UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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

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(this pamphlet accompanies 4 oversize sheets)

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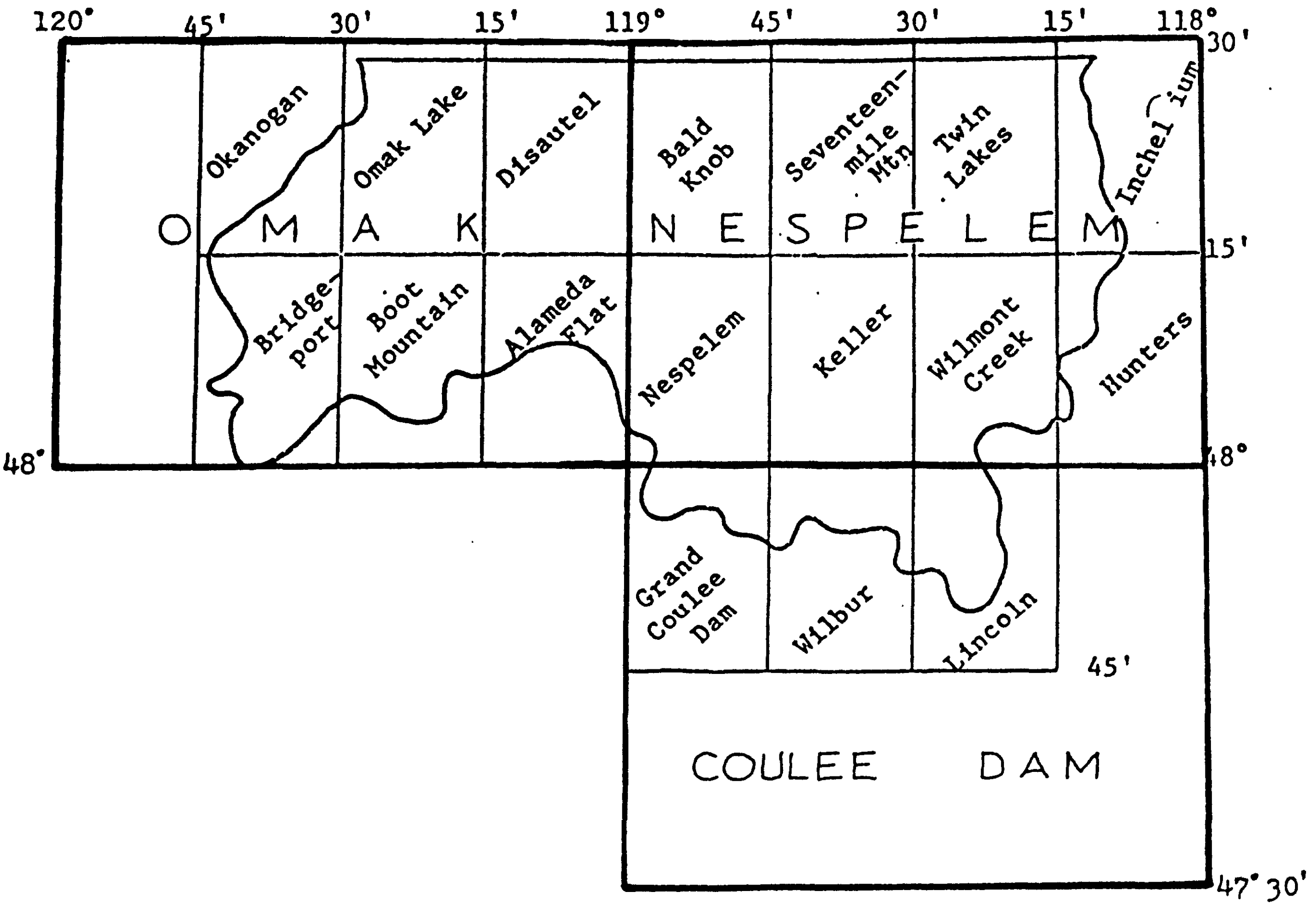
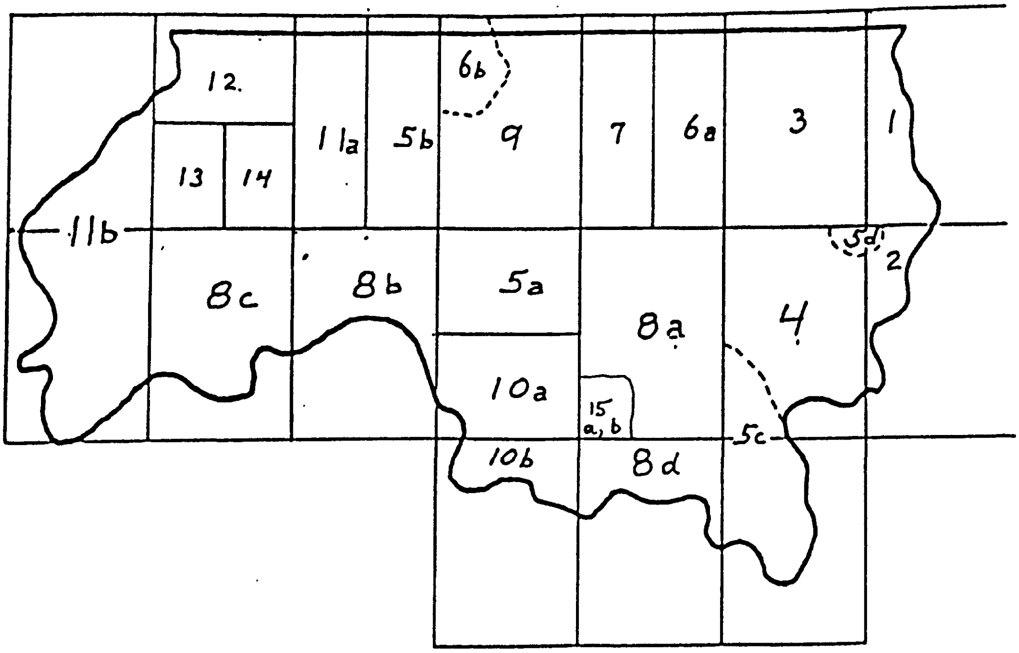


Figure 1.--15-minute and 30- by 60-minute quadrangles in the Colville Indian Reservation.



