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 1

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
To place on the predicted North American Datum 1983, move the projection lines 16 meters north and 80 meters east as shown by dashed corner ticks

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

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

by

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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 NE QUADRANGLE

Quaternary Sediments

Post-Glacial Deposits

Qal **Alluvium (Holocene)**--Silt, sand, and gravel deposits in the present-day stream channels and flood plains of the Spokane River, Chester Creek, and Bigelow Gulch. 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 when relatively steeper drainages enter the Spokane River and Chester Creek. Deposits are very poorly sorted and have minimal soil development.

Qmw **Mass-wasting deposits (Holocene to Pleistocene)**-- Landslide debris with lesser amounts of debris-flow and rockfall deposits; includes interspersed flood deposits in the Spokane NE quadrangle. Landslide debris consists of a mixture of basalt blocks and Latah Formation sediments. Because some of the landslides occurred during glacial flooding, scattered sand and pebble lenses are locally interspersed with the mass-wasting deposits. Angular basalt blocks range in size from several feet to tens of feet across. Most mass-wasting deposits occur where soft sediments of the Latah Formation underlie basalt along the south side of the Spokane River valley in the Spokane NE quadrangle.

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 sheet-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.

Qla **Glaciolacustrine deposits of glacial Lake Columbia (Late Pleistocene)**--Very light gray to pinkish or yellowish gray, predominantly quartz, feldspar, and mica grains of silt and fine sand, with 4- to 6-in.-thick clay interbeds, scattered ice-rafted boulders, and some sand and gravel lenses. Coarser-grained materials may be ice rafted, eddy deposits from the Missoula floods, or debris-flow deposits from the surrounding highlands. These lacustrine sediments underlie Peone Prairie. Their southernmost exposure is at the north boundary of the Spokane NE quadrangle. Excellent exposures of these lakebeds can be found along Bruce Road just north of the Spokane NE quadrangle.

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, and 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. Flood gravels occur predominantly in tributary valleys of the Spokane River.

Qfcg **Glacial flood-channel deposits, predominantly gravel (Pleistocene)**--Gray, yellowish gray, or light brown, poorly to moderately sorted, mostly clast supported, thick-bedded to massive mixture of boulders, cobbles, pebbles, and 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. Boulders, which can be more than 5 ft in diameter, can comprise as much as 50% of the volume in a matrix of mostly pebbles and coarse sand. Unit thickness is over 600 ft in areas underlying the Spokane River and the Hillyard Trough (Molenaar, 1988).

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. The only loess mapped in the Spokane NE quadrangle is north of the Spokane River, where its thickness generally does not exceed 3 ft.

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 NE 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%). The basalt forms the cap of the bluffs north of the Spokane River in the northern part of the Spokane NE quadrangle. Water-well logs indicate that the Priest Rapids Member here is less than 100 ft thick. There are no known instances in the quadrangle where Priest Rapids basalt rests directly on Grande Ronde Basalt. Where basal contacts are exposed or where an underlying unit can be identified in the Spokane NE quadrangle, the underlying unit is Latah Formation.

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 (10-40%) grains 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. The amount of Grande Ronde Basalt exposed in the Spokane NE quadrangle is small; the largest exposures are about 75 ft thick south of the Spokane River. The small exposures north of the Spokane River in the Spokane NE quadrangle probably are invasive into the Latah Formation.

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% TiO_2. Basalt samples from the Spokane NE and SE quadrangles consistently contain less than 3.5% MgO and fairly consistently contain greater than 2.3% TiO_2. 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 a 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, even when they directly 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 NE quadrangle. Floral assemblages in the Latah Formation indicate a Middle Miocene age (Knowlton, 1926; Griggs, 1976). The elevation of the Priest Rapids basalt/Latah Formation contact in the Spokane NE quadrangle was determined from water-well logs and is depicted on the cross sections. The easily eroded Latah Formation is commonly blanketed with a cover of colluvial and residual soils and rockfall.

Pre-Miocene Rocks

Pre-Miocene rocks in the Spokane NE quadrangle consist of a complex of metamorphosed, deformed, and mylonitized sedimentary rocks that were intruded by pre-, syn-, and post-kinematic igneous (predominantly granitic) rocks. The metamorphosed sedimentary rocks are mostly quartz-feldspar rich. They have been metamorphosed up to amphibolite-grade and are here mapped as paragneiss (unit pTmi). 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.

The 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). However, because the orthogneiss (unit pTog) south of the Spokane River was not dated for this study and because it could not be tied directly to dated rocks in the area, it is assigned a pre-Tertiary age.

The Newman Lake Gneiss (unit Kogn) and mylonites north of the Spokane River in the Spokane NE quadrangle are westward extensions of rocks included as part of the Spokane Dome in the adjacent Greenacres quadrangle (Weis, 1968; Rhodes and Hyndman, 1984). Therefore, we consider these rocks a southwestern extension of the dome. The Newman Lake Gneiss north of the river is similar in appearance to portions of the orthogneiss (unit pTog) south of the river; however, no connection was substantiated during this study.

North of the Spokane River in the Spokane NE quadrangle, a persistent east-northeast-trending mylonite zone, here called the 'Beacon Hill mylonite zone', is 20 to more than 100 ft thick. Rocks of the mylonite zone have reduction in grain size, destruction of original texture, foliation banding that, in some cases, is less that 0.1 in. thick, development of numerous augen, and presence of a well-developed and persistent lineation. This lineation trends either N70°75'E or N70°75'W, which is consistent with the trend of lineation observed in the Priest River complex (Rhodes and Hyndman, 1984).

