NATURAL RESOURCES

GEOLOGIC MAPS OF PART OF THE YAKIMA FOLD BELT, NORTHEASTERN YAKIMA COUNTY, WASHINGTON

by Robert D. Bentley, Newell P. Campbell, and John E. Powell

Open File Report 93-3
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Natural Resources
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INTRODUCTION

The maps that make up this report cover four adjoining 15-minute quadrangles (Fig. 1), three in the Toppenish basin on the south and one in the Moxee basin to the north. Detailed discussions of the major geologic structural features of the Yakima Fold Belt, which encompasses these basins, are available in Reidel and Hooper (1989), Campbell and Bentley (1981), and Brown and Ellis (1977). The relative ages of the geologic units in the four quadrangles are shown diagrammatically in Figure 2. Major element geochemical analyses of the basalt units for the sample localities shown on the maps are given in Table 1.

Two of the 15-minute quadrangles in this report are given informal names herein because there are no U.S. Geological Survey topographic quadrangle maps of these areas at that scale. The informally named Toppenish 15-minute quadrangle consists of the Wapato, Toppenish, Toppenish SE, and Hembre Mtn. 7.5-minute quadrangles. Likewise, the quadrangle we refer to as the Harrah 15-minute quadrangle is made up of the White Swan, Harrah, Toppenish Mtn., and Harrah SE quadrangles. Figure 1 shows the locations of these quadrangles, as well as the locations of other maps of this region that have been released as part of a cooperative effort between the U.S. Department of Energy and the Washington Division of Geology and Earth Resources.

GEOLOGIC UNITS

Surficial deposits

Alluvium—Silt, sand, and gravel deposits of diverse composition and largely confined to valley bottoms; locally includes lacustrine, paludal, and eolian deposits in depressions; divided into mainstream facies (unit Qam) and sidestream facies (unit Qas).

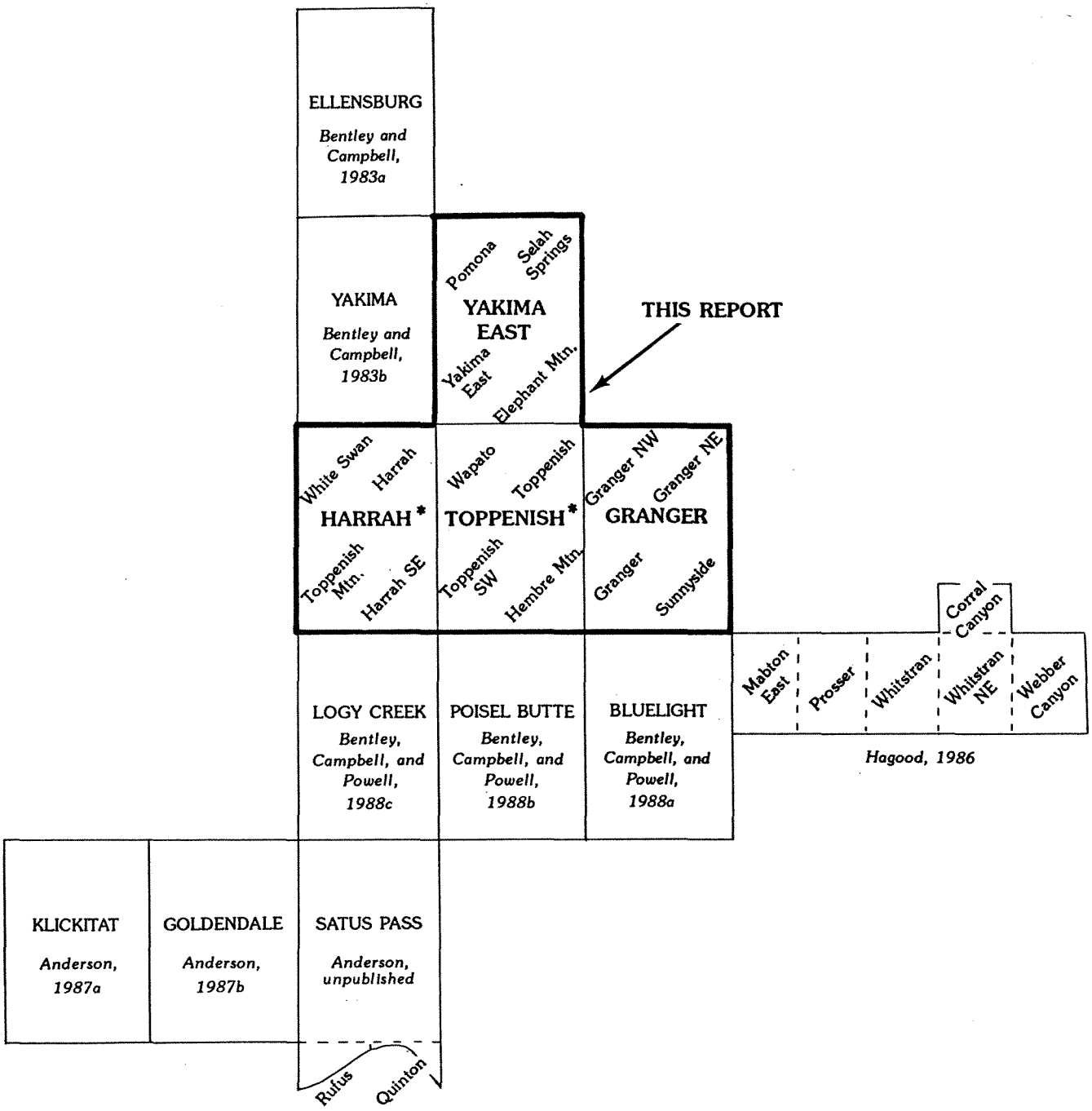
Qam Alluvium, mainstream facies—Silt, sand, and gravel deposited directly by the Yakima River; clasts of mixed lithologies. Mainstream facies of Waitt (1979).

Qas Alluvium, sidestream facies—Silt, sand, and gravel deposited by tributaries of the Yakima River; dominantly of basaltic composition. Sidestream facies of Waitt (1979).

Terrace deposits—Mainstream alluvial deposits of silt, sand, and gravel of diverse clast compositions; locally includes lacustrine, paludal, and eolian deposits; poorly indurated; slightly to moderately weathered clasts; deposited by the Yakima River and largely confined to its valley. Divided into younger, lower-level terraces (unit Qtm_1) and older, middle-level terraces (unit Qtm_2).

Qtm_1 Lower terrace deposits—Silt, sand, and gravel of diverse composition; restricted to the Yakima River valley between Selah and Prosser at elevations approximately 5 m above the modern Yakima River flood plain. Lower terrace of Campbell (1983).

Qtm_2 Middle terrace deposits—Silt, sand, and gravel of diverse composition; restricted to the Yakima River valley between Selah and Prosser at elevations approximately 10 m above the modern Yakima River flood plain. Middle terrace of Campbell (1983); corresponds to Lakedale Drift of Waitt (1979) in the Kittitas Valley.



* *informally named quadrangles in this report*

Figure 1. Geologic mapping in the Yakima Fold Belt produced under contract DE-AC06-81RL10297 between the U.S. Department of Energy and the Washington Division of Geology and Earth Resources.

