WASHINGTON STATE DEPARTMENT OF
Natural Resources
Jennifer M. Belcher - Commissioner of Public Lands

Produced in cooperation with the U.S. Geological Survey
National Cooperative Geologic Mapping Program
Agreement Number 98HQAG2062

WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
Raymond Lasmanis, State Geologist

OPEN FILE REPORT 99-6
PRELIMINARY GEOLOGIC MAPS OF THE
SPOKANE NE AND SE 7.5-MINUTE QUADRANGLES,
SPOKANE COUNTY, WASHINGTON
PLATE 2

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1946 and planetable surveys 1950. Revised from aerial photographs taken 1972. Field checked 1973

Projection and 10,000-foot grid ticks: Washington coordinate system, north zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American Datum

UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface

Secondary highway, hard surface — Unimproved road

Interstate Route — U. S. Route — State Route

Preliminary Geologic Map of the Spokane SE 7.5-Minute Quadrangle, Spokane County, Washington

by

Robert E. Derkey[1], Michael M. Hamilton[1], Dale F. Stradling[2], (Department of Geography and Anthropology), and Eugene P. Kiver[2] (Department of Geology)

[1] Washington Division of Geology and Earth Resources
904 W. Riverside, Room 209; Spokane, WA 99201-1011

[2] Eastern Washington University
Cheney, WA 99004

INTRODUCTION

This map is part of a series of 1:24,000-scale geologic maps for Spokane County in and around the city of Spokane. Geologic maps of the Mead (Derkey, 1997) and Dartford (Derkey and others, 1998) 7.5-minute quadrangles were completed earlier in response to the recent surge in growth in the northern part of the county. The Spokane NE and SE quadrangles are located north-south through the eastern part of the city.

DESCRIPTION OF MAP UNITS, SPOKANE SE QUADRANGLE

Quaternary Sediments

Post-Glacial Deposits

Qal **Alluvium (Holocene)**--Silt, sand, and gravel deposits in the present-day stream channels and flood plains of Chester Creek, Hangman Creek, California Creek, and Rock Creek. Consists of reworked glacial-flood deposits (units Qfcg, Qfg, and Qfs), loess, and volcanic ash.

Qaf **Alluvial fan deposits (Holocene)**--Alluvium consisting of gravel, sand, and silt in fan-shaped deposits that form where relatively steep drainages enter Hangman, California, and Chester Creeks. Deposits are very poorly sorted and have minimal soil development.

Glacial-Flood Deposits

Glaciers dammed the Clark Fork River near the Montana-Idaho state line. Glacial Lake Missoula formed behind the ice dam, and when it failed, large volumes of water raced through the area carrying tremendous amounts of sediment into the Columbia Basin and downstream along the Columbia River to the Pacific Ocean. Ice-dam buildup and failure was repeated many times during the Pleistocene. In the Spokane area, deep channels of the ancestral Spokane River were filled with very coarse-grained, poorly sorted gravel referred to here as flood-channel gravel (unit Qfcg). The coarse gravel of unit Qfcg is host to the Spokane Valley-Rathdrum Prairie aquifer. Outside of the deep channels, flood-gravel deposits (unit Qfg) are thinner and commonly not as coarse grained. A third type of flood deposit is sand (unit Qfs) deposited when floodwaters flowed into an existing glacial lake. The sand unit (Qfs) is widespread and appears to be the uppermost or highest of the extensive flood deposits. Following deposition of this sand, flood events appear to have been smaller and confined to lower elevations in the Spokane Valley. The units are distinguished by the predominant clast size. Contacts between the three units Qfcg, Qfg, and Qfs are mostly indistinct.

Qfs **Glacial-flood deposits, predominantly sand (Pleistocene)**--Gray, yellowish gray, or light brown, poorly to moderately well-sorted, medium-bedded to massive, subangular to subrounded, medium-fine to coarse sand with sparse pebbles, cobbles, and boulders. Some exposures appear speckled because of the mixture of light and dark fragments. Clasts consist mainly of granitic and metamorphic detritus from sources to the east. The unit locally contains beds and lenses of gravel and its thickness is variable due to the irregular underlying topography.

