WASHINGTON STATE DEPARTMENT OF
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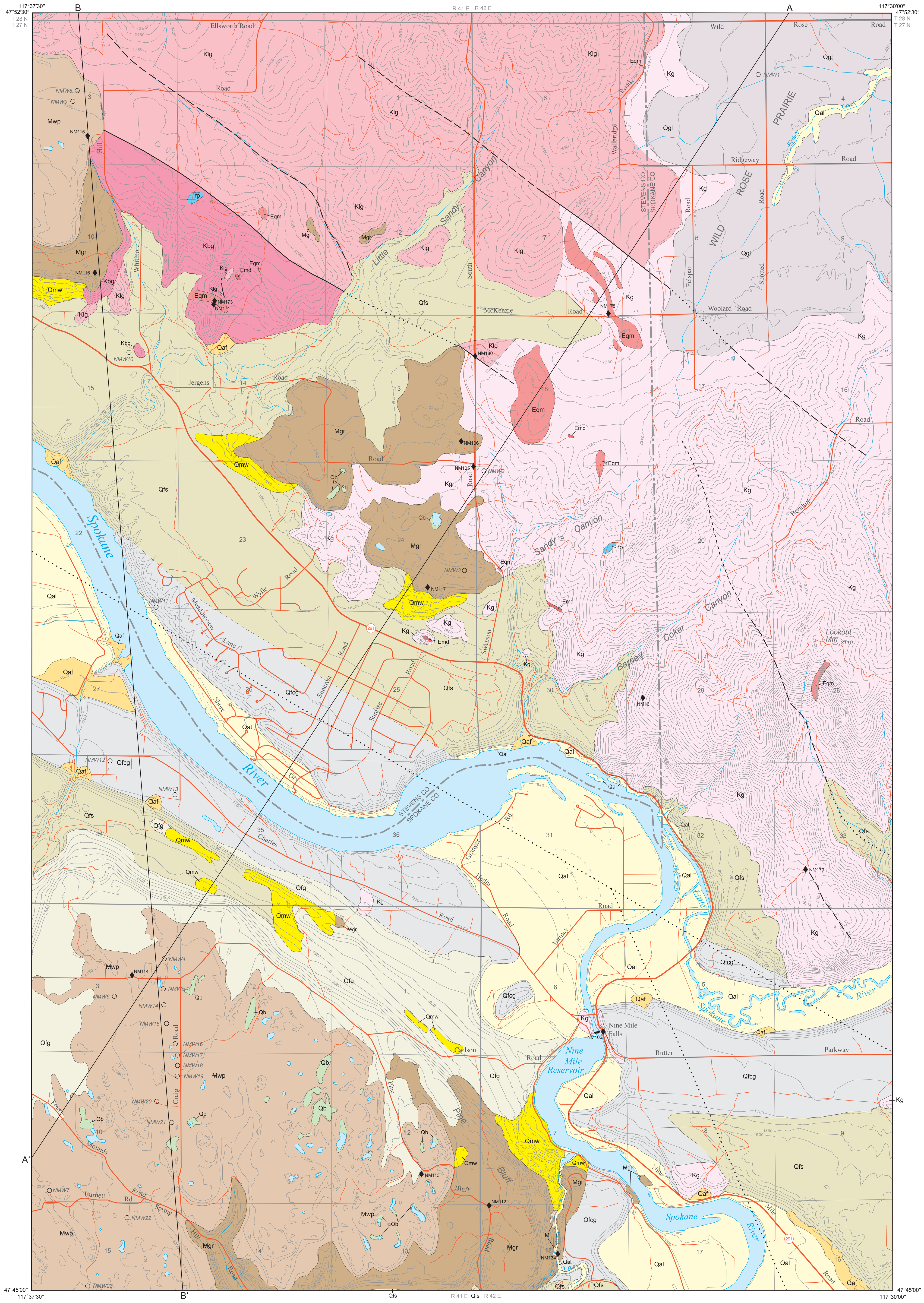
Geologic Map of the Nine Mile Falls 7.5-minute Quadrangle, Spokane and Stevens Counties, Washington

