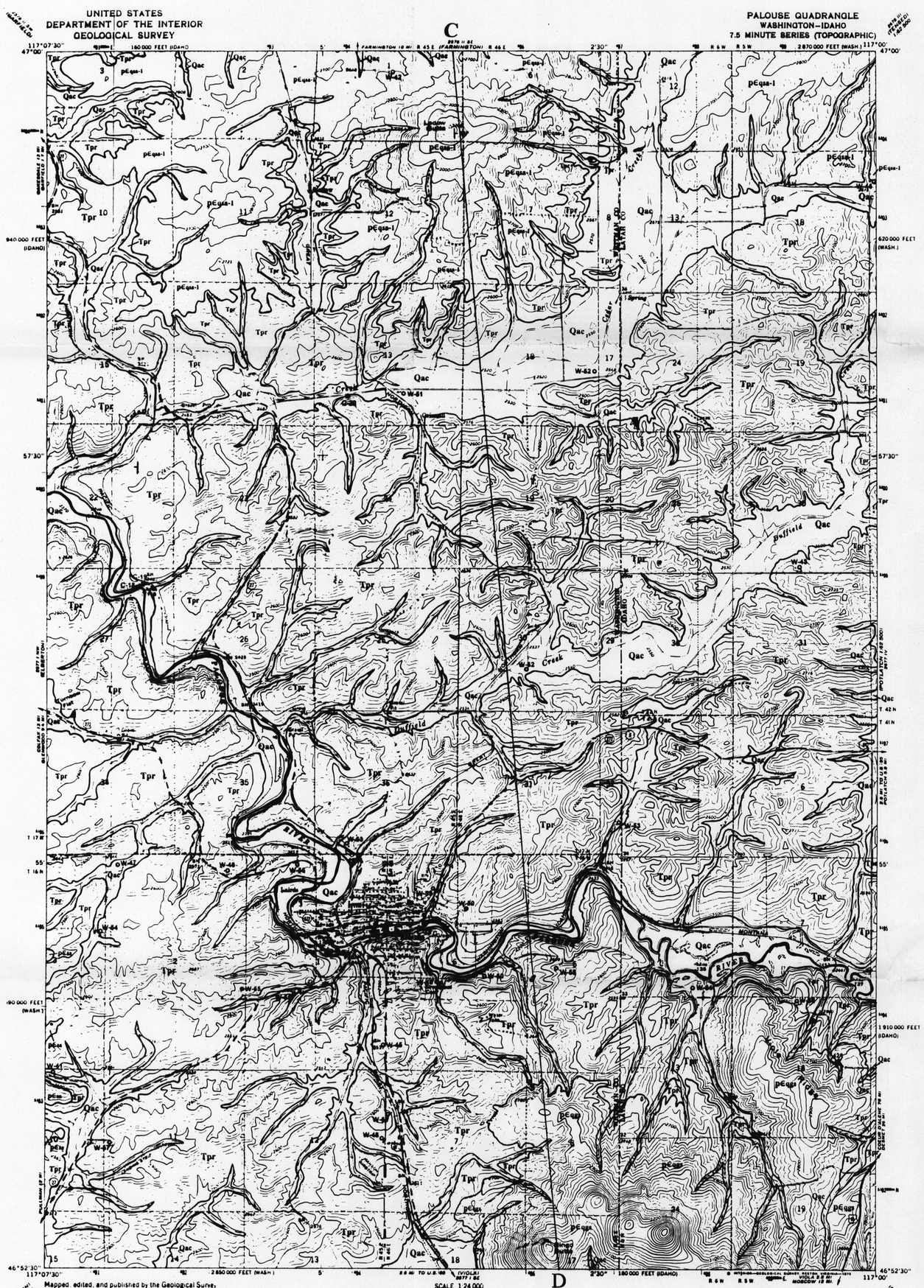
# BEDROCK MAP OF THE PALOUSE QUADRANGLE, WHITMAN COUNTY, WASHINGTON AND LATAH COUNTY, IDAHO

Chris H. Duncan and John H. Bush

1999




## Location Map

Adjoining 7.5' Quadrangles

| | | |
|---|---|---|
| *Garfield, WA* | *Farmington, WA* | *Mission Mountain, ID* |
| *Elberton, WA* | ***Palouse, WA*** | *Potlatch, ID* |
| *Albion, WA* | *Viola, WA* | *Robinson Lake, ID* |