Qfg **Glacial-flood deposits, predominantly gravel (Pleistocene)**--Gray, yellowish gray, or light brown, poorly to moderately sorted, both matrix- and clast-supported, thick-bedded to massive mixture of boulders, cobbles, pebbles, granules, and coarse sand; locally contains beds and lenses of sand and silt. Boulders consist of granitic and metamorphic rocks similar to those found in local outcrops and to the east in Idaho. Compared to flood-channel gravel (Qfcg), flood-gravel deposits (unit Qfg) generally contain more pebbles, granules, and coarse sand and fewer boulders and cobbles. Occurrences of the flood gravel in the Spokane SE quadrangle are in the northeast corner and in Hangman Creek valley.

Qglf **Glacial-lake/glacial-flood deposits, undifferentiated (Pleistocene)**--Tan to gray, fine-grained sand, silt, and clay of massive and thin-bedded lake deposits with interbedded and irregularly distributed glacial-flood sediments of sand and gravel, including locally derived detritus from the adjacent highlands. In the Spokane SE quadrangle, deposits are limited to the Hangman and California Creek valleys.

Eolian Deposits

Ql **Loess (Holocene to Pleistocene)**--Light to medium brown, unstratified silt and clay. Locally includes small amounts of fine sand and volcanic ash. Clay is mostly montmorillonite and illite in a ratio of 3:1; it also contains minor kaolinite (Hosterman, 1969). Sand and silt are composed of angular quartz with lesser amounts of feldspar and mica. Loess is thickest where glacial floods have not eroded it. In the Spokane SE quadrangle, unit Ql can be several tens of feet thick.

Tertiary Volcanic and Sedimentary Rocks

Columbia River Basalt Group

Subaerial lava flows of the Columbia River Basalt Group (CRBG) spread widely over the Columbia Plateau. Two CRBG units have been identified in the Spokane SE quadrangle: (1) Grande Ronde Basalt, magnetostratigraphic unit R2 and (2) Wanapum Basalt, Priest Rapids Member, Rosalia chemical type (Derkey and others, 1998; Tolan and others, 1989). The Priest Rapids Member is the uppermost Columbia River Basalt Group unit identified in the Spokane area. Whole-rock chemical analyses were performed by the Geoanalytical Laboratory at Washington State University (see Table 1). Peter Hooper (Wash. State Univ. Geology Dept., written commun., 1998-99) identified the chemical affinity of the samples, which was the basis for assigning the stratigraphy to basalt units.

Mv_{wp} **Wanapum Basalt, Priest Rapids Member (middle Miocene)**--Dark gray to black, fine-grained, dense basalt containing plagioclase (20-30%), pyroxene (10-20%), and olivine (1-2%) in a mostly glass matrix (40-60%). Although it is less than 100 ft thick at the north end of the quadrangle, the difference in elevation between the lowermost and uppermost contacts of the unit in the southern two-thirds of the quadrangle is almost 300 ft. This may be due to irregularities IN the underlying surface. The Priest Rapids Member lies directly on pre-Miocene rocks or Latah Formation in the northern part of the quadrangle and on Grande Ronde Basalt or locally on Latah Formation in the southern part of the quadrangle.

The Priest Rapids Member in the Spokane area is of the Rosalia chemical type, which has a higher titanium and lower magnesium and chromium content than other flows of Wanapum Basalt (Steve Reidel, Pacific Northwest National Laboratory, oral commun., 1998). The Priest Rapids Member is between 15.3 and 14.5 m.y. old and has reversed magnetic polarity (Reidel and others, 1989).