by Robert E. Derkey, Michael M. Hamilton, and Dale F. Stradling

2003

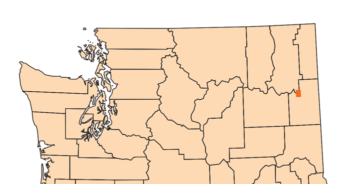


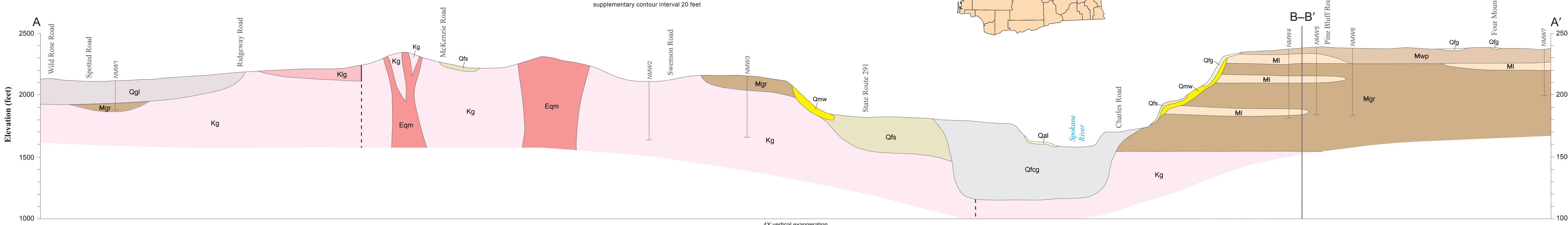
Lambert conformal conic projection
North American Datum of 1927
Base map information from the Washington Department of Natural Resources, Geographic Information System
Digital cartography by Robert E. Derkey, Chuck Caruthers, and J. Eric Schuster
Edited by Karen D. Meyers and Jaretta M. Roloff

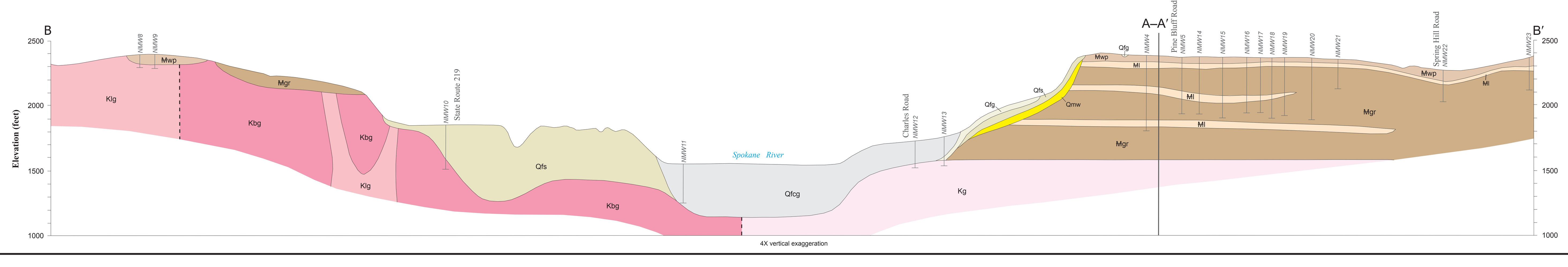
SCALE 1:24 000

1 — 0.5 — 0 — 1 MILE
1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET
1 — 0.5 — 0 — 1 KILOMETER

contour interval 40 feet
supplementary contour interval 20 feet







INTRODUCTION

The earliest geologic mapping in the Spokane area (including the Nine Mile Falls quadrangle) was by Pardee and Bryan (1926). Griggs (1966) completed a 1:125,000-scale geologic map of the western half of the Spokane 1- by 2-degree quadrangle. He later extended his mapping eastward to encompass the entire Spokane 1- by 2-degree quadrangle (Griggs, 1973). Joseph (1990) compiled a 1:100,000-scale map of the Spokane quadrangle that incorporated more detailed interpretations of Pleistocene glacial features based on Kiver and others (1979) and basalt stratigraphy based on Swanson and others (1979). In 1993 to 1994, Wendy Gerstel, Chuck Gulick, and Bob Derkey of the Washington Department of Natural Resources mapped the Quaternary deposits related to the Spokane aquifer recharge and aquifer-sensitive areas at a 1:24,000 scale. This unpublished mapping was entered into the Spokane County geographic information system (GIS), which has been available to county officials since 1996. We initiated detailed mapping of the quadrangle in July of 2002.

