UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

RECONNAISSANCE GEOLOGIC MAP OF THE COLUMBIA RIVER BASALT GROUP, NORTHERN OREGON AND WESTERN IDAHO

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards

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EXPLANATION

Contact, approximately located; dotted where concealed

Fault, dashed where approximately located; dotted where concealed

High-angle fault; bar and ball on downthrown side

Thrust fault; sawteeth on upper plate

Strike-slip fault, showing relative horizontal movement

Strike-slip fault, sense of relative horizontal movement indeterminate

Oblique-slip fault, showing relative horizontal and vertical movement

Fold, showing direction of plunge if any; dashed where approximately located; dotted where concealed

Crestline of upright anticline

Crestline of overturned anticline

Troughline of syncline

Monocline, dashed where approximately located; dotted where concealed

Abrupt decrease of dip in direction of arrows

Abrupt increase of dip in direction of arrows

Prominent photo or topographic lineament, possibly a strike-slip fault

Attitude

7 Strike and dip

Horizontal

85 Overturned

Tf Vent area with map symbol of unit in vent

Tr Dike with map symbol of unit fed by dike

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DESCRIPTION OF MAP UNITS

Qs SEDIMENTARY DEPOSITS--Alluvium, morainal and glacial outwash material, and gravel, sand and silt deposited by Missoula floods. Locally includes loess of Palouse Formation. More extensive than shown; generally mapped only where important bedrock relations are obscured

Qls LANDSLIDE DEPOSITS--Poorly sorted chaotic deposits, generally with hummocky topography. Mostly along contact of poorly lithified or clay-rich sediments and overlying flows of Grande Ronde or Wanapum Basalt. Includes deposits of block slides

Qba ANDESITE AND BASALT--Flows, cinder, and small intrusive bodies of olivine basalt and andesite erupted in the Cascade Range, chiefly from Mount Hood (Wise, 1968, 1969; White, 1980) and the King Mountain and Indian Heaven fissure zones in Washington (Hammond and others, 1976). Mostly younger than about 700,000 yrs (Hammond and others, 1976).

QTs LOESS AND ASSOCIATED FLUVIAL DEPOSITS--Mostly loess of Palouse Formation, but locally includes interbedded and underlying fine sand, silt, and stream gravel. More extensive than shown; mapped only where important bedrock relations are obscured. Mostly Pleistocene

QTg GRAVEL AND CONGLOMERATE--Unconsolidated and weakly consolidated gravel, interbedded sand, and tuffaceous deposits. Composed mostly of clasts derived from Columbia River Basalt Group and older units. Includes deposits of the Shutler formation of Hodge (1932, 1942) and "Pliocene fanglomerate" of Hogenson (1964), both correlated with the Dalles Formation by Newcomb (1966). Includes terrace gravel near Ukiah (T. 5 S., R. 31 E.) and auriferous gravel of mixed lithology near Starkey (T. 3-4 S., R. 35-36 E.). In Richland basin, lower part of unit is dominantly tuffaceous (similar to unit Tsev) and of lacustrine origin (Brooks and others, 1976)

QTb OLIVINE BASALT-- Principally olivine basalt flows and cinder in Cascade Range (Hammond, 1980; Hammond and others, 1980) and Simcoe Mountains volcanic area (Sheppard, 1967; Sylvester, 1978). Mostly Pliocene, but in large areas of Oregon Cascade Range includes rocks of Pleistocene age. Potassium-argon dates for flows in Goldendale area range from about 0.9 to 4.5 m.y. (Kienle and others, 1979), and for rocks in the upper Clackamas River area from about 0.25 to 4.2 m.y. (Sutter, 1978; Hammond and others, 1980). Locally includes flows, tuffs, and small intrusive bodies of andesitic, dacitic, and rhyolitic compositions (Sheppard, 1967)

YAKIMA BASALT SUBGROUP OF COLUMBIA RIVER BASALT GROUP--See Swanson and others (1979) for more complete descriptions of most units

SADDLE MOUNTAINS BASALT--Includes:

Tb Buford Member--Basalt flow overlying sedimentary deposits resting on Umatilla Member near Flora, Oregon. Includes Buford flow of Walker (1973b). Rests on Elephant Mountain Member a short distance north of map area. Contains sparse small plagioclase phenocrysts. Generally less than 20 m thick. Buford chemical type (Wright and others, 1980). Reversed magnetic polarity. Feeder dike occurs in Joseph Creek drainage 15 km southeast of Flora

Tem Elephant Mountain Member--Nearly aphyric basalt flows of Elephant Mountain chemical type (Wright and others, 1973). Normal to transitional magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Potassium-argon age about 10.5 m.y. (McKee and others, 1977). Occurs extensively on the Horse Heaven Plateau, Washington, and between Arlington and Boardman, Oregon. Includes the Wenaha flow of Walker (1973b) in and south of the lower Wenaha River area (Ross, 1978). Feeder dike occurs upriver from confluence of Wenaha and Grande Ronde Rivers (Ross, 1978; 1980, fig. 3)

Tcg Basalt of Craigmont--Fine- to medium-grained basalt flow with scattered plagioclase phenocrysts as long as 10 mm.