1. Campbell, A. B.--1963-64(?)

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

3. Fox, K. F., Jr.--1980-83; Becraft, G. E.--1964-73

4. Becraft, G. E. (1966); Goodge, J. W.--1983

5. Rinehart, C. D.--a, 1980-81; b, and N. Wilson 1982; c, and M. Gaona 1983; d, and J. Deen 1983

6. Holder, R. W.--a, 1980; and G. McCarley 1982; b, and G. McCarley 1983

7. Moye, F. J.--and E. King 1980; and D. Jennings 1981

8. Atwater, B. F.--a, and E. King 1980; and M. McGroder 1981; b & c, and N. Wilson 1982; d, and J. Deen 1983

9. Staatz, M. H. (1964)

10. Carlson, D. H.--a, 1981; and L. Peters 1982; b, and C. Closson 1983

11. Singer, S. H.--a, and V. Lueth 1982; b, and M. Gaona 1983

12. Goodge, J. W., and Hansen, V. L.--1983

13. Hansen, V. L.--1982

14. Goodge, J. W.--1982

15. a, Utterback, W. C., 1979-1980; b, Cochran, D. S., and Warlow, J. C. (1980)

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 Others: unpublished mapping; dates indicate field work.

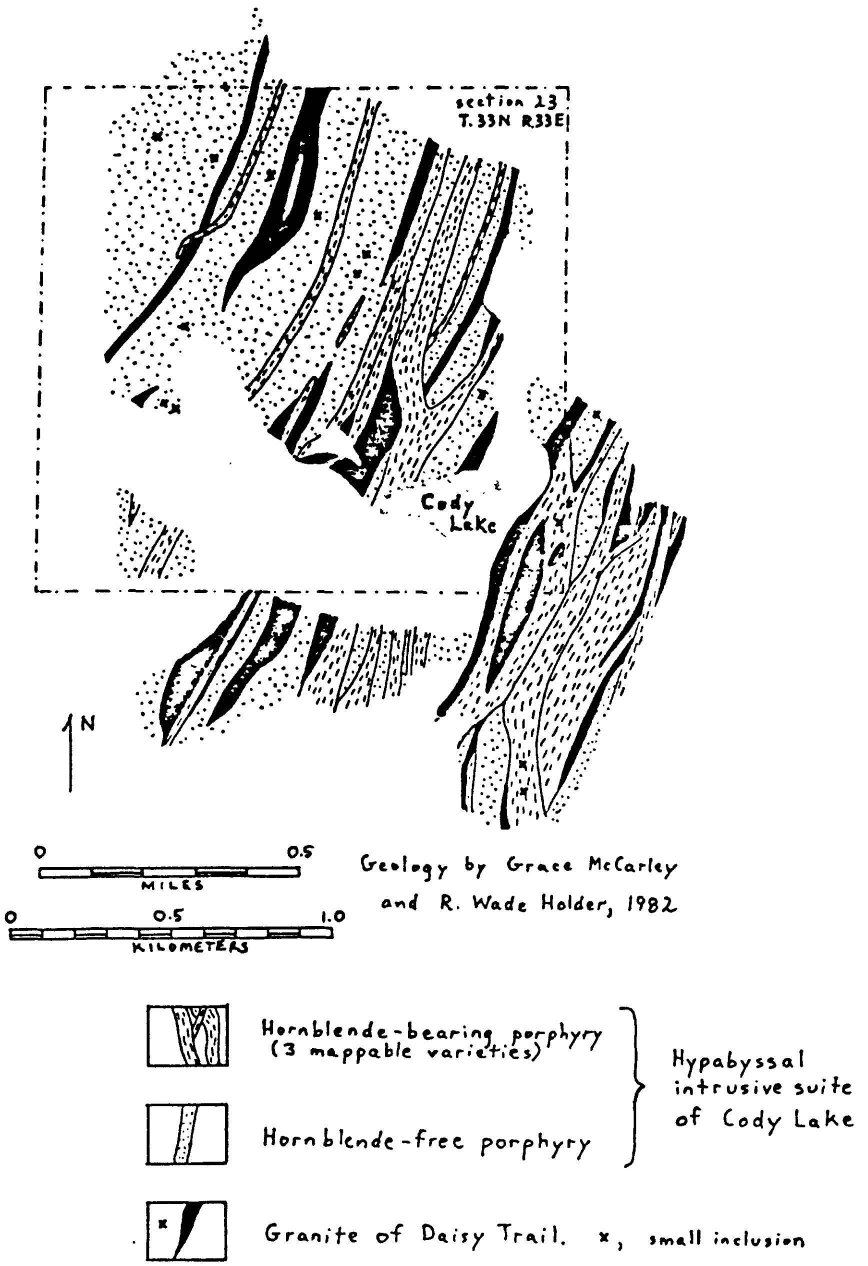


Figure 3.--Large-scale geologic map of type area for hypabyssal intrusive suite of Cody Lake, by Grace McCarley and R. Wade Holder. Country rock (the granite of Daisy Trail) is riddled by the Cody Butte. Seventeenmile Mountain quadrangle, about 1 mi south of Twentythree Mile Creek.

INTRODUCTION

The accompanying map presents a generalized view of the bedrock geology of the Colville Indian Reservation, northeastern Washington. The Reservation, covering about 2,175 mi^2 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 line near latitude 48°30'. 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-file 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 Creek (Becraft, 1966)--and unpublished mapping of parts of the Inchelium 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 Orazulike (1982) cover parts of the Alameda 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 (1981). 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, Falma J. Moye, 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 necessitated contact adjustment at quadrangle boundaries. Atwater is primarily responsible for generalization, and also for compiling descriptions of map units, in the Nespelem 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 Covada Group--but no new formal names are proposed 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); some geologists prefer "metamorphic core complex" (Coney, 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 three gneiss domes together 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.

Numbered triangles and diamonds within a unit box identify units with which the boxed unit has one or more exposed contacts. A triangle pointing up indicates that the unit intrudes the boxed unit; a triangle pointing down indicates that the unit is intruded by the boxed unit; diamonds indicate equivocal age relations. Contact relations between pre-Tertiary units 53-58 and younger rocks, are omitted for convenience.

Potassium-argon ages (for example, 49.4 ± 0.3 (b)) 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 hornblende-free, light-colored, 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 after 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 and(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 lineation of the Okanogan gneiss dome die out within the Coyote Creek, southeastward along the strike of the gneiss-dome border. But this change apperently bagins northwest of the Coyote Creek, in the plutonic complex of Boot Mountain, whose non-mylonitic parts are largely or wholly pre-Tertiary and probably predate the gneiss dome. Plate 4 therefore incorporates the view that the mylonitic border of the Okanogan gneiss dome loses definition southeastward without 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.

