



INTRODUCTION

Miocene Columbia River Basalt Group cover Eocene and older igneous and metamorphic rocks in the Olsen Canyon quadrangle. Most of the quadrangle is located just east of the southward projection of the Lincoln metamorphic complex detachment zone (Stoffel and others, 1991). Traces of that structure are preserved in the northwest part of the map area. The basaltic and andesitic flows are quartz monzonite and dacite flows and flow breccias and the Latah Formation. The basalt units range from 1100 ft elevation in the deepest well to just above 2500 ft elevation. Despite the topographic relief, well-exposed, continuous sections are rare. Contacts between flows are rarely exposed; they can be approximately located in a zone between flows that typically consists of vesicular basalt and rubble. Top-of-flow vesicular zones are thicker than the pillow basalt that occurs at the base of many of the flows in the Olsen Canyon quadrangle. The vesicular and pillow zones commonly are several feet thick. Spacing of topographic contours can suggest the location of the contact zone; more closely spaced contours are typically present just above the base of a flow, more widely spaced contours in the vesicular and pillow zones. Contact zones also can be traced by vegetation, which is more abundant there because of available water.

Whole-rock geochemistry was used to identify basalt flow units and establish the basalt stratigraphy in the quadrangle. The two exposed basalt formations are Grande Ronde Basalt and Wanupum Basalt. Exposed units of Grande Ronde Basalt are magnetotectonic units R₂ and N₂; the only representative of the Wanupum Basalt is the Priest Rapids Member. These formations range in age from about 14.5 Ma to 14.5 Ma (Reidel and others, 1999). Within Grande Ronde R₂, S. P. Reidel (Wash. State Univ. - Tri-City College, oral comm., 2009) informally identified the Wapishilla Ridge and Grosz Creek units. Unit N₂ overlies R₂ and includes the Orley and Sentinel Bluffs units, also identified by Reidel. However, sampling was insufficient to draw contacts between individual flows in Grande Ronde R₂ and N₂. These units are in turn overlain by the Wanupum Basalt, Priest Rapids Member. Basalt chemical type: Geochemical analyses of basalts in the quadrangle and adjacent areas are listed in Table 1.

Andesitic flows, flow breccias, tuff, and minor intercalated sandstone, shale, and conglomerates are exposed in the Eocene. Values northeast of the Olsen Canyon quadrangle. Wagonner (1990) considered these various volcanic units correlative with the Sampoil Volcanics (Messie, 1967; Pearson and Orlowski, 1977) that are exposed northeast of the map area. The Reidel and others (1999) informally identified the Okanogan lobe dammed the Columbia River downstream of the quadrangle. Flood waters also shaped patches of loess, some of which are preserved on Bachelor Prairie in the southwest corner of the quadrangle. Sandy remnants of loess deposits of 2400 to 2500 ft and generally less than 40 ft thick, cover some of the basalt plateaus. Wagonner (1990) mapped two exposures of glacial till (unit Gg1) near the northern boundary of the quadrangle; those deposits are characterized by deep brown to yellow-brown soils and are believed to be pre-Late Wisconsinan in age.

During the Eocene, regional NW-SE-directed extension, discussed in Rhodes and others (1989), resulted in N20°W normal faults in the Spokane area and in the westward Olsen Canyon quadrangle (Derkey and Hamilton, 2002). The Latah fault near Spokane (Derkey and Hamilton, 2002) and the Four Mount Prairie fault (Derkey and Hamilton, 2007) illustrate this extensional tectonism. The Latah fault was active in the west during the Miocene. We suggest that these N20°-30°W-trending normal faults produced a series of horsts and grabens during the Eocene. The faults may have been reactivated in the Miocene in response to the weight of the accumulating basalt; the faults are subparallel to the margin of the Columbia Basin. Consequently, we agree with Kiver and Striding (1995) that the linear courses of Hawk, Indian, and Snook Creeks are structurally controlled. Pleistocene and Holocene faults along these drainages, with the exception in exposures in sec. 9, T28N R36E, adjacent to Hawk Creek. There, a linear feature has an approximately 10-ft offset with motion down to the west. We interpret the Hawk Creek fault as one of the N20°-30°W faults, but the fault is subparallel to the map area, including those with different orientations, offset of Miocene basalt flow contacts is in the order of 10 to 20 ft. The movement, however, was probably also due to small adjustments caused by the weight of the basalt.