Chemically distinct from most other flows in Columbia River Basalt Group (V. E. Camp, unpub. data, 1979; Wright and others, 1980). Normal magnetic polarity. Occurs just north of Grangeville, Idaho. Upper age limit unknown. Two north-northeast trending feeder dikes occur along Slate Creek, about 35 km south of Grangeville

Tgv Basalt of Grangeville--Medium- to coarse-grained basalt flow with sparse plagioclase phenocrysts less than 7 mm long and abundant, commonly altered, olivine phenocrysts and microphenocrysts. Bears some resemblance chemically to Pomona and Dodge chemical types (V. E. Camp, unpub. data, 1979; Wright and others, 1980). Reversed magnetic polarity. Occurs near Grangeville, Idaho and in scattered outcrops farther west. Feeder dike occurs in Rocky Canyon (T. 30 N., R. 1 E.) west of Grangeville. Equivalent to the Amphitheater flow of Bard (1978)

Tp Pomona Member--Slightly phyric basalt flow of Pomona chemical type (Wright and others, 1973). Contains small phenocrysts of plagioclase, clinopyroxene, and olivine. Reversed magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Potassium-argon age about 12 m.y. (McKee and others, 1977). Occurs extensively on Horse Heaven Plateau and in northern Oregon along Columbia River. Locally occurs as intracanyon flow west of Hood River, Oregon (Anderson, 1980).

Twe Basalt of Weippe--Medium- to coarse-grained flow of Pomona chemical type. Reversed magnetic polarity. Petrographically similar and probably equivalent to Pomona Member, but mapped separately because the easternmost outcrops of the Pomona, in the Lewiston basin, are 35 km west of the westernmost outcrops of the basalt of Weippe (Swanson and others, 1979).

Tan Andesite-- Fine-grained, commonly platy, light to dark gray andesite erupted from local centers northeast of Baker, such as Sawtooth Ridge (Patterson, 1969; Brooks and others, 1976), and flanking Grande Ronde Valley near La Grande. Small phenocrysts of plagioclase and hornblende common. Rocks within unit have wide range of chemical compositions, with SiO_2 contents from 50 to 66 wgt percent (Wright and others, 1980). Those rocks with less than about 58 percent SiO_2 may be fractionated basalt; no adequate name for rocks of these compositions exists. Unit commonly forms hills above gently-dipping basalt flows. Potassium-argon ages for andesite at Sugarloaf, Spring, and Wilbur Mountains west of Grande Ronde Valley are about 7 m.y. (Kienle and others, 1979). Potassium-argon ages for andesite just east of Grande Ronde Valley are older, between about 9 and 12 m.y. (E. H. McKee and W. H.

Taubeneck, written commun., 1979). Informally included in Columbia River Basalt Group; later work may result in excluding unit from the group

Tfg Basalt of Ferguson Spring--Fine-grained, aphyric flow with very high P_2O_5 content (P. R. Hooper, unpub. data, 1978). Occurs only as a small remnant capping tuffaceous deposit east of Grande Ronde River in T. 4 N., R. 41 E., about 22 km north of Minam, Oregon. Normal magnetic polarity

Tslk Basalt of Sprague Lake--Sparsely plagioclase-phyric dike and flow at vent area about 7 km west of Riggins, Idaho. Chemically similar to the basalt of Sprague Lake in eastern Washington (Swanson and others, 1979); Wright and others, 1980). Normal magnetic polarity. Correlation with basalt of Sprague Lake tentative

Ta Asotin Member--Sparsely plagioclase- and olivine-phyric, commonly ophitic basalt flow of Asotin chemical type (Camp, 1976; Wright and others, 1980). Normal magnetic polarity. Occurs extensively in Clearwater embayment east of Lewiston, Idaho, but in mapped area crops out only 15-20 km northeast of Grangeville

Tawg Asotin Member and basalts of Weippe and Grangeville, Shown only where map scale and steep topography prohibit separation

Tla Basalt of Lapwai--Fine- to medium-grained, sparsely plagioclase-phyric flow assigned to the Wilbur Creek Member but with higher MgO and lower SiO_2 than rest of member (Swanson and others, 1979; Wright and others, 1980). Chemically intermediate between Wilbur Creek and Asotin chemical types (Wright and others, 1980). Contains rare small plagioclase and olivine phenocrysts. Occurs extensively in Clearwater embayment but found in mapped area only within 15-20 km northeast of Grangeville, Idaho.