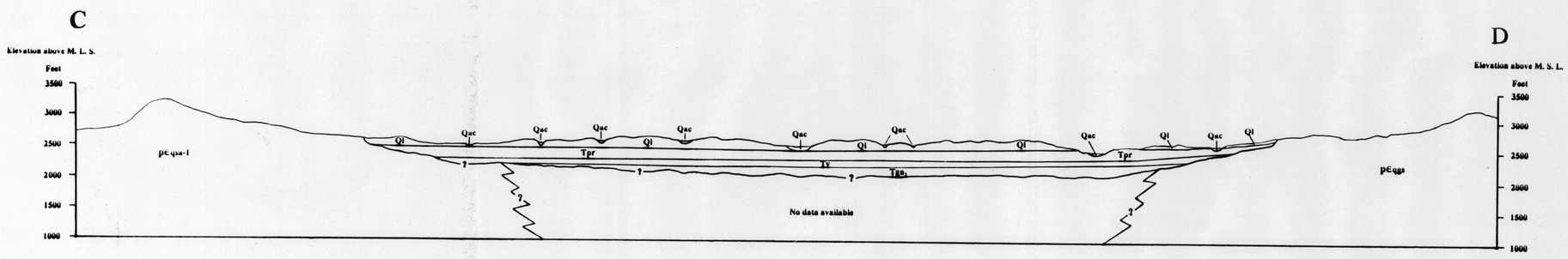
Geologic base map: U.S.G.S. 7.5' quadrangle of Potlatch, ID

**Table 4. Major and trace element analysis for Columbia River Basalts, Palouse, WA quadrangle[1].**

| Sample Location | Major Elements (normalized weight %) | | | | | | | | | | Trace Elements (ppm) | | | | | | | | | | | | | | | | Chemical Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SiO2 | Al2O3 | TiO2 | FeO* | MnO | CaO | MgO | K2O | Na2O | P2O5 | Ni | Cr | Sc | V | Ba | Rb | Sr | Zr | Y | Nb | Ga | Cu | Zn | Pb | La | Ce | Th | |
| C-18 | 49.87 | 13.49 | 3.20 | 13.93 | 0.24 | 9.19 | 5.48 | 1.16 | 2.69 | 0.75 | 30 | 101 | 34 | 377 | 556 | 26 | 282 | 176 | 44 | 15.3 | 21 | 32 | 139 | 3 | 13 | 58 | 5 | Lolo |
| C-19 | 49.74 | 13.41 | 3.21 | 14.19 | 0.23 | 9.24 | 5.40 | 1.12 | 2.69 | 0.76 | 32 | 95 | 30 | 375 | 554 | 26 | 287 | 178 | 44 | 15.2 | 20 | 29 | 138 | 5 | 20 | 59 | 6 | Lolo |
| C-20 | 50.22 | 13.65 | 3.22 | 13.59 | 0.22 | 9.43 | 4.89 | 1.13 | 2.76 | 0.79 | 29 | 100 | 34 | 374 | 612 | 29 | 292 | 181 | 45 | 16.9 | 22 | 38 | 137 | 5 | 12 | 62 | 6 | Lolo |
| C-21 | 50.11 | 13.72 | 3.26 | 13.16 | 0.236 | 9.30 | 5.57 | 1.22 | 2.65 | 0.77 | 34 | 100 | 35 | 401 | 566 | 26 | 284 | 180 | 45 | 16.1 | 24 | 36 | 137 | 7 | 17 | 79 | 3 | Lolo |
| C-22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | Lolo |

Notes: * Total Fe as expressed as FeO
1 X-ray fluorescence analysis conducted by Washington State GeoAnalytical Laboratory under the direction of P. R. Hopper

