DESCRIPTION OF MAP UNITS

[*numbers in brackets are locations keyed to Figure 4 in pamphlet*)

SURFICIAL DEPOSITS

All drainage basins

Qls LANDSLIDE DEPOSITS, UNDIFFERENTIATED—Poorly sorted deposits ranging from muddy boulder gravel to bouldery mud; clasts are angular and of only one or two local rock types; most slides have hummocky surfaces, bulbous toes, and moats at the head and margins; smaller slides generally head at theater-shaped scars; some large slides merge headward with block slides (Qlsb). Small slides designated by arrows only, showing direction of movement

Qlsb LANDSLIDE OF LARGE BLOCKS—Mainly large intact blocks whose original internal stratigraphy is partly to wholly preserved (where mapped, internal stratigraphy designated in parentheses); slides occur mainly as the headward parts of large landslides derived from regional escarpment of the Yakima Basalt Subgroup; large incipient slide near Mission Peak includes nonrotated blocks, of which the largest, essentially in place, measures 2000 x 1000 x 150 m. Elsewhere blockslides are of older rock units

mf MANMADE FILL AND MODIFIED LAND

Qs SIDESTREAM ALLUVIUM—Moderately sorted boulder-to-pebble gravel of the few rock types that crop out in relatively small drainage basins

Qf ALLUVIUM OF FANS—Poorly sorted boulder gravel to gravelly sand; subangular gravel clasts are generally of one or two rock types; forms fans of distinctly steeper gradient than floor of sidestream or trunk-stream valleys but in many places merging gradationally with deposits mapped as Qs, Qy, Qp, Qc, and Qw

Yakima and Peshastin drainage basins

Qy ALLUVIUM OF YAKIMA RIVER—Boulder to pebble gravel containing rounded stones: largely of volcanic and dike rocks, moderately of metamorphic and sedimentary rocks, and sparsely of intrusive rocks. No weathering or soil

Qp ALLUVIUM OF PESHASTIN CREEK—Subrounded cobble to boulder gravel of many rock types but dominantly amphibolite (KJia) and quartz diorite (Kmsq). No soil

LAKEDALE DRIFT—Divided into:

Qlht Hyak subdrift, till—Diamicton of angular to subrounded clasts in muddy sand matrix forming moraines and drift blanket near heads of valleys; clasts consist of several rock types; A-C soil about 0.75 m thick

0ldm Domerie subdrift, mainstream outwash—Gravel lithologically like Qy but forming terrace about 5 m above Yakima River near Cle Elum that grades upstream to moraines 9 to 30 km beyond western map boundary. A-C soil about 1 m thick

Qlrm Ronald subdrift, mainstream outwash—Cobble gravel lithologically similar to Qy but forming terrace near western map boundary lower than Bullfrog outwash surface (Qtbm) and roughly 12 m above modern Yakima flood plain. Grades upvalley to moraine 5 km beyond western boundary of map

Bullfrog subdrift-Divided into:

Qlbt Till—Poorly sorted muddy boulder diamicton forming moraine atop Lakedale terrace in Yakima River valley at western boundary of map; in Peshastin Creek valley, forms flat-topped mass at mouth of Ingalls Creek and crested moraines immediately downvalley; lithology of clasts similar to Qy or Qp; weak A-C soil. In upper Naneum Canyon, consists of angular clasts of Grande Ronde Basalt, a few of them vaguely striated; forms paired nested moraines in headwaters of Naneum Creek

Qlbm Mainstream alluvium—Mixed-lithology cobble gravel forming distinct terrace 50 m above Yakima River at upstream (western) map boundary, grading downvalley to 18 m above the river at southern map boundary; material identical to Qy but includes discontinuous mantle of loess as thick as 0.5 m and supports soil no thicker than 130 cm, no redder than 7.5 YR, and lacking an argillic B-horizon; grades from moraines (Qlbt) at western boundary of map. In Peshastin drainage, forms moraine lithologically like Qp and graded to QJbt

Qlbs Sidestream alluvium—Lithologically and texturally similar to Qs but supports a weak soil; forms terraces 10 to 20 m above Holocene surfaces in Kittitas Valley along Yakima River and 4 to 7 m above floor of Dry Creek valley

Qlbg Undifferentiated gravel—Lakedale terrace near Ellensburg containing both mainstream and sidestream gravel

KITTITAS DRIFT—Divided into Indian John and Swauk Prairie subdrifts: Indian John subdrift—Divided into:

Qkit Till—Boulder diamicton lithologically similar to Qlbt forming ill-defined moraine at Indian John Hill on southern side of Yakima Valley and distinct left-lateral moraine on the southern slope of Cle Elum Ridge

Qkim Mainstream outwash—Boulder-to-cobble gravel forming prominent 85-m-high terrace heading at Indian John moraine; occurs discontinuously in Yakima canyon south of Lookout Mountain and as nearly continuous terrace 50 to 25 m above the modern flood plain along southern side of Kittitas Valley; lithologically similar to Qy but contains distinctly weathered stones and locally is mantled with loess as thick as 1.5 m soil contains a textural B-horizon as thick as 2.5 m and as red as 5 YR

Qkis Sidestream alluvium—In Kittitas Valley basaltic gravel similar to **Qs**, forming distinct terrace on northern side of Yakima River paired to mainstream outwash (**Qkim**) south of river. Continuously traceable up Dry Creek and Green Canyon Creek valleys; terrace is best topographic reference for correlation of sidestream terraces in northern Kittitas Valley; apparently correlative terraces in upper Teanaway River valley are 10 to 12 m above modern flood plain

Qkil Lacustrine deposits—Along irrigation ditch in lower Teanaway valley, thin-bedded silt and clay containing faceted ice-rafted stones as large as 20 cm; in Yakima River valley near Teanaway River confluence, an almost horizontal terrace of sand and gravel at altitude 640 m; graded to conspicuous outwash terrace (**Qkim**) immediately downstream. As mapped, includes sidestream alluvial and deltaic debris similar to **Qkis**

Swauk Prairie subdrift—Divided into:

Qksly Younger lacustrine deposit—Poorly exposed deposit 85 m above Teanaway River on eastern end of Cle Elum Ridge of thin-bedded sand, silt, and clay containing dropstones as large as 4 cm