Previous geologic mapping covering the Olsen Canyon quadrangle area was completed by Wagonner (1990). The principal sources for the Wagonner map were reconnaissance geologic maps by Hanson and others (1979) and Swanson and others (1979a).

DESCRIPTIONS OF MAP UNITS

Quaternary Unconsolidated Sedimentary Deposits

NONGLACIAL DEPOSITS

- Qa (Alluvium (Holocene))**—Silt, sand, and gravel deposits in present-day stream channels; consists of reworked glacial till and glacioestuarine deposits, local bedrock, and loess.
- Qaf (Alluvial fan deposits (Holocene))**—Gravel, sand, and silt deposited in fans that may have relatively steep drainage energy the lower gradient of large drainages; very poorly sorted, minimal soil development.
- Qc (Loess (Holocene and Pleistocene))**—Silt with minor amounts of clay; may also include small amounts of very fine sand and volcanic ash; loess is medium-brown, ranging from light tan to yellow-brown to dark red-orange-brown; unstratified, very fine sand and silt composed of angular quartz with small amounts of feldspar and mica; also occurs where thickness and extent are too small to be mapped as a separate unit. Contacts generally feather out and are approximately local. In the southwest part of the quadrangle, loess hills have been modified by the passage of Pleistocene glacial Lake Missoula floodwaters.
- Qnw (Mass-wasting deposits (Holocene and late Pleistocene))**—Boulders, cobbles, gravel, sand, and debris from landslides; includes lesser amounts of debris-flow and rockfall deposits; dominantly a mixture of basalt blocks, but with minor amounts of fine sediments. Mass-wasting deposits were modified or obscured by glacial flooding; some mass wasting is on-going. In the large mass-wasting area in northern part of quadrangle, our analysis of basalt sample OC170 (unit Mwp, Table 1) indicates that the basalt block slid as much as 200 ft downslope to its present location.

GLACIAL DEPOSITS

The following units represent multiple outburst floods from glacial Lake Missoula, lacustrine deposition in glacial Lake Columbia, and glacial advance. Where possible, a relative age sequence is used; however, the flood units are a composite of numerous events.