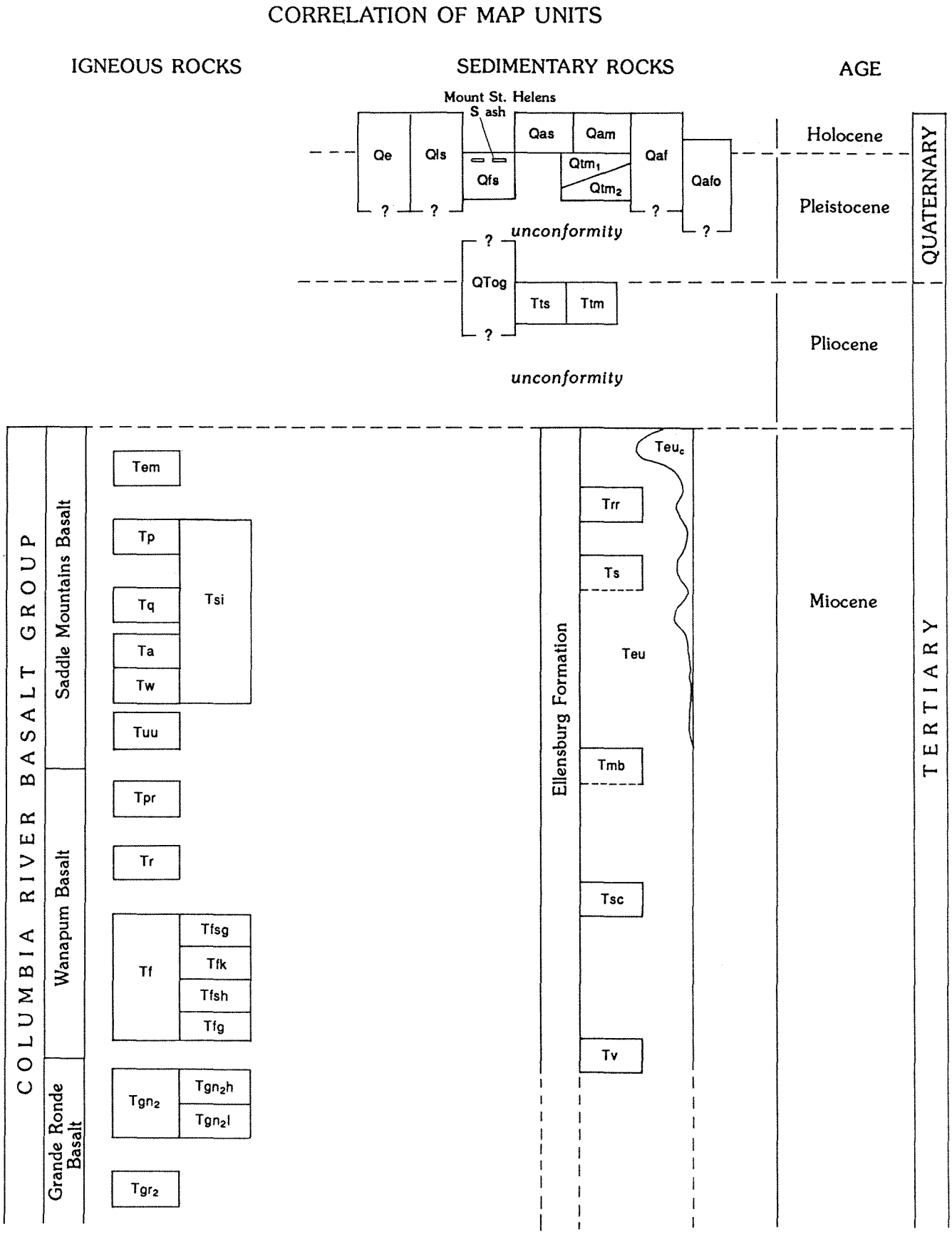


Figure 2. Correlation diagram for geologic units described in this report.

Qaf Alluvial fan deposits—Sand and gravel of diverse composition; large clasts dominantly basalt; cone shaped; surface only moderately dissected; little or no caliche development.

Qls Landslide deposits—Clay, silt, sand, and gravel, unstratified and poorly sorted; surface commonly hummocky; deposited by rotational-translational landslides and debris flows.

Qe Eolian deposits—Silt and fine sand; pale orange to brown; locally contains multiple caliche layers and tephra beds. Includes the Palouse Formation and all Holocene loess.

Qfs Catastrophic flood slackwater sediments—Silt and minor sand and gravel; rhythmically bedded and graded; deposited by Missoula (Spokane) floods; locally contains clastic dikes and ice-rafted clasts. Includes a thin layer of Mount St. Helens S ash near the top of the unit near the west edge of the Granger quadrangle. Includes the Touchet Beds (Flint, 1938).

Qafo Older alluvial fan deposits—Sand and gravel; semiconsolidated fanglomerate of primarily basalt clasts cemented by iron-stained clay; surface commonly dissected and capped by a well-developed caliche layer.

QTog Older gravel deposits—Clay, sand, and gravel alluvial fan and older sidestream deposits; moderately weathered; clay-cemented basalt clasts commonly capped by caliche; material derived from local anticlinal ridges; age uncertain but may be correlative with the Thorp Gravel.

Thorp Gravel (Waitt, 1979)—Coarse sand and gravel; moderately to highly weathered and poorly indurated stream terrace deposits related to the Yakima River drainage; divided into mainstream facies of mixed volcanic lithologies (unit Ttm), and basalt-dominant sidestream facies (unit Tts); contact with underlying Ellensburg Formation units commonly unconformable near ridges, conformable in basins.

Ttm Mainstream facies—Gravel of mixed volcanic lithologies; mainstream facies of Waitt (1979).

Tts Sidestream facies—Gravel of basalt-dominant lithology; sidestream facies of Waitt (1979).

Ellensburg Formation

Volcaniclastic sedimentary rocks present as interbeds between units of the Columbia River Basalt Group. Features common to members of this formation are their alluvial and laharic origin, white to reddish brown color, weak to moderate induration, and mixed basaltic, andesitic, and pumiceous composition.

Teu Upper Ellensburg Formation, undivided—Alluvial gravel, sand, silt, and clay and lahar deposits; basaltic clasts dominant near Umtanum Ridge; capped by a pediment surface of iron-oxide-cemented conglomerate south of the Rattlesnake Hills; lower contact at the top of the lowermost flow of the Columbia River Basalt Group. The undivided unit is the Ellensburg Formation of Smith (1903) and Mackin (1961). Component members in the map area:

Teu_c Conglomerate of Snipes Mountain (conglomerate facies of the Ellensburg; Schmincke, 1967)—Fluvial silt, sand, and gravel; light yellow-tan to reddish orange; weakly to strongly indurated; dominated by well-rounded quartzite pebbles, with significant amounts of granite, gneiss, and andesite clasts; deposited by the ancestral Columbia River; interfingers with other fluvial and laharic deposits of the Ellensburg Formation, particularly above the Elephant Mountain Member, but present in all interbeds between flows of the Saddle Mountains Basalt; first described by Russell (1893) and later by Waring (1913); may be correlative with the Hood River conglomerate (Buwalda and Moore, 1927, 1929).