ACKNOWLEDGEMENTS

The success of the USGS mapping project of 1980-1983 owes much to the cooperation and generous support from the Colville Confederated Tribes. In particular, the Tribes' Geology Department, headed by Donald A. Aubertin, and including John D. Erickson, Lane E. Fortin, Janet Hohle, and William C. Utterback, was most helpful with support of many kinds, from making available their office and laboratory facilities, to sharing their considerable geological knowledge of the reservation. Especially helpful in sharing his expertise was William C. Utterback who, during the first two years of USGS mapping, was Chief Geologist for the AMAX Inc. Mount Tolman Project, a joint venture with the Colville Tribes to explore Mount Tolman's molybdenum deposit.

Others whose help contributed greatly to the success of the Geological Survey mapping in 1980-1983 include: the Jannot family of Keller, and Norman C. McClure of Nespelem, who allowed operation of field camps on their lands; the Omak School District, and the Bureau of Indian Affairs--especially Daniel Len--for similar permission; and Gary and Dennis Jackson of Nespelem for expert and cheerful vehicle maintenance.

Excellent field assistance in USGS mapping of 1980-1983 was provided by Cheryl A. Closson, Justus B. Deen, Michael T. Gaona, Deborah Jennings, Ellen King, Virgil Lueth, Grace McCarley, Michael F. McGroder, Lisa Peters, and Nathaniel P. Wilson. Most of the contacts and faults on plates 1-3 were drafted by Cheryl A. Closson; the remainder was drafted by Justus B. Deen, Catherine R. McMasters, Bruce W. Rogers, Jeanette Smith, and Atwater and Rinehart. Rinehart drafted plate 4 and Katherine Klock typed the text.

USGS mappers of 1980-1983 gratefully acknowledge brief but stimulating visits by professors of geology from several schools in the Northwest: Bill Bonnichsen, Robert W. Jones, and Rolland R. Reid of the University of Idaho; Peter R. Hooper, Richard L. Thiessen, and A. John Watkinson of Washington State University; and Donald W. Hyndman of the University of Montana.

This report was reviewed in its entirety by Diane H. Carlson and Ray E. Wells, and an early version of plate 4 was reviewed by Kenneth F. Fox, Jr. Additional reviews of parts of the report were supplied by John D. Erickson, John W. Goodge, Vicki L. Hansen, R. Wade Holder, Falma J. Moye, Stephen H. Singer, and William C. Utterback.

DESCRIPTION OF MAP UNITS

SURFICIAL MATERIALS

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

1 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 altitude 760 m, to which they could have been rafted by bargs (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 Sanpoil River Valley (Keller and Wilbur quadrangles), and in French Valley (Omak Lake and Disautel quadrangles). The lake in the Columbia and Sanpoil 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 Sanpoil 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 southwest 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 G (unpub. correlation by A. M. Sarna-Wojcicki and C. E. Meyer, 1982, based on major-element chemistry of glass; age about 11,200 ^{14}C years according to Mehringer and others, 1984). Eolian sand abounds near the mouth of the Okanogan River, along highway 155 1-2 mi east of Omak (Minard, in press), about 1 mi northeast of the mouth of the Sanpoil River, and farther east at Sand Hills. Interbedded with the dune sand near Omak is fine volcanic ash that probably came from Mt. Mazama according to major-element analyses and correlations of A. M. Sarna-Wojcicki and C. E. Meyer (unpub. data, 1982; age between 6000 and 7000 ^{14}C years according to Lemke and others, 1975, p. 19-22). Lithologically similar ash is also interbedded with non-glacial alluvium: about 1 mi 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 glaciolacustrine deposits of the Columbia and Sanpoil River valleys, and most of these landslide deposits have formed since construction of Grand Coulee Dam (Jones and others, 1961)

Tb COLUMBIA RIVER BASALT GROUP (Miocene)--Dark-
2 gray aphyric basalt forming extensive flows. Partly covered by drift and locally interbedded with sedimentary rocks southwest 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 dike 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 cross-cut the hornblende-bearing plutons or display contacts that allow approximate contemporaneity with these plutons. K/Ar ages from the complex cluster near 50 m.y.; probably these ages closely approximate ages of primary cooling because there is little age discordance between biotite-hornblende pairs from the complex and because no intrusive rock in the map area is known to be much younger than 50 m.y.

Extrusive rocks

Ts SANPOIL VOLCANICS (Eocene)--Phyric lava flows,
3 subordinate pyroclastic and epiclastic rocks, and minor hypabyssal intrusive rocks; mostly dacite and rhyodacite. Abundant in Republic and Keller grabens; also present near mouths of Monaghan and Nez Perce Creeks (Wilmont Creek and Hunters quadrangles) at north end of a NNE-trending volcanic belt about 50 km long (Pearson and Obradovich, 1977, p. 19), and opposite mouth of Spokane River (Lincoln quadrangle), where previously unrecognized. Dominant phenocrysts plagio-clase plus two or three mafic minerals, one of these biotite and the other(s) hornblende and(or) augite; phenocrysts of quartz typically scarce. Groundmass mostly stony, locally glassy. Age: 48-50 million years according to K/Ar dates on two lava flows in reservation (table 1); greater than 49-50 million years according to K/Ar dates on three intrusions into Sanpoil Volcanics in reservation (table 1); and 51-52 million years according to K/Ar ages on biotite and hornblende from 5 lava flows in Sanpoil 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, coarsely 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), divided into:

Tsu 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

Tsl 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 underlies Sanpoil Volcanics in northeastern Washington (Pearson and Obradovich, 1977). Probably corralates with the Sanpoil Volcanics that apparently rest on the crystalline floor of the southern end of the Republic graben (Nespelem quadrangle)

To O'BRIEN CREEK FORMATION (Eocene)--Light-colored
4 epliclastic and pyroclastic rocks, mostly crystal tuff of rhyodacite and quartz latite. Exposed at margins of Keller graben, where up to 900 m thick (between Bridge and Louie Creeks), and exposed less abundantly at margins of Republic graben. Includes rhyodacite lava flow and hypabyssal intrusive equivalents near Brush Creek in Keller graben. Clasts and phenocrysts dominantly plagioclase, quartz, and biotite; hornblende absent. Age about 54 m.y. according to a single K/Ar date from the Pend Oreille River area 45 mi east of the reservation (Pearson and Obradovich, 1977, p. 13)

Hypabyssal intrusive rocks

INTRUSIVE RHYOLITE NEAR WEST FORK (Eocene)--
5 Forms light-colored dikes and plugs intruding upper unit of Sanpoil Volcanics in eastern part of Republic graben (Seventeenmile 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 aplite dikes (not shown on map) cutting the intrusive suite of Cody Lake. K/Ar age about 50 m.y. (table 1)

