





## **Geologic Map of the Nine Mile Falls 7.5-minute Quadrangle, Spokane and Stevens Counties, Washington**

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	Priest Rapids Member of the Wanapum Basalt, Columbia River	This quadrangle map was produced in cooperation with the U.S. Geological Survey						
Mwp	<b>Basalt Group (middle Miocene)</b> —Dark gray to black, fine-grained, dense basalt consisting of plagioclase (20–30%), pyroxene (10–20%), and olivine (1–2%) in a mostly glass matrix (40–60%); variable thickness; very thin where it laps upon pre-Miocene highlands; lies directly on pre-Miocene rocks, Latah Formation, or Grande Ronde Basalt; contact with the underlying Grande Ronde Basalt occurs between 2200 and 2300 ft elevation in this quadrangle. Basalt is of the Rosalia chemical type, which has higher titanium and lower magnesium and chromium content than other flows of the Wanapum Basalt (Steve Reidel, Pacific Northwest National Laboratory, oral commun., 1998); between 14.5 and 15.3 m.y. old and has reversed magnetic polarity (Reidel and others, 1989). <b>Grande Ronde Basalt magnetostratigraphic units Ra and Na</b>	(USGS) National Cooperative Geological Mapping Program (agreement number 02HQAG0047). Jerry Stacey, who lives in the quadrangle, showed the senior author the location of one of the faults. A field visit with Tom Frost (USGS) resulted in a better understanding of the geology of the granitic rocks in the quadrangle. Fred Miller (USGS) also provided information about the granitic rock in the Chewelah 1:100:000-scale quadrangle. Ted Doughty (Eastern Wash. Univ.) spent a day in the field with the senior author and provided thin-section information. Eva Muller provided a preliminary soil survey for the Spokane Count portion of the quadrangle, which assisted in mapping areas where outcrops were sparse. Josh Logan, Karen Meyers, Eric Schuster, Chuck Caruthers, Anne Heinitz, and Jari Roloff of the Washington Division of Geology and Earth Resources provided editorial, digitizing, cartographic, and layout expertise for this report. Th Washington Department of Ecology provided access to water well logs for the						
Mgr	<b>Columbia River Basalt Group (middle Miocene)</b> —Dark gray to dark greenish gray, fine-grained basalt consisting of pale green augite and	quadrangle and allowed us to copy logs important to our study.						
	pigeonite grains (10–40%) and plagioclase laths and sparse phenocrysts (10–30%) in a matrix of black to dark brown glass (30–70%) and opaque minerals; locally vesicular with plagioclase laths tangential to vesicle boundaries; some vesicles contain botryoidal carbonate and red amorphous secondary minerals; thickness is quite variable due to irregular underlying topography. Identified in the map area on the basis of chemical analyses; between 15.6 and 16.5 m.y. old (Reidel and others, 1020)	<ul> <li>Armstrong, R. L.; Parrish, R. R.; van der Heyden, Peter; Reynolds, S. J.; Rehrig, W. A., 1987, Rb-Sr and U-Pb geochronometry of the Priest River metamorphic complex—Precambrian X basement and its Mesozoic–Cenozoic plutonic–metamorphic overprint, northeastern Washington and northern Idaho. <i>In</i> Schuster, J. E., editor, Selected papers on the geology of Washington: Washington Division of Geology and Earth Resources Bulletin 77, p. 15-40.</li> </ul>						
MI	Latah Formation (middle Miocene)—Lacustrine and fluvial deposits of finely laminated siltstone, claystone, and minor sandstone; light gray	Griggs, A. B., 1966, Reconnaissance geologic map of the west half of the Spokane quadrangle, Washington and Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-464, 1 sheet, scale 1:125,000.						
	to yellowish gray and light tan; commonly weathers brownish yellow with stains, spots, and seams of limonite; poorly indurated; exposures are limited in the map area; unconformably overlies pre-Miocene rocks or is interbedded with Grande Ronde Basalt (unit Mgr); easily eroded	Griggs, A. B., 1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Series Map I-768, 1 sheet, scale 1:250,000.						
	and commonly blanketed by colluvium, talus, and residual soils; floral assemblages indicate a Miocene age (Knowlton, 1926; Griggs, 1976). <b>Mafic dikes (Eocene)</b> —Fine-grained mafic dikes that intrude all of the	Griggs, A. B., 1976, The Columbia River Basalt Group in the Spokane quadrangle, Washington, Idaho, and Montana; with a section on Petrography, by D. A. Swanson: U.S. Geological Survey Bulletin 1413, 39 p., 1 plate.						
Emd	Cretaceous granitic units; contains phenocrysts of hornblende and biotite in a fine-grained matrix of feldspar, quartz, hornblende, and biotite; mostly altered; alteration minerals include chlorite and epidote; light to	Joseph, N. L., compiler, 1990, Geologic map of the Spokane 1:100,000 quadrangle, Washington–Idaho: Washington Division of Geology and Earth Resources Open File Report 90-17, 29 p., 1 plate.						
	mafic dikes in the Fan Lake area about 15 mi northeast of the Nine Mile Falls quadrangle are "spatially, mineralogically, and compositionally related to the Silver Point Quartz Monzonite" (Miller, 1974). The Fan	Kiver, E. P.; Rigby, J. G.; Stradling, D. F., 1979, Surficial geologic map of the Spokane quadrangle, Washington: Washington Division of Geology and Earth Resources Open-File Report 79-11, 1 sheet, scale 1:250,000.						
	Lake area yielded a K-Ar age of $47.3 \pm 1.6$ Ma on hornblende and $46.8 \pm 1.4$ Ma on biotite (Miller, 1974). Silver Point Ouartz Monzonite (Eocene)—Ouartz monzonite	Knowlton, F. H., 1926, Flora of the Latah formation of Spokane, Washington, and Coeur d'Alene, Idaho. <i>In</i> Shorter contributions to general geology 1925: U.S. Geological Survey Professional Paper 140-A, p. 17-81.						