Trr Rattlesnake Ridge Member (Schmincke, 1967)—Alluvial clay, silt, sand, and local gravel lenses and lahar deposits; underlies the Elephant Mountain Member and overlies the Pomona Member of the Saddle Mountains Basalt.

Ts Selah Member (Schmincke, 1967)—Alluvial clay, silt, sand, and local gravel lenses and lahar deposits; stratigraphic position defined by the overlying Pomona Member of the Saddle Mountains Basalt and the next basalt stratigraphically below.

Tmb Mabton Member of Schmincke (1967)—Alluvial clay, silt, sand, and gravel and lahar deposits; stratigraphic position defined by the overlying Umatilla Member of the Saddle Mountains Basalt and the next basalt stratigraphically below.

Tsc Squaw Creek Member (Mackin, 1947)—Alluvial clay, silt and fine sand; locally diatomite; white to tan; weakly to moderately indurated; underlies the Roza Member (Roza Member invasive into unit Tsc locally) and overlies the uppermost Frenchman Springs Member flow.

Tv Vantage Member (Swanson and others, 1979)—Alluvial clay, silt, and coarse sand, locally pebbly; white to tan; weakly to moderately indurated; dominated by dacitic and andesitic grains; local pumiceous clasts and hyaloclastic units; underlies the Wanapum Basalt and overlies the Grande Ronde Basalt.

Columbia River Basalt Group

Saddle Mountains Basalt

Tem Elephant Mountain Member—Black to blue-black on fresh surfaces, weathers gray; fine-grained; aphyric to sparsely plagioclase-phyric; normal magnetic polarity (Choiniere and Swanson, 1979); Elephant Mountain chemical type (Wright and others, 1973); K-Ar age about 10.5 Ma (McKee and others, 1977). A single flow in the area of this report.

Tsi Intracanyon flows complex of Saddle Mountains Basalt, undivided—Blue-black on fresh exposures, weather gray; aphyric to sparsely plagioclase-phyric; normal magnetic polarity (except the Pomona Member); in the map area present only in ancient river channels (1) along the south side of Yakima Ridge, where it locally includes some or all of the following: Pomona Member (unit Tp), Esquatzel Member (unit Tq), Huntzinger flow of the Asotin Member (unit Ta), and Wahluke flow of the Wilbur Creek Member (unit Tw); (2) on Selah Butte, where it contains a single flow of the Esquatzel Member (unit Tq), and (3) along Selah Creek. In some locations, geochemical analyses have identified the included flows; these intracanyon flows are not divisible at this map scale.

Tp Pomona Member—Gray to blue-black on fresh surfaces, weathers gray; fine-grained; sparsely to slightly phyric, with abundant white to colorless plagioclase microphenocrysts, sparse plagioclase glomerocrysts and sparse olivine phenocrysts; invasive contacts with Ellensburg units common; well-developed entablature and fanning columns; where more than 50 m thick, well-developed 0.5- to 1-m-diameter columns dominant; reversed magnetic polarity (fluxgate magnetics; Choiniere and Swanson, 1979); Pomona chemical type (Swanson and others, 1979); K-Ar age of about 12 Ma (McKee and others, 1977). This is the Wenas Basalt of Smith (1901). A single flow in the map area.

Tq Esquatzel Member (Swanson and others, 1979)—Blue-black on fresh exposures, weathers gray; fine-grained; sparsely plagioclase-phyric flow of Esquatzel chemical type (Swanson and others, 1979); normal magnetic polarity (fluxgate magnetics; Choiniere and Swanson, 1979); exposed in intracanyon flows on Selah Butte, and following an ancient river channel along Yakima Ridge.

Ta Asotin Member, Huntzinger flow (Mackin, 1961)—Blue-black on fresh exposures, weathers gray; fine-grained; sparsely plagioclase-phyric flow of Asotin chemical type (Swanson and others, 1979); normal magnetic polarity; the single intracanyon flow follows an ancient river channel along Yakima Ridge.

Tw Wilbur Creek Member, Wahluke flow (Swanson and others, 1979)—Black to blue-black on fresh exposures; weathers gray-black; fine-grained; aphyric with plagioclase microphenocrysts and rare phenocrysts; Wilbur Creek chemical type (Swanson and others, 1979); normal magnetic polarity; the single intracanyon flow follows an ancient river channel along Yakima Ridge.

Tuu Umatilla Member, Umatilla flow—Black to blue-black on fresh surfaces, weathers gray to red-orange; fine-grained; aphyric to very sparsely plagioclase-phyric; normal magnetic polarity; Umatilla chemical type (Wright and others, 1973).

Wanapum Basalt

Tpr Priest Rapids Member—Gray-black on fresh surfaces, weathers rusty brown; medium- to coarse-grained; aphyric, with rare plagioclase phenocrysts; diktytaxitic; well-developed colonnade, with 0.5- to 1.5-m-diameter columns; upper flow is of Lolo chemical type (Swanson and others, 1979); lower flow is Rosalia chemical type (Swanson and others, 1979); reversed magnetic polarity (fluxgate magnetics; Rietman, 1966); approximate age (K-Ar) 14.5 Ma (Watkins and Baksi, 1974); one to three flows in the map area.

Tr Roza Member—Gray-black on fresh surfaces, weathers reddish brown; fine- to medium-grained; 0.5- to 1-cm plagioclase phenocrysts and glomerocrysts; commonly several hundred phenocrysts per square meter of flow surface; well-developed colonnade of columns as much as a meter in diameter; locally diktytaxitic; Frenchman Springs chemical type (Wright and others, 1973); normal magnetic polarity (fluxgate magnetics), but laboratory results indicate transitional polarity after demagnetization (Reidel and others, 1989); resembles the plagioclase-phyric flows of the Frenchman Springs Member, but the Roza has more and smaller phenocrysts; one to two flows in the map area.

Tf Frenchman Springs Member, undivided—Gray to black on fresh surfaces, weathers gray to reddish brown; highly to sparsely plagioclase-phyric; normal magnetic polarity (fluxgate magnetics; Choiniere and Swanson, 1979); rare thin sedimentary interbeds; Frenchman Springs chemical type (Wright and others, 1973, Beeson and others, 1985); probably the Kelley Hollow and Ginkgo flows; lowermost flow of the sequence commonly pillowed at the base.

Tfsg Sentinel Gap flows—Gray-black on fresh exposures, weathers gray to reddish gray; fine- to medium-grained; generally aphyric; an average of about three glomerocrysts (plagioclase phenocrysts that reach 2 cm in diameter) per 10 m^2 of flow surface; colonnade of 1.5- to 2-m-diameter columns; locally pillowed base in lowermost flow; some hackly entablatures. One flow is present in most of the map area, but locally two or more crop out on Yakima and Ahtanum Ridges. This unit is the basalt of Sentinel Gap of Beeson and others (1985) and is equivalent to Mackin's (1961) Sentinel Gap flows and to the flows of Union Gap of Bentley and others (1988a).

Tfk Kelley Hollow flow—Gray-black on fresh surfaces, weathers reddish gray; fine- to medium-grained; phyric, with scattered (1-100 per m^2) plagioclase phenocrysts and glomerocrysts as large as 2 cm in diameter; thin entablature and well-developed colonnade; columns 0.5 to 1.5 m in diameter. This flow overlies the Sand Hollow flow of Mackin (1961), but it is the basalt of Sand Hollow of Beeson and others (1985) and the flow of Badger Gap of Bentley and Campbell (1983b) in the western part of Toppenish Ridge.