Th HYPABYSSAL INTRUSIVE SUITE OF CODY LAKE
6 (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 denotes areas where the ratio of hypabyssal porphyry to country rock appears to exceed 1:10, and label "Th" denotes areas where country rock appears to be entirely absent. Individual dikes shown (by paired lines) only where strike known. Groundmass of porphyry typically holocrystalline at centers of large dikes but cryptocrystalline at chilled margins of dikes. Most of the intrusions abound in equant white

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 Sanpoil Volcanics. Hornblende-free intrusions, in contrast, cut the O'Brien Creek but not the Sanpoil despite a great abundance of hornblende-free porphyry in dike 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 Sanpoil Volcanics. All hypabyssal porphyry contains hornblende where known to cut the porphyritic granodiorite of Mission Creek, the diorite of Devil's Elbow, the grano-diorite 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 Sanpoil 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 7 VARIED GRANITE NEAR STEPSTONE 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 8 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

Tdl 9 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 (Eocene)--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 (Eocene)--Medium-grained equigranular hornblende-biotite-quartz monzodiorite 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 para-gneissic 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 south-eastern 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 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. Merges into the unit, undivided granitic rocks near Gold Creek, along the common boundary of the Disautel and Bald Knob quadrangles, from Stepstone 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 Swimpkin Creek pluton near the eastern pert of their mutual contact. K-Ar biotite age about 49 m.y. (table 1)

Tgmw
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

Tga
16
GRANITE WEST OF ARMSTRONG MOUNTAIN (Eocene)--Biotite granite and granodiorite, medium-grained (2mm av), equigranular, homogeneous, and leucrocratic (CI 5), contains sparse but widespread sphene 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 (augite)-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; Hall Creek pluton, east of Republic graben 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 Brush Creek, 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 miarolitic cavities. Yields K/Ar ages between 44 and 51 m.y. (table 1). For convenience, also includes a small (2 mi^2) 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 (Staatz, 1964, p. 23)

Brecciated rocks

Tic
18
INTRUSIVE COMPLEX NORTH OF GRANT LAKE (Eocene)--Crops out as a small ellipical 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
19
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 identifyable 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
20 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 scalloped line, and appaar 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

gpg
21 GNEISSIC PORPHYRITIC 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, sphene, 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)

gfv
22 GNEISSIC GRANODIORITE OF FRENCH VALLEY--Light- to medium-gray biotite granodiorite exposed southeast and northeast of Omak; massive to well foliated and lineated. Mostly medium grained (0.5-5 mm) and equigranular, but sparse (<1 percent) K-feldspar megacrysts (1-2 cm) are present locally near contact with the gneissic porphyritic granodiorite of Mission Creek. Minor sphene, hornblende, apatite, and iron oxides noted; hornblende locally abundant near contacts with Tonasket Gneiss. Penetrative mylonitic foliation and lineation common, though locally inconspicuous in equigranular rock. Cut by numerous thin (0.5 m) dikes of pegmatite, aplite, and granite. In some places contains xenoliths of probable Mission Creek; in others, gradational into the Mission Creek over as much as 50 m. The northeasternmost part consists mainly of biotite and biotite-hornblende tonalite whose correlation with French Valley is uncertain (shown as "gfv?")

23 PARAGNEISS AND ORTHOGNEISS OF HALL CREEK--Mostly well-lineated sillimanite-grade rocks in the northeastern part of the reservation, bounded primarily by the granite of Daisy Trail to the south and west and by chlorite-grade rocks of the Covada Group on the east. Contact with the Daisy Trail is broadly gradational through granitic gneiss; contact with the Covada is a narrow gradational change in metamorphic grade, both with and without associated zones of sheared or brecciated rock, that dips gently eastward. Divided into:

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

hog 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

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

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

hq Quartzite--Unlayered to thickly layered

hqs 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
24 PLUTONIC COMPLEX OF JOHNNY GEORGE MOUNTAIN--Granitoid rocks characterized by marked variation in texture, grain size, and composition, occupy about 80 mi^2 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 Swawilla Basin), to pegmatite; also they include medium-grained sphene-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

rectangles (rock mostly coarse-grained and porphyritic). Migmatite in the southwestern part of the Johnny George is well-exposed 1.5 mi south of Pheasant Spring at altitudes 375-385 m during vernal lowering of Franklin D. Roosevelt Lake. This migmatite comprises, from old to young: scattered relicts of dark (CI 10-25) biotite gneiss, medium-grained equigranular biotite granodiorite and granite with CI 2-10, aplite and pagmatite, and dikes of dark-colored fine-grained biotite diorite(?) that are locally intruded by the granitic rocks they cut. The same migmatite also contains a few dikes and pods of granodiorite porphyry, and all major components of the migmatite are cut by tabular to irregular-shaped bodies of the diorite of Devil's Elbow and by associated aplite dikes containing miarolitic cavities and pyrite. Additional Devils Elbow, exposed along the vernal shore of Roosevelt Lake between Sixmile and Ninemile Creeks, cuts well-lineated biotite granite. Southeastern margin of the Johnny George is a gently east-dipping fault marked by a breccia zone (the breccia west of Fort Spokane), toward which the linear fabric in the Johnny George intensifies. Northern contact, with the granite of Daisy Trail, is poorly exposed and perhaps gradational. On the west, in natural exposures 1.8 mi north of the mouth of Whitestone Creek, the Johnny George overlies the diorite of Devils Elbow along a moderately west-dipping contact that appears to present ambiguous age relationships: the contact is gradational across several meters; and though porphyritic fine-grained biotite-hornblende diorite probably cuts the Johnny George above the contact, similar porphyritic diorite may also cut the Devils Elbow baneath the contact. Near and south-southeast of the mouth of Whitestone Creek, the Johnny George abuts the Covada Group and the granite of Swawilla Basin along a concealed part of the Brody Creek fault. The Johnny George is shown relatively upthrown along this fault because the Covada, apparently a pendant west of the fault, may have baen uplifted and erosionally removed east of the fault; and because, along with the diorite of Devils Elbow east of the fault, hornblende-biotite granodiorite in migmatite south of Pheasant Spring is a likely plutonic equivalent of some of the hypabyssal-porphyry dikes west of the fault

OLDER PLUTONIC ROCKS

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 Paleozoic metasedimentary rocks; and all may have baen affected by Eocene heating so that their K/Ar ages, many of which are close to 50 m.y., might be minimum ages. In plate 4, the rocks are organized primarily by location and relative age; in the following description they are grouped mainly by lithology.