Eqm	consisting of distinct microperthitic orthoclase phenocrysts up to 1 in. long accompanied by smaller, zoned-plagioclase, hornblende, biotite, and quartz crystals in a fine- to very fine-grained groundmass; generally light gray with a greenish tinge at contact with host rocks; hornblende has a long dimension of as much as 0.4 in, and is associated with biotite;	<ul><li>Miller, F. K., 1974, Preliminary geologic map of the Newport Number 3 quadrangle, Pend Oreille, Stevens and Spokane Counties, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-9, 1 sheet, scale 1:62,500, with 7 p. text.</li></ul>						
	orthoclase phenocrysts are euhedral; other phenocrysts range from euhedral to anhedral, most are subhedral; titanite is the most common accessory mineral, followed by magnetite, apatite, zircon, and rare	<ul> <li>Miller, F. K., 2000, Geologic map of the Chewelah 30' x 60' quadrangle,</li> <li>Washington and Idaho: U.S. Geological Survey Miscellaneous Field Studies</li> <li>Map MF-2354, 1 sheet, scale 1:100,000, with 56 p. text.</li> </ul>						
	allanite (Miller and Clark, 1975); as much as 50 percent of the rock is groundmass; consists of dikes and irregularly shaped intrusive bodies. Two samples from the Chewelah 1:100,000-scale quadrangle to the north gave whole-rock Rb-Sr ages of 39.4 Ma and 46.2 Ma (Armstrong and others, 1987); recalculated K-Ar ages on rocks from the Chewelah	Miller, F. K.; Clark, L. D., 1975, Geology of the Chewelah–Loon Lake area, Stevens and Spokane Counties, Washington, with a section on potassium-argon ages of the plutonic rocks, by J. C. Engels: U.S. Geological Survey Professional Paper 806, 74 p., 2 plates.						
	1:100,000-scale quadrangle were 51 Ma on biotite and 62 Ma on hornblende (Miller and Clark, 1975).	Miller, F. K.; Engels, J. C., 1975, Distribution and trends of discordant ages of the plutonic rocks of northeastern Washington and northern Idaho: Geological Society of America Bulletin, v. 86, no. 4, p. 517-528.						
Klg	muscovite quartz monzonite; consists of microcline and albite in microperthitic combination, quartz, and muscovite; microcline and albite content are nearly equal; muscovite can range up to 10 percent but is	Milne, S. S.; Hayashi, S. K.; Gese, D. D., 1975, Stratigraphy of Scabland meadows in southeast Spokane County [abstract]: Northwest Scientific Association, 48th Annual Meeting, Program and Abstracts, abstract no. 81.						
	generally less than 5 percent; rarely contains a trace to 2 percent biotite; pink to cream colored; leucocratic dikes cut biotite granite (unit Kbg). Miller and Clark (1975) reported that exposures of leucocratic granitic rocks noted by Griggs ( <i>in</i> Miller and Clark, 1975) south of Clayton (~6 mi north of the map area) were the same unit as their leucocratic	Pardee, J. T.; Bryan, Kirk, 1926, Geology of the Latah Formation in relation to the lavas of the Columbia Plateau near Spokane, Washington. <i>In</i> Shorter contributions to general geology 1925: U.S. Geological Survey Professional Paper 140, p. 1-16. (140-A?)						
Kbg	<ul> <li>muscovite quartz monzonite and that because the plagioclase is albite the rock could be classified chemically as granite.</li> <li>Biotite granite (Cretaceous)—Massive, medium- to coarse-grained, equigranular biotite granite to quartz monzonite; quartz forms clots or aggregates of crystals and is intergrown with potassium feldspar:</li> </ul>	<ul> <li>Reidel, S. P.; Tolan, T. L.; Hooper, P. R.; Beeson, M. H.; Fecht, K. R.; Bentley, R. D.; Anderson, J. L., 1989, The Grande Ronde Basalt, Columbia River Basalt Group; Stratigraphic descriptions and correlations in Washington, Oregon, and Idaho. <i>In</i> Reidel, S. P.; Hooper, P. R., editors, Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 230, p. 21, 53</li> </ul>						
	potassium feldspar also forms some phenocrysts and clots of phenocrysts; anhedral to subhedral black biotite comprises 2 to 7 percent of the rock and generally is interstitial to other minerals; leucocratic dikes (unit Klg) cut the biotite granite; considered the same as biotite- bearing intrusive rock near Four Mound Prairie and in Corkscrew Canyon in the adjacent Four Mound Prairie quadrangle to the west (Joseph, 1990).	<ul> <li>Swanson, D. A.; Anderson, J. L.; Bentley, R. D.; Byerly, G. R.; Camp, V. E.;</li> <li>Gardner, J. N.; Wright, T. L., 1979, Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U.S. Geological Survey Open-File Report 79-1363, 26 p., 12 plates.</li> </ul>						
Kg	<b>Biotite muscovite granite (Cretaceous)</b> —Medium- to coarse-grained, massive, muscovite-biotite granite to quartz monzonite; contains medium-gray anhedral quartz (20–40%) that commonly forms graphic intergrowths with feldspar; potassium feldspar and plagioclase (50–70%) are present in a ratio of about 2:3; large crystals of potassium feldspar in some exposures enclose small biotite grains; plagioclase is commonly altered; subhedral biotite comprises as much as 10 percent of the rock and forms clots; muscovite ranges from 0 to 10 percent of the rock and is present as single euhedral crystals, in clots, or with biotite; undisturbed outcrops are medium gray due to lichen cover; light gray in	<i>Disclaimer:</i> This product is provided 'as is' without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular use. The Washington Department of Natural Resources will not be liable to the user of this product for any activity involving the product with respect to the following: (a) lost profits, lost savings, or any other consequential damages; (b) the fitness of the product for a particular purpose; or (c) use of the product or results obtained from use of the product. This product is considered to be exempt from the Geologist Licensing Act [RCW 18.220.190 (4)] because it is geological research conducted by the State of Washington, Department of Natural Resources, Division of Geology and Earth Resources.						