Mv_{gR2} **Grande Ronde Basalt, magnetostratigraphic unit R2 (middle Miocene)**--Dark gray to dark greenish gray, fine-grained basalt containing plagioclase (10-30%) as laths and sparse phenocrysts and pale green augite and pigeonite grains (10-40%) in a matrix of black to dark brown glass (30-70%) and opaque minerals. The rock is locally vesicular with plagioclase laths tangential to vesicle boundaries. Some vesicles contain botryoidal carbonate and red amorphous secondary minerals. Due to the irregular underlying topography and the probable invasive nature of at least some of the flows of Grande Ronde Basalt in the quadrangle, the thickness is unknown. The basal contact is not exposed anywhere in the quadrangle.

Chemical analyses were used to identify the Grande Ronde Basalt as magnetostratigraphic unit R2 rather than N2 of previous workers (Swanson and others, 1979). N2 basalt generally contains more than 4.5% MgO and less than 2% TiO2. Basalt samples from the Spokane NE and SE quadrangles consistently contain less than 3.5% MgO and fairly consistently contain greater than 2.3% TiO2. Such a chemical composition better fits the chemical signature of R2 basalt (Steve Reidel, Pacific Northwest National Laboratory, oral commun., 1998). The Grande Ronde Basalt is between 15.6 and 16.5 m.y. old (Reidel and others, 1989).

Miocene Sedimentary Rocks

The oldest CRBG flows did not reach the Spokane area; however, they did block the ancestral drainages and large lake(s) formed. The pre-Miocene rocks were subjected to extensive weathering. Clay, silt, and sand from the adjacent highlands were deposited in the lake(s). These sediments are known as the Latah Formation. The Grande Ronde Basalt flows that reached the Spokane area often burrowed or sank into the poorly consolidated Latah sediments. They are called invasive flows. When preserved, Latah Formation lakebeds are baked at the contact where they overlie Grande Ronde Basalt in the Spokane area (Robinson, 1991; Derkey and others, 1998).

Mc_l **Latah Formation (middle Miocene)**--Light gray to yellowish gray and light tan, poorly indurated, lacustrine and fluvial deposits of finely laminated siltstone, claystone, and minor sandstone. The unit commonly weathers brownish yellow with stains, spots, and seams of limonite. It unconformably overlies granitic basement in the Spokane SE quadrangle. Floral assemblages in the Latah Formation indicate a Miocene age (Knowlton, 1926; Griggs, 1976). The highest elevation of the Priest Rapids basalt/Latah Formation contact north of the Spokane SE quadrangle is about 2,290 ft. The thickness of the Latah Formation in the Spokane SE quadrangle could not be determined; however, because pre-Latah exposures are relatively closely spaced, there is little room for a deep basin containing a thick sequence of Latah sediments. The Latah is easily eroded and therefore, it commonly is blanketed with a cover of colluvial and residual soils and rockfall.

Pre-Miocene Rocks

Pre-Miocene rock units in the Spokane NE and SE quadrangles consist of a complex of metamorphosed, deformed, and foliated sedimentary rocks that were intruded by pre-, syn-, and post-kinematic igneous (predominantly granitic) rocks. The metamorphosed sedimentary rocks are mostly quartz-feldspar rich. Some have been metamorphosed to amphibolite-grade and are here mapped as paragneiss (unit pTmi). Other units (Ymsr, pTmis) are lower grade metamorphic rocks and are here referred to as metasedimentary rocks. Previous authors have placed these metamorphosed sedimentary rocks in the Precambrian Belt Supergroup (Griggs, 1973; Armstrong and others, 1987; Rehrig and others, 1987; Joseph, 1990); however, because they were not dated during this study, they are assigned a pre-Tertiary age only.

Igneous rocks in the two quadrangles appear to be multi-stage intrusives because within individual outcrops some igneous dikes are less deformed and foliated than others. They range from extensively foliated with development of augen to unfoliated, thus the pre-, syn-, and post-kinematic designation for the granitic rocks in the quadrangles. Rhodes and Hyndman (1984) noted similar characteristics for igneous rocks of the Spokane Dome. Most igneous rocks of the Spokane area are believed to be Cretaceous to Tertiary in age (Weis, 1968; Griggs, 1966, 1973; Joseph, 1990). The orthogneiss (unit pTog) south of the Spokane River was not dated for this study and so is assigned a pre-Tertiary age because it could not be tied directly to dated rocks in the area.