Hornblende-free rocks

pgcc 25 PORPHYRITIC GRANITE OF COYOTE CREEK--Forms a large pluton in the west-central part of the reservation that consists of leucocratic (CI 3-5) generally massive, porphyritic biotite granite and granodiorite. 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, darker (CI 5-10) matrix is widespread, though mostly dispersed among typical rocks. Near the mouth of Coyote Creek locally bears muscovite and alternates with large masses of aplite, locally resembles the quartz porphyry of Mount Tolman, and locally grades into rock that resembles some of the hornblende-free porphyry of the hypabyssal-intrusive suite of Cody Lake. Although the Coyote Creek typically lacks a discrete border phase, rocks along the contact with the plutonic complex of Boot Mountain are notably darker (CI 5-10) northwest of Kartar Creek, and are further distinguished by containing ellipsoidal quartz and aligned biotite that define a weak concordant foliation there. Near the northwestern margin of the pluton, the Coyote Creek contains sparse discrete bands of mylonitic foliation and lineation, discordant with the pluton's margin but parallel to mylonitic structures in rocks of the Okanogan gneiss dome. Exposed age relations: a thin dike of the Whitelaw phase of the granite of Moses Mountain appears to cut the Coyote Creek at one locality 2 mi north of Armstrong Mountain; diorite in the intrusive complex north of Grant Lake contains inclusions of Coyote Creek, along highway 155; the Coyote Creek is cut by both hornblende-baaring and hornblende-free porphyry in the hypabyssal-intrusive suite of Cody Lake and by a dike of the granite west of Armstrong Mountain; the plutonic complex of Boot Mountain is cut by the Coyote Creek east of Omak Lake. K-Ar biotite age about 51 m.y. (table 1)

ggm 26 GARNET-BEARING GRANITE OF McGINNIS LAKE--Fine- to medium-grained locally pegmatitic, light-colored biotite granite with 1-2 percent pyralspite-series garnet. Forms a body between Joe Moses and Peter Dan Creeks (Nespelem quadrangle) that intrudes the porphyritic granite of Keller Butte and the quartz porphyry of Mount Tolman. Contains magnetite, myrmekitic intergrowths of quartz and feldspar, and less than 3 percent biotite. Quartz commonly flattened parallel to contacts with older rocks; these contacts sharp, unchilled, and against the Keller Butte, commonly occupied by pods of quartz

pgk 27 PORPHYRITIC GRANITE OF KELLER BUTTE--Medium- to coarse-grained equigranular to locally porphyritic, light-colored biotite granite. Forms large bodies in highlands between Nespelem and Sanpoil Rivers (Nespelem, Grand Coulee Dam, and Keller quadranlges), 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 Daisy Trail and much of the porphyritic granite of Coyote Creek. Pegmatite dikes probably issued from the Keller Butte cut the granite of Swawilla Basin near Keller Butte and also cut the porphyritic granodiorite of Manila Creek. Other field relations are ambiguous with regard to the age of the Keller Butte relative to the age of the Swawilla basin; along the Keller Butte's southern margin their mutual contact is sharp, but neither unit is chilled. K/Ar age, on weathered biotite from southern edge of largest body of the Keller Butte, is about 60 m.y. (table 1)

agm
28 ALTERED GRANITE OF MEADOW CREEK--Biotite granite, coarse-grained and porphyritic with biotite and feldspar largely altered to sericite. Forms small body centered about a mile south of Keller, on northeast side of Mount Tolman. Protolith possibly the porphyritic granodiorite of Manila Creek or the porphyritic granite of Keller Butte; alteration older than hypabyssal-intrusive suite of Cody Lake and possibly coeval with late-stage crystallization of the porphyritic granite of Keller Butte (W. C. Utterback, oral commun., 1983)

qpm
29 QUARTZ PORPHYRY OF MOUNT TOLMAN--Light-colored biotie granite whose large phenocrysts of orthoclase (2-5 cm) and smaller phenocrysts of rounded quartz are set in a fine-grained groundmass. Forms three mapped bodies, one near Buffalo and McGinnis Lakes (Nespelem quadrangle), another at Mount Tolman (between Meadow and Jack Creeks; Keller quadrangle), the third north of Hellgate Canyon (Wilbur quadrangle). Similar quartz porphyry is present, but not shown on the map, west of Condon Spring in the porphyritic granite of Coyote Creek (Alameda Flat quadrangle). Contact between the Mount Tolman and the porphyritic granite of Keller Butte are locally gradational; probably these two units are textural variants in a single pluton. K/Ar muscovite and sericite ages about 55-60 m.y. (table 1)

gsb
30 GRANITE OF SWAWILLA BASIN--Medium-grained, mostly equigranular or seriate, light-colored biotite granite and granodiorite that locally contains white mica. Extends almost continuously near Columbia River from Grand Coulee Dam to Whitestone Ridge (Grand Coulee Dam and Wilbur quadrangles), and also extends northward outboard of faults bounding the Keller graben (Nespelem and Keller quadrangles). Locally porphyritic from subequant potassium feldspar 1.0-1.5 cm long. Average grain size commonly varies from outcrop to outcrop between as little as 1 mm and as much as 4 mm. Color index less than 7, typically 3-5. White mica, found mainly northeast of Swawilla Basin, is particularly abundant in 1- to 2-mm granite located north of John Tom Creek (Keller quadrangle) and near Eagle Peak fault 1 mi south of Dick Creek (Wilbur quadrangle), but nowhere is it known to predominate over biotite. Some varieties are indistinguishable in hand specimen from parts of the main phase of the granite of Moses Mountain and from some hornblende-free parts of the plutonic complex of Johnny George Mountain. K/Ar biotite age about 60 m.y. (table 1)

ggc
31 GRANITE OF GEORGE CREEK--Light-colored, medium-grained, mostly equigranular biotite granite along Columbia River in southeasternmost part of reservation. Overlain, probably depositionally, by Sanpoil Volcanics. Lack of lineation and foliation distinguishes this rock from nearby plutonic complex of Johnny George Mountain

gdt
32 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-lineated (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 sliver 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 interleave 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 granitic 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 52-54 m.y. if the Cody Lake is largely coeval with the Sanpoil Volcanics and O'Brien Creek Formation (see descriptions for the Cody Lake, Sanpoil, and O'Brien Creek)

gfc
33 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 CI ranging from 2-10. Foliation 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 particulary 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 50 percent volumetric limit of Salmon Creek in the Felix Creek

eg EQUIGRANULAR GRANITE OF VIRGINIA LAKE--Four
ega separate plutons of biotite granite lie on a slightly curved line about 25 mi long
34 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 interpreted as an aplitic phase of the parent equigranular granite. The Virginia Lake is likely correlative with the Pogue Mountain quartz monzonite of Menzer (1983)