Yielded discordant K-Ar ages of 48 Ma on biotite and 53 Ma on

to and most likely of the same age as the Mount Spokane granite.

muscovite (Miller and Engels, 1975), which are probably reset; similar

Roof pendants—Small bodies of predominantly quartzite and minor

argillite; one sample of quartzite contains diopside; only the larger

Precambrian Belt Supergroup rocks exposed north of the map area

bodies are shown on the map at this scale; probably related to

(Miller, 2000).

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## OWLEDGMENTS

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TRACE ELEMENT GEOCHEMISTRY																	
	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
NM106	4	16	34	307	721	49	324	185	39	14.5	21	15	126	11	23	59	8
NM112	18	53	36	329	489	28	311	154	32	11.9	20	36	115	9	22	47	5
NM113	16	36	38	422	572	31	285	215	50	18.8	20	26	150	2	27	60	3
NM114	17	30	45	431	565	29	289	221	52	18.6	23	25	153	7	26	70	6
NM115	17	35	43	438	577	33	283	217	49	19.3	24	17	151	2	26	54	4
NM116	4	27	36	325	738	43	322	184	40	14.3	22	13	133	5	41	51	6
NM117	5	19	44	354	709	44	325	182	39	14.8	22	17	135	8	29	54	6
NMF134	16	50	36	340	712	32	332	164	35	12.9	19	25	111	4	1	52	1
NM102	1	1	9	54	1141	130	797	207	27	28.2	20	4	72	17	52	88	13
NM105	81	384	27	161	792	94	456	181	28	13.1	17	43	75	7	32	56	10
NM171	3	23	14	99	737	170	316	150	23	11.6	19	13	172	21	22	61	10
NM173	18	52	10	65	1109	133	611	195	18	14.4	17	7	59	15	43	87	15
NM178	14	11	7	33	1802	103	1074	174	12	16.2	18	6	39	34	73	112	15
NM179	2	0	8	16	461	250	312	89	24	21.9	21	3	45	22	16	58	7
NM180	3	0	4	0	42	181	22	85	31	20.8	16	2	17	30	18	55	21
NM181	1	0	7	19	1238	195	475	160	12	23.4	22	6	66	23	45	78	8