Qkst Till—Boulder diamicton of same diverse rock types as **Qy**; forms massive morainal embankments at Thorp and Swauk Prairies and distinct nested moraines in saddle on Lookout Mountain; at Swauk Prairie is capped by as much as 3m of loess that includes a buried paleosol having a 2.8-m-thick textural B-horizon as red as 5 YR; at Thorp Prairie is only thinly and discontinuously capped by loess. Roadcuts briefly exposed in 1977 on eastern slope of Swauk Prairie revealed two layers of till separated by nonglacial sand and mud

Qksm Mainstream outwash—Gravel similar to Qy forming distinct terrace along southern side of Yakima River; terrace grades downvalley from 100 m above river at Thorp Prairie moraine to 40 m above river at southern boundary of map

Qkss Sidestream alluvium—In northern Kittitas Valley, basaltic gravel forming terraces intermediate in height between Indian John (**Qkis**) and Thorp (**Tts**) sidestream terraces; sand, gravelly sand, and sandy gravel form broad terraces about 35 m above floor of each fork of the Teanaway River

Qkslo Older lacustrine facies—2-m bed of thin-bedded, light-gray to grayish-blue clay and interbedded silt; clay contains rare dropstones of coarse sand and granules; overlies older till; underlies 3-m bed grading upward from very fine sand to coarse sand that in turn underlies till (**Qkst**) forming Swauk Prairie. Causes landsliding in new roadcuts on outer slope of the Swauk Prairie moraine

KITTITAS DRIFT, UNDIFFERENTIATED—Divided into:

Qkt Till—Till forming lateral moraines in upper Naneum Canyon outside **Qlbt** moraines; composed of unsorted angular to subrounded clasts of Grande Ronde Basalt inconspicuously striated and faceted; surface soil in places shows an argillic B-horizon. Similar deposits lithologically like **Qp** form moraines on both sides of Peshastin Creek valley and in lower Hansel Creek

Qks Sidestream gravel—In Kittitas Valley, terrace gravel of clasts of Grande Ronde Basalt; forms terrace above Lakedale and Holocene sidestream surfaces but below level of Thorp sidestream surfaces. In Peshastin valley similar terrace deposits lithologically reflect the local crystalline bedrock

Qlm LOOKOUT MOUNTAIN RANCH DRIFT—Diamicton containing rounded to subangular, faceted, striated stones of diverse rock types similar to Qy; forms subdued moraines 0 to 85m above the outer Kittitas moraine **(Qkst)** on Lookout Mountain; Soil contains 7 YR to 5YR argillic B-horizon at least 45 cm thick; correlative moraine along western side of Horse Canyon

THORP GRAVEL—Divided into:

Ttm Mainstream alluvium-Weakly cemented moderately sorted cobble to pebble gravel with thin interbeds of sand, silt, and tephra; gravel clasts subangular to rounded; diverse rock types dominated by durable silicic volcanic rocks evidently derived from the underlying Ellensburg Formation; forms conspicuous terrace along both sides of Yakima River in Kittitas Valley 220 to 70 m above the river, distinctly above the **Qksm terrace.** Soil locally has reddish argillic B-horizon as thick as 50 cm

Tts Sidestream alluvium—Weakly cemented, moderately sorted boulder to cobble gravel of angular to subrounded clasts of Grande Ronde Basalt; forms high terrace that slopes from northern mountain front of Kittitas Valley to the mainstream terrace (**Ttm**); contains minor chert, opal, vein quartz, quartzite, and durable felsites, none of which occur within modern drainage basins incised in the Thorp; surface clasts have thick rinds and deep cracks

Wenatchee and Columbia drainage basins

Qc ALLUVIUM OF COLUMBIA RIVER—Gravel containing rounded clasts as large as 30 cm; widely diverse rock types, including many medium-grained granitic to gneissic rock types with color indices (CI) below 20 but only a few more mafic varieties; includes stones of Swakane Biotite Gneiss, Yakima Basalt Subgroup, many varieties of porphyritic dike rocks, quartzite, and chert-pebble conglomerate; below Rock Island greatly enhanced in clasts of basalt

Qw ALLUVIUM OF WENATCHEE RIVER—Cobble-to-boulder gravel containing rounded clasts of coarse medium-grained quartz diorite, granodiorite, and weakly foliated gneiss with CI>20, derived from quartz diorite of Mount Stuart batholith but contains only a few granitic rocks with CI<20; includes muscovite and biotite gneiss, dark-colored fine-grained schist, green amphibolite, hornfels, several other metamorphic rock types, and various dike rocks. In map area contains small but conspicuous component of pyroxene-and amphibole-bearing porphyry derived from Eagle Rock (north of map boundary) and small component of the Yakima Basalt Subgroup derived from landslide and debris-flow deposits upvalley (north) of map boundary

Qb BOG DEPOSITS—Mud and peat

Qt TALUS DEPOSITS—Loose angular locally derived boulders forming steep slopes

HOLOCENE DRIFT—Divided into:

Qsy Younger subdrift—Inner cluster of Neoglacial moraines (informally Brynhild) of angular to subangular quartz-diorite boulders in upper basin of Enchantment Lakes area [2]; average lichen cover less than 5 percent; *Rhizocaron* thallus to 12 mm; maximum depth of weathering pits 6 cm; depth of soil oxidation 2 cm; devoid of trees and overlying tephra. Only moraine crests shown on map

Qso Older subdrift—Outer moraine (informally Brisingamen) of quartz-diorite boulders in Enchantment Lakes area beyond limits of Brynhild moraines; average lichen cover 20 to 80 percent; maximum diameter of thallus of *Rhizocaron* 210 mm; weathering pits as deep as 13 cm; depth of soil oxidation 23 cm or more; in places supports stands of western larch; overlain by Mazama tephra. Only moraine crests shown on map

Qrg ROCK-GLACIER DEPOSITS—Angular locally derived boulders forming bulbous tongue

Qe EOLIAN DEPOSITS—Loose well sorted medium sand deflated from Quaternary deposits along the Columbia River

Ql LOESS—Deposits of wind deposited silt

GRAVEL OF LATE FLOODS—Divided into:

Qlfy Younger-phase deposits—Surfaces of gravel generally less than 30 m above river, at West Bar and Malaga separated from **Qlfo** by steep erosional scarp that truncates giant current dunes of **Qlfo**; some bars form broad whaleback having shallow moat at inner margin; surfaces generally not ornamented with giant current dunes but densely studded with boulders to 3 m in intermediate diameter, rarely as large as 10 m; riverward slopes of several bars of **Qcgl** and **Qlfo** as high as 90 m above the river similarly boulder-studded. Not everywhere distinguishable from unit **Qlfo**

Qlfo Older—phase deposits-Surfaces marked by giant current dunes 50 to 60 m above the natural surface grade of Columbia River but below tops of sidestream delta terraces (**Qsdt**) unmodified by floodwater; giant current dunes spaced 100 m or less; composed of gravel similar to **Qc** except for rare boulders as large as 3 m; not overlain by lacustrine sediment. Not everywhere distinguished from **Qcg**l

Qlf Gravel, undivided—Surfaces geomorphically similar to those of Qlfy but altitude similar to both **Qlfo** and **Qlfy**

Qsa Sand—Loose, medium to very coarse sand above level of **Qlfo**; probably suspended load of late flood(s)

Qsi Silt—Thinly and evenly to rhythmically bedded silt and very fine sand, evidently polygenetic and in various stratigraphic positions: (1) overlies **Qcgu** and **Qcgl** in the Columbia River valley, (2) forms distinct terrace at altitude 275 m in canyon west of Birch Flat [33], (3) occurs as discontinuous patches at altitudes below 275 m in lower Wenatchee valley, and (4) overlies **Qwtu** near Monitor, where beds 0.3 m thick fine upward from medium sand to clay

COLUMBIA RIVER FLOODS DEPOSITS—Divided into:

Qcgl Gravel of lower—level bars-Similar to **Qcgu** except that surfaces of bars are only 60 to 90 m above the river and embellished with giant current dunes spaced 100 m; surficial layer of bar at mouth of Moses Coulee is redeposited **Qmc**; great bar north side of Columbia near Crescent Bar [44] contains rock types derived from upvalley, but long sweeping foresets dip upvalley and material is sandy pebble gravel fining upvalley to medium sand. Loess cap thinner than 0.5 m or is absent entirely. Not exclusively distinguished from **Qcgu** or **Qcg**

Qcg Miscellaneous gravel—Small patches at intermediate to low altitudes, probably mostly contemporaneous with **Qcgl**

Qcus Deposits on upland surfaces—Sand and pebble gravel in discontinuous patches overlying older surficial deposits or bedrock; extensive deposits on Babcock Bench [46] overlie intricate scabland. Probably mostly contemporaneous with **Qcgu**

Qmc Gravel of Moses Coulee floods—Along riverwise railroad near mouth of Moses Coulee, a poorly sorted boulder gravel almost entirely of basalt and displaying foreset bedding that dips up Columbia River valley; between southern abutment of Rock Island Dam and southern abutment of railroad bridge is moderately sorted pebble to basaltic granule gravel displaying long foresets dipping gently upvalley; at Rock Island Dam, top of deposit interbedded with and overlain by silt disconformably overlain by **Qcgl**

Qcgu Gravel of upper bar—Moderately sorted mixed-lithology cobble-to-boulder gravel containing rare angular boulders as large as 2 m of Swakane Biotite Gneiss and quartz diorite; internal structure is long downvalley-dipping foresets as tall as 15 m; shallow moat at valley-side margin; surface near Pangborn airfield [38] 180 m above river level displays giant current dunes spaced 215 m and whose lee slopes face downvalley; maximum thickness of deposit 150 m or more. Mantled with 0.5 to 1.5 m of loess. Soil contains neither textural B-horizon nor K-horizon, calcification being restricted to overgrowths less than 1 mm thick on the undersides of stones

Qfg GRAVEL OF FANCHER FIELD [37]—Cobble-to-granule gravel of rounded stones of diverse rock types of Columbia River provenance; generally is moderately to well sorted, lacks huge boulders characteristic of younger flood deposits but has thick crossbeds dipping downvalley; to southeast contains much sand and granule gravel; capped by 0.5 to 2 m of caliche that locally divides into multiple layers; caliche overlain by 1 to 3 m of loess; forms extensive terrace at altitudes 410 to 435 m, 30 to 50 m above the altitude of uncalichified gravel forming upper bars of Columbia River flood deposits (**Qcgu**) farther downvalley

Qlsy YOUNGER LANDSLIDE DEPOSITS—Angular debris from Yakima Basalt Subgroup; overlies **Qcgl** but is partly eroded by younger floods

Qlso OLDER LANDSLIDE DEPOSITS—Hummocky diamicton underlying **Qlfo, Qlfy, Qsa, Qcgu, Qcg**l and **Qmc**; upper surface of toe of slide along and in Columbia River near Malaga and Rock Island has high erosional relief; huge slide complexes on both sides of Columbia River valley between Wenatchee and Rock Island Dam are sparsely strewn up to altitude 325 m with very angular light-colored granodiorite boulders ice-rafted by great floods. Landslide complex northeast of East Wenatchee consists near mountain front of huge rotated, somewhat deformed blocks (**Qlsb**) of the Grande Ronde Basalt and Ellensburg Formation; to southwest is highly fractured deformed blocks and divided debris of the Grande Ronde Basalt deposited in valleys cut into Wenatchee Formation (Tw); east of river is thickly mantled with loess and eolian sand

Qwtl LOWER TERRACE GRAVEL OF WENATCHEE RIVER—Gravel similar to **Qw** but forming terrace 10 m above modern flood plain; weathering and soil development very weak

Qtd GRAVEL OF "d" TERRACE—Gravel similar to Qc but forming terrace 20 to 30 m above Columbia River; unlike flood bars, terrace is flat and lacks giant current ripples, whaleback form, and inner-margin moat; locally contains rare boulders as large as 0.8 m and grades northward into surface clearly swept by floodwater; soil lacks B-horizon

