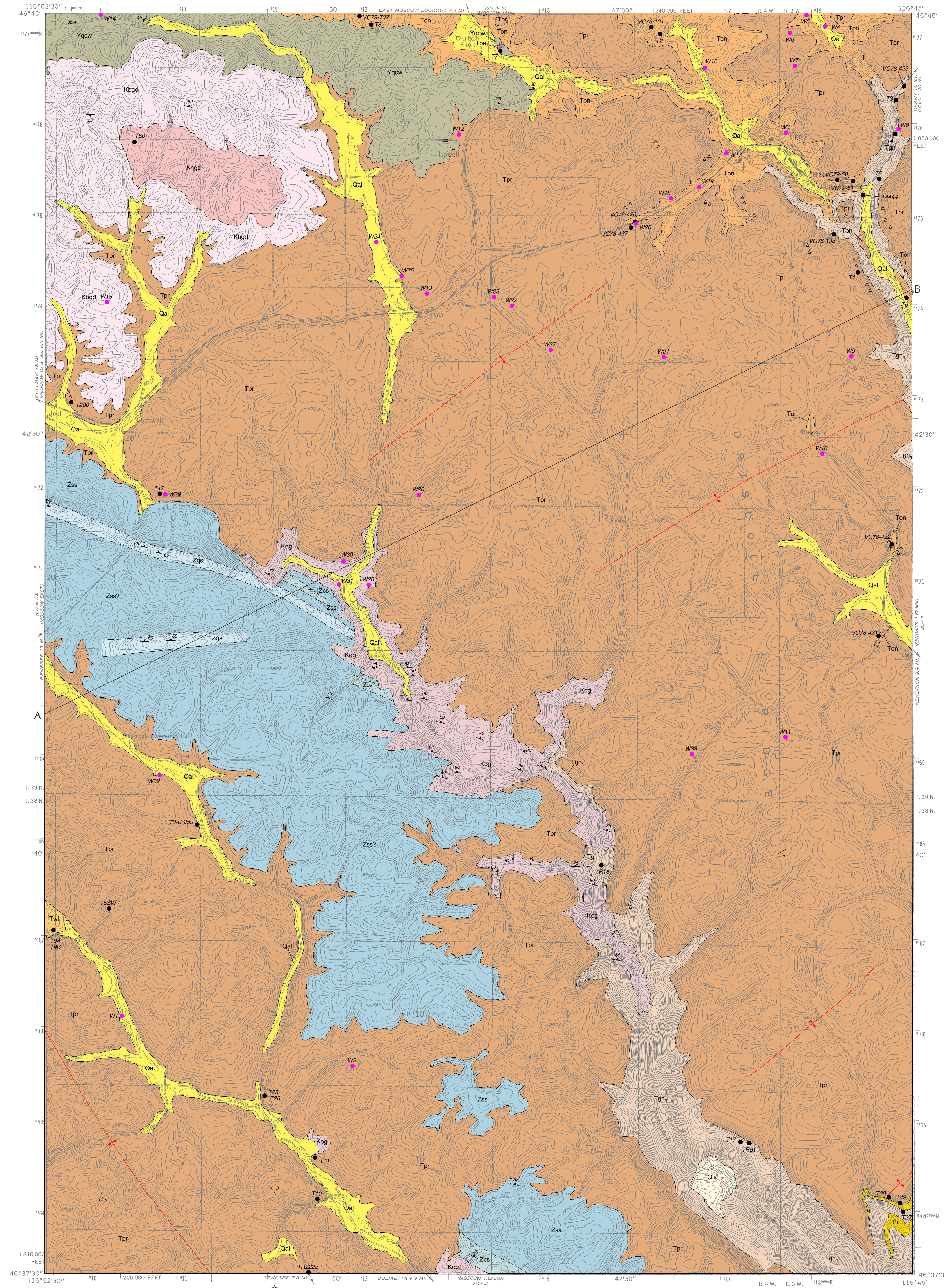
Geologic Map of the Troy Quadrangle, Latah County, Idaho

John H. Bush, Reed S. Lewis, and Kurt L. Priebe

2007



Base map from USGS digital raster graphic 1960.
Topography by photogrammetric methods from aerial photographs taken 1957. Field check 1960.
1927 North American Datum.
Projection and 10,000-foot grid ticks: Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
National geodetic vertical datum of 1929.

UTM Grid and 1960 Magnetic North Declination at Center of Map

SCALE 1:24,000

Contour interval 20 feet

IDAHO

QUADRANGLE LOCATION

Field work conducted 1995-2003.

This geologic map was funded in part by the U.S. Geological Survey's National Cooperative Geologic Mapping Program.