pgm PORPHYRITIC GRANODIORITE OF MANILA CREEK--
35 Medium- to coarse-grained biotite granodiorite and granite exposed 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 smaller and(or) tabular. Locally abounds in metasedimentary xenoliths, the largest of which show on the map; also, west of Nespalem River, contains many aligned, disc-shaped mafic inclusions up to 1 m in diameter (Broch, 1979), some of which closely resemble fine-grained, sphene-bearing parts of the plutonic complex of Boot Mountain. Near Ninemile Creek, well-developed foliation and lineation are parallel with structures in the adjacent Covada Group, but nearly perpendicular to overall strike of the Manila Creek's intrusive contact with the Covada; 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 granites of Keller Butte and Coyote Creek. Near Mica Mountain (Grand Coulee Dam quadrangle) and Mount Tolman (Keller quadrangle), abundantly cut by aplo-pegmatite that may have come from Swawilla Basin and(or) the Keller Butte; similarly, aplo-pagmatite 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 metamorphic 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)

pTgp GRANODIORITE PORPHYRY NEAR GOLD LAKE--Quartz-
36 andesine 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

pgcl PORPHYRITIC GRANITE AND GRANODIORITE OF COOK
37 LAKE--From northernmost 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 subround aggregates of quartz, and by the co-occurence of sphene and red garnet. In its northwesternmost part, the rock shows varied development of foliation near contacts where it becomes contaminated 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 aplite and pegmatite dikes are common

gsm GRANODIORITE OF SOAP LAKE MOUNTAIN--Comprises
38 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 sphene. Shows steeply dipping flow foliation near margins. Contains recognizable inclusions of the orthogneiss near Wakefield, and abundant cognate inclusions, as well as inclusions of metamorphic 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 the Soap Lake Mountain may be co-magmatic

pgo PORPHYRITIC GRANODIORITE SOUTHWEST OF OMAK
39 LAKE--Coarse-grained (3-10 mm), mostly coarsely 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 euhedral and elongate quartz; normally zoned plagioclase; biotite; and minor hornblende, sphene, allanite, epidote, and iron oxide. 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; sphene and hornblende contents increase near the inclusions. Medium-grained (3-5 mm) alaskite, possibly 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 alaskite 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 northwest 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 40 GRANODIORITE OF BARNABY CREEK--Forms small, isolated intrusions into Covada Group in northeastern corner of map area. Hornblende mostly altered to chlorite

ggm 41 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 hornblande-biotite granite and granodiorite (CI-5-20), the more mafic, nonporphyritic variety separately mappable, locally. K-feldspar phenocrysts (<1 cm) commonly 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)

gsc 42 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 43 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 Monse. Compositional types include quartz diorite, tonalite, leucocratic trondjemite, and some amphibolitic schist

pTrc 44 REED 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 Okanogan, 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 migmatitic 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 paragneiss, 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 45 GRANODIORITE OF ROGERS BAR (pre-Tertiary)--Medium-grained, equigranular, sphene-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 46 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 clinozoisite and epidote (Staatz, 1964, p. 19)

Mixed rocks

pcs 47 PLUTONIC COMPLEX WEST OF STEVENS LAKE--Varied migmatitic 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. Foliation between component rock types is locally more pronounced than foliation within an individual lithologic type

pcb pcbe pcbm 48 PLUTONIC COMPLEX OF BOOT MOUNTAIN--Large, wedge-shaped body extending and widening southeastward from Omak Lake. Varied, commonly migmatitic, 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 contain hornblende, lighter rocks (CI 3-10) generally do not. Most rocks contain sphene. Unit commonly includes layers, lenses, and irregular masses of fine-grained (0.1-0.5 mm) dark (CI 20-40) dioritic rock, some of which may represent metamorphosed relicts of a protolith but others of which (southwest of Goose Lake, in SE/4 sec. 29, T. 31 N., R. 29 E.) originated as dikes. Dikes of aplite and pegmatite locally abundant. Gneissosity and tabular inclusions in southern part generally strike within 30° of north. Mylonitic foliation north of Kartar Creek partly cross-cuts and partly reorients this fabric and becomes increasingly common progressively northwestward from that locality; the mylonitic rocks are labelled "pcbm" . Locally, the Boot Mountain contains sparse large (5 cm) K-feldspar megacrysts along contact with the porphyritic granodiorite of Mission Creek and roughly tabular aggregates of many such megacrysts near contact with the porphyritic granite of Coyote Creek. Near Omak Lake, brecciated parts of unit are riddled with chlorite-lined fractures and conspicuously colored by pink feldspar and bluish-gray quartz. Near mouth of Harrison Creek, the Boot Mountain consists primarily of light-colored fine- to coarse-grained biotite granite that is riddled with closely spaced (0.2-5 cm) fractures lined with a purplish oxide. Near the southeast corner of sec. 8, T. 31 N., R. 29 E., this shattered granite grades into a maroon cataclasite that does not crop out on the facing ridge, northwest of Harrison Creek. That part of the complex labelled pcbe is distinct from rest of the Boot Mountain only by its lack of migmatitic character, except along the contact with the Salmon Creek schist and gneiss, and further, by being generally equigranular and somewhat more homogeneous than the rest of the Boot Mountain. K-Ar ages from pcbe: biotite, 49 m.y.; hornblende 72 m.y. (table 1)

csm
49 PLUTONIC AND METAMORPHIC COMPLEX OF SQUAW MOUNTAIN--Crops out as a northeastward-trending body west of Nespelem. Greenstone and metadiorite; schist and gneiss composed of pelitic and subordinate psammitic and calc-silicate rocks; and equigranular, medium-grained, sphene-poor granitoids that resemble parts of the plutonic complex of Boot Mountain. Largely riddled with hypabyssal-porphyry dikes. Linear contact (Multnomah fault) with Coyote Creek pluton probably represents the western margin of the southerly extension of the Republic graben

ugg
50 UNDIVIDED GRANITIC ROCKS NEAR GOLD CREEK--Biotite granite and granodiorite centered about 15 mi north of Nespelem. Probably dominated by rocks of Moses Mountain and Coyote Creek plutons. Merges into the granite of Moses Mountain along the common boundary of the Disautel and Bald Knob quadrangles, from Stepstone 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. Rocks in the Bald Knob quadrangle contiguous with the granite of Moses Mountain, along this segment of the boundary, were not examined by UGSG mappers in 1980-1983

NON-MYLONITIC METAMORPHOSED ROCKS--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.