Pre-Miocene rock types of the Spokane SE quadrangle include gneiss, feldspathic quartzite, siltite, and a variety of granitic intrusions. Metamorphism and foliation in varying degrees and extent have affected much of the rock throughout the quadrangle, with the highest intensity in unit pTmi. Foliation has a fairly consistent south to southwest dip.

Igneous rocks, collectively mapped as unit Ki in the Spokane SE quadrangle, include fine- to coarse-grained granitic rocks, leucocratic granite/aplite, quartz-feldspar-muscovite pegmatites (anatectic), hornblende diorite, and hornblendite. Most of unit Ki in the quadrangle is medium- to coarse-grained granitic rock.

Previous workers mapped metasedimentary rocks, largely quartzo-feldspathic sandstone, siltite, and some quartzite occurring in the southern two-thirds of the quadrangle, as part of the Ravalli Group (unit Ymsr) of the Belt Supergroup (Griggs, 1966, 1973; Joseph, 1990). We use that designation for this map. The relationship of these metasedimentary rocks (unit Ymsr) to the metamorphosed sedimentary rocks (unit pTmi) exposed in the northern part of the quadrangle is not well understood.

Northwest-trending high-angle faults cut the orthogneiss (unit pTog) and paragneiss (unit pTmi). These structures are parallel to prominent linear features in the orthogneiss (unit pTog) in the Spokane NE quadrangle. The contact between units pTog and pTmi is low-angle and may be a thrust; exposures were insufficient to determine the nature of the contact.

Ki **Biotite-muscovite granite (Cretaceous)**--Light gray, locally with a light pink tinge; medium- to coarse-grained; includes fine-grained biotite-muscovite granite, hornblende-bearing diorite, and mafic dikes too small to map separately. Biotite-muscovite granite contains quartz (20-30%); K-feldspar and plagioclase (60-70%) in approximately equal amounts (proportions, however, are variable); euhedral to subhedral biotite (as much as 10%), locally forming monomineralic clusters or clustered with muscovite; muscovite (0-3%) present as single euhedral crystals or clustered with other muscovite; and accessory sphene and opaque minerals. Areas mapped as biotite-muscovite granite (unit Ki) may include considerable gneissic and schistose host rocks. Foliation and deformation sometimes obscure the distinction between igneous and host rocks. Scattered occurrences of hornblende diorite observed in the Spokane SE quadrangle and included in unit Ki are extensively weathered/altered and reduced to grus.

pTog **Quartz-feldspar-mica orthogneiss (pre-Tertiary)**--Light to medium gray, medium- to coarse-grained, weak to moderate foliation with compositional banding ranging in thickness from 0.1 in. to several inches. The unit is a complex of igneous intrusions with the older and larger granitic bodies cut by dikes and sills of leucocratic granite/aplite, pegmatite, and granitic rock. Consequently, the mineralogy is variable. Typically, the unit contains 10-20% quartz, 50-70% feldspar, and 5-20% biotite and muscovite. Where micaceous minerals are more abundant and the foliation more intense, the rock is a schist. Mylonite zones up to several inches wide are scattered throughout the unit. This unit differs from the structurally overlying unit pTmi by containing more feldspar and having weaker foliation.

pTmi **Quartz-feldspar-mica paragneiss with granitic bodies (pre-Tertiary)**--Light to medium gray, fine- to medium-grained with a local mylonitic/cataclastic fabric. Lighter gray colored rock occurs in areas rich in pegmatitic material and leucogranite. Typically the paragneiss contains 30-50% quartz (locally up to 80%), up to 40% feldspar, and up to 20% muscovite and biotite (schistose layers contain more than 50%). Sillimanite, clinozoisite(?), hornblende, chlorite, and garnet can be up to 10% of the rock. Compositional bands vary from 0.1 in. to several inches in width. The unit is pervasively intruded by pre-, syn-, and post-kinematic granitic rocks, emplaced commonly as sills along foliation and less commonly as dikes.