## Cross-section along the North-South (C-D) line




**Cross-Section Scale**

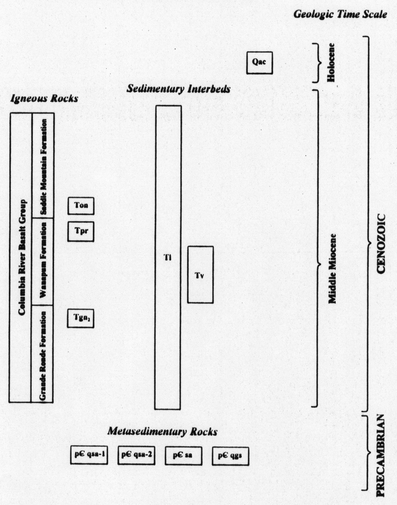
**Vertical Scale (2x horizontal) 1:12,000**

**Horizontal Scale 1:24,000**

Note: Loess (Ql) shown only on cross-section

## Explanation

### Correlation of Map Units




### INTRODUCTION

The bedrock map of the Palouse quadrangle represents a compilation of previous research, water well data (Table 3) and additional field work. Distribution of the Palouse Formation loess was not illustrated in order to produce a bedrock map. Bedrock outcrops are limited to less than one percent of the area and therefore all contact lines are interpretative. Contacts between pre-basalt units and the Columbia River Basalt Group (CRBG) are especially difficult to determine because of thick overburden and lack of well data in places. Colluvium from the steptoes exceeds 300 feet in places and grades laterally into the Palouse Formation. Regional maps by Griggs (1973), Rember and Bennett (1979), Swanson and others (1977, 1979a and 1980), and Tullis (1940, 1944), and Gulick (1994) were used in the compilation. The basalt chemistry was analyzed by the GeoAnalytical Laboratory at Washington State University.

### DESCRIPTION OF MAP UNITS

Basement (pre-basalt) rocks here and on the surrounding quadrangles have been mapped as several different units including Precambrian pre-Belt Supergroup, Belt Supergroup, metamorphosed Belt Supergroup, Cambrian metasediments, and Cretaceous metamorphosed and unmetamorphosed Idaho batholith rocks (Tullis, 1940, 1944; Bond, 1978; Griggs, 1973; Swanson and others, 1980; Rember and Bennett, 1979; Hooper and Webster, 1982). Gulick (1994) placed the non-intrusive rocks into pre-Cretaceous metasedimentary units. In the Palouse area these rocks tend to compose the hills (steptoes) that are higher than 2700 feet in elevation. Bush and Provant (1998) for the adjoining Viola quadrangle to the south place these rocks in the Precambrian and suggest that they are part of the Belt Supergroup. For the Palouse quadrangle these pre-basalt rocks were divided into three metasedimentary units and tentatively placed in the Precambrian. Only outcrops of the Priest Rapids member of the Wanapum Formation were noted on the Palouse quadrangle.

The stratigraphic nomenclature of the CRBG is based on that presented by Swanson and others (1979b). The group is divided into four formations: from base upward, these are the Imnaha, Grande Ronde, Wanapum, and Saddle Mountains. The uppermost Grande Ronde Formation is interpreted to occur beneath the Priest Rapids throughout much of the quadrangle (Cross-section C-D). The Priest Rapids Member is separated from the Grande Ronde in the subsurface by clastic sediments that belong to the Vantage Member of the Latah Formation (Siems and others, 1974, and Bush and others, 1998).

Although a bedrock map, Holocene sediments associated with major drainages were included on the map. The distribution of these sediments was useful in interpreting subsurface bedrock and structural trends.

### SURFICIAL DEPOSITS

**Qac** — ALLUVIUM AND COLLUVIUM (Holocene)--Stream and slope wash deposits. Compositions variable; commonly reworked loess and basalt with resistant quartz fragments from nearby granitoid and metasediment outcrops. The distribution of sediments along the Palouse River, Cedar Creek and Duffield creek all show wide upstream sedimentation patterns in the center of the quadrangle. Upstream Gradients are approximately 20 feet/mile and those downstream are approximately 60 feet/mile. These changes in gradient and deposition patterns are believed to caused by a slight increase in the attitude of the gentle westward dipping (<1 degree) Priest Rapids Member. The change in attitude is interpreted to have been caused by post Priest Rapids basining of the CRGB, possibly over a pre-basalt high that trends north-northwest. Another possible cause is that it represents the edge of a flow front of one of the Priest Rapids flow units or flows emplaced from the south-southwest.

