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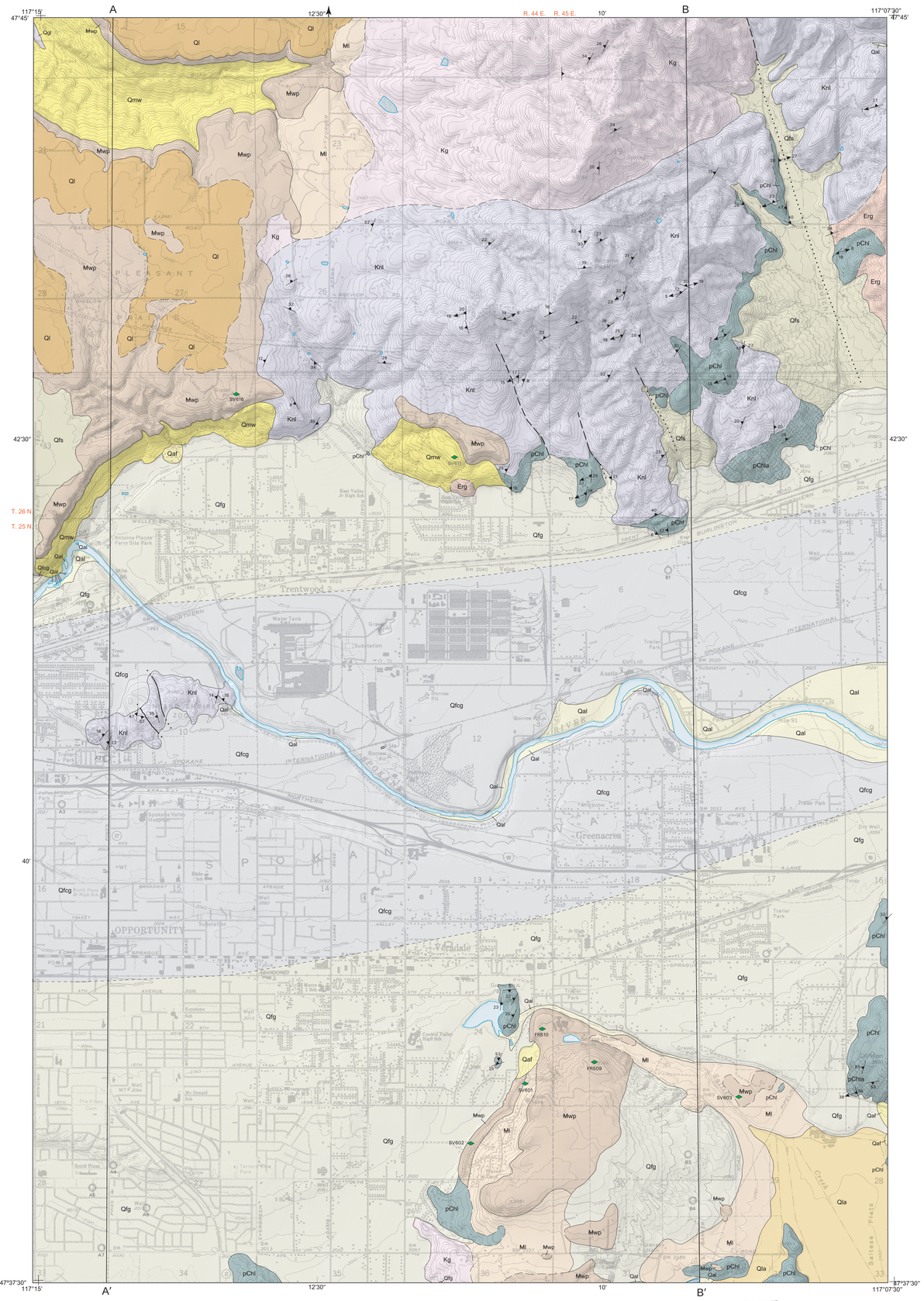


Lambert conformal conic projection
North American Datum of 1927; to place on North American Datum of 1983, move the projection lines 15 meters north and 79 meters east as shown by crosshair corner ticks
Base map from scanned and rectified U.S. Geological Survey 7.5-minute Greenacres quadrangle, 1973, photorevised 1986
Shaded relief generated from U.S. Geological Survey 10-meter Digital Elevation Model, vertical exaggeration 3x
Digital cartography by Charles G. Caruthers, Anne C. Heinitz, and J. Eric Schuster
Editing and production by Karen D. Meyers