In the Spokane SE quadrangle, foliation and folding increase to the northeast. The northeast boundary of the unit is in possible fault contact with unit pTog, and the southwest boundary is a less well defined contact with unit Ymsr.

$pTmi_s$ **Sillimanite-biotite schist with subordinate graphite-andalusite schist and quartzite (pre-Tertiary)**-- Light to medium gray, fine- to medium-grained sillimanite-biotite schist; gray to dark gray, fine-grained graphite-andalusite schist; and light gray to white, fine- to medium-grained feldspathic quartzite. Described by Page (1942) from examination of underground workings of the Silver Hill tin and tungsten deposits. Color and composition can be quite variable due to additions of igneous material, including granite, leucogranite, aplite, and pegmatite intrusions, all of which have been subjected to varying degrees of deformation, foliation, and metamorphism. Quartz-feldspar-muscovite pegmatite dikes containing cassiterite mineralization were metamorphosed and contain andalusite and sillimanite. This unit differs from unit pTmi in that it contains graphite-andalusite schist, has more sillimanite, and contains tin- and tungsten-bearing pegmatite bodies. The contact with unit Ymsr is not well exposed; however, the contact was placed at a low angle because mineral exploration drilling of the Silver Hill tin deposits (unpublished property owner files) intercepted a different lithology at a shallow depth.

Yms_r **Ravalli Group (Precambrian Y)**-- White, light gray, or pale yellowish orange feldspathic quartzite, dark-gray feldspathic biotite vitreous quartzite, and gray-green siltite; fine- to medium-grained; thin- to medium-bedded with some massive sections. Feldspathic quartzite typically contains 30-70% quartz, 20-30% feldspar, and 1-5% biotite. Siltite contains more feldspar and less quartz. Schistose sections consist of foliated muscovite-rich layers that decrease in abundance to the southwest. Small granite (unit Ki) sills and dikes are scattered throughout, but are too small to include at this map scale.

EXPLANATION OF MAP SYMBOLS

Contact--Dashed where approximately located; short dashed where inferred or indefinite

Fault--Short dashed where inferred or indefinite; dotted where concealed

15 Strike and dip of foliation and plunge of lineation

242 + Water well location--Numbers correspond with well numbers on cross sections

561 • Basalt geochemistry sample location--Numbers correspond to sample numbers in appendix

Cartographic design and production by Keith G. Ikerd,
Washington Division of Geology and Earth Resources

Appendix: Geochemical analyses for units of the Columbia River Basalt Group in and near the Spokane NE and Spokane SE quadrangles

A total of 29 samples from the Spokane NE and SE quadrangles were analyzed by x-ray fluorescence methods and assigned to basalt units. Two samples from adjacent quadrangles are also included: 216SP from the Spangle quadrangle (SE1/4, sec. 11, T23N, R43E) about 1 mi south of the Spokane SE quadrangle and 222FR from the Freeman quadrangle (NW1/4 sec. 27, T24N, R44E) about 1.5 mi east of the Spokane SE quadrangle. Analyses were performed by the Geoanalytical Laboratory, Department of Geology, Washington State University, Pullman, WA 99164-2812. A description of analytical methods, precision, and accuracy is given in Johnson and others, (1998). Total Fe is reported as FeO. Letters at the end of sample nos. indicate the quadrangle of origin: NE, Spokane NE; SE, Spokane SE; FR, Freeman; SP, Spangle. Sample locations in the Spokane NE and SE quadrangles are shown on Plates 1 and 2 respectively. Peter Hooper (Wash. State Univ. Geology Dept., written commun., 1998-99) identified the samples. Sample results are separated into three groups: whole rock and normalized whole rock, major elements and trace elements for each of the two basalt types identified and for two samples for which basalt type could not be determined.