Digital cartography by Jane S. Freed and Loudon R. Stanford at the Idaho Geological Survey's Digital Mapping Lab.

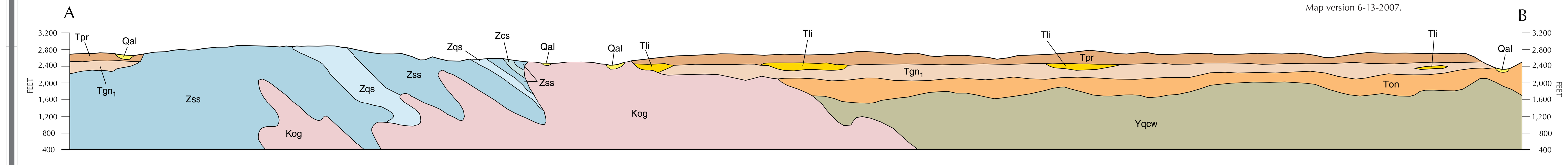
Reviewed by John D. Kauffman and Dean L. Garwood.

Map edited by Roger C. Stewart.

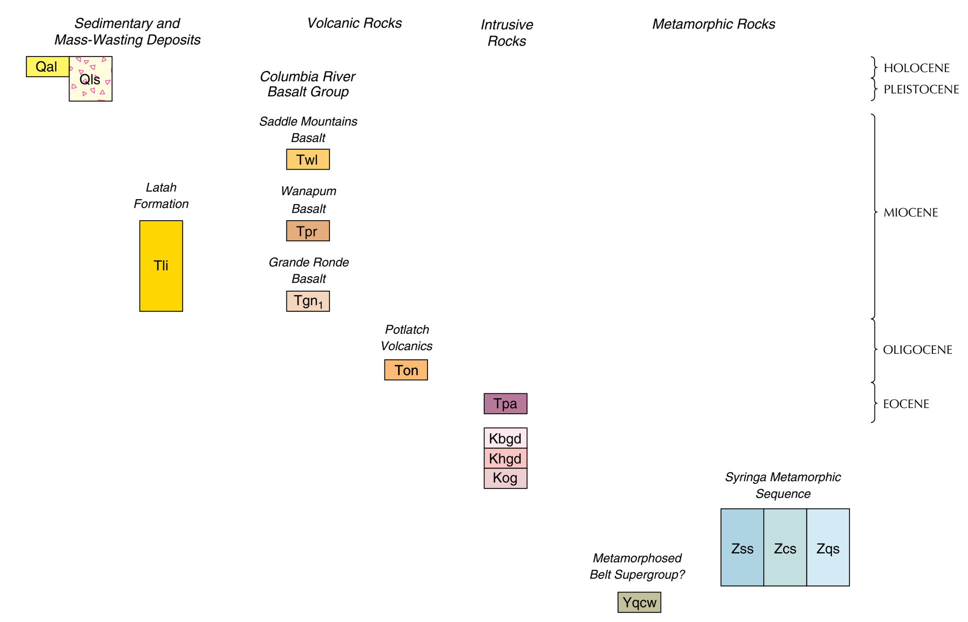
Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run and fading but will deteriorate with long-term exposure to light.

PDF map (Acrobat Reader) may be viewed at www.idahogeology.org.

Map version 6-13-2007.



CORRELATION OF MAP UNITS



INTRODUCTION

The bedrock map of the Troy quadrangle is based largely on field observations, mapping, and water well data. Regional maps by Bond (1962), Rember and Bennett (1979), Swanson and others (1979a), and Swanson and others (1980) as well as larger scale maps by Tullis (1944) and Anderson (1991) have also been consulted. The colluvium on steep canyon walls and the loess of the Palouse Formation are not illustrated in keeping with the emphasis on bedrock mapping. Locally, well-exposed outcrops occur in canyon areas though contacts are rarely exposed; most of these contact lines are interpretive. Basalt samples were analyzed at the GeoAnalytical Laboratory at Washington State University (Table 1). Paleomagnetic determinations were conducted at the Idaho Geological Survey. Water well data (Table 2) were obtained from the Idaho Department of Water Resources in Coeur d'Alene, and well locations were field checked. The map represents a major revision of the earlier work by Bush and Priebe (1995).

The quadrangle is located in the northwestern part of the Clearwater embayment of Bond (1963) where flows of the Columbia River Basalt Group were emplaced from the south onto a steep topography developed on various basement rocks, which are now exposed on surrounding hills and in isolated canyons of the dissected basalt plateau. The flows dip gently to the south on the eastern side of the quadrangle where they are crossed by at least four minor northeast- to southwest-trending monoclines. The dip was determined from a structural contour map on the uppermost Grande Ronde Basalt (Bush and Priebe, 1999). That basalt surface drops 600 feet in elevation from Troy to Juliaetta, 12 miles to the south. The elevation changes are abrupt, occurring over short distances across the monoclines.