Tfsh Sand Hollow flow—Gray-black on fresh surfaces, weathers gray to reddish gray; fine- to medium-grained; generally aphyric, with rare phenocrysts as much as 2 cm in diameter and an average of three glomerocrysts per 10 m^2 of flow surface; locally hackly entablature; colonnade of 1.5- to 2-m-diameter columns; locally pillowed base. This is the Sand Hollow flow of Mackin (1961); to the east it is equivalent to the lower basalt of Sand Hollow of Beeson and others (1985).

Tfg Ginkgo flows—Gray-black on fresh surfaces; weathers reddish gray; fine- to medium-grained; phyric, with 100 to 200 plagioclase glomerocrysts that reach 2 cm in diameter per square meter of surface; thin entablature and well-developed colonnade of columns 0.5-1.5 m in diameter; pillowed base; laboratory results indicate a south excursion inclination with normal polarity; one to two flows in the map area. This is the basalt of Ginkgo of Beeson and others (1985).

Grande Ronde Basalt

The Grande Ronde chemical type (formerly termed the Yakima chemical type by Wright and others, 1973) is divided into high- and low-Mg chemical types (Swanson and others, 1979). This formation is also divided into upper and lower, normal and reversed magnetostratigraphic units on the basis of dominant polarity. Only the upper polarity units are present in the map area.

Tgn_2 Upper basalt flows of normal polarity—undivided.

Tgn_2h Upper basalt flows of normal polarity, high-Mg Grande Ronde chemical type (Swanson and others 1979), Sentinel Bluffs unit of Reidel and others (1989)—Gray-black on fresh surfaces, weathers reddish brown and gray; commonly moderately microphyric, with 1- to 3-mm-long equant plagioclase phenocrysts in fine- to medium-grained basalt; four or five multi-tiered flows of normal magnetic polarity; the lowest flow is of the McCoy chemical subtype (Myers, Price, and others, 1979). In the Yakima Canyon area, the highest flow is the Rocky Coulee

flow (Landon and Long, 1989), which overlies the Cohassett flow (Landon and Long, 1989);the next two lower flows are unnamed and in part equivalent to the Birkett and unnamed flows of Landon and Long (1989), which overlie the McCoy Canyon flow of Landon and Long (1989). To the south of Yakima Canyon, two or more flows of the Museum unit of Mackin (1961) overlie the Rocky Coulee flow.

Tgn2l Upper basalt flows of normal polarity; low-Mg Grande Ronde chemical type (Swanson and others 1979)—Black, fine-grained, dense, aphyric; thick, massive, hackly entablatures over colonnades; as many as five flows of this unit are present; the upper flow is the Umtanum unit of Reidel and others (1989) and of the Umtanum chemical subtype of Myers, Price and others (1979); the lower flows are in part equivalent to the Ortley unit of Reidel and others (1989). Although sedimentary interbeds are commonly present near the top and bottom of this unit, their continuity is obscured by invasive basalt flows; consequently, no interbeds are shown on the map.

Tgr2 Upper basalt flows of reversed magnetic polarity—Black to gray-black on fresh surfaces, weather reddish gray to grayish black; fine- to medium-grained; mostly aphyric, but contain local scattered plagioclase phenocrysts as much as 1 cm in diameter in some flows; poorly developed colonnade with columns as much as 0.5 m in diameter; poorly developed entablature with hackly and brick-bat jointing; some flows with multiple lobes; zeolites commonly present in vesicles; sedimentary interbeds present in the White Swan area; low-Mg Grande Ronde chemical type. These are flows within the R_2 unit of Swanson and others (1979). Flows in the map area may be equivalent to the Wapshilla Ridge unit of Reidel and others (1989).

Table 1. Major element analyses of rocks from the "Harrah", "Toppenish", Granger, and Yakima East 15′ quadrangles, Washington. 7.5′ quadrangles are shown in Figure 1. Analysis by X-ray fluorescence, Department of Geology, Washington State University, Pullman, WA, under the direction of P. R. Hooper. All analyses are normalized to 100 percent on a volatile-free basis. Fe_2O_3 is set arbitrarily at 2.00 percent