Whole-rock, major element analyses results (weight percent) of samples determined to be Grande Ronde Basalt, magnetostratigraphic unit R2

Sample	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Total
184NE	55.45	13.84	2.530	10.24	0.249	7.24	2.73	1.86	3.26	0.521	97.92
192SE	53.79	14.26	1.834	10.50	0.191	8.92	4.75	1.26	2.94	0.293	98.73
193SE	53.62	14.09	1.933	11.54	0.207	8.56	4.29	1.24	2.91	0.427	98.82
213SE	55.08	13.37	2.446	11.86	0.213	7.10	3.12	1.90	3.27	0.432	98.79
215SE	54.68	13.87	2.205	11.95	0.190	7.77	3.47	1.52	3.02	0.397	99.08
216SP	55.26	13.35	2.403	12.17	0.207	7.08	3.23	1.82	3.18	0.409	99.11
217NE	56.23	13.50	2.260	11.20	0.199	6.88	3.38	1.84	3.34	0.399	99.23
220SE	54.30	14.01	1.818	11.34	0.183	8.75	4.79	1.13	2.88	0.295	99.49
486NE	54.84	13.32	2.319	12.35	0.202	6.94	3.26	1.70	3.29	0.404	98.62
542SE	54.61	13.30	2.432	11.81	0.215	7.09	3.20	1.88	3.21	0.420	98.17

Whole-rock, major element analyses results (weight percent) of samples determined to be Wanapum Basalt, Priest Rapids Member, Rosalia chemical type

Sample	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Total
101NE	49.54	12.94	3.681	14.39	0.234	8.62	4.25	1.40	2.73	0.795	98.58
105NE	50.34	13.01	3.693	13.27	0.216	8.78	4.08	1.25	2.78	0.784	98.21
107NE	49.30	12.63	3.637	14.60	0.245	8.51	4.40	1.35	2.75	0.780	98.20
108NE	49.76	12.85	3.690	13.85	0.236	8.79	3.88	1.20	2.71	0.793	97.76
130NE	49.60	12.70	3.685	14.24	0.216	8.77	4.00	1.19	2.66	0.792	97.86
189SE	49.67	12.60	3.645	14.44	0.236	8.53	4.28	1.26	2.82	0.783	98.26
A190SE	50.58	12.90	3.693	13.71	0.232	8.75	4.09	1.24	2.83	0.796	98.82
191SE	49.05	12.75	3.681	14.53	0.276	8.58	4.15	1.41	2.69	0.798	97.91
194SE	49.53	12.57	3.635	14.86	0.242	8.47	4.31	1.37	2.71	0.786	98.49
219SE	50.07	12.77	3.646	14.60	0.271	8.68	4.00	1.25	2.67	0.787	98.74
221SE	50.56	12.79	3.670	14.44	0.228	8.62	4.35	1.18	2.77	0.784	99.39
222SE	50.61	13.12	3.790	13.61	0.221	8.82	4.38	1.18	2.73	0.782	99.25
538SE	49.49	12.65	3.645	14.67	0.239	8.49	4.27	1.29	2.70	0.790	98.24
540SE	49.02	13.02	3.622	14.76	0.251	8.65	4.11	1.26	2.60	0.750	98.05
543SE	49.81	13.10	3.620	13.93	0.239	8.71	4.00	1.27	2.69	0.775	98.15
561SE	48.39	12.61	3.651	15.34	0.257	8.79	4.11	1.25	2.67	0.778	97.85
567NE	49.18	12.66	3.603	15.03	0.246	8.50	4.40	1.31	2.69	0.777	98.40
568NE	49.45	12.69	3.611	14.57	0.244	8.51	4.44	1.29	2.77	0.775	98.35
596SE	49.69	12.68	3.623	15.55	0.280	8.57	4.01	1.22	2.73	0.816	99.17