The most significant structural feature in the basalt sequence occurs in the southwest part of the quadrangle where a narrow northwest-trending topographic ridge can be traced into the adjoining Moscow East quadrangle to the west and the Green Knob quadrangle to the south. This ridge is part of a linear structure, named the Cottonwood fault by Bond (1963), that extends for over 30 miles. To the south on the Green Knob quadrangle, it is shown as a steep westward-dipping fault (Bush and others, 2001). At several places along its length, the structure is fold dominated, particularly on the northwest segment. Although a thick loess cover hinders detailed mapping, the structure is interpreted to be primarily a low-amplitude anticline or monocline in the Troy quadrangle.

DESCRIPTION OF MAP UNITS

SEDIMENTARY AND MASS-WASTING DEPOSITS

Alluvial and Landslide Deposits

Qal — **Alluvium (Holocene)**—Stream, slope-wash, and debris-flow deposits. Predominantly silt interbedded with silty sand, granules, and pebbles. Silt is mostly reworked loess; gravel fragments are basalt and granitoid mineral grains. Stream channel and overbank deposits typically are thin and interfinger with laterally thickening deposits of slope wash and debris flows derived from the erosion and mass wasting of loess of the Palouse Formation. Middle Potlatch Creek contains poorly sorted coarse deposits of subangular to rounded basalt and granitoid granules, cobbles, and boulders.

Qls — **Landslide and slump deposits (Pleistocene and Holocene)**—Poorly sorted and poorly stratified angular basalt fragments mixed with silt and clay. Includes blocks of basalt and sedimentary interbeds that have been rotated backward and moved downslope.

Latah Formation Sediments

Tli — **Latah Formation interbeds (Miocene)**—Sand, silt, and clay deposits of the Latah Formation interbedded with basalt flows. Commonly, these sediments are not thick or well enough exposed to show at the map scale. In the northeast part of the quadrangle, sediments interbedded with basalt flows range from white kaolinite-rich clay to micaceous, poorly sorted quartz sand. The number and thicknesses of these interbeds decrease to the south and southwest. Most sediments represent reworked weathered crystalline rocks deposited in alluvial environments of ponded streams created by advancing lava. Many sediments contain wood fragments, scattered leaf fossils, and in rare instances petrified logs. The contact between the Grande Ronde Basalt and the overlying Priest Rapids Member is generally separated by sediment or a saprolite developed on top of the uppermost Grande Ronde flow. Sediments also occur between some Grande Ronde flows, although they are generally thin and discontinuous.

VOLCANIC ROCKS

Columbia River Basalt Group

The stratigraphic nomenclature for the Columbia River Basalt Group follows that of Swanson and others (1979b). In Idaho, the group is divided into four formations. From base upward, these are Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. The Imnaha Basalt is not exposed in the Troy quadrangle. The Grande Ronde Basalt, a series of flows erupted between 16.1 Ma and 15.0 Ma (Hooper and others, 2002), is subdivided into the informal R_1, N_1, R_2, and N_2 magnetostratigraphic units. Of these units, only flows of the N_1 are exposed in the quadrangle in the canyons of Big Meadow, Little Bear, and Potlatch creeks. The Wanapum Basalt is a series of flows that erupted between 15.6 Ma and 14.5 Ma (Swanson and others, 1979a; Tolan and others, 1989). The only Wanapum Basalt unit in the quadrangle is the Priest Rapids Member, which forms most of the upland surface. Saddle Mountains Basalt, consisting of flows that erupted between 14.5 Ma and 6.0 Ma (Swanson and others, 1979a; Tolan and others, 1989), is limited to one unit, the basalt of Lewiston Orchards (Weissenfels Ridge Member). This unit is exposed only in one area at the southwestern edge of the quadrangle.

Saddle Mountains Basalt

Twl — **Basalt of Lewiston Orchards, Weissenfels Ridge Member (Miocene)**—Medium- to coarse-grained basalt with phenocrysts of plagioclase and olivine in an intergranular groundmass with minor glass (Hooper and others, 1985). Remanent magnetic polarity is normal (Camp, 1976; Swanson and others, 1979b). Poorly exposed in the southwest edge of the quadrangle. Two samples from one outcrop have chemistry (Table 1) similar to the basalt of Lewiston Orchards reported by Swanson and others (1979b).