Qtcl, **Qtcu** GRAVEL OF "c" TERRACE—Similar to Qtd except forms two discrete terraces 45 m (**Qtcl**) and 60 m (**Qtcu**) above Columbia River; in railroad cuts along southern side of Wenatchee River overlies flood gravel containing angular boulders as large as 1.4 m and displays crude foreset beds dipping up Wenatchee valley; altitudinally related to Columbia-floods bars **Qcgl** and **Qcgu**. Soil lacks B-horizon

Qtb GRAVEL OF "b" TERRACE—Small patch in Columbia River valley immediately upslope from **Qtc** and lithologically like **Qc**; broader surface in lower Wenatchee valley is lithologically like **Qw**; Wenatchee valley terrace 70 to 80 m above rivers and separated from "c" terrace by abrupt scarp; includes 5- to 15—m mantle of very coarse to fine sand, apparently backwash from floods along Columbia valley. Nowhere on surface of gravel or on capping loess is soil redder than 10 YR or has textural B-horizon, nor does deposit contain a buried paleosol

Qsdt SIDESTREAM DELTA-TERRACE—Angular to subrounded, poorly sorted gravel of clasts of Yakima Basalt Subgroup and interbedded arkosic sand; forms terraces at mouths of Rock Island, Stemilt, and Squilchuck Creeks; internal structure in Stemilt Creek body is tall foreset bedding dipping steeply toward the Columbia River; at Rock Island Creek, directly overlies Qsi

Qst SIDESTREAM TERRACE ALLUVIUM—Terrace of basaltic gravel, sand, and mud 5 to 7 m above floors of Squilchuck Creek and lower Moses Coulee

Qwtu UPPER TERRACE-GRAVEL OF WENATCHEE RIVER—Gravel identical to **Qw** but forms prominent terrace more than 40 m above Wenatchee River; soil on terrace lacks textural B-horizon, and granodiorite stones are mostly fresh; unlike lower terrace (Qwtl), upper terrace is extensively overlain by thin-bedded silt (**Qsi**)

Qwtus UPPER SIDESTREAM TERRACE-ALLUVIUM—Alluvium of incised sidestream terrace that is graded to incise **l** Qwtu mainstream terrace

Qts GRAVELLY SAND OF "a" TERRACE—Poorly exposed fine to coarse sand, pebbly sand, and sandy small-pebble gravel; pebbles are of locally derived Swakane Biotite Gneiss, although deep cuts reveal a few clasts of granite of Columbia River provenance; forms terrace in lower Wenatchee valley at altitude of about 320 m, separated from Qtb by 50-m-high scarp; capped by 1 to 3 m of massive silt containing rare angular pebbles of leucocratic plutonic rocks and of Yakima Basalt Subgroup

Qsi SAND, LOCALLY DERIVED—Loose very coarse to very fine sand arkose capping divide between tributaries north of Wenatchee River; crossbeds and cross laminations dip southward; content of angular feldspar grains derived from tributary heads to the north; deposit is as high as 60 m above gravelly sand terrace (**Qta**), which Qsl grades downslope into or abuts

Qdy DIAMICTON—Diamicton mainly of angular basalt clasts similar to units **Tdyy** and **Tdyo**, albeit matrix is uncemented; only rarely contains very large entablature boulders; deposited variously on minor divides and along modern stream valleys. Evidently formed by debris flows guided by existing topography; mostly derived from **Tdyy** and **Tdyo**, but near Mission Peak [30] derived directly from bedrock and is associated with large-block landslides (Qlsb). Distinguished geomorphically from **Tdyy** and **Tdyo** but otherwise indistinct from **Qis** and **Qiso** in area

Twh HIGH GRAVEL OF WENATCHEE RIVER—Gravel identical to Qw except that unstable and nondurable rocks (arkose, quartz diorite) are impoverished with respect to hard, resistant rock types (quartz, amphibolite, dike rocks); caps knoll 130 m above Wenatchee River; similar isolated deposits upvalley beyond map boundary occur on divides as high as 525 m above valley floor

Tdyy YOUNGER DIAMICTITE—Similar to Tdyo except that deposits occupy secondary divides descending toward, but as much as 180 m above, modern drainages; rarely contains very large entablature boulders; evidently derived from Tdyo. At and near Beehive Mountain, a lateral ridge and moat separate unit from mounds of eroded Tdyo that protrude through Tdyy as "islands"

Tdyo OLDER DIAMICTITE—Diamictite of angular granule- to boulder-sized clasts of basalt; largest unjointed clasts are unmodified prisms of colonade as much as 1 m in diameter, and largest jointed clasts are of entablature to 20 m in intermediate diameter; the very large clasts occur as isolated blocks or are clustered in irregular lenses to at least 300 m in diameter and 80 m thick; rare angular deformed tabular blocks of the Ellensburg Formation.

Occupies divides descending toward the Columbia River valley parallel to tributaries like Squilchuck and Stemilt Creeks, which have incised as deeply as 300 m into bedrock, inverting the ancient topography; debris derived from Mission Peak area

BEDROCK

YAKIMA BASALT SUBGROUP OF THE COLUMBIA RIVER BASALT GROUP—Divided into: Wanapum Basalt—Includes:

Twp Priest Rapids Member—Fine- to medium-grained basalt flow with sparse plagioclase and olivine phenocrysts less than 8 mm long. Intergranular to intersertal groundmass texture. Reversed magnetic polarity. Occurs only in Kittitas Valley along Caribou Creek

Twr Roza Member—Fine- to medium-grained basalt flow with 5 to 10 percent plagioclase phenocrysts but few glomerocrysts. Phenocrysts more than 5 mm long and uniformly distributed throughout flow. Intergranular to intersertal groundmass texture. Transitional magnetic polarity

Twf Frenchman Springs Member—Two or more flows of fine- to medium-grained basalt. Contains abundant to sparse plagioclase phenocrysts and glomerocrysts commonly 1 to 2 cm across, irregularly distributed throughout the flow. Lowest flow is generally more highly porphyritic than overlying one and commonly has pillowed base. Normal magnetic polarity. Includes the Ginkgo flow of Mackin (1961), which contains many large plagioclase phenocrysts and glomeroporphyritic clots and the Sand Hollow flow of Mackin (1961), which has few such phenocrysts and clots. West of long 120°07'30", a flow apparently more porphyritic than the Sand Hollow and less porphyritic than Ginkgo forms lower flow in the member; may be one of the Kelly Hollow flows of Bentley (1977) or an unusual facies of the Sand Hollow or Ginkgo flows. Flows north of West Bar sparsely porphyritic except for a highly porphyritic flow on Badger Mountain west of Rock Island Creek. Member is sparsely porphyritic where exposed in fault blocks near Parke and Caribou Creek along east side of Kittitas Valley. Locally includes the Vantage Member of Ellensburg Formation where Vantage is too thin to show separately