- Gf1 (Glacial flood deposits, dominantly sand (Pleistocene))**—Sand and gravels with sparse pebbles, cobbles, and shells; light brown, tan, or light yellow; sand is medium to coarse; sand grains subangular to subrounded; poorly to moderately well sorted; thin-bedded to massive; contains beds and lenses of gravel; includes some exposures of glacial-lake sediments too small to map separately. Most clasts are granitic and metamorphic detritus from sources to the east; speckling in some exposures is caused by the mixture of light and dark fragments.
- Gf2 (Glacial flood deposits, dominantly gravel (Pleistocene))**—Gravel, cobbles, boulders, granules, and sand; sparse beds and lenses of sand and silt; gray, yellowish gray, and light brown; poorly to moderately well sorted, thin-bedded to massive; locally composed of boulders and cobbles in a matrix of mostly pebbles and coarse sand; clast-supported in places. Deposits were draped across the pre-flood topography and modified by later flows. Most boulders and cobbles are of local lithologies and units found to the north and east.
- Gq (Glacioestuarine deposits of glacial Lake Columbia (Pleistocene))**—Silt and fine sand interbedded with clay and silt; predominantly quartz, feldspar, and mica grains; very light gray to pinkish tan and light-brown; commonly includes sparse to locally abundant basalt pebbles, cobbles, and boulders with angular to subangular bedrock cliffs; well-bedded, commonly laminated; as much as 300 ft thick in Hawk Creek and tributaries.
- Gp (Glacial lake/glacial flood deposits, undifferentiated (Pleistocene))**—Sand and silt; massive and thin-bedded lake deposits with irregularly distributed interbedded glacial flood sand and gravel; tan to gray; sparse finely laminated layers interbedded with dominantly massive or graded sand; conformably overlies unit Gqf1; inferred to have been deposited by floods of moderate magnitude into glacial Lake Columbia, approximately 200 ft thick.
- Gpl (Older glacial lake/glacial flood deposits, undifferentiated (Pleistocene))**—Sand and silt; fine-grained, massive and thin-bedded lake deposits with interbedded irregularly distributed glacial-flood sand and gravel; pebbles to boulder clasts and interbeds locally abundant; tan to gray; coarse layers commonly graded; some layers cross-laminated or cross-bedded, contorted (arch-and-swirl), or disrupted by flame structures; varying masses of the coarse layers; includes detritus from adjacent highlands. Most coarse layers were deposited by outburst flood waters flowing from the east into glacial Lake Columbia. A 20- to 30-ft-thick terrace-forming coarse gravel bed at the top of this unit (see 1 and 12, T27N R35E) contains north-dipping forest beds exposed along Lake Roosevelt; the forests are believed to be from a subsequent density current deposit that flowed down Hawk Creek and then northward up the Columbia River. Atwater (1986) concluded that glacioestuarine-outburst flood deposits in the Sampoil River valley are late Wisconsinan in age; Kiver and Striding (1992) and Kiver (1982) have suggested that some deposits are older.
- Til (Pleistocene)**—Pebbles, cobbles, and boulders in a matrix of clay and sand; unsorted and unstratified; deep red-brown to yellow-brown, well-developed B soil horizons; clasts rounded to subangular of various lithologies, and deeply weathered. Hanson and others (1979) believe that poorly preserved stratifiers on large till clasts and the well-developed B soil horizon suggest a pre-plate Wisconsinan age.

Tertiary Volcanic Rocks

COLUMBIA RIVER BASALT GROUP

Basalt unit contacts are poorly exposed and approximately located in a contact zone; as shown on the map, they may be as much as 30 ft above or below their actual position.

Wanupum Basalt

Mwp (Priest Rapids Member, basalt of Rosalia (middle Miocene))—Basalt; dark gray to black; fine-grained; dense; consisting of plagioclase, pyroxene, and olivine in a mostly glass matrix; typically appa to sparsely plagioclase and (or) olivine phenocrysts; varied thickness (in at least 400 ft) in the map area, but thinnest where it laps upon pre-Miocene highlands (quartz monzonite of Hawk Creek in this quadrangle); lies directly on pre-Miocene rocks, Latah Formation (in water well logs); Grande Ronde Basalt. The Rosalia Member is a basaltic type that has high titanium and lower magnesium and chromium contents than all other compositional types of the Wanupum Basalt (Swanson and others, 1979b) and erupted between 14.5 and 15.3 Ma; it has reversed magnetic polarity (Tolan and others, 1989).

Grande Ronde Basalt

N₂ and R₂ magnetotectonic units (middle Miocene)—Basalt; dark gray to dark greenish gray, fine-grained, consisting of pale green augite and plagioclase grains (10-40%) and plagioclase laths and sparse phenocrysts (10-30%) in a matrix of black to dark brown glass (50-70%) and opaque minerals; locally vesicular, with plagioclase laths tangential to vesicle boundaries; thickness varying due to irregular underlying topography, identified on the basis of chemical analyses; erupted between 15.6 and 16.5 Ma (Reidel and others, 1989).

Mwp₂ N₂ contains ophiolite and red amorphous secondary minerals filling some vesicles and is 300 to 400 ft thick. It has normal magnetic polarity. S. P. Reidel (Wash. State Univ. - Tri-City College, oral comm., 2008) informally identified the Sentinel Bluffs and Orley units in this map area from whole-rock chemistry analyses (Table 1), but the units are not shown separately on the map. Sample OC169 was mapped as in place, but is apparently a small block of Wanupum Basalt, Priest Rapids Member (unit Mwp).