Wanapum Basalt

Tpr — **Priest Rapids Member (Miocene)**—Medium- to coarse-grained basalt with phenocrysts of plagioclase and olivine in a groundmass of pyroxene, illmenite blades, and minor devitrified glass. In places, phenocrysts of plagioclase as large as 4 mm are common. The flows have reverse magnetic polarity (Wright and others, 1973; Swanson and others, 1979b). Five sites cored for paleomagnetic analysis have reverse magnetic polarity. The member consists of two to four flows or flow units with a total thickness of about 250 feet and is well exposed in numerous quarries throughout the quadrangle. However, contacts between individual flow units and flows are rarely exposed. Samples from eleven localities analyzed for whole rock chemistry (Table 1) are the Lolo chemical type of Wright and others (1973).

Hyaloclastites are locally interbedded with the Priest Rapids Basalt. They consist of massive to crudely layered, poorly sorted, granule to pebble breccia containing basalt, obsidian, and scoria clasts in an altered palagonitic glass matrix. Most units are crudely bedded, 0.5-1.5 feet thick, and are in places graded. Bush and others (1995b) interpreted these deposits to be near-vent breccias primarily because of the near proximity of chemically similar dikes. Later work determined the dikes extend across the hyaloclastites from overlying and underlying Priest Rapids flows. These deposits are now interpreted to have formed by local explosive events as dammed streams released water across the lava flows or as flows entered recently formed lakes. This mechanism for the formation of similar hyaloclastites has been described for the Priest Rapids Member in the lower Columbia River Gorge (Tolan and Beeson, 1984). The hyaloclastites are most common along Little Bear Creek southeast of Troy (see symbols on map) where exposures 10-20 feet thick occur between two Priest Rapids flows or flow units; the deposits can be traced laterally for over 5 miles. Smaller deposits are common along the Priest Rapids-basement rock contact at several localities in the quadrangle.

Grande Ronde Basalt

Tgn1 — **Grande Ronde N_1 magnetostratigraphic unit (Miocene)**—Dense, dark gray, fine- to very fine-grained basalt of Grande Ronde chemical type (Wright and others, 1973; Swanson and others, 1979a). Good exposures occur near Troy in Little Bear Creek canyon. The two uppermost flows were analyzed for paleomagnetic directions; both have normal polarity. The lower contact is exposed south of the quadrangle in the southern reaches of Middle Potlatch Creek. The unit is approximately 600 to 700 feet thick.

POTLATCH VOLCANICS

Onaway Member

The Onaway Member was originally named for exposures near Onaway and Potlatch in northern Latah County and was considered part of the Columbia River Basalt Group (Camp, 1981). Bush and others (1995a) agreed with Camp. $^{40}Ar/^{39}Ar$ and K-Ar dates, however, show a late Oligocene age for these rocks (Kauffman and others, 2003). Compared chemically to most Columbia River basalt flows, the Onaway Member is generally lower in SiO_2 and higher in Al_2O_3, TiO_2, Na_2O, and P_2O_5; trace elements also show distinctive differences from most Columbia River basalts, having generally low Cr and high Ba, Sr, Zr, Nb, and Ce (Table 1). On a total alkali-silica diagram, these rocks plot in the trachybasalt and trachyandesite fields compared to the basalt, basaltic andesite, and andesite fields of Columbia River basalts (Kauffman and others, 2003; Kauffman and others, 2006). During our mapping, we found the Onaway (Sample T444) to be overlain by Grande Ronde Basalt along Little Bear Creek just east of Troy. Near Potlatch, the Onaway Member is associated with trachytic rocks of similar age, and the name Potlatch Volcanics has been suggested for this Oligocene sequence (Kauffman and others, 2006).

Ton — **Onaway Member (Oligocene)**—Dark gray to black, fine-grained, sparsely to commonly plagioclase-phyric basalt. Phenocryst content ranges from 0 to 20 percent plagioclase laths that are typically 1 cm or less in length, but uncommonly reach 3 cm. Other minerals include opaque oxides, olivine, and clinopyroxene. Unit typically has brown weathering rinds and locally weathers to gray or purplish gray clay, commonly with shades of yellow to white. Outcrops have normal polarity, as measured in the field. In Troy, the unit is extensively weathered and has been mined commercially for clay. Water well data for the community of Troy indicate the Onaway Member is at least 500 feet thick.

INTRUSIVE ROCKS

Tpa — **Porphyritic andesite dike (Eocene?)**—Gray andesite with phenocrysts of biotite, amphibole, and plagioclase. Although chemically an andesite, the rock plots near the dacite field on a total alkali versus silica diagram (sample T7, Lewis and Frost, 2005). One small outcrop was seen in the Dutch Flat area near the northern border of the quadrangle. Its age and relationship to other rock units are unclear, but it is probably a dike. Similar andesites crop out in the bottom of Dry Creek, 4 miles east of Troy, as dikes crosscutting granodiorite.