TKi **Fine-grained, biotite-muscovite granite (Tertiary? to Cretaceous)**--Light to medium gray, fine- to medium-grained, unfoliated to weakly foliated, equigranular, irregularly shaped bodies of muscovite-biotite quartz monzonite to granite. The granite consists of quartz, K-feldspar, plagioclase, biotite, and minor muscovite. Rocks mapped as unit TKi are much less foliated than their host rocks. This is especially true where the host rock is biotite-muscovite granite. Because it intrudes unit Ki and is less foliated than adjacent unit Ki, unit TKi is here assigned a Tertiary(?)-Cretaceous age. This unit may be equivalent to the Tertiary-age Mount Rathdrum granite of Rhodes and Hyndman (1984).

Ki **Biotite-muscovite granite (Cretaceous)**-- Generally medium- to light-gray in roadcuts and other fresh exposures, locally with a light pink tinge, medium- to coarse-grained, locally porphyritic. Can be quite variable in color and texture, even within a single or adjacent outcrops. Mylonite is present in zones and has affected to varying degrees and extent most of this unit south of Bigelow Gulch and north of the Spokane River in the central and east-central parts of the Spokane NE quadrangle. Intensity of mylonitization and foliation increases southward from Bigelow Gulch and reaches maximum intensity at the contact with Newman Lake Gneiss (unit Kogn) on Beacon Hill and the ridge that extends eastward from Beacon Hill (the informally designated 'Beacon Hill mylonite zone'). Foliated but not intensely mylonitized, unit Ki contains more biotite than unit TKi and is medium to dark gray in color. Local unfoliated pods of unit Ki south of Bigelow Gulch are identical to unit Ki exposed north of Bigelow Gulch. Locally, the unit includes fine-grained biotite-muscovite granite (unit TKi) bodies that are too small or poorly exposed to map separately. Contacts of units TKi and Ki, when observed, are sharp.

The description of the this unit is based upon Derkey and others' (1998) description from more extensive exposures in the Dartford quadrangle immediately northwest of the Spokane NE quadrangle. Based upon samples from the Dartford and Spokane NE quadrangles, the unit contains 20-40% quartz, locally as clusters of broken and annealed quartz grains and often as graphic inter-growths with K-feldspar. K-feldspar and plagioclase (50-70%) occur in a ratio of about 2:3, with local K-feldspar phenocrysts. Subhedral biotite (up to 10%) locally forms monomineralic clusters or is clustered with muscovite. Biotite sometimes is altered to chlorite. Muscovite (0-3%) is present as single euhedral crystals or clusters with muscovite or biotite. Accessory minerals include garnet, apatite, zircon (with metamict halos in association with biotite), epidote, and rutile.

Kog_n **Newman Lake Gneiss (Cretaceous)**-- Medium- to dark-gray, medium- to coarse-grained, quartz-feldspar-biotite granodiorite containing distinct megacrysts of subhedral to euhedral orthoclase up to 2 in. in length and 0.5 in. in width. The megacrysts contain anhedral to euhedral plagioclase grains. Foliation due to mylonite development is not uniformly distributed through the unit. Zones of cataclasis consisting of trains of smaller quartz-feldspar grains with interspersed muscovite can be observed in thin section. In weakly mylonitized and foliated rocks, the K-feldspar megacrysts are rounded and reduced in size; in some areas, foliation more closely resembles rock cleavage. The Beacon Hill mylonite zone occurs at the contact between the Newman Lake Gneiss and the structurally overlying and mylonitized Cretaceous biotite-muscovite granite (unit Ki). Rocks in the Beacon Hill mylonite zone are light gray to greenish gray with foliation bands that are less than 0.1 in. thick. The Beacon Hill mylonite zone is at least 20 ft thick and in some areas is more than 100 ft thick.

pTog **Quartz-feldspar-mica orthogneiss (pre-Tertiary)**-- Light to medium gray; medium- to coarse-grained; weak to moderate foliation with bands ranging in thickness from 0.1 in. to several inches. This unit is a complex of numerous igneous bodies with older and larger granitic bodies being intruded by dikes and irregularly shaped bodies of leucocratic granite/aplite, pegmatite, and granitic rock. Consequently, the mineralogy is variable. Typically, unit pTog 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 contains more feldspar and has a less well developed foliation than the structurally overlying unit pTmi.

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 occurs in areas rich in pegmatitic and leucogranitic material. Typically the paragneiss contains 30-50% quartz (locally up to 80%), up to 40% feldspar, and up to 20% muscovite/biotite (schistose layers contain more than 50%). Sillimanite, clinozoisite(?), hornblende, chlorite, and garnet are irregularly distributed and can be up to 10% of the rock. Foliation bands vary from 0.1 in. to several inches in width. The unit is pervasively intruded by pre-, syn-, and post-kinematic granitic rocks, commonly emplaced as sills along foliation and less commonly as dikes.

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ACKNOWLEDGMENT

These geologic maps were prepared in cooperation with the U.S. Geological Survey National Cooperative Geologic Mapping Program (Agreement no. 98HQAG2062)

EXPLANATION OF MAP SYMBOLS

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

Fault--Short dashed where inferred or indefinite

Fault or lineament--Presence of offset identified on ground, location and extent inferred from linear features on aerial photographs

Mylonite zone

18 Strike and dip of foliation and plunge of lineation

128 Water well location--Numbers correspond with well numbers on cross sections

568 ★ Basalt geochemistry sample location--Numbers correspond to sample numbers in appendix