Ten Basalt of Eden--Fine- to medium-grained, plagioclase- and olivine-phyric basalt flow or flows. Plagioclase phenocrysts as much as 6 mm long, and olivine phenocrysts about 3 mm across. Distinctive chemical composition, characterized by about 1.2 wgt percent P_2O_5 (Ross, 1978; Wright and others, 1980). Normal magnetic polarity. Occurs in Akers Butte-Howard Butte area north of Minam, Oregon, farther north in the Elbow Creek area, and farther west near Fry Meadows Guard Station. Feeder dike crosses Grande Ronde River in T. 4-5 N., R. 41 E. Commonly exhibits complex invasive relations with tuffaceous sedimentary deposits (Ross, 1978). Unit and associated sedimentary deposits are confined southeast of a major northeast-trending fault, which may have controlled site of deposition

Tens Basalt of Eden and tuffaceous sedimentary deposits, undivided--Mapped only where invasive relations are complex and exposures poor owing to landsliding and forest cover

Tu Umatilla Member--Fine-grained basalt flow or flows of Umatilla chemical type (Wright and others, 1980) and its older variant, the Sopher Ridge chemical type (P. R. Hooper, unpub. data, 1979; Wright and others, 1980). Typified by very even grain size and near lack of phenocrysts. Normal magnetic polarity (Rietman, 1966). Includes Bear Creek flow of Ross (1978), probably equivalent to the flow of Sopher Ridge type. Occurs on Horse Heaven Plateau, along Columbia River east of Umatilla, Oregon, at scattered localities on northwest flank of Blue Mountains uplift east of Adams, Oregon, and extensively between crest of uplift and Joseph Creek. Commonly overlain by tuffaceous sedimentary deposit in Grande Ronde River drainage area. Major vent area occurs just north of mapped area at Puffer Butte (Price, 1974, 1977; Swanson and others, 1980), and feeder dikes occur along strike in mapped area in Joseph Creek (T. 6 N., R. 45 E.) and in Little Sheep Creek (T. 1 S., R. 47 E.; Kleck, 1975)

WANAPUM BASALT--Includes:

Tpr Priest Rapids Member--Fine- to coarse-grained basalt flows of Rosalia and Lolo chemical types (Wright and others, 1980) with reversed magnetic polarity (Rietman, 1966). Flows of Rosalia chemical type are nearly aphyric and contain groundmass olivine visible with hand lens in fine-grained samples. Flows of Lolo chemical type generally contain phenocrysts of olivine and commonly plagioclase. Flows of Lolo chemical type consistently overlie flows of Rosalia chemical type on Horse Heaven Plateau and farther west. Flows of Rosalia chemical type occur north of Slate Creek (T. 31 N., R. 4 and 5 E.) and along north edge of mapped area east of Grangeville; flows of Lolo type dominate farther north in Clearwater embayment. Feeder dikes of Lolo chemical type occur along Slate Creek, forming the southernmost known part of a linear vent system possibly 160 km long containing dikes of both chemical types

Tr Roza Member--Basalt flows of Roza chemical type (Wright and others, 1973) that consistently contain several percent single, in places clotted, plagioclase phenocrysts averaging nearly 10 mm across and evenly distributed throughout most flows. Transitional or reversed

magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Very extensive unit elsewhere on Columbia Plateau (Swanson and others, 1979, 1980), but in mapped area occurs only in three small outcrops along Crow Creek, Oregon (T. 2 N., R. 45 E.). Feeder dikes occur along Joseph Creek (T. 5 N., R. 45 E.) (Price, 1977), farther south along the creek (T. 4 N., R. 45 E.), and at confluence of Crow and Chesnimnus Creeks (T. 3 N., R. 45 E.). These dikes form the southern part of a linear vent system at least 160 km long (Swanson and others, 1975).