The Palouse River makes a sharp turn to the northwest around a pre-basalt argillite-siltite high just north of Kamiak Butte, a major pre-basalt steptoe southeast of the city of Palouse. This northwest trend may have been caused by the Palouse selecting a route around the more resistant pre-basalt rocks or it may have been pushed into this position by advancing flows from the south and southwest.

### COLUMBIA RIVER BASALT GROUP: WANAPUM FORMATION

**Tpr** — PRIEST RAPIDS MEMBER (Miocene)--Medium to coarse-grained basalt with microphenocrysts of plagioclase and olivine in a groundmass of intergranular pyroxene, ilmenite blades, and minor devitrified glass. Other workers have previously identified and described these flows (Bingham and Grolier, 1966; Wright and others, 1973; Swanson and others, 1977; 1979b). The flows have reversed geomagnetic polarity (Wright and others, 1973; Swanson and others, 1979b). These basalts are exposed in quarries, road cuts, and crop out along the Palouse River throughout the quadrangle. Figure 1 is a structural contour map on the base of the member and Figure 2 is an isopach map of the member. The structural contour map shows that the basalt rises in elevation close to basement highs. The isopach map shows thickening away from basement highs. These relations are not totally a function of thinning towards the highs during emplacement, but could also reflect in part post-emplacement erosion and basining. Well data on surrounding maps were used to construct the original maps, but the final version were modified using interpretive information.

Five outcrops were sampled and analyzed for verification and are the Lolo chemical type of Wright and others (1979). Hooper and Webster (1982) note that in the Pullman area to the south the Lolo chemical type underlies much of the area and that the Rosalia chemical type occurs in patches. Distribution maps for the Priest Rapids by Anderson and others (1987) show the Palouse-Pullman area to be near the souther limit of the Rosalia flows. Plate 3 Cross-sections show the interpretation of the Rosalia flows terminating west and southwest of the Palouse quadrangle.

One exposure within the eastern city limits of Palouse has been interpreted as a potential near vent locality (Swanson and others, 1980). The exposure consits of two Priest Rapids flows or flow units separated by a sequence approximately 15 feet thick of highly weathered vesicular basalt, cross-bedded quartz-feldspar sand, and palagonitic obsidian breccia. The sand, breccia, and overlying flow dip 5 degrees to the east. The presence of obsidian, lightweight vesicular material and spindle-shaped scoria led Bush and Seward (1992) to agree with the near vent interpretation and they suggest the outcrop to represent an eroded rampart. However, the obsidian and weathered vesicular basalt may be due to rapid cooling and alteration caused by contact with a major water source. Analysis of both flow types indicate that they are of the Lolo chemical type suggesting little time between their emplacement.

### COLUMBIA RIVER BASALT GROUP: GRANDE RONDE FORMATION

**Tgn2** — GRANDE RONDE FORMATION (Miocene)--Consists of flows of fine-grained to very fine-grained aphyric basalt. Though not exposed on the quadrangle the Grande Ronde is interpreted to occur beneath the Priest Rapids Member throughout much of the quadrangle. Regional maps of nearby areas by Swanson and others (1980), Hooper and Webster (1982) and Gulick (1994) all show the Grande Ronde beneath the Priest Rapids on nearby quadrangles. Cross-section C-D shows the interpretation of the top of Grande Ronde normal polarity second chemical type (n2) flows of Swanson and others (1979b) to occur at 2250 feet in elevation beneath the town of Palouse. On the basis of basalt reported in deep wells near Potlatch, ID (Kirkham, 1927) it is interpreted that the Grande Ronde extends into the central portion of the Potlatch quadrangle (Plate 3 Cross-section E-F-G).

### LATAH FORMATION

**Tv** — VANTAGE MEMBER (Miocene)--Consists of clay, silt and sand deposits that range from a few feet to over 100 feet in thickness. The sand is angular to subrounded, poorly sorted, and consists primarily of quartz with feldspar and muscovite common in places. This unit is not known to crop out on the Palouse quadrangle but is encountered in numerous domestic wells in the Palouse area. The data from these wells (Table 3) was useful in constructing Cross-section C-D. The term "Vantage" (Tv) is used for interbeds bounded by the Wanapum on top and Grande Ronde flows beneath (Siems and others, 1974; Bush and others, 1998). Although the name has been used as part of the Ellensburg Formation of western Washington (Swanson and others, 1979b) it is not improper to use the term on the eastern edge of the basin where it is part of the Latah Formation. Where the sediments are not bounded by the Wanapum and Grande Ronde the more encompassing terms Latah Formation (Tl) or Latah interbeds should be used.