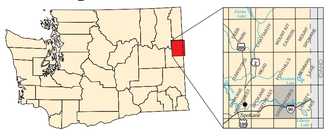
SCALE 1:24 000

1 — 0.5 — 0 — 1 MILE

1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET

1 — 0.5 — 0 — 1 KILOMETER

contour interval 20 feet
supplementary contour interval 10 feet



Geologic Map of the Greenacres 7.5-minute Quadrangle, Spokane County, Washington

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

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INTRODUCTION

The first published geologic map of the area 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 complete a 1:250,000-scale map of the entire Spokane 1- by 2-degree quadrangle (Griggs, 1973). The most detailed geologic mapping of the Greenacres 7.5-minute quadrangle is a 1:62,500-scale map of the Greenacres 15-minute quadrangle (Weis, 1968). Joseph (1990) compiled a 1:100,000-scale map of the Spokane quadrangle that incorporated detailed interpretations of Pleistocene glacial flood geology of Kiver and others (1979) and basalt stratigraphy based on Swanson and others (1979). In 1993 and 1994, Wendy Gerstel, Charles Gulick, and Robert Derkey of the Washington State Department of Natural Resources mapped the Quaternary deposits related to the Spokane aquifer recharge and aquifer sensitive areas at 1:24,000 scale; this unpublished mapping has been available to Spokane County officials since 1996 through the county's geographic information system (GIS). The subsurface extent of flood deposits filling channels depicted in the cross sections is based upon unpublished seismic reflection profiling contracted by the Division of Geology and Earth Resources in 1994.

DESCRIPTION OF MAP UNITS

Quaternary Sedimentary Deposits

Qal — **Alluvium (Holocene)**—Silt, sand, and gravel deposits in present-day stream channels, on flood plains, and on terraces; consists of reworked glacial flood deposits (units Qfg and Qfs) and 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; consists mostly of reworked glacial flood deposits (units Qfg and Qfs) and loess; very poorly sorted; mostly lacks a large drainage source; has minimal soil development.

Qla — **Lacustrine and peat deposits (Holocene)**—Lacustrine deposits of fine-grained sand, silt, clay, and peat deposited in post-flood lakes; upvalley surfaces may include minor alluvium; light gray to dark gray and dark brown; located predominantly in peat bogs; brown to yellow-brown fibrous peat, sedimentary peat, and muck found beneath Saltese Flats; locally mixed with sand and silt; can contain interbedded volcanic ash. The peat was mapped by Rigg (1958).

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 (unit Ml) 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 continues to the present; mass-wasting events that occurred during glacial flooding incorporated flood materials as scattered sand and pebble lenses.

Ql — **Loess (Holocene and Pleistocene)**—Silt with lesser amounts of clay; locally includes small amounts of fine sand and volcanic ash; light to medium brown; unstratified; clay mostly montmorillonite and illite in a ratio of 3:1, with minor kaolinite (Hosterman, 1969); fine sand and silt composed of angular quartz with lesser amounts of feldspar and mica; except where eroded, generally 1 or 2 ft thick in the quadrangle.

Qgl — **Glaciolacustrine deposits of glacial Lake Columbia (Pleistocene)**—Silt and fine sand interbedded with clay and silt lakebeds; composed predominantly of quartz, feldspar, and mica grains; very light gray to pinkish tan and light brown.

The following units are outburst flood deposits from 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 local sources and sources to the east; gray, yellowish gray, or light brown; subrounded to well rounded; poorly to moderately well sorted; medium bedded to massive; uneven distribution and thickness due to irregular underlying topography and varying degrees of erosion; mostly deposited when glacial Lake Missoula outburst floods flowed into a high stand of glacial Lake Columbia.

Qfg — **Glacial flood deposits, predominantly gravel (Pleistocene)**—Thick-bedded to massive mixture 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 boulders and cobbles in a matrix of mostly pebbles and coarse sand; boulders and cobbles consist predominantly of local bedrock units and units found to the east and northeast in Idaho; found mainly outside of the principal flood channel, which approximates the present course of the Spokane River.

Qfcg — **Glacial flood-channel deposits, predominantly gravel (Pleistocene)**—Thick-bedded to massive mixture 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 boulders and cobbles in a matrix of mostly pebbles and coarse sand; boulders and cobbles consist predominantly of local bedrock units and units found to the east and northeast in Idaho. This unit differs from unit Qfg in that it fills the deep, ancestral channel of the Spokane River, which now forms the Spokane Valley–Rathdrum Prairie aquifer. The flood deposits filling the channels are known to be several hundred feet thick. Boundaries between this unit and unit Qfg are based on location of these channels rather than clast-size differences.