Tob Olivine basalt--Diktytaxitic, commonly olivine- and plagioclase-phyric basalt flows. Characterized by relatively high MgO (about 8 wgt percent) and Al_2O_3 (16.5-17 wgt percent) and low K_2O (0.5-0.6 wgt percent) (Wright and others, 1980). Easily recognized in field because of diktytaxitic texture. Overlies basalt of Powatka and underlies Umatilla Member; age relative to Roza and Priest Rapids Members unknown. Thin tuffaceous sedimentary deposits commonly underlie and overlie unit

Tpo Basalt of Powatka--Fine-grained, aphyric basalt flow lacking distinguishing physical characteristics but identifiable by its chemical composition (Wright and

others, 1980) and general stratigraphic position. Characterized by P_2O_5 content of about 1 wgt percent (Ross, 1978; Wright and others, 1980). Occurs on east flank of Blue Mountains uplift, north of Grande Ronde Valley, and in Troy basin, where it was first recognized by Ross (1978). Normal magnetic polarity

Tf Frenchman Springs Member--Basalt flows of Frenchman Springs chemical type (Wright and others, 1973). Many flows contain irregularly distributed plagioclase glomerocrysts as much as 50 mm across, but some flows, particularly the younger ones, are virtually aphyric. Generally fine- to medium-grained. Normal magnetic polarity (Rietman, 1966). Overlies thin saprolite developed on top of Grande Ronde Basalt in places in Blue Mountains, and commonly rests on thin tuffaceous or subarkosic sandstone and siltstone farther west. Basal flow is pillowed in many places. Unit can be subdivided into several recognizable flows throughout much of area; these flows were not mapped separately, but their identification helped to define structural relations. Very extensive in western part of mapped area and in Blue Mountains north of Umatilla River. Not recognized east of Troy basin. Feeder dikes occur in north-northwest zone 20-25 km wide extending from lat. 45° 30' north of La Grande to north edge of

mapped area and far beyond (Swanson and others, 1979, 1980). Dikes are subvertical in most places but dip about 20 degrees east in a zone south of Milton-Freewater and about 20 degrees west in a zone from Pikes Peak south to Tollgate. One gently dipping dike may occur in Vansycle Canyon (T. 5 N., R. 33 E.)

Tpf Basalt of Powatka and Frenchman Springs Member, undivided--Mapped only where topography and scale preclude separation

Tek Basalt of Lookingglass--Fine-grained, aphyric basalt flow with distinctive chemical composition characterized by "intermediate" P_2O_5 content of about 0.65 wgt percent (Wright and others, 1980). Overlain by Frenchman Springs Member and underlain by basalt of Dodge (Eckler Mountain Member). Occurs only in upper reaches of North Fork of Umatilla River, South Fork of Walla Walla River, and in Lookingglass Creek drainage. Normal magnetic polarity

Tpk Basalts of Powatka and Lookingglass, undivided--Mapped only where topography and scale preclude separation

Eckler Mountain Member--Petrographically and chemically distinctive basalt flows between basalt of Lookinglass and Grande Ronde Basalt. Saprolite generally underlies and locally overlies unit. Normal magnetic polarity. Subdivided into three map units:

Tes Basalt of Shumaker Creek--Fine-grained, nearly aphyric basalt younger than basalt of Dodge and older than Roza Member. Crops out as flow north of mapped area

(Swanson and others, 1980), but in area occurs only as dikes along Chesnimnus Creek (T. 3 and 4 N., R. 45 E.) and about 90 km farther south-southeast along North Pine Creek (T. 7 S., R. 47 E.). Similar chemically to basalt of Lookingglass but distinguished by having lower TiO_2 (2.4 vs. 2.7 wgt percent) and higher P_2O_5 (0.8 vs. 0.65 wgt percent)

Ted Basalt of Dodge--Coarse-grained, moderately to highly plagioclase-phyric basalt flows in Blue Mountains north of South Fork Walla Walla River and in Wenaha and Grande Ronde River drainages. Abundant olivine altered to clay minerals, commonly causing rock to break down to grus during mechanical weathering. Generally two flows present, the lower being more highly phyric than the upper. Along Wenaha and Grande Ronde Rivers, commonly forms reddish-brown rounded cliffs. Chemically distinctive except for similarity to some very high MgO flows of Grande Ronde Basalt (Wright and others, 1980). Interbedded with Frenchman Springs Member on east side of South Fork Walla Walla River (sec. 32, T. 5 N., R. 39 E.), but in other places in mapped area underlies the Frenchman Springs. Feeder dikes of similar composition and hand specimen appearance occur in T. 6 and 2 N., R. 41 E. and T. 6, 5, and 4 N., R. 43 E. Dikes with similar chemistry but considerably fewer plagioclase

phenocrysts in T. 6 and 5 N., R. 45 E., T. 6 N., R. 46 E., and T. 2 S., R. 46 E. included within unit but may be feeders for high MgO flows of Grande Ronde Basalt