Grande Ronde Basalt—Fine- to medium-grained basalt flows. Nonporphyritic to very sparsely plagioclase porphyritic except unit **Tgrp.** Groundmass textures dominantly intersertal with small clots of plagioclase and clinopyroxene. Complexly jointed. Pillows, hyaloclastites, and invasive flows common. Locally includes thin sedimentary deposits of Ellensburg Formation. Many flows in southeastern part of quadrangle display typical jointing patterns including basal colonnade, central entablature, and, in some flows, upper colonnade, all thoroughly described in nearby areas by Mackin (1961, p. 9-12), Swanson (1967, p. 1083-1086), and Diery and McKee (1969, p. 52-54). Cliffs just east of Crescent Bar [44] (studied by McDougall, 1976, p. 780, and Waters, 1961, p. 598) and along most tributary canyons west of Columbia River show these features well. Jointing patterns in much of area are considerably affected by interaction of flows with water and sediment. Subdivided on basis of magnetic polarity and locally distinctive outcrop characteristics. Includes:

Tgn2 Upper flows of normal magnetic polarity—Subdivided into following units:

Tgb Basalt of Beaver Creek—Youngest flow in unit in northeastern part of mapped area. Well-developed colonnade; pillowed base in places

Tgk Basalt of Keane Ranch—Several invasive flows and associated hyaloclastite and peperite. Includes flows of at least three different chemical compositions

Tgd Invasive flow of Duffy Creek—Shown only in extreme northeast corner of mapped area

Tgrp Basalt of Rocky Point—How, possibly two flows in places, containing 2 to 5 percent plagioclase phenocrysts less than 5 mm long. Lowermost flow in unit **Tgn2**, along North Fork of Manastash Creek, consists largely of unsorted hyaloclastite with sand- to boulder-size fragments of broken pillows with or without glassy rinds. Deposit is 10 to 15 m thick, unbedded, and locally contains intermixed sand. Vertical dewatering conduits occur in places

Tgr2 Flows of reversed magnetic polarity—Subdivided into following units:

Tghc Invasive flow of Howard Creek (Howard Creek Member of Rosenmeir, 1968, p. 22-25)—Upper contact is more complex than that of other invasive flows, consisting largely of a thick hyaloclastite and, locally, peperite. Well exposed 500 m southeast of Grouse Spring [28] in upper part of Naneum basin and along the west side of Diamond Head. Chilled sill-like contact against sedimentary rocks is exposed locally, as along the road to Grouse Spring at elevation 1510 m

Tgh Invasive flow of Hammond—Same as Hammond sill of Hoyt (1961)

Tgn1 Lower flows of normal magnetic polarity—Occurs only along Naneum Creek and contains at least two invasive flows

ELLENSBURG FORMATION—Includes:

Tev Volcaniclastic rocks—Mostly sandstone and siltstone but includes conglomerate, diamictite of probable laharic origin, and very minor amounts of micaceous feldspathic siltstone. Weakly lithified. Volcaniclastic detritus mostly andesitic and dacitic. Clasts commonly pumiceous. Volcanic debris probably freshly erupted from volcanoes in Cascade Range. Interbedded with and overlies Grande Ronde Basalt

Tes Sandstone, siltstone, and conglomerate—Micaceous feldspathic sandstone, siltstone, and very minor amount of pebble conglomerate and dark mudstone. Weakly indurated. Interbedded with Grande Ronde and, locally, Wanapum Basalt. Includes:

Tesv Vantage Member—Occurs between Grande Ronde and Wanapum Basalts. Maximum thickness about 30 m, average thickness 5 to 10 m. Pinches out toward Naneum Ridge anticline

Tda DIAMICTITE OF ANDESITE—Cliff-forming massive diamictite north of East Wenatchee, mostly angular porphyritic andesite to dacite clasts as large as 0.75 m set in a volcaniclastic matrix. About 2 percent of gravel fraction is rounded—about 1 percent porphyritic andesite and dacite and 1 percent vein quartz and various intrusive and metamorphic rock types

HORNBLENDE ANDESITE PORPHYRY COMPLEX OF HORSE LAKE MOUNTAIN [34]—Includes:

Thf Homblende andesite porphyry—Gray, commonly with black shiny hornblende prisms to several centimeters long; euhedral plagioclase and stubby pyroxene crystals in a dense gray matrix which in some rock is crowded with microphenocrysts of plagioclase, hypersthene, opaque minerals, and rare quartz and K-feldspar. Matrix is commonly pilotaxitic to intersertal. Some rocks pervasively altered to chlorite, clays, zeolite, and calcite. Includes masses of fine-grained slightly porphyritic to xenomorphic granular pyroxene gabbro altered to actinolite, clays, and calcite and rare muscovite. Sills commonly about 10 cm to 15 m thick and with good columnar jointing (Bay!ey, 1965, p. 12-23)

Thbd Breccia dike—Angular fragments less than one millimeter to several meters across of sandstone, argillite, cumulative hornblende gabbro, quartz diorite, and quartz gabbro in a chloritic mesostasis with small plagioclase laths. Also contains abundant euhedral hornblende phenocrysts to 6 cm long with abundant groundmass inclusions. Pilotaxitic marginal phase similar to hornblende andesite porphyry (**Thp**) with only a few inclusions

Thd Area of numerous hornblende porphyry andesite dikes and sills shown as overprint over country rock. In Horse Lake Mountain summit area, dikes and sills make up more than 60 percent of terrain

Southwestern sequence

Tbf BASALT OF FROST MOUNTAIN [22]—Dense black microporphyritic olivine basalt; microphenocrysts of plagioclase, clinopyroxene, and olivine in intersertal matrix of plagioclase, clinopyroxene, opaque ore, and brown glass. Locally altered to siliceous white rock. Locally columnar jointed