**Tl**

### PRE-BASALT ROCKS

**pЄqgs** — QUARTZITE, GNEISS AND SCHIST (Precambrian)-- Consists of interlayered units of quartzite, schist and gneiss. The quartzite is white to creamy white, light-gray to bluish-purplish-gray, pink and reddish-brown. It consists primarily of recrystallized quartz with small grains and crystals of feldspar, muscovite, biotite and rutile. The quartzite is massive bedded and has been recrystallized, but inconspicuous relict bedding planes and laminations are present in places. In comparison to some of the nearby exposures on Kamiak Butte they are not as "clean". The quartzite forms the tops of Ringo Butte and Viola Ridge and generally the less resistant gneiss and schist crop out only rarely in road cuts and exposures at lower elevations. The schist and gneiss are thinly banded and are mineralogically simple consisting primarily of quartz, feldspar, muscovite and biotite.

Many of the numerous buttes on surrounding quadrangles in western Latah and eastern Whitman counties are capped with quartzite. A few of these are Bald, Tomer, Kamiak, Randall, Parker and Angel buttes. There has not been an accepted stratigraphic framework presented for these quartzite units (Savage, 1973; Hooper and Webster, 1982; Webster and Nunez, 1982). At Bald Butte, these units are "roof pendants" over an intrusive core where contact or subsequent metamorphic effects have made the silica rich "intrusive" rocks difficult to distinguish from the older quartzite units. Field work by Bush and Provant (1998) along the southern edge on the adjoining Viola quadrangles suggests a Precambrian age for Viola ridge and Ringo Butte exposures. Exposures on Randall Butte just southeast of Ringo contains massive bedded finely laminated impure quartzites between gneiss and schist units that can be mapped eastward into Idaho on the Robinson Lake and Princeton quadrangles where they appear to grade into argillites, siltites and quartzites that belong to the Belt Supergroup. However, the lack of exposure and proximity of the underlying intrusive rocks makes this interpretion difficult to substantiate. Outcrops on Parker and Angle Butte just south of the Palouse quadrangle have recrystallized in places to a granoblastic texture and are similar in appearance to the quartzites exposed on Kamiak and Steptoe Butte to the west and northwest of the Palouse quadrangle.

**pЄqsa-1** — QUARTZITE, SILTITE AND ARGILLITE-1 (Precambrian)--Consists primarily of quartzite with minor siltite and argillite. The quartzite is somewhat similar to the quartzite on the southern end of the quadrangle and (pЄ qsa-3) on the Potlatch quadrangle but is not as recrystallized. They are best exposed on top of Ladow Butte in the northern part of the quadrangle. Outcrops are poor and dominated by quartzite, but in places light colored argillite and siltite are interbedded with the quartzite. They are illustrated as a separate unit because correlation between these and the quartzites of Ringo Butte and Viola Ridge should not be implied. Griggs (1973), who mapped the Belt Supergroup rocks from northern Idaho and northeastern Washington into the northern edges of Latah and Whitman counties, placed the rocks along the northeaster border of the Palouse quadrangle in the Striped Peak Formations of the Belt Supergroup.

**pЄsa** — SILTITE AND ARGILLITE (PRECAMBRIAN)--Consists of greenish-gray, argillite and siltite with minor micaceous phyllite in places. Relict Bedding consists of alternating light-gray siltite and dark-gray argillite laminations and micolaminations. Gulick (1994) noted two occurrences of the unit to the west on the adjoining Elberton quadrangle. From those occurrences the unit was extended onto the western edge of the Palouse quadrangle by mapping float and interpreting shallow well data. This unit along with quartzites exposed on Kamiak Butte located just to the south form a pre-basalt high that the Palouse River flows around to the north-northwest.