Ter Basalt of Robinette Mountain--Aphyric diktytaxitic olivine basalt flow with abundant olivine partly altered to iridescent iddingsite. Chemically distinctive by its high MgO (about 8 wgt percent), CaO (11 wgt percent), and Al_2O_3 (17 wgt percent) contents; distinguished chemically from basalt of unit Tob by lower K_2O (about .3 vs .5 wgt percent). Occurs in small exposures within 3 km east and west of confluence of North and South Forks of Wenaha River (T. 5 and 6 N., R. 40 E.). Collapsed pahoehoe (Swanson and others, 1975) occurs in these exposures, suggesting nearby vent. Feeder dikes define linear trend through outcrop area, from Beaver Creek (T. 6 N., R. 40 E.) south for 7 km to South Fork Wenaha River, and another dike occurs along this trend in Minam River (T. 2 N., R. 41 E.), about 35 km farther south. This linear trend continues for 18 km northward in Washington (Swanson and others, 1980)

Tkd Basalts of Lookingglass and Dodge, undivided--Mapped only where topography and scale preclude separation

Tpd Basalt of Powatka, Frenchman Springs Member, and basalt of Dodge, undivided--Mapped only where topography and scale preclude separation

Tpkd Basalt of Powatka, Frenchman Springs Member, and basalts of Lookingglass and Dodge, undivided--Mapped only where topography and scale preclude separation

Tsm Dikes of unknown affinity, probably Saddle Mountains or Wanapum Basalt--Occur along Joseph Creek, in Imnaha River drainage, and on lower Salmon River (T. 30 N., R. 3 and 4 W). Chemical compositions differ from those of known flows. Most have similarities to Asotin chemical type but have higher TiO_2 content (1.60-1.85 vs. less than 1.50 wgt percent); some of Price's (1977) "Pomona dikes" have this composition. Includes Kleck's (1975) "Haas Ridge dikes" and Price's (1977) dike J 6, which show similarities to Lolo and Sprague Lake chemical types. Tentatively considered to be of Wanapum or Saddle Mountains age, although youngest stratigraphic unit cut by dikes is lower Grande Ronde Basalt (unit Tgn_1)

Twr Basalt of Windy Ridge--Flow beneath basalt of Grangeville and above Grande Ronde Basalt (unit Tgr_2) on Windy Ridge north of confluence of Wolf Creek and Snake River (T. 29 N., R. 2 W.). Similar chemically to most dikes in unit Tsm but higher in TiO_2 (2.20 vs. 1.00-1.85 wgt percent). Includes dike in Getta Creek (T. 28 N., R. 2 W.; Kleck, 1977, no. WO-80) and one along strike at Pittsburgh Landing along Snake River (T. 2 N., R. 51 E.)

Tgo Basalt of Powder River--Sequence of olivine-bearing, commonly olivine-phyric, basalt flows in Baker Valley-Lower Powder Valley area, and in isolated exposures near Sawtooth Ridge (T. 7 S., R. 42 and 43 E.). Dominantly reversed magnetic polarity near Baker Valley and normal polarity farther east. Chiefly high-Al_2O_3 basalt, with MgO contents from 5 to 9 wgt percent and low K_2O (0.2 to 0.9 wgt percent) and TiO_2 (0.7 to 1.6 wgt percent) contents. Severely faulted. Inadequately mapped. Overlies Grande Ronde Basalt (unit Tgn_1) and underlies andesite at Sawtooth Ridge. Chemically resembles olivine basalt flows in units Tob and Ter. South of Baker flows appear to have erupted from cinder cones. Includes flow rich in P_2O_5 (0.95 wgt percent) capping Sparta Butte (T. 8 S., R. 44 E.). Flows southwest of Baker Valley laterally continuous into Strawberry Volcanics of Brown and Thayer (1966). Questionably included in Columbia River Basalt Group; further work may exclude unit from group

GRANDE RONDE BASALT--Basalt flows, aphyric to very sparsely plagioclase-phyric, comprising thickest and most voluminous formation in Columbia River Basalt Group. Generally fine-grained and petrographically non-distinctive. A few flows in lower reversely magnetized part of section (R_1 of Swanson and

others, 1979) contain numerous plagioclase phenocrysts. Chemical composition varies within a broad field now termed Grande Ronde chemical type (Yakima chemical type of Wright and others, 1973). In western part of mapped area, flows of high-Mg Grande Ronde chemical type generally overlie somewhat finer-grained, hackly flows of low-Mg type in upper normally magnetized (N_2) part of section. Flows range in thickness from less than 1 m to more than 50 m but are generally between 15 and 25 m. Many flows near margin of Columbia Plateau are invasive into interbedded subarkosic sediments, forming sill-like bodies as much as 120 m thick, Covers and laps out on rugged topography developed on older rocks around margins of Columbia Plateau, where flows are commonly pillowed. In some places flows undergo a facies change near the margin of the plateau, thickening and becoming hackly jointed within a few kilometers of the margin, with a pillowed zone at or very close to contact with the older rocks. Divided into magnetostratigraphic units on basis of dominant magnetic polarity:

Tgn_2 Upper flows of normal magnetic polarity--Magnetostratigraphic unit N_2. Thins eastward and pinches out at about long.

117° 15', except for isolated remnants associated with vent areas west of Imnaha River

Tgr_2 Upper flows of reversed magnetic polarity--Magnetostratigraphic unit R_2. Thins eastward and pinches out at about long. 116° 30', except for isolated patches farther east

Tgn_1 Lower flows of normal magnetic polarity-- Magnetostratigraphic unit N_1. Identification of unit along Grande Ronde River west of La Grande, and along Birch Creek southeast of Pilot Rock questionable; flows in these areas could represent a normal polarity interval within unit R_2, as suggested by stratigraphic thicknesses of R_2 in nearby areas

Tgr_1 Lower flows of reversed magnetic polarity--Magnetostratigraphic unit R_1. Occurs only in eastern part of mapped area. Overlies either Imnaha Basalt or older nonbasaltic rocks

Tgd Feeder dikes for flows of Grande Ronde Basalt--Mostly 3-6 m wide. Correlated with Grande Ronde Basalt on basis of chemical composition. Dominantly feeders for units Tgn_2 and Tgr_2. Dikes occur throughout mapped area east of long. 118° 15'. Feeder dike and associated vent areas for flows in unit Tgr_2 found along Lone Rock Creek (T. 5 S., R. 23 E.). Mapped dikes most highly concentrated along Joseph Creek (T. 5 and 6 N., R. 45 and 46 E.)

PICTURE GORGE BASALT-- Flows of plagioclase-phyric and aphyric basalt of Picture Gorge chemical type (Wright and others, 1973). Generally medium- to coarse-grained, but commonly fine-grained along Brown Creek (T. 6 S., R. 24 E.) where flows are hackly jointed, aphyric, and resemble Grande Ronde Basalt except for chemical composition. Columnar jointing generally poorly formed, except for Butte Creek invasive flow of Cockerham (1974) along Butte Creek (T. 6 S., R. 19-20 E.). Weathers to rounded outcrops in most places except along Brown Creek. Upper flow generally highly plagioclase-phyric. Crops out along Butte Creek and nearby John Day River, nearly continuously south of lat. 45° 10' between long. 118° 45' and 120° 00', and in headwaters of Grande Ronde River and tributaries such as Fly and Beaver Creeks (T. 4-5 S., R. 35-37 E.). Subdivided into two units on basis of magnetic polarity:

$Tpgr_2$ Flows of reversed magnetic polarity--Underlies reversely magnetized flows of Grande Ronde Basalt (unit Tgr_2) in many places east of long. 120° 00'. Generally consists of only one highly plagioclase-phyric flow.

Tpg Flows of normal magnetic polarity--Underlies unit $Tpgr_2$ conformably. Probably correlative with lower flows of normal magnetic polarity in Grande Ronde Basalt (unit Tgn_1). Interbedded with unit Tgn_1(?) along Butte

Creek (Cockerham, 1974; Nathan and Fruchter, 1974). Feeder dikes occur in Lone Rock Creek drainage (Robinson, 1975). Includes both aphyric and plagioclase-phyric flows. Unconformably overlies older rocks

Ti IMNAHA BASALT--Basalt flows conformably underlying Grande Ronde Basalt in Idaho and in Oregon south of Wallowa Mountains and along Imnaha and Snake Rivers. Generally coarse-grained, grusy-weathering, and plagioclase-phyric with phenocrysts between 5 and 25 mm in length. Normal magnetic polarity in mapped area (Hooper and others, 1979). Generally equivalent to lower basalt of Bond (1963). Chemically distinct from Grande Ronde Basalt, as shown by average analyses obtained by P. R. Hooper and associates in Swanson and others (1979a). Includes numerous feeder dikes between long. 117° 15' and 116° 15', and outlying dikes along South Fork Clearwater River (lat. 45° 50', long. 115° 48'). Unconformably overlies older rocks