Tap ANDESITE OF PEOH POINT—Gray to black hornblende-hypersthene dacite porphyry; holocrystalline-glomeroporphyritic fine-grained granular. Local crude columnar jointing

Tta TANEUM ANDESITE—Mostly gray to green and brown, generally highly altered porphyritic to nonporphyritic andesite, dacite, and rhyolite flows, tuffs, and breccia; greenish-blue, purple, and white altered ash-flow tuffs, commonly welded, with relict quartz and plagioclase phenocrysts

Tm MANASTASH FORMATION—Sandstone, shale, and conglomerate. Light-greenish-gray or tan, massive, medium- to coarse-grained feldspathic sandstone averaging 55 to 60 percent quartz and 5 to 10 percent lithic clasts. Minor seams of bituminous coal; leaf fossils locally

Western sequence

ROSLYN FORMATION—Includes:

Tru Upper member—Medium- to fine-grained, white-weathering to yellow, micaceous, lithofeldspathic sandstone, some with calcite cement. Dark olive-gray to greenish-yellow siltstone, predominantly quartz and feldspar; thin-bedded to laminated. Subordinate 0.6- to 6-m thick seams of well-jointed, banded bituminous coal. See "Coal Measures" of Bressler (1951, p. 31)

Trm Middle member—Similar to upper member (Tru) but only very minor stringers of coal

Trl Lower member—Mostly white, weathering to yellowish and pale orange, medium- to coarse-grained, micaceous, in part zeolitic, lithic, feldspathic, and lithofeldspathic sandstone with crossbedding, pebble stringers, and cut-and-fill structures in beds to 15 cm thick. Abundant conglomerate and pebbly sandstone with rounded pebbles of granitic and aphanitic extrusive or hypabyssal rock. Includes Bressler's (1951, p. 35) basal beds of red to red-brown fine-grained sandstone with minor angular clasts of quartz, metamorphic rock fragments, some feldspar, and other rocks. Some sandstone with abundant calcite

RHYOLITE—Includes:

Trhf Rhyolite flows, tuff, and tuffaceous shales; some interbedded sandstone—Flows are white rhyolite weathering irregularly to brown and yellow. Commonly poorly exposed. Earthy or finely granular by spherulitic devitrification. Microphenocrysts of quartz and plagioclase in mesostasis of very fine-grained quartz, plagioclase, K-feldspar, sericite, hematite, and chlorite; rare plagioclase microlites. Clayton (1973, p. 29) reports sanidine phenocrysts and a $Si0_2$ content greater than 80 percent. Light-brown interbedded tuff and shales with volcanic clasts of rhyolite or altered rhyolite as above

Trhi Rhyolite dikes and plugs—Similar to extrusive rhyolite but appears to crosscut structure and lacks sedimentary interbeds

Ttb TEANAWAY BASALT —Basalt, basaltic tuff, and breccia with minor andesite, dacite, and rhyolite. Black, generally dense to glassy nonporphyritic pyroxene and rare divine basalt, weathering red brown to yellow. Commonly fine-grained intersertal with plagioclase laths and clinopyroxene; interstices of brown glass or alteration products (Clayton, 1973, p. 18-19). Blocky to columnar-jointed flows characterized by large chalcedony and calcite amygdules. Tuff and breccia commonly altered to clays. Siliceous varieties including welded tuff are white, purple, and highly altered but contain relict phenocrysts of quartz, plagioclase, and rare K-feldspar

Ts SWAUK FORMATION—Relatively dark gray weathering to tan, zeolitic, and locally calcic micaceous feldspathic to lithofeldspathic sandstone averaging about 35 to 40 percent quartz and 15 to 20 percent lithic clasts, 65 percent volcanic rock. Thin to very thick bedded, poorly sorted, locally crossbedded with lesser amounts of carbonaceous siltstone and shale, pebbly sandstone, light-colored micaceous sandstone, and conglomerate

Tsa Arkosic sandstone fades-White feldspathic sandstone, similar in appearance to sandstone of Chumstick Formation (**Tc**), poorly sorted, thick-bedded, and crossbedded. Interbedded with shale (**Tssh**)

Tssh Shale facies of Tronsen Ridge—Evenly and thinly bedded, locally crossbedded, relatively dark grayish or tannish micaceous lithofeldspathic sandstone, alternating with evenly bedded dark carbonaceous siltstone and shale. Light-colored, finely laminated, fine-grained sandstone and siltstone without crossbedding and lesser amounts of thick-bedded and crossbedded sandstone and pebble conglomerate

Tsc Conglomerate facies-20 to 50 percent conglomerate and conglomeratic sandstone in feldspathic and lithofeldspathic sandstone, siltstone, and shale. In vicinity of Scotty [8] and Ruby [4] Creeks, boulders to pebbles of chert, argillite, granitic and metamorphic rock in matrix of micaceous lithofeldspathic to feldspathic sandstone, crossbedded with cut-and-fill structures. In the vicinity of Mission Peak [30] and Mount Lillian, pebbles are predominantly light-colored volcanic rocks

Tsf Monolithologic fanglomerate facies—North of Shaser Creek [7], mostly rounded clasts of serpentinized peridotite in serpentinite sand matrix; contains beds of ironstone (see Lamey, 1950). In the Leavenworth fault zone north of Tronsen Creek and north of Red Hill [9] fanglomerate is made of subangular to rounded granodiorite in angular granodiorite sand. Locally strongly sheared

Tsir Ironstone—Iron-rich sandstone, shale, and conglomerate, locally well bedded. Iron minerals are limonite, hematite, and magnetite. Conglomerate composed of peridotite and serpentinized peridotite in iron-rich matrix. Most deposits are rich in nickel (Broughton, 1944; Lamey, 1950)

Tsp SILVER PASS VOLCANIC ROCKS OF FOSTER (1960)—Mostly discontinuous beds of mafic tuff and breccia interbedded in Swauk Formation, dark-yellowish-green and containing altered mafic microporphyry-bearing plagioclase, hornblende, and pyroxene. Alteration minerals are calcite, smectite, chlorite, epidote, and zeolite. Major outcrop area west of Swauk Pass is interbedded altered tuffs and arkosic sandstone. Probable Silver Pass shown on north side of South Cle Elum Ridge is poorly exposed, altered, sheared, and locally recrystallized silicic tuff and breccia