Whole-rock, major element analyses results (weight percent) of samples of undetermined Columbia River Basalt Group affiliation

Sample	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Total
190SE	52.92	14.99	4.283	9.55	0.145	8.58	2.02	1.42	3.19	0.902	98.00
218SE	53.13	14.59	4.157	10.25	0.159	8.91	2.58	1.44	3.07	0.878	99.16

Normalized, whole-rock, major element analyses results (weight percent) of samples determined to be Grande Ronde Basalt, magnetostratigraphic unit R2

Sample	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5
184NE	56.63	14.13	2.584	10.46	0.254	7.39	2.79	1.90	3.33	0.532
192SE	54.48	14.44	1.858	10.63	0.193	9.03	4.81	1.28	2.98	0.297
193SE	54.26	14.26	1.956	11.68	0.209	8.66	4.34	1.25	2.94	0.432
213SE	55.75	13.53	2.476	12.01	0.216	7.19	3.16	1.92	3.31	0.437
215SE	55.19	14.00	2.226	12.07	0.192	7.84	3.50	1.53	3.05	0.401
216SE	55.76	13.47	2.425	12.28	0.209	7.14	3.26	1.84	3.21	0.413
217NE	56.67	13.61	2.278	11.29	0.201	6.93	3.41	1.85	3.37	0.402
220SE	54.58	14.08	1.827	11.39	0.184	8.79	4.81	1.14	2.89	0.297
486NE	55.61	13.51	2.351	12.52	0.205	7.04	3.31	1.72	3.34	0.410
542SE	55.63	13.55	2.477	12.03	0.219	7.22	3.26	1.92	3.27	0.428

Normalized, whole-rock, major elements analyses results (weight percent) of samples determined to be Wanapum Basalt, Priest Rapids Member, Rosalia chemical type

Sample	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5
101NE	50.25	13.13	3.73	14.60	0.237	8.74	4.31	1.42	2.77	0.81
105NE	51.26	13.25	3.76	13.52	0.220	8.94	4.15	1.27	2.83	0.80
107NE	50.20	12.86	3.70	14.87	0.249	8.67	4.48	1.37	2.80	0.79
108NE	50.90	13.14	3.77	14.16	0.241	8.99	3.97	1.23	2.77	0.81
130NE	50.69	12.98	3.77	14.56	0.221	8.96	4.09	1.22	2.72	0.81
189SE	50.55	12.82	3.71	14.69	0.240	8.68	4.36	1.28	2.87	0.80
A190SE	51.19	13.05	3.74	13.87	0.235	8.85	4.14	1.25	2.86	0.81
191SE	50.10	13.02	3.76	14.84	0.28	8.76	4.24	1.44	2.75	0.82
194SE	50.29	12.76	3.69	15.09	0.246	8.60	4.38	1.39	2.75	0.80
219SE	50.71	12.93	3.69	14.78	0.27	8.79	4.05	1.27	2.70	0.80
221SE	50.87	12.87	3.69	14.52	0.229	8.67	4.38	1.19	2.79	0.79
222SE	50.99	13.22	3.82	13.72	0.223	8.89	4.41	1.19	2.75	0.79
538SE	50.38	12.88	3.71	14.94	0.243	8.64	4.35	1.31	2.75	0.80
540SE	50.00	13.28	3.69	15.06	0.256	8.82	4.19	1.29	2.65	0.76
543SE	50.75	13.35	3.69	14.19	0.244	8.87	4.08	1.29	2.74	0.79
561SE	49.45	12.89	3.73	15.68	0.263	8.98	4.20	1.28	2.73	0.80
567NE	49.98	12.87	3.66	15.28	0.250	8.64	4.47	1.33	2.73	0.79
568NE	50.28	12.90	3.67	14.81	0.248	8.65	4.51	1.31	2.82	0.79
596SE	50.11	12.79	3.65	15.68	0.28	8.64	4.04	1.23	2.75	0.82

