ROL-277</td>
<td>V. L. Hansen</td>
<td>Omak Lake</td>
<td>48°19.57' N 119°29.30' W</td>
<td>Biotite</td>
<td>9.42</td>
<td>6.71</td>
<td>52</td>
<td>48.9±1.2</td>
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<td>Hornblende</td>
<td>1.32</td>
<td>1.39</td>
<td>59</td>
<td>72.1±1.8</td>
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</table>

1 Decay constants for K: $^{40}K = s/167×10^{-10}$ mol/mol; $\lambda_0 = 4.962×10^{-10}$ yr$^{-1}$; $\lambda_0 + \lambda$ = $0.581×10^{-10}$ yr$^{-1}$; dates of Fox and others (1976) recalculated with these constants by means of Dalrymple's (1978) conversion table.

n.a., not available; do., ditto.
REFERENCES


CONVENTIONAL SYMBOLS

CONTACT

Location approximate. Length of dashes has no geologic significance. Precision implied by use of dashed line may vary between quadrangles

Concealed

Gradational

Interfingering

FAULT—Dashed where approximate, dotted where concealed, queried where doubtful

High angle, showing sense of displacement and dip

Low angle. Barbs point in direction of dip. In Twin Lakes quadrangle, symbol represents narrowly gradational contact between low- and high-grade rocks along which the rocks are sheared or brecciated only locally. In Omak Lake and Lincoln quadrangles, stippled dashed line with barbs denotes inferred extension of breccia zone bordering gneiss dome.

Stippled-dashed line without barbs denotes inferred extension of breccia zone whose dip is unknown

AXIS OF LARGE FOLD—Dashed where location approximate, dotted where concealed, queried where doubtful

Anticline, showing plunge

Syncline

AXIS OF SMALL FOLD

Trend and plunge of inclined axis
STRIKE AND DIP OF BEDDING—Dot on symbol where top of bed known from sedimentary structures

Upright
Vertical
Overturned

STRIKE AND DIP OF FOLIATION

Inclined
Vertical
Horizontal. Shown with wavy tails where foliation approximately horizontal

STRIKE AND DIP OF CLEAVAGE

STRIKE AND DIP OF JOINT

TREND AND PLUNGE OF LINEATION

Inclined
Horizontal

SHEARED ROCK

BRECCIATED ROCK—Protolith shown where known. Not shown in units that are characteristically brecciated (the intrusive complex of Grant Lake and the breccia west of Fort Spokane)

LOCALITY OF SAMPLE FOR POTASSIUM-ARGON AGE DETERMINATION (see table 1)
EXAMPLES OF COMBINED SYMBOLS

Foliation and lineation

Foliation and axis of small fold

Foliation and bedding parallel

Small fault, showing dip of plane and trend of lineation on the plane
### ADDITIONAL SYMBOLS, USED MOSTLY FOR ONE OR A FEW UNITS

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>![symbol]</td>
<td>INFERRRED MARGIN OF CORDILLERAN ICESHEET&lt;br&gt;Terminal. Bar and ball toward ice&lt;br&gt;Recessional. Marked by end moraine</td>
</tr>
<tr>
<td>3</td>
<td>Tsu</td>
<td>PYROCLASTIC ROCK&lt;br&gt;EPICLASTIC ROCK&lt;br&gt;AUTOCLASTIC BRECCIA&lt;br&gt;TRACE OF INDIVIDUAL LAVA FLOW--Shown only in Republic graben</td>
</tr>
<tr>
<td>5</td>
<td>![symbol]</td>
<td>PLUG OR LARGE DIKE (sole means of representing unit)</td>
</tr>
<tr>
<td>6</td>
<td>Th</td>
<td>DIKE SWARM--Ratio of hypabyssal porphyry to country rock generally exceeds 1:10&lt;br&gt;(see fig. 3 for an example)&lt;br&gt;STRIKE AND DIP OF INDIVIDUAL DIKE&lt;br&gt;Inclined&lt;br&gt;Vertical&lt;br&gt;Dip unknown</td>
</tr>
<tr>
<td>20-22</td>
<td>tg, gpg, gfv</td>
<td>APPROXIMATE EASTERN LIMIT OF PENETRATIVELY MYLONITIC ROCK IN THE OKANOGAN GNEISS DOME</td>
</tr>
<tr>
<td>24</td>
<td>pcj</td>
<td>DIORITE&lt;br&gt;RELATIVELY HOMOGENEOUS GRANITE&lt;br&gt;PORPHYRITIC COARSE-GRAINED GRANITE</td>
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</tbody>
</table>
32  gdt  SMALL METAMORPHIC INCLUSION
51  pTsc  DUNITE
58  Ocp  BLUE QUARTZITE
0cc  ABUNDANT APLO-PEGMATITE DIKES