pTsc
51 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

sdh
52 SCHIST NEAR DEERHORN CREEK--Dark-colored (CI 15-20) hornblende-orthoclase-biotite-quartz-plagioclase schist separating greenstone from light-colored biotite granite and aplo-pegmatite near the West Fork of the Sanpoil River (Bald Knob quadrangle). Banded with veins of pegmatite. Called quartz diorite by Staatz (1964, p. 29-30), who interpreted it as a deformed batholithic margin. Alternatively, a paragneiss

pTm
53 METASEDIMENTARY ROCKS BETWEEN OMAK 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. The isolated bodies elsewhere are mostly fine- to coarse-grained pelitic and psammitic granofels, schist, and gneiss, locally accompanied by calcareous and meta-volcanic rocks. Orthoquartzite 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 graywacke west of that graben, may belong to the nearby Covada Group, whose age is Ordovician, at least in part (Snook and others, 1981)

pTg 54 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)

pTsp 55 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 56 ULTRAMAFIC AND MAFIC ROCKS NEAR BRIDGE CREEK (pre-Tertiary)--Talc-carbonate rock, greenstone, 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 edjacent parts of the Covada Group accumulated; alternatively, the Bridge Creek and the Covada were brought together tectonically from widely separated areas

pTmi 57 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 metagabbro, which forms a small body between the North and South Forks of Hall Creek, 9 mi north-northeast of Twin Lakes; and greenstone, 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.

58 COVADA GROUP (Ordovician)--Low- to medium-grade metasedimentary and minor meta-volcanic rocks abundantly exposed between the lower Sanpoil 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:

Oc

Ocp 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; schist near the porphyritic granodiorite of Manila Creek contains andalusite in some places and sillimanite in a few others

Occ 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 phyllitic 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

Ocg 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
[Number in parentheses following name of map unit refers to numbering system in correlation and description of map units]

Field Number	Collector	15-minute Quadrangle	Latitude North	Longitude West	Mineral	K_2O (percent)	Radiogenic ^{40}Ar (10^{-10} mol/g)	Radiogenic ^{40}Ar (percent of total ^{40}Ar)	[1]Age (m.y.)	Remarks
SANPOIL VOLCANICS, UPPER UNIT (3)										
FM8480-1	F. J. Moye	Seventeenmile Mountain	48°25.61'	118°43.47'	Biotite	[2]n.a.	n.a.	n.a.	48.5±0.3	Lava flow probably near top of Sanpoil section in this part of Republic graben
78KF28L-3	K. F. Fox, Jr.	Keller	48°13.99'	118°40.17'	Biotite	8.13	5.97	82.8	50.3±0.4	Vitrophyric lava flow underlain by about 150 m of ash-flow tuff
INTRUSIVE RHYOLITE NEAR WEST FORK (5)										
FM9480-1	F. J. Moye	Seventeenmile Mountain	48°28.03'	118°42.47'	Biotite	8.58	6.20	92.8	49.5±0.3	Unit intrudes part of upper unit of Sanpoil Volcanics
HYPABYSSAL-INTRUSIVE SUITE OF CODY LAKE (6)										
FM82681-2	F. J. Moye	Seventeenmile Mountain	48°15.95'	118°41.07'	Biotite Hornblende	n.a. n.a.	n.a. n.a.	n.a. n.a.	46.7±0.4 38.0±0.4	Dike probably comagmatic with the adjacent diorite of Devils Elbow. Ages spurious?
FM91780-3	do.	do.	48°27.68'	118°38.63'	Hornblende	0.966	0.696	70.4	49.4±0.3	Dike intrudes part of upper unit of Sanpoil Volcanics
FM82980-10	do.	do.	48°27.23'	118°38.04'	Biotite	7.02	5.16	64.6	50.3±0.3	do.
GRANITE OF DEADHORSE CREEK (8)										
FM91780-2	F. J. Moye	Seventeenmile Mountain	48°16.43'	118°41.65'	Biotite	9.38	6.79	82.9	49.6±0.3	Unit intrudes diorite of Devils Elbow
HORNBLENDE-BEARING GRANITOID ROCKS OF SWIMPTKIN CREEK (12)										
O-419	K. F. Fox, Jr.	Disautel	48°25.65'	119°09.15'	Biotite Hornblende	8.89 0.864	6.39 0.623	77.7 57.9	49.2±1.5 49.4±1.5	Reported by Fox, Rinehart, Engels, and Stern (1976, p. 1220)
SS-340	S. H. Singer	Disautel	48°24.80'	119°10.58'	Biotite Hornblende	8.60 1.00	6.21 0.66	53 38	49.5±1.2 45.3±1.1	— Contaminated?
GRANITE OF MOSES MOUNTAIN, CLARK CREEK PHASE (14)										
SS-341	S. H. Singer	Disautel	48°24.20'	119°10.84'	Biotite	8.73	6.29	56	49.4±1.2	Unit intrudes diorite of Swimptkin Creek
GRANITE WEST OF ARMSTRONG MOUNTAIN (16)										
SS-351	S. H. Singer	Disautel	48°15.40'	119°08.37'	Biotite	8.15	6.26	44	52.5±1.3	Unit probably intrudes granite of Coyote Creek
DIORITE OF DEVILS ELBOW (17)										
RWH-54453	R. W. Holder	Seventeenmile Mountain	48°28.61'	118°32.37'	Biotite Hornblende	8.93 0.678	5.91 0.471	57 28	45.2±1.1 47.7±1.2	Hall Creek pluton
N-51C	C. D. Rinehart	Nespelem	48°09.99'	118°46.08'	Biotite	8.62	6.24	55	49.6±1.2	Devils Elbow pluton
FM91780-1	F. J. Moye	Seventeenmile Mountain	48°16.28'	118°42.50'	Biotite	8.29	6.04	78.0	49.9±0.3	do.
GNEISSIC PORPHYRITIC GRANODIORITE OF MISSION CREEK (21)										
O-425	K. F. Fox, Jr.	Omak Lake	48°23.45'	119°26.52'	Biotite	9.45	6.50	82.9	47.2±1.4	Reported by Fox, Rinehart, Engels, and Stern (1976, p. 1220)
PORPHYRITIC GRANITE OF COYOTE CREEK (25)										
O-424B	K. F. Fox, Jr.	Disautel	48°16.85'	119°08.42'	Biotite	9.02	6.63	77.8	50.4±1.5	Reported by Fox, Rinehart, Engels, and Stern (1976, p. 1220)
BA-82-54E	B. F. Atwater	Alameda Flat	48°01.16'	119°08.11'	Biotite	8.96	6.69	68	51.1±1.3	—