Normalized, whole-rock, major element analyses results (weight percent) of samples of undetermined Columbia River Basalt Group affiliation

Sample	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5
190SE	54.00	15.30	4.37	9.74	0.148	8.76	2.06	1.45	3.26	0.92
218SE	53.58	14.71	4.19	10.34	0.160	8.99	2.60	1.45	3.10	0.89

Trace element analyses results (ppm) of samples determined to be Grande Ronde Basalt, magnetostratigraphic unit R2

Sample	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
184NE	0	22	34	366	1102	42	367	186	40	14.1	25	7	140	7	15	53	7
192SE	7	59	38	329	441	29	313	152	33	10.7	22	28	111	2	30	50	5
193SE	0	50	32	280	503	31	320	165	37	12.0	21	22	120	5	20	49	7
213SE	0	19	30	371	710	46	334	184	39	15.1	20	5	135	2	27	55	7
215SE	15	40	35	425	601	39	331	175	36	14.2	22	37	123	6	25	35	5
216SE	0	22	28	345	656	44	326	181	38	15.2	23	6	134	10	26	50	5
217NE	0	18	36	311	731	50	326	186	38	15.9	22	9	128	10	28	52	8
220SE	8	56	38	324	460	26	308	151	32	11.6	22	27	106	9	9	51	4
486NE	0	19	30	334	680	46	329	185	39	14.9	21	6	130	9	24	66	6
542SE	0	18	25	356	665	45	322	181	39	13.9	26	6	135	8	29	70	5

Trace element analyses results (ppm) of samples determined to be Wanapum Basalt, Priest Rapids Member, Rosalia chemical type

Sample	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
101NE	4	31	40	454	525	32	295	213	52	19.8	23	19	156	5	21	78	5
105NE	8	38	34	464	527	27	297	207	50	18.9	25	19	151	8	31	71	8
107NE	6	33	36	451	501	32	289	209	50	19.0	22	13	155	5	36	65	6
108NE	13	39	36	450	551	26	304	211	50	19.1	25	16	160	4	26	81	7
130NE	3	32	32	441	601	28	304	213	51	19.0	25	12	155	5	35	63	7
189SE	2	30	37	444	482	30	291	211	50	18.5	28	12	156	4	24	71	8
A190SE	6	34	37	436	552	29	296	213	50	19.7	23	12	158	8	29	67	6
191SE	3	33	37	449	512	30	288	209	51	19.0	22	9	165	5	15	85	7
194SE	3	29	41	454	509	31	288	211	50	19.7	24	12	159	3	32	74	6
195NE	1	39	38	438	525	30	291	207	49	18.7	21	16	157	7	26	75	7
219SE	2	32	35	424	528	30	295	210	49	19.1	23	15	156	5	31	51	4
221SE	1	31	31	444	607	27	297	208	49	19.3	24	10	155	10	32	74	5
222SE	8	31	41	447	543	27	298	208	52	20.1	25	9	159	8	26	38	5
538SE	0	32	38	438	562	29	295	212	50	18.8	25	11	153	5	22	64	5
540SE	2	34	34	435	513	28	303	205	47	17.7	23	13	152	7	27	50	6
543SE	7	32	36	438	501	29	299	207	50	17.6	22	23	161	5	30	70	7
561SE	0	35	41	445	530	30	295	207	47	18.5	24	8	150	5	20	61	3
567NE	4	38	35	434	514	30	287	208	50	19.2	25	21	160	8	31	60	5
568NE	5	33	32	445	489	31	288	207	50	19.4	21	12	158	6	38	48	4

Trace element analyses results (ppm) of samples of undetermined Columbia River Basalt Group affiliation

Sample	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
190SE	2	34	32	476	967	40	365	249	61	22.2	28	14	221	8	28	74	2
218SE	7	35	38	468	618	36	346	240	58	22.6	27	16	180	10	30	74	4