Kbgd — **Biotite granodiorite (Cretaceous)**—Medium- to fine-grained, massive to moderately foliated, equigranular to porphyritic biotite granodiorite and granite.

Khgd — **Hornblende granodiorite (Cretaceous?)**—Medium-grained, massive to weakly foliated and weakly lineated, equigranular hornblende granodiorite and minor pyroxene-quartz-plagioclase rock (granofels?). The granodiorite is unusual in that it lacks biotite. The granofels has an equant texture with numerous 120-degree grain intersections (i.e., crystalloblastic texture) yet has the composition of pyroxene tonalite. Unit may represent granodiorite that has intruded and partially assimilated calc-silicate country rocks. Alternatively, the granodiorite magma may have brought granulite-facies basement rocks (granofels) to higher crustal levels. Chemical data for sample T50 (SE¼, sec. 8, T. 39 N., R. 4 W.) are given in Lewis and Frost (2005).

Kog — **Biotite-bearing orthogneiss (Cretaceous)**—Strongly foliated, medium-grained biotite-bearing orthogneiss. Predominantly tonalite in composition but may include granodiorite in the southernmost exposures along Middle Potlatch Creek. Mode of sample from the NW¼, sec. 34, T. 39 N., R. 4 W., is 20 percent quartz, 65 percent plagioclase, and 15 percent biotite. Anderson (1991) reports a metamorphic (crystalloblastic) fabric with approximately 45 percent andesine (An_{32}), 25 percent biotite, 25 percent quartz, and 5 percent almandine garnet.

METAMORPHIC ROCKS

Syringa Metamorphic Sequence

Amphibolite-facies muscovite-biotite schist, feldspar-poor quartzite, and calc-silicate rocks underlie the western and southern parts of the quadrangle. The Syringa metamorphic sequence is characterized by feldspar-poor quartzite (typically 3 percent or less feldspar) and contrasts with Belt Supergroup quartzite that typically contains 15-25 percent feldspar. Preliminary U-Pb dating of detrital zircons from Syringa quartzite at Mason Butte, 18 miles east of the quadrangle, suggests this quartzite may be as young as 680 Ma and thus postdate the Belt Supergroup (Peter Oswald and Jeff Vervoort, written commun., 2005).

Zss — **Schist and gneiss of the Syringa metamorphic sequence (Neoproterozoic)**—Poorly exposed, medium- to coarse-grained plagioclase-biotite-quartz schist, biotite gneiss, micaceous quartzite, and calc-silicate rocks. Common throughout are thin intervals of quartzite similar to *Zqs* and calc-silicate rocks similar to *Zcs*.

Zcs — **Calc-silicate rocks of the Syringa metamorphic sequence (Neoproterozoic)**—Varied diopside-, actinolite-, hornblende-, garnet- and scapolite-bearing granofels, gneiss, and quartzite.

Zqs — **Quartzite of the Syringa metamorphic sequence (Neoproterozoic)**—Coarsely recrystallized quartzite, lesser amounts of biotite schist, and minor calc-silicate rocks. Compositional layering on the scale of decimeters is defined by thin layers of schist alternating with massive quartzite. Quartzite characteristically very pure and coarse grained. Resembles vein quartz except typically has large mica flakes well aligned between tabular quartz grains. Commonly associated with *Zcs*.

Metamorphosed Belt Supergroup(?)

Quartzite and calc-silicate rocks in the northwest part of the quadrangle are tentatively assigned to the Belt Supergroup. These rocks contrast with those of the Syringa metamorphic sequence in that they contain significant amounts of feldspar.

Yqcw — **Quartzite and calc-silicate gneiss of the Wallace (?) Formation (Mesoproterozoic)**—Millimeter- to centimeter-scale layered calc-silicate quartzite and biotite-feldspar quartz gneiss. Contains quartz and plagioclase and varied amounts of diopside and hornblende. Poorly exposed. Unit may have been derived from calcareous quartzite of the middle member of the Wallace Formation of the Belt Supergroup that is widely exposed north of the area (Lewis and others, 2000).

ACKNOWLEDGMENTS

The authors would like to thank Steve Gill for field checking well locations. John Kauffman and Dean Garwood reviewed the map and provided helpful comments and suggestions.

SYMBOLS

Contact, approximately located.

Fold axis, approximately located.

Monocline, anticlinal flexure; shorter arrow on steeper limb.

Anticline.

77 Strike and dip of foliation.

20 Estimated strike and dip of basalt flows determined from regional trends.

TR16 Sample location and number.

W33 Water well location and number.

Outcrop of hyaloclastite.

Table 2. Located wells for the Troy quadrangle.