Map no.	Geologic unit		Sample no.	LOCATION QQSec	Sec	Twp	Rge	7.5′ Quad	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	TOTAL
1	Tem	Elephant Mtn. Mem.	RB79-089	SE/4,NW/4	02	09N	19E	Toppenish SW	50.55	13.81	3.42	2.00	13.19	0.24	8.93	3.81	1.29	2.28	0.49	100.01
2	Tem	Elephant Mtn. Mem.	RB79-085	NE/4,NE/4	03	09N	20E	Hembre Mtn.	50.96	13.78	3.46	2.00	13.42	0.22	8.57	3.94	1.25	1.89	0.51	100.00
3	Tem	Elephant Mtn. Mem.	RB79-156	SE/4,NW/4	17	09N	20E	Hembre Mtn.	50.55	13.81	3.40	2.00	13.51	0.24	8.48	3.92	1.25	2.34	0.50	100.00
4	Tem	Elephant Mtn. Mem.	RB79-088	SW/4,SW/4	32	10N	20E	Hembre Mtn.	50.83	13.94	3.44	2.00	12.96	0.23	8.42	4.18	1.34	2.15	0.50	99.99
5	Tem	Elephant Mtn. Mem.	RB79-087	SW/4,SE/4	32	10N	20E	Hembre Mtn.	51.96	14.63	3.66	2.00	11.10	0.29	9.18	3.01	1.25	2.32	0.60	100.00
6	Tem	Elephant Mtn. Mem.	RB79-180	SE/4,SE/4	30	12N	20E	Toppenish	50.63	13.89	3.49	2.00	13.08	0.23	8.54	3.91	1.32	2.41	0.51	100.01
7	Tem	Elephant Mtn. Mem.	RB79-172	SW/4,SE/4	26	12N	21E	Granger NW	50.94	13.88	3.48	2.00	12.81	0.21	8.59	3.82	1.29	2.48	0.50	100.00
8	Tem	Elephant Mtn. Mem.	RB79-211B	NW/4,SW/4	28	12N	21E	Granger NW	51.07	14.08	3.48	2.00	12.73	0.22	8.68	3.69	1.25	2.30	0.50	100.00
9	Tem	Elephant Mtn. Mem.	RB79-166	NE/4,NE/4	35	12N	21E	Granger NW	50.75	13.98	3.51	2.00	12.95	0.20	8.70	3.98	1.23	2.20	0.51	100.01
10	Tem	Elephant Mtn. Mem.	RB79-169	NE/4,SE/4	26	12N	22E	Granger NE	50.71	13.80	3.48	2.00	13.46	0.23	8.50	4.04	1.07	2.21	0.50	100.00
11	Tem	Elephant Mtn. Mem.	RB79-167	NE/4,SE/4	26	12N	22E	Granger NE	50.64	13.94	3.56	2.00	13.12	0.22	8.66	3.91	1.07	2.34	0.53	99.99
12	Tem	Elephant Mtn. Mem.	RB79-165	SE/4,NE/4	26	12N	22E	Granger NE	50.86	13.94	3.51	2.00	12.84	0.22	8.61	4.06	1.06	2.41	0.49	100.00
13	Tem	Elephant Mtn. Mem.	RB79-160	SE/4,SE/4	35	12N	22E	Granger NE	50.63	13.80	3.44	2.00	13.38	0.23	8.38	4.18	1.24	2.22	0.50	100.00
				number of samples = 10				mean	50.90	13.99	3.51	2.00	12.84	0.23	8.63	3.88	1.21	2.30	0.51	
								standard deviation	0.38	0.23	0.06	0.00	0.62	0.02	0.21	0.32	0.10	0.10	0.03	
14	Tsi	Intracanyon flow	RB85-037	SW/4,NE/4	11	13N	19E	Pomona	55.19	16.00	2.04	2.00	7.99	0.15	8.15	4.15	1.59	2.29	0.46	100.01
15	Tp	Pomona Member	RB79-215	SW/4,NE/4	13	09N	17E	Toppenish Mtn.	56.33	15.73	1.81	2.00	6.14	0.17	8.80	4.34	1.46	2.93	0.29	100.00
16	Tp	Pomona Member	RB79-216	SE/4,NW/4	08	09N	18E	Harrah SE	51.92	15.05	1.64	2.00	8.65	0.18	10.79	6.50	0.69	2.35	0.23	100.00
17	Tp	Pomona Member	RB79-207	NE/4,NE/4	18	09N	18E	Harrah SE	52.15	15.33	1.66	2.00	8.01	0.19	10.76	6.80	0.68	2.19	0.23	100.00
18	Tp	Pomona Member	RB79-086	SE/4,NE/4	03	09N	20E	Hembre Mtn.	51.29	16.05	1.85	2.00	9.51	0.16	11.02	5.53	0.33	2.01	0.26	100.01
19	Tp	Pomona Member	RB79-177	NE/4,SE/4	02	11N	21E	Granger NW	51.66	15.71	1.72	2.00	8.52	0.19	11.14	6.20	0.43	2.16	0.26	99.99
20	Tp	Pomona Member	RB79-179	NE/4,SW/4	02	11N	22E	Granger NE	51.47	14.97	1.55	2.00	8.38	0.24	11.92	6.47	0.52	2.24	0.25	100.01
21	Tp	Pomona Member	RB79-210	NE/4,SE/4	25	12N	17E	White Swan	52.22	15.35	1.62	2.00	8.68	0.18	10.64	6.35	0.61	2.13	0.23	100.01
22	Tp	Pomona Member	RB79-211	NE/4,SE/4	25	12N	17E	White Swan	51.94	15.44	1.61	2.00	8.36	0.18	10.74	6.67	0.52	2.31	0.24	100.01
23	Tp	Pomona Member	RB79-209	NE/4,NE/4	35	12N	17E	White Swan	51.55	15.13	1.66	2.00	9.05	0.19	10.75	6.79	0.58	2.07	0.22	99.99
24	Tp	Pomona Member	RB78-032	SW/4,SE/4	17	12N	19E	Yakima East	51.35	14.98	1.63	2.00	9.11	0.19	10.86	6.77	0.55	2.33	0.22	99.99
25	Tp	Pomona Member	RB79-171	NE/4,NE/4	35	12N	21E	Granger NW	51.87	15.33	1.65	2.00	9.15	0.22	10.78	5.93	0.60	2.23	0.24	100.00
26	Tp	Pomona Member	RB79-170	NE/4,SE/4	26	12N	22E	Granger NE	51.71	15.43	1.53	2.00	8.37	0.18	11.30	6.74	0.45	2.07	0.22	100.00
27	Tp	Pomona Member	RB79-173	SW/4,SW/4	31	12N	22E	Granger NE	51.67	15.40	1.60	2.00	8.73	0.19	10.95	6.50	0.58	2.15	0.23	100.00
28	Tp	Pomona Member	RB79-161	NE/4,SE/4	35	12N	22E	Granger NE	51.84	15.69	1.70	2.00	8.69	0.17	11.10	6.15	0.19	2.21	0.26	100.00
29	Tp	Pomona Member	RB79-162	NE/4,SE/4	35	12N	22E	Granger NE	53.06	15.17	1.50	2.00	8.43	0.18	10.11	6.27	0.96	2.10	0.22	100.00
30	Tp	Pomona Member	RB79-163	NE/4,SE/4	35	12N	22E	Granger NE	51.60	15.30	1.66	2.00	9.34	0.20	10.62	6.44	0.54	2.04	0.26	100.00
31	Tp	Pomona Member	RB79-159	NE/4,SE/4	35	12N	22E	Granger NE	51.91	15.54	1.67	2.00	8.15	0.19	10.93	6.76	0.46	2.16	0.23	100.00
32	Tp	Pomona Member	RB85-050	SW/4,SE/4	04	13N	19E	Pomona	51.92	16.37	1.59	2.00	7.65	0.18	10.54	6.91	0.45	2.17	0.23	100.01
33	Tp	Pomona Member	RB78-017	NE/4,SE/4	09	13N	19E	Pomona	52.17	15.26	1.57	2.00	8.80	0.18	10.65	6.53	0.62	2.01	0.22	100.01
34	Tp	Pomona Member	RB78-020	SW/4,SE/4	09	13N	19E	Yakima East	52.15	15.23	1.61	2.00	8.92	0.19	10.82	6.14	0.55	2.15	0.22	99.98
35	Tp	Pomona Member	RB85-062	NE/4,SE/4	11	13N	19E	Pomona	52.92	15.92	1.71	2.00	8.14	0.18	9.73	6.07	0.85	2.17	0.31	100.00
36	Tp(Tsi)	Pomona Member	RB85-038	SW/4,NW/4	11	13N	19E	Pomona	52.33	15.89	1.71	2.00	8.12	0.18	9.67	6.87	0.89	2.03	0.30	99.99