The laminations and microlaminations of this argillite-siltite unit are typical of the Belt Supergroup throughout nearby northern Idaho and are very similar to argillitic units of the Wallace Formation. Based on the lithological similarity the unit is believed to correlate to the Belt Supergroup, but correlation to Wallace Formation is only speculation.

### SYMBOLS

- Contact Approximately Located
- O W-1 — Location of Well Reported in Table 3
- ● C-1 — Location of Chemical Analysis reported in Table 3
- 65 — Attitude of Major Foliation
- 65 — Attitude of Basalt Flows and Bedded

**T-99-7.** *Bedrock Geologic Map of the Palouse Quadrangle, Whitman County, Washington, and Latah County, Idaho,* By Chris H. Duncan and John H. Bush, 1999, scale 1:24,000, 1 sheet

LIBRARY
DEPARTMENT OF NATURAL RESOURCES
GEOLOGY AND EARTH RESOURCES DIVISION
OLYMPIA, WASHINGTON 98504

Idaho Geological Survey
Technical Report 99-7
Duncan and Bush
1999

This Technical Report is a reproduction of independent mapping. Its format and content may not conform to agency standards.

### REFERENCES CITED

Bond, J.G., 1978, Geologic Map of Idaho: Idaho Bureau of Mines and Geology, scale 1:500,000.

Bush, J.H., and K.L. Priebe, 1995, Geologic Map of the Troy quadrangle, Latah County, Idaho: Idaho Geological Survey, Technical Report, 95-5, scale 1:24,000.

Bush, J.H., K.L. Othberg, and K.L. Priebe, 1995, Onaway Member intracanyon Columbia River Basalt flows, Latah County, Idaho (abs.): Geological Society of America Abstract with Programs, V.27, no.4, p. 8.

Bush, J.H., A.P. Provant, and S.W. Gill, 1998, Bedrock Map of the Moscow West quadrangle, Latah and Whitman Counties, Idaho and Washington: Idaho Geological Survey, scale 1:24,000.

Bush, J.H., and A.P. Provant, 1998, Bedrock Map of the Viola quadrangle, Latah and Whitman Counties, Idaho and Washington: Idaho Geological Survey, scale 1:24,000.

Bush, J.H and C.H. Duncan, 1998, Unpublished bedrock map of the Palouse quadrangle, Idaho and Washington, scale 1:24,000.

Camp, V.E., 1981, Geologic studies of the Columbia Plateau: Part II, Upper Miocene basalt distribution reflecting source locations, tectonism, and drainage history in the Clearwater embayment, Idaho: Geological Society of America Bulletin, v. 92, p. 669-678.

Gulick, G.W., 1994, Geologic Map of the Pullman 1:100,000 quadrangle, Washington-Idaho: Washington Division of Geology and Earth Resources, Open File Report 94-6.

Heinemann, R., 1994, The relation between streams and ground-water flow systems within the Pullman-Moscow area of Washington and Idaho: University of Idaho M.S. thesis, p. 58.

Hooper, P.R., and G.D. Webster, 1982, Geology of the Pullman, Moscow West, Colton and Uniontown 7.5 Minute quadrangles, Washington and Idaho: Washington Division of Geology and Earth Resources, Geologic Map GM-26, scale 1:62,000.

Kirkham, R.D., 1927, Groundwater for Municipal Supply at Potlatch, Idaho: Idaho Bureau of Mines and Geology, Pamphlet No. 23, p.12.

Rember W.C., and E.H. Bennett, 1979, Geologic map of the Pullman quadrangle, Idaho: Idaho Bureau of Mines and Geology, scale 1:250,000.

Savage, C.N., 1973, A geological field trip in Benewah and Whitman Counties, Idaho and Washington, in D.T. Bishop and J.D. Powell, Compilers, Belt Symposium 1973: University of Idaho-Idaho Bureau of Mines and Geology, v.1, p. 253-320.

Siems, B.A., J.H. Bush, and J.W. Crosby, III, 1974, TiO2 and geophysical logging criteria for Yakima Basalt correlation, Columbia Plateau: Geologic Society of America Bulletin, v. 85, p. 1081-1088.

Swanson, D.A., T.L. Wright, V.E. Camp, J.N. Gardner, R.T. Helz, S.A. Price, and M.E. Ross, 1977, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1139, scale 1:250,000.