GEOLOGIC SYMBOLS

Contact—long-dashed where approximately located; short-dashed where inferred

Fault, unknown offset—long-dashed where approximately located; short-dashed where inferred; dotted where concealed

Well location

Geochemistry sample location

DESCRIPTION OF MAP UNITS

Holocene and Pleistocene Sedimentary Deposits

Qal **Alluvium (Holocene)**—Silt, sand, and gravel deposits in present-day stream channels, on flood plains, and on lower terraces; consists of reworked glacial flood deposits (units Qfcg, Qfg, and Qfs) and reworked loess; may include small alluvial fans and minor mass-wasting deposits that extend onto the flood plain from tributaries.

Qaf **Alluvial fan deposits (Holocene)**—Gravel, sand, and silt deposited in fans at the base of steep drainages; very poorly sorted; most lack a large drainage source; minimal soil development.

Qb **Bog deposits (Holocene and Pleistocene)**—Peat with lesser amounts of silt, ash, marl (bog lime), and gyttja (freshwater mud with abundant organic matter); located predominantly in Channeled Scabland depressions on basalt bedrock (Milne and others, 1975).

Qmw **Mass-wasting deposits (Holocene and late Pleistocene)**—Landslide debris with lesser amounts of debris-flow and rock-fall deposits; consists mostly of a mixture of basalt blocks and Latah Formation sediments; basalt blocks range in size from several feet to hundreds of feet in diameter. Most mass-wasting events occurred during or shortly after Pleistocene catastrophic flood events, but some mass wasting continued to the present; mass-wasting events that occurred during glacial flooding incorporated flood materials as scattered sand and pebble lenses interspersed with the mass-wasting deposits.

Qgl **Glaciolacustrine deposits of glacial Lake Columbia (Pleistocene)**—Silt and sand interbedded with clay and silt lakebeds; consists predominantly of quartz, feldspar, and mica grains; very light gray to pinkish or yellowish gray; contain scattered boulders and some sand and gravel lenses; occurs in the northeast corner of the quadrangle; coarser-grained materials may have been ice rafted or may be debris-flow deposits from the surrounding highlands. Includes abundant flood sand (unit Qfs), which capped the lake beds during a last stand of glacial Lake Columbia and occurs primarily as erosional remnants at higher elevations.

The following units are deposits from outburst floods of glacial Lake Missoula. They are a composite of numerous flood events and do not represent deposits from any single flood event.

Qfs **Glacial flood deposits, predominantly sand (Pleistocene)**—Medium- fine- to coarse-grained sand and granules with sparse pebbles, cobbles, and boulders; may contain beds and lenses of gravel; composed mainly of granitic and metamorphic detritus from sources to the east; gray, yellowish gray, or light brown; subangular to subrounded; poorly to moderately well sorted; thin bedded to massive; appears speckled in some exposures because of the mixture of light and dark fragments; distribution uneven and thickness variable due to irregular underlying topography and varying degrees of preservation from erosion. Includes some occurrences of glacial-lake and glacial-flood deposits that are too small to map separately; includes rhythmically bedded lake-bed sediments and sand and granule flood deposits similar to exposures along Hangman Creek about 10 mi southeast of the quadrangle; appears to have been deposited when Lake Missoula outburst floods flowed into a high stand of glacial Lake Columbia.

Qfg **Glacial flood deposits, predominantly gravel (Pleistocene)**—Thick-bedded to massive mixtures of boulders, cobbles, pebbles, granules, and sand; contains beds and lenses of sand and silt; gray, yellowish gray, or light brown; poorly to moderately sorted; both matrix and clast supported; locally composed of cobbles and some boulders in a matrix of mostly pebbles and coarse sand; derived from granitic and metamorphic rocks similar to those exposed both locally and to the northeast and east in Idaho; found outside the main flood channel, which approximates the present course of the Spokane River.

Qfcg **Glacial flood channel deposits, predominantly gravel (Pleistocene)**—Thick-bedded to massive mixtures of boulders, cobbles, pebbles, granules, and sand; may contain beds and lenses of sand and silt; gray, yellowish gray, or light brown; poorly to moderately sorted; both matrix and clast supported; locally composed of cobbles and boulders in a matrix of mostly pebbles and coarse sand; derived from granitic and metamorphic rocks similar to those exposed both locally and to the northeast and east in Idaho. Differs from flood gravel (unit Qfg) in that it occurs only in the main flood channel, which is known to be several hundred feet deep and appears to be entirely filled with flood deposits; boundaries between this unit and unit Qfg are based primarily on location rather than clast differences; forms the channel of the Spokane River.