Map no.	Geologic unit		Sample no.	LOCATION QQSec	Sec	Twp	Rge	7.5′ Quad	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	TOTAL
37	Tp	Pomona Member	RB85-023	SW/4,SE/4	13	13N	20E	Elephant Mtn.	52.41	15.38	1.69	2.00	8.60	0.19	10.22	6.83	0.39	2.04	0.24	99.99
38	Tp	Pomona Member	RB78-010	SW/4,SW/4	13	13N	20E	Elephant Mtn.	52.02	15.40	1.56	2.00	8.50	0.18	10.64	6.77	0.54	2.17	0.20	99.98
39	Tp(Tsi)	Pomona Member	RB85-029	NE/4,NW/4	15	13N	20E	Elephant Mtn.	52.35	15.69	1.72	2.00	8.46	0.18	9.44	6.72	0.94	2.19	0.32	100.01
40	Tp	Pomona Member	RB78-006	NE/4,NW/4	22	13N	20E	Elephant Mtn.	52.58	15.91	1.66	2.00	7.20	0.18	11.01	6.28	0.60	2.34	0.24	100.00
41	Tp(Tsi)	Pomona Member	RB78-003	NE/4,NW/4	23	13N	20E	Elephant Mtn.	52.52	15.73	1.59	2.00	8.38	0.18	9.80	6.23	1.17	2.09	0.30	99.99
42	Tp	Pomona Member	RB85-041	SW/4,NE/4	24	13N	20E	Elephant Mtn.	52.46	15.46	1.74	2.00	8.01	0.20	10.27	6.83	0.50	2.29	0.24	100.00
43	Tp	Pomona Member	RB85-042	SE/4,SW/4	26	13N	20E	Elephant Mtn.	52.40	15.54	1.77	2.00	8.08	0.19	10.50	6.82	0.36	2.12	0.23	100.01
44	Tp	Pomona Member	RB85-039	SW/4,SW/4	19	13N	21E	Elephant Mtn.	52.60	15.46	1.73	2.00	8.54	0.18	10.25	6.52	0.43	2.05	0.24	100.00
45	Tp	Pomona Member	RB78-007	NE/4,SW/4	15	14N	19E	Pomona	52.36	15.27	1.55	2.00	8.87	0.19	10.54	6.63	0.45	1.94	0.20	100.00
46	Tp	Pomona Member	RB85-035	SW/4,SE/4	35	14N	19E	Pomona	52.56	15.71	1.74	2.00	8.05	0.19	10.63	6.13	0.48	2.29	0.24	100.02
47	Tp	Pomona Member	RB85-034	SW/4,SE/4	35	14N	19E	Pomona	52.50	15.39	1.72	2.00	8.66	0.19	10.21	6.64	0.41	2.04	0.23	99.99
48	Tp	Pomona Member	RB85-010	SW/4,NW/4	08	14N	20E	Selah Springs	51.35	14.99	1.80	2.00	9.07	0.20	10.67	7.14	0.43	2.09	0.25	99.99
49	Tp	Pomona Member	RB85-009	SW/4,NW/4	08	14N	20E	Selah Springs	52.14	15.33	1.71	2.00	8.63	0.19	10.16	7.16	0.41	2.02	0.24	99.99
				number of samples = 35				mean	52.21	15.47	1.66	2.00	8.46	0.19	10.54	6.47	0.59	2.17	0.24	
								standard deviation	0.83	0.31	0.08	0.00	0.61	0.01	0.57	0.50	0.25	0.17	0.03	
50	Tq(Tsi)	Esquatzel Member	RB85-047	SW/4,SE/4	04	13N	19E	Pomona	54.12	14.77	3.26	2.00	10.67	0.20	7.81	3.40	1.52	1.86	0.39	100.00
51	Tq(Tsi)	Esquatzel Member	RB78-025	SW/4,SW/4	08	13N	19E	Yakima East	53.48	14.32	3.16	2.00	11.18	0.21	7.84	3.33	1.75	2.35	0.37	99.99
52	Tq(Tsi)	Esquatzel Member	RB78-019	NE/4,SE/4	09	13N	19E	Pomona	53.23	14.09	3.02	2.00	11.89	0.19	7.66	3.57	1.75	2.22	0.38	100.00
53	Tq(Tsi)	Esquatzel Member	RB78-016	NE/4,SW/4	10	13N	19E	Pomona	53.44	14.27	3.03	2.00	11.71	0.20	7.49	3.75	1.74	2.01	0.36	100.00
54	Tq(Tsi)	Esquatzel Member	RB85-032	NE/4,NE/4	07	13N	20E	Selah Springs	53.55	14.50	3.16	2.00	11.44	0.20	7.66	3.68	1.57	1.87	0.37	100.00
55	Tq(Tsi)	Esquatzel Member	RB85-033	SE/4,NW/4	07	13N	20E	Selah Springs	55.19	15.26	3.36	2.00	8.08	0.18	7.99	3.81	1.86	1.88	0.41	100.02
56	Tq(Tsi)	Esquatzel Member	RB78-009	SW/4,NW/4	09	13N	20E	Selah Springs	53.48	14.16	3.13	2.00	11.42	0.20	7.72	3.40	1.76	2.36	0.38	100.01
57	Tq(Tsi)	Esquatzel Member	RB85-028	NE/4,NW/4	15	13N	20E	Elephant Mtn.	53.66	14.55	3.21	2.00	11.25	0.20	7.61	3.72	1.55	1.88	0.38	100.01
58	Tq(Tsi)	Esquatzel Member	RB78-012	NE/4,SE/4	24	13N	20E	Elephant Mtn.	52.88	13.99	3.09	2.00	12.01	0.20	7.64	3.76	1.71	2.35	0.36	99.99
				number of samples = 9				mean	53.67	14.43	3.16	2.00	11.07	0.20	7.71	3.60	1.69	2.09	0.38	
59	Ta(Tsi)	Asotin Member	RB78-023	NE/4,NE/4	07	13N	19E	Pomona	51.11	16.22	1.36	2.00	8.09	0.16	11.13	7.26	0.41	2.07	0.19	100.00
60	Ta(Tsi)	Asotin Member	RB78-022	NE/4,NE/4	08	13N	19E	Pomona	52.87	15.73	1.69	2.00	8.25	0.19	10.59	4.84	1.21	2.29	0.34	100.00
61	Ta(Tsi)	Asotin Member	RB78-015	NE/4,SE/4	10	13N	19E	Pomona	50.75	16.21	1.36	2.00	7.51	0.17	11.24	7.64	0.57	2.34	0.20	99.99
62	Ta(Tsi)	Asotin Member	RB85-031	SW/4,NW/4	15	13N	20E	Elephant Mtn.	51.54	16.14	1.59	2.00	7.52	0.18	10.29	7.72	0.61	2.18	0.24	100.01
				number of samples = 4				mean	51.57	16.08	1.50	2.00	7.84	0.18	10.81	6.87	0.70	2.22	0.24	
63	Tw(Tsi)	Wilbur Creek Member	RB85-053	NE/4,SE/4	11	13N	19E	Pomona	53.61	15.94	1.84	2.00	8.49	0.18	9.49	4.99	0.90	2.19	0.36	99.99
64	Tw(Tsi)	Wilbur Creek Member	RB85-036	NE/4,SE/4	11	13N	19E	Pomona	53.00	15.67	1.80	2.00	8.72	0.19	9.01	5.92	1.25	2.07	0.37	100.00
65	Tw(Tsi)	Wilbur Creek Member	RB85-051	SW/4,NE/4	11	13N	19E	Pomona	53.48	15.74	1.83	2.00	8.47	0.18	9.79	4.80	1.03	2.31	0.36	99.99
66	Tw(Tsi)	Wilbur Creek Member	RB85-030	SW/4,NW/4	15	13N	20E	Elephant Mtn.	53.62	15.54	1.93	2.00	9.09	0.19	8.62	5.25	1.38	1.97	0.42	100.01
67	Tw(Tsi)	Wilbur Creek Member	RB85-013	NE/4,SE/4	15	14N	19E	Pomona	52.87	15.73	1.79	2.00	8.63	0.19	9.12	6.06	1.15	2.10	0.35	99.99
68	Tw(Tsi)	Wilbur Creek Member	RB85-015	NE/4,SE/4	15	14N	19E	Pomona	53.13	15.83	1.81	2.00	8.42	0.19	9.20	5.86	1.16	2.05	0.36	100.01
69	Tw(Tsi)	Wilbur Creek Member	RB85-014	NE/4,SE/4	15	14N	19E	Pomona	53.02	15.71	1.78	2.00	8.68	0.19	9.09	6.18	1.18	1.81	0.36	100.00
70	Tw(Tsi)	Wilbur Creek Member	RB85-012	NE/4,SE/4	15	14N	19E	Pomona	52.94	15.72	1.80	2.00	8.81	0.19	9.03	6.15	1.15	1.87	0.35	100.01
				number of samples = 8				mean	53.21	15.74	1.82	2.00	8.66	0.19	9.17	5.65	1.15	2.05	0.37	