Well number	Owner's name	Elevation (feet)	Total depth (feet)	Static water level (feet)	Depth to water-bearing interval(s) (feet)	Pump test (gallons per minute)
W1	Erik Stauber	2,475	80	37	71	45
W2	Garry Esser	2,530	53	19	47	25
W3	City of Troy	2,510	515	60	58; 118; 493	170
W4	Wayne Gash	2,620	201	60	180	11
W5	City of Troy	2,665	250	48	63; 207	150
W6	City of Troy	2,730	400	62	150; 265	25
W7	Ludwig Winlinget	2,715	107	35	87	18
W8	Shirley Johnson	2,630	260	160	---	40
W9	Jerry Johnston	2,710	46	5	35	30
W10	Phil Wilder	2,630	204	95	184	12
W11	Alford Boggs	2,640	237	207	---	20
W12	Charles Whiteley	2,730	230	68	211	17
W13	Ulf Stauber	2,700	303	250	---	10
W14	Brent Bradberry	2,960	404	140	93	1
W15	Kola Olson	2,785	303	104	145	1
W16	Karl Stosveck	2,580	79	10	39	10
W17	City of Troy	2,545	553	170	362	6
W18	Ted Begorine	2,615	109	60	98	40
W19	C.E. Bud Johnson	2,550	60	---	36	7
W20	LeRoy Carlson	2,705	115	42	96	8
W21	Andy Schumacker	2,680	217	37	205	25
W22	Tari Kirk	2,700	140	37	110; 130	60
W23	Bart Schumacker	2,660	162	95	160	20
W24	Doug Hays	2,630	143	19	39; 106; 124	75
W25	Burt Nelson	2,675	180	---	158	30
W26	Lyle Jensen	2,610	63	6	45	12
W27	Orville Fredrickson	2,650	225	123	150	20
W28	Ray Jensen	2,520	90	---	74	7
W29	North Idaho Crushing	2,585	145	11	42; 70; 112	30
W30	Mark Jensen	2,525	225	70	205	35
W31	Ray Jensen	2,520	175	8	152	12
W32	Tami Huff	2,590	245	110	210	7
W33	Jack Driscoll	2,620	259	125	110; 256	15

Table 1. Major oxide and trace element chemistry of basalt samples collected in the Troy quadrangle.