ELLENSBURG AND DALLES FORMATIONS--Weakly lithified sedimentary rocks interbedded with and overlying Columbia River Basalt Group. Includes Rhododendron Formation in Clackamas River drainage. Mapped only where thickness or exposed area is large. Occurs as unmapped interbeds between flows of Columbia River Basalt Group as old as

Imnaha Basalt, but much more common and voluminous between and above flows of Saddle Mountains Basalt. Subdivided into two units:

Tsev VOLCANICLASTIC DEPOSITS--Well to poorly sorted, weakly lithified andesitic to rhyolitic detritus chiefly erupted from volcanoes in Cascade Range and transported into area by water, mudflows, wind, and locally by pyroclastic flows. Includes tuffaceous deposits in eastern part of mapped area that may have had local sources or sources south and southeast of area. May grade laterally in deposits of unit QTg in places

Tss CONGLOMERATE OF SNIPES MOUNTAIN--Weakly consolidated river gravel and sand containing abundant quartzite and metavolcanic clasts. Interpreted as channel deposit of ancestral Columbia River in post-Elephant Mountain Member time. Occurs on Horse Heaven Plateau in Goldendale area. Locally includes volcaniclastic detritus, and may grade laterally into unit Tsev

Ts QUARTZITIC CONGLOMERATE--Composed chiefly of quartzite, granitoids, and fine-grained metamorphic rocks. Very coarse in places, with cobbles more than 75 cm diameter. Occurs between Grande Ronde Basalt (unit Tgr_2) and older rocks near China Diggings (T. 5-6 S., R. 36-37 E.). Age unknown, but probably middle or early Tertiary

Twt ASHFLOW TUFF-- Silicic tuff, generally welded, in Richland, Oregon area. Generally more than one flow present. In

places may grade laterally or vertically into unit QTg. Flowbanded rhyolite occurs locally (Brooks and others, 1976)

Tmv MIOCENE VOLCANIC ROCKS--Basaltic andesite, andesite, and lesser dacite and rhyolite flows and breccias, chiefly in Cascade Range. Underlies Grande Ronde Basalt with erosional and in places angular unconformity. Includes the Eagle Creek Formation, lava flows of Council Bluff (Hammond and others, 1976; Hammond, 1980), flows of Three Corner Peak (Hammond, 1980), Nohorn andesite of Hammond and others (1980), and, south of Baker Valley, extensive rhyolite flows (Brooks and others, 1976). Potassium-argon and fission track ages indicate middle and early Miocene age (Hammond and others, 1977). May include some volcanic rocks of Oligocene age

Tov OLIGOCENE VOLCANIC ROCKS--Includes flows, tuffs, and breccias, mostly andesitic and dacitic, in John Day, Ohanapecosh, and Stevens Ridge Formations. Generally zeolitized. Fission track ages for Ohanapecosh and Stevens Ridge are early to late Oligocene (Vance and Naeser, 1977). Age of John Day Formation on basis of K-Ar dates (Swanson and Robinson, 1968) and paleontologic evidence (Woodburne and Robinson, 1977) ranges from about 36 m.y. to 18-19 m.y.

Tev EOCENE VOLCANIC ROCKS--Clarno Formation and outliers along McKay (T. 1 S., R. 33-34 E.) and Birch (T. 2 S., R. 33 E.) Creeks (Walker, 1973; Hogenson, 1964; Pigg, 1961). Chiefly flows and breccias of andesite and basaltic andesite

Tiu INTRUSIVE ROCKS, UNDIVIDED--Fine- to medium-grained, commonly porphyritic, generally mafic plugs, dikes, and irregular intrusive bodies. Mostly associated with early and middle Tertiary volcanism. In Cascade Range, includes plugs related to late Tertiary and perhaps Quaternary volcanism

TMzg PLUTONIC ROCKS--Coarse-grained granitoids, chiefly granodiorite and quartz monzonite, along eastern and southeastern margins of Columbia Plateau. Includes outliers of Idaho Batholith. Probably mostly of Cretaceous and Eocene age

MzPzm METAMORPHIC ROCKS--Chiefly low grade metasedimentary and metavolcanic rocks of Permian, Triassic, and Jurassic age. Mostly part of Seven Devils Group (Vallier, 1977). Also includes Coon Hollow, Hurwal, and Martin Bridge Formations, as well as Paleozoic(?) to Late Jurassic high grade metamorphic rocks in Snake River Canyon (Vallier, 1977) and elsewhere. South of lat. 45° and west of long. 117°, chiefly consists of Elkhorn Ridge Argillite and Clover Creek Greenstone (Brooks and others, 1976). Metaplutonic bodies locally present