Pre-Quaternary Igneous and Sedimentary Rocks

Mwp **Priest Rapids Member of the Wanapum Basalt, Columbia River Basalt Group (middle Miocene)**—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).

Mgr **Grande Ronde Basalt, magnetostratigraphic units R_2 and N_2, Columbia River Basalt Group (middle Miocene)**—Dark gray to dark greenish gray, fine-grained basalt consisting of pale green augite and 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, 1989).

Ml **Latah Formation (middle Miocene)**—Lacustrine and fluvial deposits of finely laminated siltstone, claystone, and minor sandstone; light gray 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 and commonly blanketed by colluvium, talus, and residual soils; floral assemblages indicate a Miocene age (Knowlton, 1926; Griggs, 1976).

Emd **Mafic dikes (Eocene)**—Fine-grained mafic dikes that intrude all of the 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 dark gray; only the largest dikes are shown at this map scale. Similar 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 Lake area yielded a K-Ar age of 47.3 ±1.6 Ma on hornblende and 46.8 ±1.4 Ma on biotite (Miller, 1974).

Eqm **Silver Point Quartz Monzonite (Eocene)**—Quartz monzonite 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; 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 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 1:100,000-scale quadrangle were 51 Ma on biotite and 62 Ma on hornblende (Miller and Clark, 1975).

Klg **Leucocratic intrusive rocks (Cretaceous)**—Medium-grained 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 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 (in Miller and Clark, 1975) south of Clayton (~6 mi north of the map area) were the same unit as their leucocratic muscovite quartz monzonite and that because the plagioclase is albite the rock could be classified chemically as granite.

Kbg **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; 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).

Kg **Biotite muscovite granite (Cretaceous)**—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 roadcuts and fresh exposures; weathers yellow with limonitic staining. Yielded discordant K-Ar ages of 48 Ma on biotite and 53 Ma on muscovite (Miller and Engels, 1975), which are probably reset; similar to and most likely of the same age as the Mount Spokane granite.

rp **Roof pendants**—Small bodies of predominantly quartzite and minor argillite; one sample of quartzite contains diopside; only the larger bodies are shown on the map at this scale; probably related to Precambrian Belt Supergroup rocks exposed north of the map area (Miller, 2000).

ACKNOWLEDGMENTS

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MAJOR ELEMENT GEOCHEMISTRY

	SiO2	Al2O3	TiO2	FeO	MnO	CaO	MgO	K2O	Na2O	P2O5	Total
NM106	55.36	13.29	2.252	12.06	0.206	6.81	3.16	1.81	3.10	0.387	98.43
NM112	54.40	14.21	1.841	11.47	0.197	8.88	4.68	1.21	2.67	0.295	99.86
NM113	50.59	12.83	3.624	15.09	0.246	8.57	4.38	1.32	2.62	0.788	100.06
NM114	50.60	12.87	3.661	14.87	0.227	8.56	4.20	1.32	2.64	0.813	99.76
NM115	50.02	12.63	3.652	15.27	0.246	8.46	4.33	1.40	2.54	0.780	99.33
NM116	55.42	13.49	2.425	12.54	0.226	6.97	3.01	1.77	3.07	0.407	99.32
NM117	54.82	13.32	2.427	13.09	0.219	7.12	3.09	1.82	3.06	0.412	99.38
NMF134	53.87	14.08	1.935	11.09	0.195	8.89	3.96	1.29	2.80	0.310	98.42
NM102	67.75	16.28	0.466	3.33	0.087	3.58	1.15	3.23	3.41	0.255	99.54
NM105	59.24	13.93	0.828	6.95	0.109	4.35	6.92	2.72	2.59	0.232	97.87
NM171	65.45	15.81	0.604	4.59	0.129	4.29	2.13	3.61	2.60	0.168	99.38
NM173	67.44	14.96	0.516	3.40	0.063	3.18	2.19	4.23	3.27	0.220	99.47
NM178	69.18	15.36	0.362	2.39	0.044	2.33	1.14	4.37	3.73	0.150	99.06
NM179	72.78	15.22	0.166	1.47	0.066	1.55	0.45	4.15	3.59	0.171	99.61
NM180	77.28	13.15	0.094	0.42	0.010	0.48	0.10	4.80	3.42	0.016	99.77
NM181	72.47	15.16	0.236	1.69	0.053	1.89	0.48	4.07	3.37	0.118	99.53

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