Swanson, D.A., J.L. Anderson, R.D. Bently, G.R. Byerly, V.E. Camp, J.N. Gardner, and T.L. Wright, 1979a, Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U.S. Geological Survey Bulletin 1457-G, p. 59.

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

Swanson, D.A., T.L. Wright, V.E. Camp, J.N. Gardner, T.T. Helz, S.A. Price, and M.E. Ross, 1980, Reconnaissance Geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1139, scale 1:250,000.

Tullis, E.L., 1940, Geology and petrography of Latah County, Idaho: University of Chicago Ph.D. thesis, p. 281.

Tullis, E.L., 1944, Contributions to the geology of Latah County, Idaho: Geological Society of American Bulletin, v. 55, p. 131-164.

Webster, G.D., and L. Nunez, 1982, Geology of the steptoes and Palouse Hills of eastern Washington, a roadlog of the area south of Spokane, Washington. in S. Roberts and D. Fountain, eds., Tobacco Root Geological Society 1980 field conference guidebook. Tobacco Root Geological Society (Spokane, Wash), p. 45-57.

Wright, T.L., M.J. Grolier, and D.A. Swanson, 1973, Chemical variation related to the stratigraphy of the Columbia River Basalt: Geological Society of America Bulletin, v. 84, no. 2, p. 371-385.

Wright, T.L., D.A. Swanson, R.T. Helz, and G.R. Byerly, 1979, Major oxide, trace element, and glass chemistry of Columbia River basalt samples collected between 1971 and 1977: U.S. Geological Survey Open-file Report 79-711, p. 146.

**Table 3. Well data in feet for Palouse, WA qaudrangle**

| Well No. | Well Head Elevation | Elevation Top of Tpr | Elevation Bottom of Tpr | Thickness of Tpr | Elevation Top of Tv | Elevation Bottom of Tv | Thickness of Tv | Elevation Top of Tgru | Elevation Bottom of Tgru | Thickness of Tgru | Elev. Top of Precambrian |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-41 | 2570 | - | - | - | - | - | - | - | - | - | 2569 ? |
| W-42 | 2700 | - | - | - | - | - | - | - | - | - | 2677 |
| W-43 | 2630 | 2566 | *2550 | +16 | - | - | - | - | - | - | - |
| W-44 | 2620 | - | - | - | - | - | - | - | - | - | 2573 |
| W-45 | 2570 | 2536 | *2467 | +69 | - | - | - | - | - | - | - |
| W-46 | 2540 | 2534 | 2366 | 168 | 2366 | *2310 | +56 | - | - | - | - |
| W-47 | 2505 | 2484 | *2402 | +82 | - | - | - | - | - | - | - |
| W-48 | 2590 | 2532 | 2336 | 196 | 2336 | *2290 | +46 | - | - | - | - |
| W-49 | 2500 | 2475 | 2312 | 163 | 2312 | *2295 | +17 | - | - | - | - |
| W-50 | 2540 | 2526 | 2380 | 146 | 2380 | *2360 | +20 | - | - | - | - |
| W-51 | 2505 | 2490 | 2292 | 198 | - | - | - | - | - | - | 2268 |
| W-52 | 2535 | 2513 | 2324 | 189 | 2324 | *2305 | +19 | - | - | - | - |
| W-53 | 2525 | 2514 | *2470 | +44 | - | - | - | - | - | - | - |
| W-54 | 2570 | 2484 | *2440 | +24 | - | - | - | - | - | - | - |
| W-55 | 2540 | 2509 | 2374 | 135 | 2374 | *2350 | +24 | - | - | - | - |
| W-56 | 2490 | 2459 | 2345 | 114 | 2345 | *2250 | +95 | - | - | - | - |
| W-57 | 2595 | 2544 | 2382 | 162 | 2382 | *2362 | +20 | - | - | - | - |
| W-58 | 2530 | 2527 | 2394 | 133 | - | - | - | - | - | - | 2365 ? |
| W-59 | 2540 | 2518 | 2334 | 184 | 2334 | 2320 | +14 | - | - | - | - |
| W-60 | 2530 | 2447 | *2318 | +129 | - | - | - | - | - | - | - |
| W-61 | 2620 | 2591 | 2370 | 221 | 2370 | 2365 | +5 | - | - | - | - |
| W-62 | 2535 | 2445 | 2306 | 139 | 2306 | 2265 | 41 | 2265 ? | 2180 ? | 85 | 2180 ? |
| W-63 | 2510 | 2497 | 2292 | 205 | 2292 | *2255 | +37 | - | - | - | - |
| W-64 | 2470 | - | - | - | - | - | - | - | - | - | 2458 |
| W-65 | 2580 | 2543 | *2445 | +98 | - | - | - | - | - | - | - |
| W-66 | 2625 | - | - | - | - | - | - | - | - | - | 2531 |