Eastern sequence (Chiwaukum graben)

Tw WENATCHEE FORMATION—Lower half predominantly bluish-gray, muscovite-bearing and, in places, tuffaceous shale and siltstone with interbed of friable limonitic quartz sandstone. Red oxidized zones in upper part of lower shale. Overlain by crossbedded quartz sandstone, beds 5 to 15 m thick, in turn overlain by thinly laminated light-gray-weathering to yellowish-brown shale, grading upward into similarly colored sandstone with little muscovite but otherwise similar to lowermost sandstone interbeds. Quartz clasts in sandstone are typically angular to subangular. Uppermost part is conglomerate, made of rounded to subrounded clasts of felsic volcanic rocks and some vein quartz and chert in a friable feldspathic sandstone matrix with appearance of an arkose in which feldspar has altered to clay. Soils developed on shales are clay-rich and characteristically expand to a popcornlike texture. South of Malaga, similar to quartz-rich sandstone and red and green shales of type Wenatchee. Near Lion Rock is green and yellow to white dacitic to rhyolitic lapilli tuff and breccia composed of altered glass shards; locally strongly eutaxitic with microphenocrysts of plagioclase and quartz. Similar tuff exposed on old State Highway 97 east of Swauk Prairie [13] is interbedded with coarse-grained tuffaceous arkose. Locally contains carbonized wood. Where exposed along highway 970 unit is red, green, and brown shale, and orange clayey feldspathic sandstone and may be part of large Lookout Mountain [14] landslide

CHUMSTICK FORMATION—Includes:

Tc Sandstone, shale, and conglomerate—White, locally gray, medium- to coarse-grained, micaceous feldspathic sandstone averaging 35 to 40 percent quartz and 10 to 15 percent lithic clasts, 90 percent volcanic rock. Crossbedded and channeled, interbedded with lesser amounts of thin pebbly sandstone and green to bluish shale

Tcn Shaly unit of Nahahum Canyon—Shaly sandstone and shale with thin bedding accented by thin laminae of biotite and organic matter. Some thin turbidite beds. Grades laterally into unit **Tc**

Tcte Tuff of Eagle Creek—Coarse-grained light-greenish-gray tuff with pumice clasts and flakes of carbonized wood; equals Tt1 of Whetten and Laravie (1976). Tuff in upper East Fork of Mission Creek correlated on basis of lithology

Tctcb Tuff of Cashmere (b)—Coarse-grained dense pumiceous vitric tuff. Thickness variable to 3 m. Continuous with tuff (Tt2) in Cashmere quadrangle (Whetten and Waitt, 1978)

Tctca Tuff of Cashmere (a)—Dense fine-grained, crystal vitric tuff, 2-4 m thick. Continuous with tuff (Tt1) in Cashmere quadrangle (Whetten and Waitt, 1978)

Tcr Red conglomerate-Massive red to purple and green conglomerate in beds 6 m thick with 1- to 2-m thick dark-colored sandstone interbeds. Clasts are quartz diorite, phyllite and chert, as in other conglomerate, and amygdaloidal basalt and rhyolite

Tcf Fanglomerate and monolithologic fanglomerate—In vicinity of Peshastin Creek, monolithologic fanglomerate made of well-rounded cobble- to small-boulder-size clasts of serpentinized peridotite in green to rusty brown matrix (Cashman, 1974, p. 12) interbedded with angular to subangular clasts of quartz diorite to 1 m in size in angular unsorted matrix of quartz diorite to granodiorite sand. In Mission Ridge area, quartz diorite to granodiorite material only

Tcb Basalt, basaltic breccia, and tuff—Black to dark-brown and gray to green dense basalt and amygdaloidal basalt; flows(?) and clasts in basaltic sand matrix. Some clasts of indurated feldspathic sandstone. Crudely bedded and locally interbedded in feldspathic sandstone of unit **Tc**

Small Tertiary intrusive bodies

Tmd MISCELLANEOUS DIKES, SILLS, AND PLUGS—Individual intrusive masses and areas intruded by numerous dikes and sills, generally more than 50 percent of terrain. Mostly andesite but ranges in composition from diabase to dacite and rhyolite (Gresens, 1976), generally considerably altered. An intrusive dacite dome on the south side of Dry Gulch [36] has a partial shell of perlite and breccia. Core is porphyritic xenomorphic with broken quartz phenocrysts or xenoclasts (Coombs, 1952, p. 198-199)

Tcl CAMAS LAND DIABASE OF SOUTHWICK (1966)—Dark-brown to black diabase and gabbro weathering to pale gray. According to Southwick (1966, p. 5-8), most of the rock is coarse-grained ophitic diabase with normally zoned labradorite to andesine, subcalcic augite, and pigeonite. Marginal phases contain olivine and have intergranular and intersertal groundmass. Alteration is slight

Tdg DIABASE, GABBRO, AND BASALT—Fine- to medium-grained black diabase and gabbro weathering to brown and reddish brown. Contains labradorite, clinopyroxene, rare olivine, and opaque ores. Subophitic to ophitic texture; variously altered to smectites, calcite, and chlorite (Stout, 1961, p. 350)

TEANAWAY DIKE SWARM—In the area of the Teanaway dike swarm, density of dots (on published version of map) represents proportion of terrain underlain by dikes. Dikes are mostly dark green and brown to black basalt and diabase weathering reddish brown. Includes pale, dull holocrystalline dikes with plagioclase laths and granular clinopyroxene in intergranular texture. Interstices are filled with quartz, plagioclase, zeolite, and clays (Southwick, 1966, p. 9). Waxy, partly glassy dikes with andesine, clinopyroxene, and minor olivine; altered to chlorophaeite and devitrified glass (Southwick, 1966, p. 10-11)

Thg HYPERSTHENE GABBRO—Heterogeneous, fine- to medium-grained gabbro with hypersthene and clinopyroxene commonly altered to pale-green amphibolite and clays. Calcic plagioclase is rimmed with graphic intergrowths of albite(?) and K-feldspar and feldspar and quartz. Locally brecciated and mylonitized