Mwp₂ R₂ possesses some vesicles lined by botryoidal carbonate and red amorphous secondary minerals. The thickness exceeds 400 ft, and the unit has reversed polarity. S. P. Reidel (Wash. State Univ. - Tri-City College, oral comm., 2008) informally identified the Grosz Creek and Wapishilla Ridge units from whole rock chemistry analyses (Table 1), but the units are not shown separately on the map.

Tertiary Sedimentary Rocks

M (Latah Formation (middle Miocene))—Siltstone, claystone, and minor sandstone; finely laminated lacustrine and fluvial deposits; light gray to yellowish gray and light-tan, commonly weathers to brownish yellow with stains, spots, and seams of limonite; poorly indurated. Exposures in the map area occur in mass-wasting deposits (unit Qnw) and are also present in water wells. Log logs from the Olsen Canyon quadrangle show that in places this unit is interbedded with Grande Ronde Basalt; the thickest bed found between the N₂ and R₂ magnetotectonic units. Fossil plant assemblages indicate a Miocene age (Knowlton, 1926; Griggs, 1976).

Tertiary Igneous Rocks

Egmi (Quartz monzonite of Hawk Creek (Eocene))—Hornblende-biotite quartz monzonite; medium- to dark-gray, in places with greenish-grey, medium-grained, locally fine-grained, characterized by primary equigranular to subequal granitic (c. 1 mm) and clusters of grains, epidote veins as much as 2 mm wide, and biotite and hornblende occurring together at the interstices between quartz and feldspar. Most biotite is fresh, and most hornblende is chloritic; quartz is gray or clear; feldspar is white and anhedral. The unit contains blocks of fine-grained tuff. The only known volcanic rocks in the region are the Eocene Sampoil Volcanics. Therefore we suggest that the quartz monzonite of Hawk Creek is also volcanic. Our conclusion is also based on the similarity of the quartz monzonite of Hawk Creek to the Eocene Silver Point Quartz Monzonite described by Derkey and Hamilton (2007) and Derkey and others (2003) in quadrangles east of the Olsen Canyon quadrangle. Quartz monzonite of Hawk Creek is exposed only near the southern border of the quadrangle.

Dacite flows and flow breccias of the Sampoil Volcanics (Eocene)

Evd (Dacite flows and flow breccias of the Sampoil Volcanics (Eocene))—Flows and flow breccias, subordinate tuff and sedimentary rocks, and minor hypabyssal intrusive rocks (Atwater and Kierulff, 1984); abundant plagioclase phenocrysts, some hornblende, pyroxene, and biotite phenocrysts, and sparse quartz phenocrysts in a granular to glassy groundmass. This unit occurs only in the northeast part of the quadrangle.

Tectonic Unit

Ta (Tectonic breccia (Tertiary))—Breccia; heterogeneous mixture of volcanic and granitic rock fragments ranging in size from 1 mm to 1 m; weakly indurated, locally shattered, and locally faulted. The tectonic breccia marks the trace of the low-angle, east-dipping fault separating the mylonitically deformed rocks in the Lincoln metamorphic complex (lower plate) from the brittle deformed rocks in the upper plate (Wagonner, 1990).

GEOLOGIC SYMBOLS

- Contact—long dash where approximately located, short dash where inferred or mid-inferite.
- - - - - Fault, unknown offset—long dash where approximately located, short dash where concealed, queried where uncertain.
- U D High-angle dip-slip fault—Relative movement shown by U and D; long dash where approximately located, dotted where concealed, queried where uncertain.
- W Well—Numbers correspond to well numbers on cross sections.
- OC# Basalt geochemistry sample location—Numbers correspond to sample numbers in Table 1.

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Table 1. Geochemical analyses of basalt samples from the Olsen Canyon quadrangle. Analyses performed at the Washington State University GeoAnalytical Laboratory; instrumental precision is described in Johnson and others (1998). Values for oxides are given in percent; single elements in parts per million (ppm). * Total Fe expressed as FeO. S. P. Reidel (Wash. State Univ. - Tri-City College, oral comm., 2009) provided identification of flow units.