Sample number	Unit name	Map unit	Major elements in weight percent: SiO_2	Al_2O_3	TiO_2	FeO*	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Trace elements in parts per million: Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
T2	Onaway	Ton	48.38	16.78	3.689	11.71	0.166	8.10	4.96	1.76	3.65	0.795	18	20	17	189	354	26	660	303	30	60.9	24	15	122	3	40	71	5
T6	Onaway	Ton	50.57	16.47	2.887	11.83	0.193	6.50	4.11	2.38	3.98	1.089	0	0	16	156	519	37	498	374	41	68.2	25	0	157	3	45	103	5
T8	Onaway	Ton	48.54	16.57	3.579	11.28	0.167	8.63	5.51	1.64	3.44	0.643	16	33	21	238	340	23	750	273	29	47.6	23	8	116	3	34	81	4
T444	Onaway	Ton	49.83	17.13	3.144	11.52	0.162	6.89	3.51	2.34	4.41	1.050	0	9	14	179	512	35	542	388	43	62.9	27	17	149	1	44	110	3
VC78-131	Onaway	Ton	48.41	16.14	3.830	13.11	0.170	7.48	4.63	1.83	3.59	0.610																	
VC78-422	Onaway	Ton	52.50	17.44	4.100	12.41	0.100	7.96	1.13	0.37	2.70	1.090																	
VC79-702	Onaway	Ton	48.64	16.82	3.480	12.15	0.170	8.12	5.09	1.58	3.20	0.550																	
T4	Grande Ronde	Tgn1	55.20	14.18	1.875	11.11	0.197	8.07	4.33	1.61	3.09	0.327	2	25	40	344	538	32	323	157	37	12.9	22	29	114	6	24	52	5
T5	Grande Ronde	Tgn1	54.99	14.52	1.932	10.75	0.222	8.26	4.40	1.31	3.29	0.332	6	22	36	372	588	29	333	159	37	12.7	23	31	120	5	23	44	2
T16	Grande Ronde	Tgn1	54.68	14.00	1.878	11.95	0.199	7.96	4.34	1.30	3.36	0.331	3	22	41	359	513	30	320	159	37	11.2	24	23	121	8	11	57	5
T27	Grande Ronde	Tgn1	56.66	13.94	2.426	10.23	0.191	7.21	3.38	2.19	3.31	0.470	4	10	37	359	913	50	341	192	43	14.1	21	19	145	8	28	55	5
T61	Grande Ronde	Tgn1	56.23	13.69	2.393	11.48	0.195	7.06	3.39	1.93	3.19	0.450	3	10	35	363	720	49	323	186	40	16.0	23	18	131	11	16	60	7
VC78-423	Grande Ronde	Tgn1	53.97	14.70	1.860	12.04	0.210	8.17	4.42	1.56	2.57	0.300																	
VC79-051	Grande Ronde	Tgn1	53.97	14.93	1.900	12.08	0.220	7.97	4.17	1.59	2.64	0.330																	
T1	Priest Rapids	Tpr	50.37	13.73	3.244	13.07	0.219	9.28	5.37	1.15	2.76	0.805	34	97	38	362	483	26	293	181	46	18.5	21	29	141	3	28	72	3
T3	Priest Rapids	Tpr	50.21	13.58	3.265	13.50	0.222	9.15	5.34	1.25	2.70	0.786	37	96	39	358	495	28	285	182	46	17.9	25	32	141	2	27	51	6
T10	Priest Rapids	Tpr	51.22	14.59	3.418	11.79	0.200	9.51	4.57	1.14	2.76	0.804	34	102	42	381	580	26	305	192	49	19.5	21	36	156	4	33	60	4
T11	Priest Rapids	Tpr	50.27	13.60	3.244	13.43	0.220	9.21	5.32	1.20	2.72	0.795	40	103	38	369	502	27	288	181	45	17.6	22	35	136	4	26	53	5
T12	Priest Rapids	Tpr	50.05	13.40	3.224	13.91	0.240	9.11	5.38	1.22	2.69	0.780	33	93	39	352	480	28	279	180	45	17.4	24	33	142	1	33	49	4
T25	Priest Rapids	Tpr	50.06	13.38	3.225	13.89	0.231	9.02	5.34	1.18	2.89	0.783	31	89	38	361	487	29	284	183	47	16.6	20	30	140	5	19	71	4
T26	Priest Rapids	Tpr	50.43	13.40	3.353	13.53	0.232	9.18	5.00	1.23	2.83	0.815	34	88	39	377	506	29	288	187	48	17.0	20	37	154	7	22	52	4
T28	Priest Rapids	Tpr	50.10	13.81	3.109	13.26	0.214	9.20	5.68	1.12	2.76	0.737	41	98	42	353	462	24	289	173	45	16.0	19	32	139	2	26	42	2
T29	Priest Rapids	Tpr	50.51	13.42	3.316	13.62	0.216	9.15	4.82	1.18	2.96	0.811	32	94	41	366	494	27	288	186	48	16.3	23	35	143	5	32	66	3
T200	Priest Rapids	Tpr	51.22	13.76	3.188	12.74	0.226	9.03	5.20	1.24	2.62	0.781	33	91	47	367	494	29	279	180	46	18.7	22	37	131	4	18	56	7
TR2222	Priest Rapids	Tpr	50.02	13.13	3.474	14.23	0.243	9.12	4.91	1.34	2.69	0.843	22	98	33	396	500	28	278	189	49	18.5	19	32	145	6	25	70	6
T5SW	Priest Rapids ?	Tpr?	52.08	16.15	3.830	8.51	0.156	10.50	3.61	1.15	3.11	0.905	33	130	44	418	589	22	341	201	50	18.8	25	31	179	1	33	61	6
VC78-133	Priest Rapids	Tpr	49.83	14.20	3.060	14.06	0.230	9.12	5.34	1.07	2.23	0.670																	
VC78-421	Priest Rapids	Tpr	49.68	13.95	3.090	14.39	0.230	8.91	5.51	1.01	2.36	0.670																	
VC78-426	Priest Rapids	Tpr	50.46	14.44	3.270	13.01	0.200	9.48	4.61	1.15	2.48	0.700																	
VC78-427	Priest Rapids	Tpr	50.28	14.14	3.150	13.47	0.230	9.39	4.87	1.11	2.44	0.710																	
VC79-050	Priest Rapids	Tpr	49.63	14.48	3.120	13.83	0.230	9.24	5.08	1.05	2.47	0.670																	
T9A	Lewiston Orchards	Twl	48.82	15.56	2.232	11.33	0.183	10.92	7.70	0.37	2.37	0.512	86	291	40	277	415	4	243	157	37	20.2	24	45	102	2	14	45	3
T9B	Lewiston Orchards	Twl	49.90	15.34	2.259	10.68	0.178	11.17	6.97	0.48	2.48	0.528	78	286	40	277	372	7	254	163	38	20.6	20	48	110	4	23	60	2

* Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO.
** Analytical results of samples collected by V. Camp in 1978 used with permission (Camp, written commun., 2002).
All analyses performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