Table 1. Major element analyses of rocks from the "Harrah", "Toppenish", Granger, and Yakima East 15′ quadrangles, Washington *(continued)*

Map no.	Geologic unit		Sample no.	LOCATION QQSec	Sec	Twp	Rge	7.5′ Quad	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	TOTAL
71	Tuu	Umatilla Member	RB79-108	NE/4,SW/4	01	09N	18E	Harrah SE	55.58	15.31	2.82	2.00	8.78	0.23	6.14	2.06	2.88	3.32	0.89	100.01
72	Tuu	Umatilla Member	RB79-203	SW/4,SW/4	01	09N	18E	Harrah SE	53.96	14.54	2.60	2.00	10.55	0.37	6.73	2.54	2.92	2.96	0.84	100.01
73	Tuu	Umatilla Member	RB79-110	NE/4,SE/4	03	09N	18E	Harrah SE	54.51	14.88	2.70	2.00	9.84	0.22	6.46	2.71	2.97	2.84	0.85	99.98
74	Tuu	Umatilla Member	RB79-212	NE/4,NE/4	11	09N	18E	Harrah SE	54.99	14.56	2.68	2.00	9.90	0.21	6.29	2.37	3.09	3.05	0.86	100.00
75	Tuu	Umatilla Member	RB79-091	NE/4,SW/4	02	09N	19E	Toppenish SW	55.65	15.14	2.74	2.00	9.00	0.16	6.16	2.08	3.00	3.16	0.92	100.01
76	Tuu	Umatilla Member	RB79-092	SE/4,SW/4	03	09N	19E	Toppenish SW	57.07	15.99	3.15	2.00	6.85	0.14	5.56	1.57	3.13	3.57	0.97	100.00
77	Tuu	Umatilla Member	RB79-155	SE/4,NW/4	17	09N	20E	Hembre Mtn.	53.51	14.71	2.83	2.00	11.26	0.21	6.49	3.03	2.68	2.53	0.76	100.01
78	Tuu	Umatilla Member	RB79-154	SW/4,NE/4	17	09N	20E	Hembre Mtn.	54.84	15.27	2.87	2.00	8.93	0.21	6.84	2.41	2.58	3.20	0.84	99.99
79	Tuu	Umatilla Member	RB79-095	SE/4,NE/4	18	09N	20E	Hembre Mtn.	54.59	15.00	2.96	2.00	9.95	0.22	6.33	2.38	2.77	2.96	0.85	100.01
80	Tuu	Umatilla Member	RB79-178	SE/4,NE/4	05	11N	22E	Granger NE	54.26	14.59	2.56	2.00	10.71	0.22	6.16	2.62	3.13	2.87	0.87	99.99
81	Tuu	Umatilla Member	RB78-030	SW/4,SE/4	17	12N	19E	Yakima East	55.10	14.73	2.60	2.00	10.01	0.21	6.13	3.08	2.63	2.68	0.83	100.00
82	Tuu	Umatilla Member	RB79-031	SE/4,NW/4	26	12N	19E	Yakima East	53.74	14.62	2.74	2.00	10.87	0.27	6.76	2.57	2.88	2.75	0.80	100.00
83	Tuu	Umatilla Member	RB79-032	SW/4,NW/4	26	12N	19E	Yakima East	54.51	14.98	2.86	2.00	10.03	0.19	6.61	2.47	2.70	2.87	0.79	100.01
84	Tuu	Umatilla Member	RB79-175	NE/4,SE/4	32	12N	22E	Granger NE	53.77	14.47	2.71	2.00	10.96	0.23	6.52	2.77	2.84	2.93	0.80	100.00
85	Tuu	Umatilla Member	RB78-021	SW/4,SE/4	08	13N	19E	Yakima East	56.37	15.40	2.99	2.00	5.98	0.18	7.59	2.39	3.10	3.14	0.86	100.00
86	Tuu	Umatilla Member	RB78-018	NE/4,SE/4	09	13N	19E	Pomona	55.03	14.75	2.63	2.00	10.29	0.23	6.22	2.72	2.78	2.53	0.82	100.00
87	Tuu	Umatilla Member	RB78-005	SW/4,SE/4	22	13N	20E	Elephant Mtn.	55.31	14.64	2.69	2.00	10.48	0.23	6.31	2.24	2.68	2.58	0.85	100.01
88	Tuu	Umatilla Member	RB78-039	SW/4,SW/4	25	13N	20E	Elephant Mtn.	54.99	14.88	2.71	2.00	9.91	0.20	6.60	2.22	2.76	2.87	0.86	100.00
				number of samples = 18				mean	54.88	14.91	2.77	2.00	9.68	0.22	6.44	2.46	2.86	2.93	0.85	
								standard deviation	0.89	0.38	0.15	0.00	1.34	0.05	0.40	0.35	0.17	0.27	0.05	
89	Tpr	Priest Rapids Member	RB79-206	NE/4,SE/4	13	09N	17E	Toppenish Mtn.	49.67	13.71	3.45	2.00	13.41	0.24	8.48	4.60	1.33	2.46	0.65	100.00
90	Tpr	Priest Rapids Member	RB79-205	SE/4,NE/4	13	09N	17E	Toppenish Mtn.	50.90	14.07	2.86	2.00	12.27	0.23	9.02	4.37	1.27	2.53	0.48	100.00
91	Tpr	Priest Rapids Member	RB79-109	SW/4,NE/4	02	09N	18E	Harrah SE	49.79	14.41	3.15	2.00	11.71	0.23	9.37	5.37	0.97	2.33	0.66	99.99
92	Tpr	Priest Rapids Member	RB79-112	SE/4,NW/4	08	09N	18E	Harrah SE	51.76	14.25	3.00	2.00	12.01	0.23	8.12	4.05	1.50	2.50	0.58	100.00
93	Tpr	Priest Rapids Member	RB79-093	NE/4,NE/4	06	09N	19E	Toppenish SW	50.14	13.73	3.48	2.00	12.98	0.23	8.63	4.50	1.21	2.45	0.65	100.00
94	Tpr	Priest Rapids Member	RB78-031	SW/4,NE/4	17	12N	19E	Yakima East	50.24	13.56	3.40	2.00	13.27	0.23	8.28	4.55	1.27	2.52	0.67	99.99
95	Tpr	Priest Rapids Member	RB85-040	SW/4,SW/4	19	13N	21E	Elephant Mtn.	53.27	14.45	3.16	2.00	11.55	0.21	7.51	3.89	1.54	2.04	0.38	100.00
96	Tpr	Priest Rapids Member	RB85-008	SE/4,SW/4	21	14N	20E	Selah Springs	50.14	13.51	3.70	2.00	13.58	0.24	8.27	4.79	1.08	2.01	0.69	100.01
				number of samples = 8				mean	50.74	13.96	3.28	2.00	12.60	0.23	8.46	4.52	1.27	2.36	0.60	
97	Tfsg	Sentinel Gap flow	RB79-204	NE/4,SE/4	01	09N	18E	Harrah SE	52.47	14.27	3.06	2.00	10.37	0.24	8.44	4.40	1.51	2.68	0.56	100.00
98	Tfsg	Sentinel Gap flow	RB79-214	SE/4,NW/4	10	09N	18E	Harrah SE	53.09	14.43	3.11	2.00	10.73	0.21	7.99	3.52	1.67	2.66	0.58	99.99
99	Tfsg	Sentinel Gap flow	RB79-213	NE/4,NW/4	11	09N	18E	Harrah SE	53.01	14.22	3.14	2.00	11.31	0.20	8.32	3.77	1.11	2.33	0.59	100.00
100	Tfsg	Sentinel Gap flow	RB78-002	SW/4,NE/4	11	13N	20E	Selah Springs	51.47	13.88	2.99	2.00	12.10	0.22	8.24	4.25	1.50	2.81	0.54	100.00
101	Tfsg	Sentinel Gap flow	RB78-004	NE/4,NW/4	23	13N	20E	Elephant Mtn.	52.21	14.30	2.90	2.00	11.94	0.22	8.01	3.71	1.55	2.54	0.61	99.99
102	Tfsg	Sentinel Gap flow	RB85-044	NE/4,NW/4	07	13N	21E	Selah Springs	53.24	14.54	3.00	2.00	11.83	0.21	7.90	3.34	1.38	1.94	0.62	100.00
103	Tfsg	Sentinel Gap flow	RB85-016	NE/4,SE/4	15	14N	19E	Pomona	52.37	14.32	3.17	2.00	11.61	0.22	8.07	4.43	1.20	2.07	0.54	100.00
104	Tfsg	Sentinel Gap flow	RB85-006	SE/4,SW/4	21	14N	20E	Selah Springs	52.85	14.21	3.11	2.00	11.88	0.23	8.03	4.08	1.30	1.77	0.53	99.99
				number of samples = 8				mean	52.59	14.27	3.06	2.00	11.47	~0.22	8.13	3.94	1.40	2.35	0.57	