Pre-Quaternary Igneous 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, pyroxene, and olivine in a mostly glass matrix. Basalt is of the Rosalia chemical type (Table 1), which has higher titanium and lower magnesium and chromium than other flows of Wanapum Basalt (Steve Reidel, Pacific Northwest National Laboratory, oral commun., 1998). This unit is between 14.5 and 15.3 m.y. old and has reversed magnetic polarity (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; easily eroded and commonly blanketed by colluvium, talus, and residual soils; floral assemblages indicate a Miocene age (Knowlton, 1926; Griggs, 1976).

Erg — **Rathdrum Mountain Granite of Rhodes and Hyndman (1984) (Eocene)**—Quartz monzonite to granite; contains quartz, potassium feldspar, plagioclase, biotite, and minor muscovite; plagioclase contains myrmekitic intergrowths; leucocratic; weathers to pinkish to limonitic color; fine-grained; equigranular; massive to locally foliated, especially near contacts with the enclosing rocks; forms irregular masses, sills, and dikes that crosscut or are concordant to the foliation of enclosing mylonitic rocks; locally foliated nature suggests it is late synkinematic. Discordant ages for undeformed Rathdrum Mountain Granite are early Eocene (52 Ma) (Bickford and others, 1985).

Kg — **Biotite muscovite granite (Cretaceous)**—Two-mica granite to quartz monzonite; medium to coarse grained; mostly massive; foliated near contact with Newman Lake Gneiss (unit Knl); contains medium-gray anhedral quartz that commonly forms graphic intergrowths with feldspar; potassium feldspar and plagioclase 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 forms clots; muscovite ranges from 0 to 10 percent of the rock and is present as single euhedral grains, in clots, or with biotite; light gray in roadcuts and fresh exposures; weathers yellow with limonitic staining. This unit is similar to and most likely of the same age as the granite of Mount Spokane, for which Armstrong and others (1987) report a lower intercept age of 60 to 75 Ma from analysis of extremely discordant zircons. K-Ar ages of 48 Ma (biotite) and 53 Ma (muscovite) from the Mount Spokane granite (Miller and Engels, 1975) record cooling during formation of the Priest River metamorphic complex.

Knl — **Newman Lake Gneiss (Cretaceous)**—Variously foliated megacryst-bearing granodiorite; crystalline portions commonly medium to dark gray, altered and weathered exposures typically light gray to greenish gray, locally bleached to cream color; medium- to coarse-grained; contains distinctive megacrysts of subhedral to euhedral orthoclase up to 2 in. long and 0.5 in. wide in a crushed matrix of quartz, feldspar, and mica; megacrysts range from euhedral in zones of weak mylonitization to almost completely reduced or destroyed in intensely mylonitized rocks. Prominent mylonitic foliation is widespread in the Newman Lake Gneiss and underlying Hauser Lake Gneiss (unit pChl), but is not uniformly distributed through the Newman Lake Gneiss. A pronounced mineral lineation trending N70°E is present in Newman Lake Gneiss; however, it is not as readily discernable as it is in the underlying Hauser Lake Gneiss. The contact between the Newman Lake Gneiss and underlying Hauser Lake Gneiss is tectonic and generally abrupt; concordant bodies of the Newman Lake Gneiss are sometimes present in the Hauser Lake Gneiss near the contact, which originally may have been an intrusive contact.

pChl — **Hauser Lake Gneiss (Precambrian)**—Interlayered granofels and semipelitic to pelitic schist and gneiss containing variable amounts of quartz, potassium feldspar, plagioclase, biotite, sillimanite, and garnet; gray, tan, and brown; coarse grained (locally migmatitic); pelitic part of unit is thinly banded and is intensely crumpled on a small scale in many places; contains discontinuous dikes and irregular crosscutting bodies of feldspar, quartz, and pre-, syn-, and post-kinematic, leucocratic, two-mica pegmatite; contains concordant, structurally disrupted layers and boudins of garnet-hornblende amphibolite. Prominent mylonitic foliation and mineral lineation (N70°E) defined by aligned sillimanite are present throughout nearly all of the Hauser Lake Gneiss. Weissenborn and Weiss (1976) suggested that the protolith for the Hauser Lake Gneiss was the Prichard or Burke Formation of the Precambrian Belt Supergroup. The amphibolites are interpreted as metamorphosed mafic sills (Doughty and others, 1998), which are common in the Prichard Formation. Locally divided into:

pChla — Areas where garnet-hornblende amphibolite bodies are particularly large and (or) concentrated; however, considerable Hauser Lake Gneiss occurs with the amphibolite.