Pre-Tertiary basement

ROCKS OF THE MOUNT STUART BATHOLITH—Includes:

Kmsq Biotite-hornblende-quartz diorite—Medium-grained hypidiomorphic granular; massive to strongly gneissic near margins of pluton. Includes some granodiorite

Kmsg Biotite-hornblende granodiorite—Medium-grained hypidiomorphic granular. Massive to weakly gneissic in area of Enchantment Lakes, rich in mafic inclusions. Near summit of Mount Stuart cut by aplite and pegmatite dikes and contains vuggy feldspar clots and radial bursts of tourmaline

Kmsm Granodiorite metaporphyry and metaquartz diorite—Similar to metaporphyry in contact complex, but nonschistose

Kmsc Contact complex—Mostly hornblende and biotite schist, gneissic leucoquartz diorite, schistose hornblende-biotite granodiorite metaporphyry with minor serpentinite, altered; as much as 10 m thick, trending mostly northwest. Some rocks thermally metamorphosed. Probably related to metaporphyry in unit **Kmsm**

Kmsd Hornblende feldspar dacite and granodiorite dike complex (diagonal line overprint on other units) —Fine-and medium-grained hornblende feldspar dacite porphyry and medium-grained hornblende biotite granodiorite dikes, commonly altered; as much as 10 m thick, trending mostly northwest. Some rocks thermally metamorphosed. Probably related to metaporphyry in unit **Kmsm**

sg SWAKANE BIOTITE GNEISS—Fine- to medium-grained biotite-plagioclase-quartz gneiss; commonly granoblastic and locally strongly cataclastic to mylonitic, with varying amounts of muscovite and garnet and small amounts of sphene, zircon, apatite, and magnetite (Waters, 1932, p. 615). Amphibolite, hornblende schist, and calc-silicate schist locally. Alaskite and pegmatite dikes and sills

INGALLS TECTONIC COMPLEX—Includes:

KJisc Silicate carbonate rock—Bright orange craggy masses of silica, calcite, and magnesium(?) carbonate derived from alteration of serpentinite along faults. Locally, small patches of garnierite, hence called nickel dikes (Pratt, 1958, p. 164-165; Miller, 1975, p. 32-33)

Kjia Amphibolite and schistose amphibolite-Very fine grained massive to weakly foliate amphibolite; minor epidote minerals, biotite, opaque ores, and sphene. Probably metamorphosed Hawkins Formation (Smith, 1904, p. 4) or sheared and recrystallized gabbro or diabase

KJihs Hornblende schist, schistose amphibolite, and lesser amounts of mica schist—Mostly very fine grained actinolitic hornblende and hornblende plagioclase schist; locally, cordierite biotite schist, garnet biotite schist, and small pods of serpentinized peridotite. Probably more thoroughly metamorphosed greenstone and associated sedimentary rocks of the Hawkins Formation. Probably includes metamorphosed Peshastin Formation

KJid Diabase and gabbro—Mostly highly heterogeneous uralitized pyroxene gabbro and diabase ranging from hypidiomorphic granular to ophitic or diabasic. Southwick (1974, p. 398) reports anorthite in the least-altered anorthositic varieties. Shearing and brecciation is common with recrystallization to weakly foliate amphibolite. Layered structure is uncommon; cumulate textures are lacking in eastern part (Southwick, 1974, p. 98) but present in the western part (Miller, 1975, p. 42). Esmeralda Peaks[5] and Hawkins Mountain are mostly diabase

KJisp Foliated and massive serpentinite, serpentinized peridotite, and metaserpentinite and metaperidotite—Prior to serpentinization, ultramafic rocks were mostly harzburgite, with minor wehrlite and dunite (Southwick, 1974, p. 397). South of the Stuart Range, harzburgite (shown without shearing symbol) is characterized by spinel foliation and some compositional layering including chromite pods and layers. A relatively unserpentinized block of hornblende-bearing lherzolite (shown without shearing symbols) lies west of Mount Stuart (Miller and Frost, l977, p. 284, Cowan and Miller, 1980, p. 2). In an irregular aureole around Mount Stuart batholith, ultramafic rocks are commonly thermally metamorphosed to talc-tremolite and anthophyllite rocks, all bearing newly formed forsterite and characteristically orange weathering and blocky jointed (Miller, 1975, p. 33; Frost, 1973b). West and southeast of Mount Stuart areas of strongly sheared serpertinite (shearing symbols) from Cowan and Miller (1980, p. 2)

KJim Metabasalt (greenstone), tuff, and breccia—Predominantly massive greenstone with lesser amounts of metabreccia and tuff, mostly in greenschist facies: Hawkins Formation of Smith (1904, p. 4) Breccias contain metamorphosed andesite or keratophyre (Southwick, 1974, p. 395-396). Locally includes fine-grained amphibolite and metadiabase

KJiar Argillite, phyllite, sandstone, metasandstone and conglomerate, metamorphosed flows and breccias, and minor chert and marble—Predominantly black hackly argillite to slaty argillite with subordinate very fine grained, angular, poorly sorted dark lithic subquartzose sandstone with graded beds, local rhythmite. Subordinate volcanic-lithic microbreccia and small pebble conglomerate. Red, gray, and black radiolarian chert and metachert. Dacitic to andesitic tuffs, breccias, and flows, mostly metamorphosed, minor on east (Southwick, 1974, p. 395), more abundant in De Roux Creek area (Miller, 1975, p. 6). Locally includes very fine grained amphibolite, cordierite-biotite schist, and calc-silicate granulite. Includes most of Peshastin Formation of Smith (1904, p. 3-4)

LOW-GRADE METAMORPHIC SUITE—Includes:

pJmg Greenschist—Very fine gained epidote-chlorite-quartz schist with varying amounts of crossite. Relict pillow structure in greenschist northwest of Keenan Meadows [23]. Includes pegmatitic biotite gneiss, hornblende gabbro, and quartz plagioclase gneiss west of Buck Meadows

pJmp Phyllite-Dark graphitic albite-muscovite -quartz phyllite grades into fine-grained mica schist. Includes minor greenschist and blue amphibole schist and pods of metagabbro. Well-developed cleavage, crinkled, and isoclinally folded