Map no.	Geologic unit		Sample no.	LOCATION QQSec	Sec	Twp	Rge	7.5′ Quad	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	TOTAL
105	Tfk	Kelley Hollow flow	RB85-052	NE/4,SE/4	11	13N	19E	Pomona	52.73	14.70	3.09	2.00	10.99	0.20	8.40	4.18	0.99	2.21	0.51	100.00
106	Tfk	Kelley Hollow flow	RB85-045	SW/4,NW/4	07	13N	21E	Selah Springs	54.16	15.65	3.21	2.00	8.88	0.17	8.54	3.37	1.20	2.27	0.54	99.99
107	Tfk	Kelley Hollow flow	RB85-059	SE/4,NW/4	09	14N	19E	Pomona	52.26	14.40	2.92	2.00	12.15	0.21	7.84	4.68	1.04	2.02	0.48	100.00
108	Tfk	Kelley Hollow flow	RB85-007	SE/4,SW/4	21	14N	20E	Selah Springs	52.19	14.56	2.91	2.00	11.68	0.23	8.26	4.69	1.04	1.96	0.48	100.00
109	Tfsh	Sand Hollow flow	RB85-046	SW/4,NW/4	07	13N	21E	Selah Springs	52.36	14.48	2.99	2.00	11.67	0.23	8.09	4.45	1.04	2.20	0.50	100.01
110	Tfsh	Sand Hollow flow	RB85-058	SE/4,NW/4	09	14N	19E	Pomona	52.18	14.27	2.96	2.00	11.69	0.23	8.16	4.68	1.17	2.18	0.48	100.00
111	Tfg	Ginkgo flow	RB85-024	SE/4,SW/4	07	13N	21E	Elephant Mtn.	51.77	14.04	3.24	2.00	12.50	0.23	7.90	4.49	1.34	1.93	0.56	100.00
112	Tfg	Ginkgo flow	RB85-057	SE/4,NW/4	09	14N	19E	Pomona	52.03	14.21	3.26	2.00	12.49	0.23	7.97	4.17	1.25	1.80	0.58	99.99
113	Tgn_2h	Rocky Coulee flow	RB85-056	NE/4,NE/4	09	14N	19E	Pomona	54.15	15.39	1.86	2.00	9.13	0.21	8.59	5.13	1.00	2.26	0.29	100.01
114	Tgn_2h	McCoy Canyon flow	RB85-001	NE/4,NE/4	13	14N	20E	Selah Springs	55.13	15.62	2.19	2.00	7.73	0.20	8.51	4.73	1.16	2.43	0.30	100.00
115	Tgn_2l	Umtanum flow	RB85-005	SW/4,SE/4	11	14N	20E	Selah Springs	56.58	15.41	2.41	2.00	8.06	0.21	7.40	3.66	1.76	2.14	0.38	100.01
116	Tgn_2l	Umtanum flow	RB85-002	NE/4,NE/4	13	14N	20E	Selah Springs	55.85	15.11	2.31	2.00	9.81	0.21	7.07	3.52	1.64	2.12	0.36	100.00
117	Tgn_2l	Umtanum flow	RB85-004	SE/4,NW/4	13	14N	20E	Selah Springs	57.70	15.89	2.53	2.00	6.77	0.19	7.14	3.36	1.81	2.23	0.39	100.01
118	Tgn_2l	Umtanum flow	RB85-003	SW/4,NE/4	13	14N	20E	Selah Springs	57.35	15.93	2.52	2.00	7.24	0.19	7.05	3.14	1.87	2.34	0.38	100.01
119	Tgn_2l	Umtanum flow	RB85-020	NE/4,SE/4	32	15N	19E	Pomona	55.99	15.20	2.21	2.00	9.67	0.20	6.87	3.48	1.89	2.15	0.33	99.99
				number of samples = 5				mean	56.69	15.51	2.40	2.00	8.31	0.20	7.11	3.43	1.79	2.20	0.37	
120	Tgr_2	Meeks Table flow	RB85-021	NE/4,SE/4	32	15N	19E	Pomona	57.11	15.31	2.12	2.00	8.67	0.20	6.97	3.39	1.86	2.08	0.29	100.00
121	Tgr_2	Meeks Table flow	RB85-055	NE/4,NW/4	33	15N	19E	Pomona	56.05	15.13	2.01	2.00	9.75	0.20	6.93	3.72	1.56	2.36	0.28	99.99
122	Tgr_2	Waterworks flow	RB85-022	NE/4,SE/4	32	15N	19E	Pomona	56.35	15.14	2.15	2.00	9.95	0.19	6.54	3.43	1.70	2.24	0.31	100.00
123	Tgr_2	Waterworks flow	RB85-054	SE/4,NE/4	32	15N	19E	Pomona	55.40	14.94	2.14	2.00	10.28	0.21	7.03	3.74	1.75	2.19	0.32	100.00

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