REFERENCES

Anderson, M.A., 1991, The geology and structural analysis of the Tomer Butte, Middle Potlatch Creek and Little Potlatch Creek area, Latah County, Idaho: University of Idaho M.S. thesis, 69 p.
Bond, J.G., 1962, Geology of the Clearwater embayment in Idaho: University of Washington Ph.D. dissertation, 193 p.
———, 1963, Geology of the Clearwater embayment: Idaho Bureau of Mines and Geology Pamphlet 128, 83 p.
Bush, J.H., D.L. Garwood, R.S. Lewis, G.N. Potter, and W.C. McClelland, 2001, Bedrock geologic map of the Green Knob quadrangle, Latah County, Idaho: Idaho Geological Survey Geologic Map 31, scale 1:24,000.
Bush, J.H., K.L. Othberg, and K.L. Priebe, 1995a, Onaway Member intracanyon Columbia River basalt flows, Latah County, Idaho: Geological Society of America Abstracts with Programs, v. 27, no. 4, p. 5.
———, 1995b, Priest Rapids vents near Troy, Joel, and Spring Valley Reservoir, Latah County, Idaho: Geological Society of America Abstracts with Programs, v. 27, no. 4, p. 5.
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.
———, 1999, Bedrock geologic map of the Stanford quadrangle, Latah County, Idaho: Idaho Geological Survey Technical Report 99-8, scale 1:24,000.
Camp, V.E., 1976, Petrochemical stratigraphy and structure of the Columbia River basalt, Lewiston basin area, Idaho-Washington: Washington State University Ph.D. dissertation, 201 p.
———, 1981, Geological studies of the Columbia Plateau: Part II, upper Miocene basalt distribution reflecting source location, tectonism, and drainage history in the Clearwater embayment, Idaho: Geological Society of America Bulletin, v. 92, p. 669-678.
Hooper, P.R., G.B. Binger, and K.R. Lees, 2002, Ages of Steens and Columbia River flood basalts and their relationship to extension-related calc-alkalic volcanism in eastern Oregon: Columbia Society Bulletin, v. 114, no. 1, p. 43-50.
Hooper, P.R., G.D. Webster, and V.E. Camp, 1985, Geologic map of the Clarkston 15-minute quadrangle, Washington and Idaho: Washington Division of Geology and Earth Resources, Geologic Map GM-31, 11 p., 1 plate, scale 1:48,000.
Kauffman, J.D., J.H. Bush, and R.S. Lewis, 2003, Newly identified Oligocene volcanics along the eastern margin of the Columbia Plateau, Latah and surrounding counties, Idaho: Geological Society of America Abstracts with Programs, v. 35, no. 6, p. 549.
———, 2006, Oligocene alkaline volcanic rocks along the eastern margin of the Columbia Plateau, northern Idaho: Idaho Geological Survey Technical Report 06-7, 9 p.
Lewis, R.S., R.F. Burmester, J.D. Kauffman, and T.P. Frost, 2000, Geologic map of the St. Maries 30' x 60' quadrangle, Idaho: Idaho Geologic Survey Geologic Map 28, scale 1:100,000.
Lewis, R.S., and T.P. Frost, 2005, Major oxide and trace element analyses for igneous and metamorphic rock samples from northern and central Idaho: Idaho Geological Survey Digital Analytical Data 2.
Rember, W.C., and E.H. Bennett, 1979, Geologic map of the Pullman quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map 15, scale 1:250,000.
Swanson, D.A., J.L. Anderson, R.D. Bentley, 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 Open-File Report 79-1363, scale 1:250,000.
Swanson, D.A., T.L. Wright, V.E. Camp, J.N. Gardner, R.T. Helz, S.M. Price, S.P. Reidel, 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. Geologic Survey Miscellaneous Geologic Investigations Series Map I-1139, scale 1:250,000.
Swanson, D.A., T.L. Wright, P.R. Hooper, and R.D. Bentley, 1979b, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.
Tolan, T.L., and M.H. Beeson, 1984, Intrcanyon flows of the Columbia River Basalt Group in the lower Columbia River Gorge and their relationship to the Troutdale Formation: Geological Society of America Bulletin, v. 95, p. 463-477.
Tolan, T.L., S.P. Reidel, M.H. Beeson, J.L Anderson, K.R. Fecht, and D.A. Swanson, 1989, Revisions to the estimates of the areal extent and volume of the Columbia River Basalt Group, *in* S.P. Reidel and P.R. Hooper, eds., Volcanism and Tectonism in the Columbia River Flood-Basalt Province: Geological Society of America Special Paper 239, p. 1-21.
Tullis, E.L., 1944, Contribution to the geology of Latah County, Idaho: Geological Society of America Bulletin, v. 55. no. 2, p. 131-163.
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.

Published and sold by the Idaho Geological Survey
University of Idaho, Moscow, Idaho 83844-3014