Sample no.	WANUPUM BASALT, PRIEST RAPIDS MEMBER (unit Mwp)														Latitude	Longitude														
	SiO ₂	TiO ₂	Al ₂ O ₃	FeO*	MgO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	Total	Ni	Cr	Sr			Y	Ba	Rb	Sr	Zr	Y	Nb	Co	Cu	Zn	Pb	La	Ce	Th
OC140	48.89	3.547	12.54	14.38	0.236	4.34	8.39	26.3	1.38	0.785	91.11	13	10	39	412	582	33	289	227	51	171	22	23	155	6	34	70	4	60	1
OC150	48.69	3.590	12.59	14.46	0.236	4.23	8.41	26.5	1.19	0.770	97.01	14	12	39	415	680	30	294	224	50	165	22	24	156	3	35	64	4	60	0
OC162	48.07	3.677	12.47	14.26	0.236	4.35	8.67	26.8	1.21	0.771	96.16	11	10	39	428	599	29	298	228	49	167	21	23	157	3	34	67	5	59	1
OC163	48.77	3.624	12.60	14.38	0.237	4.32	8.41	25.2	1.21	0.771	97.11	11	39	428	599	29	298	228	49	167	21	23	157	3	34	67	5	59	1	
OC164	49.24	3.664	12.57	14.60	0.244	4.22	8.41	24.5	1.25	0.770	97.57	14	10	39	420	680	30	299	227	49	162	20	23	156	3	33	70	4	61	1
OC169	48.94	3.588	12.56	14.61	0.237	4.24	8.37	25.6	1.20	0.773	112	11	38	419	583	31	294	225	49	159	22	23	154	5	36	66	5	59	2	
OC170	48.51	3.583	12.49	14.61	0.238	4.17	8.51	25.7	1.14	0.775	96.66	13	39	421	595	31	299	224	49	162	22	24	155	6	35	66	5	62	1	

Sample no.	GRANDE RONDE BASALT, SENTINEL BLUFFS AND ORLEY UNITS, N ₂ MAGNETOTECTONIC UNIT (unit Mgr ₂)														Latitude	Longitude														
	SiO ₂	TiO ₂	Al ₂ O ₃	FeO*	MgO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	Total	Ni	Cr	Sr			Y	Ba	Rb	Sr	Zr	Y	Nb	Co	Cu	Zn	Pb	La	Ce	Th
OC137	51.03	1.979	13.58	11.81	0.214	4.44	8.68	27.6	0.96	0.753	96.33	8	27	37	340	525	25	322	250	35	102	19	34	116	7	20	34	7	23	1
OC138	52.75	1.866	13.90	11.27	0.205	4.85	8.67	28.8	1.02	0.758	97.57	11	40	397	485	26	320	258	33	97	19	34	114	8	20	41	8	23	1	
OC139	52.21	1.826	14.07	11.15	0.197	4.82	8.87	28.3	1.03	0.756	97.30	11	40	397	485	26	320	258	33	99	20	31	117	6	22	39	8	23	1	
OC141	51.88	1.989	13.47	10.93	0.212	4.87	8.57	28.1	1.19	0.791	97.35	9	25	338	486	26	307	155	33	96	19	31	117	6	22	39	8	23	1	
OC142	52.55	1.821	13.80	11.31	0.202	4.82	8.55	28.2	1.14	0.730	97.35	11	40	366	508	28	309	158	33	94	20	32	117	6	22	43	8	24	0	
OC152	53.68	1.870	14.02	11.32	0.201	3.87	7.72	28.3	1.36	0.483	97.16	13	34	335	688	35	325	171	36	97	20	32	117	7	28	48	8	26	0	
OC174	52.30	2.002	13.56	11.86	0.207	4.37	8.36	26.9	1.10	0.620	96.80	9	34	366	508	28	307	155	33	94	19	30	117	6	22	38	8	24	0	
OC175	53.21	1.857	13.94	11.26	0.212	4.44	8.69	28.5	1.19	0.730	98.00	10	34	366	508	28	309	158	33	109	20	31	118	5	23	47	8	26	0	
OC177	53.08	1.863	14.08	11.27	0.191	4.48	8.69	27.8	1.07	0.631	97.53	11	39	341	572	26	321	162	34	97	19	3								