Trp INTRUSIVE COMPLEX--Chiefly quartz diorite and albite granite, gabbro and altered gabbro, and minor peridotite, pyroxenite, and serpentine (Brooks and others, 1976). South of lat. 45°, of pre-Upper Triassic age. Small fault sliver of serpentinized periditite in Idaho west of Lightning Creek (T. 30 N., R. 4 E.) of unknown age

pЄb BELT SUPERGROUP, UNDIVIDED--Chiefly argillite and quartzite. Metamorphosed to schist and gneiss in many places in border zone of Idaho Batholith. Includes mafic sills of Precambrian age, locally metamorphosed to amphibolite

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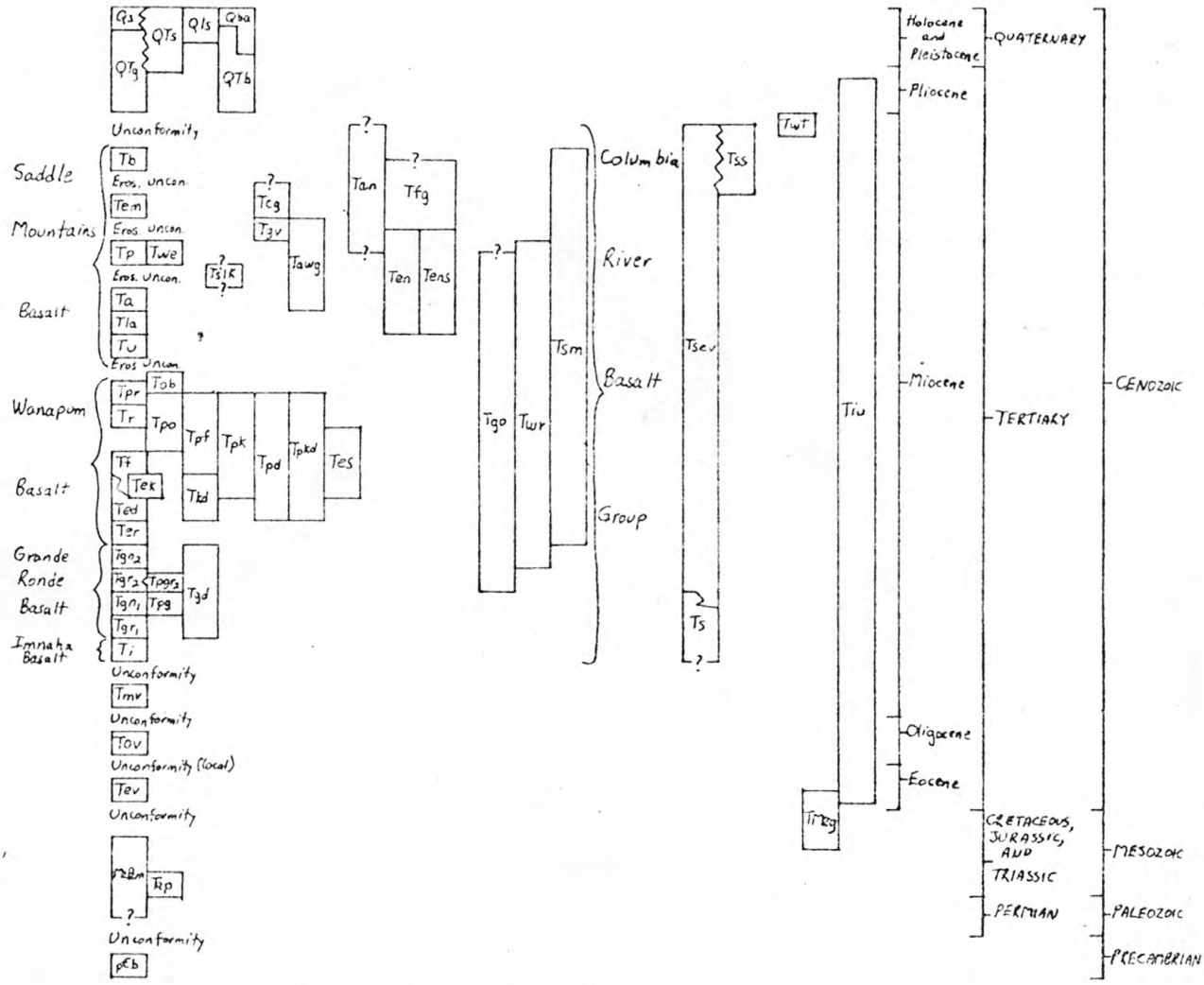
CORRELATION OF MAP UNITS



This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.