Notes: * Well completed above unit base
+ Well completed above unit base

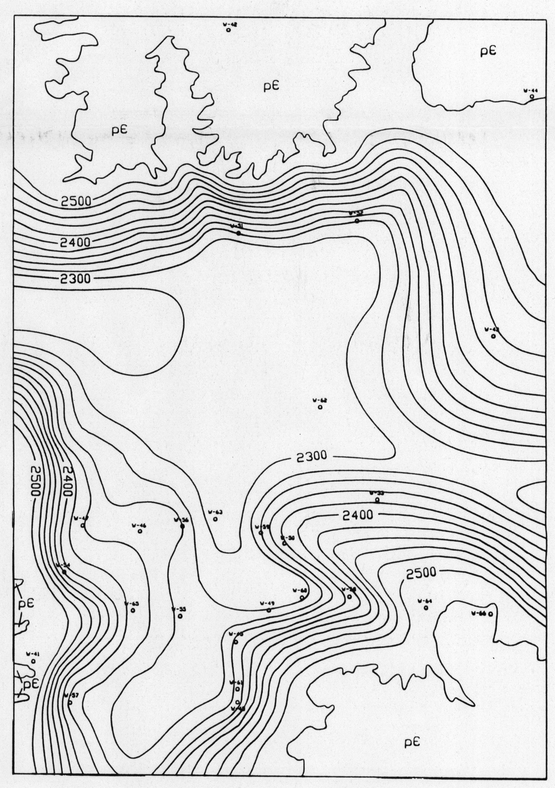



**Figure 3. Structural contour map of the lower unit contact, Priest Rapids basalt (Tpr), Palouse, WA quadrangle. Contour lines (20 foot intervals) are interpreted from well logs (Table 3). Not shown are elevations exceeding 2500 feet due to the unpredictable nature of the contact and locally extensive colluvium.**

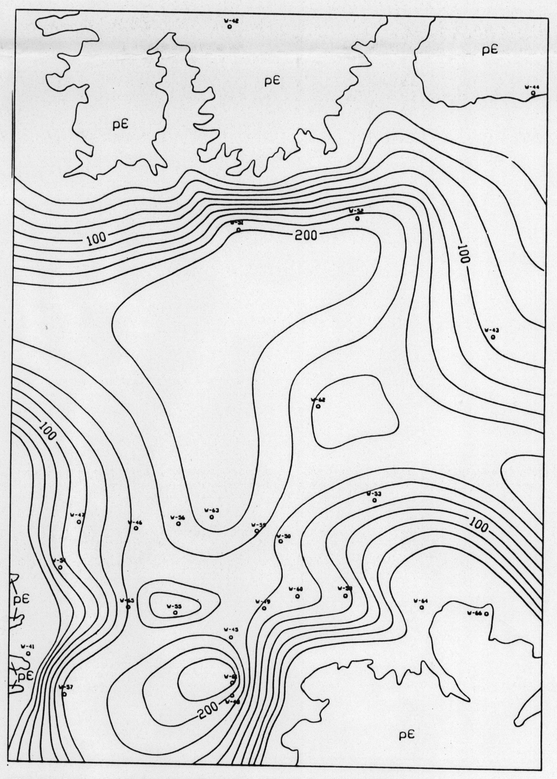



**Figure 4. Isopach map of the Priest Rapids basalt (Tpr), Palouse, WA quadrangle. Contour line (20 foot intervals) are interpreted from well logs (Table 1). Not shown is unit thickness below 40 feet due to the unpredictable nature of the contact and locally extensive colluvium.**