PORPHYRITIC GRANITE OF KELLER BUTTE (27)										
A65677	W. C. Utterback and R. Badley	Grand Coulee Dam	47°59.67'	118°50.30'	Biotite	n.a.	n.a.	n.a.	61.3±2.3	Biotite weathered
ALTERED GRANITE OF MEADOW CREEK (28)										
KELLER	n.a.	Keller	48°03.58'	118°41.53'	K-feldspar	11.46	10.33	89.6	51.2±1.8	Reported by Armstrong, Harakal, and Hollister (1982)
QUARTZ PORPHYRY OF MOUNT TOLMAN (29)										
A-56471	W. C. Utterback and C. Dykeman	Keller	48°03.39'	118°42.20'	Sericite	n.a.	n.a.	n.a.	55.7±2.0	From AMAX core DH-6. State coordinates: N392,653; W2,521,050
A-56470	do.	do.	48°03.24'	118°42.14'	Muscovite	n.a.	n.a.	n.a.	57.7±2.1	From AMAX core DH-24. State coordinates: N391,787; W2,521,050
GRANITE OF SWAWILLA BASIN (30)										
A65679	W. C. Utterback and R. Badley	Nespelem	48°00.47'	118°48.43'	Biotite	n.a.	n.a.	n.a.	58.8±2.2	Unit probably intruded by porphyritic granite of Keller Butte
GRANITE OF DAISY TRAIL (32)										
RWHNE985C	R. W. Holder	Seventeenmile Mountain	48°15.00'	118°31.57'	Biotite	9.03	6.57	73.3	49.9±0.3	Homogeneous, medium grained
PORPHYRITIC GRANODIORITE SOUTHWEST OF OMAK LAKE (39)										
MOL-39	V. L. Hansen	Omak Lake	48°17.63'	119°26.39'	Biotite	9.53	7.44	75	53.4±1.3	--
GRANITE AND GRANODIORITE NEAR METEOR (41)										
K-51B	K. F. Fox, Jr.	Twin Lakes	48°15.32'	118°22.52'	Biotite	8.40	6.68	92.8	54.5±0.4	--
REED CREEK QUARTZ DIORITE GNEISS OF MENZER (1983) (44)										
Mol-276	V. L. Hansen	Omak Lake	48°16.68'?	119°26.91'?	Biotite Hornblende	9.22 1.35	7.77 1.50	80 57	57.4±1.4 75.2±1.9	--
GRANODIORITE NEAR ROGERS BAR (45)										
K-52B	K. F. Fox, Jr.	Wilmont Creek	48°03.51'	118°17.54'	Hornblende	0.998	1.04	16.6	71.1±2.0	--
PLUTONIC COMPLEX OF BOOT MOUNTAIN, EQUIGRANULAR PHASE (48)										
Mol-277	V. L. Hansen	Omak Lake	48°19.57'	119°29.30'	Biotite Hornblende	9.42 1.32	6.71 1.39	52 59	48.9±1.2 72.1±1.8	--

[1] Decay constants for K: $^{40}K/K = 1/167 \times 10^{-4}$ mol/mol; lambda B = 4.962×10^{-10} yr^{-1}; lambda epsilon plus lambda epsilon prime = 0.581×10^{-10} yr^{-1}; dates of Fox and others (1976) recalculated with these constants by means of Dalrymple's (1979) conversion table.

[2] n.a., not available; do., ditto.

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Streckeisen, A. L., 1973, Plutonic rocks classification and nomenclature recommended by the IUGS Subcommission of the systematics of igneous rocks: Geotimes, v. 18, no. 10, p. 26-30.

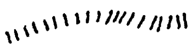
White, R. O., 1981, Geology of the Schminski molybdenum deposit (Colville Indian Reservation), Ferry County, Washington: Pullman, Washington, Washington State University, M.S. thesis, 103 p.

CONVENTIONAL SYMBOLS

CONTACT

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

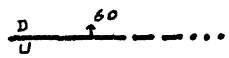
Concealed



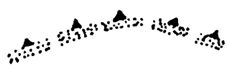
Gradational

Interfingering

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



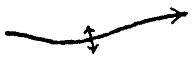
High angle, showing sense of displacement and dip



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

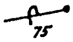
AXIS OF SMALL FOLD

Trend and plunge of inclined axis

STRIKE AND DIP OF BEDDING--Dot on symbol where top of bed known from sedimentary structures


Upright

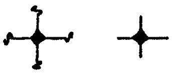

Vertical


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


Inclined


Vertical

TREND AND PLUNGE OF LINEATION


Inclined


Horizontal

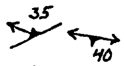

SHEARED ROCK


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)

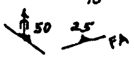

HOL-39

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

EXAMPLES OF COMBINED SYMBOLS

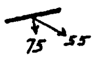


Foliation and lineation



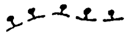
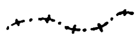
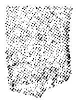
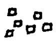
Foliation and axis of small fold

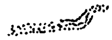
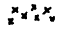
Foliation and bedding parallel



Small fault, showing dip of plane and trend of lineation on the plane

ADDITIONAL SYMBOLS, USED MOSTLY FOR ONE OR A FEW UNITS

Unit Number	Unit Letter	Symbol	Meaning
1	--		INFERRED MARGIN OF CORDILLERAN ICESHEET
			Terminal. Bar and ball toward ice
			Recessional. Marked by end moraine
3	Tsu		PYROCLASTIC ROCK
			EPICLASTIC ROCK
			AUTOCLASTIC BRECCIA
			TRACE OF INDIVIDUAL LAVA FLOW--Shown only in Republic graben
5	--		PLUG OR LARGE DIKE (sole means of representing unit)
6	Th		DIKE SWARM--Ratio of hypabyssal porphyry to country rock generally exceeds 1:10 (see fig. 3 for an example)
			STRIKE AND DIP OF INDIVIDUAL DIKE
			Inclined
			Vertical
			Dip unknown
20-22	tg, gpg, gfv		APPROXIMATE EASTERN LIMIT OF PENETRATIVELY MYLONITIC ROCK IN THE OKANOGAN GNEISS DOME
24	pcj		DIORITE
			RELATIVELY HOMOGENEOUS GRANITE
			PORPHYRITIC COARSE-GRAINED GRANITE

32	gdt		SMALL METAMORPHIC INCLUSION
51	pTsc	*d*	DUNITE
58	Ocp		BLUE QUARTZITE
	Occ		ABUNDANT APLO-PEGMATITE DIKES