GEOLOGIC SYMBOLS

Contact—Long dashed where approximately located, short dashed where inferred

Fault, unknown offset—Dashed where approximately located, dotted where concealed

Foliation in metamorphic rock—Showing strike and dip

Mineral lineation—Showing bearing and plunge

SV611 — Basalt geochemistry sample location—Numbers correspond to sample numbers in Table 1

B1 — Water well—Numbers correspond to well numbers on cross sections

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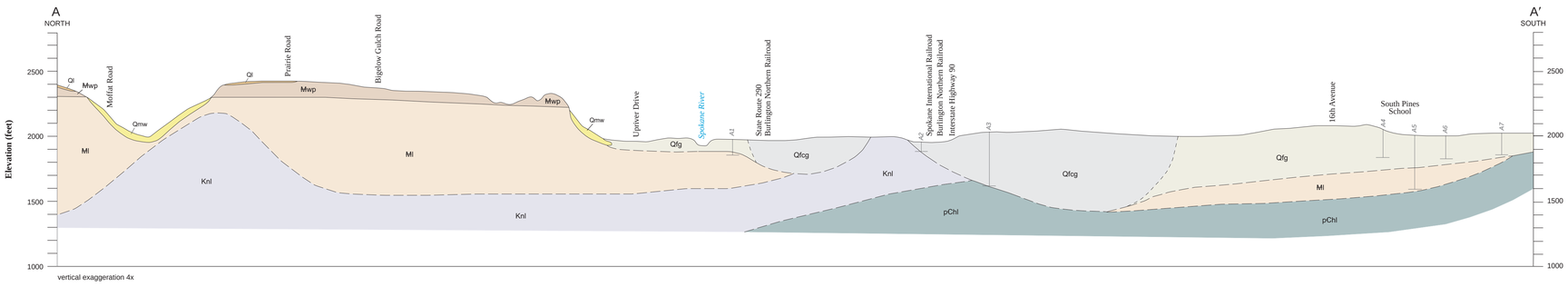

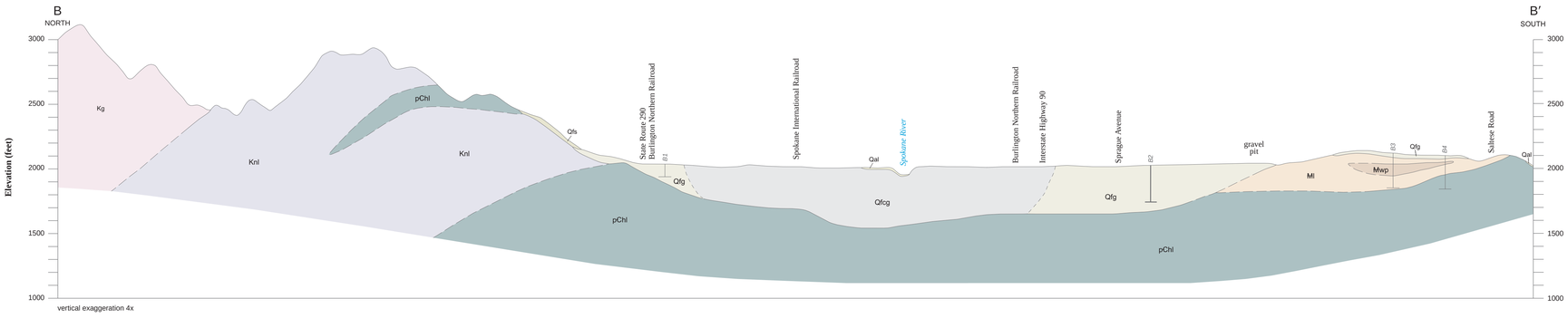

Table 1. Geochemical analyses of Columbia River Basalt Group samples performed by x-ray fluorescence at the Washington State University GeoAnalytical Lab. Instrumental precision is described in detail in Johnson and others (1999). Total Fe is expressed as FeO. All samples are Priest Rapids Member of the Wanapum Basalt (unit Mwp) with the exception of sample SV601, which is probably an altered sample of basalt that is invasive into Latah Formation (unit Ml). Sample SV611 is from a basalt block in a mass-wasting deposit (unit Qmw)

MAJOR ELEMENTS—UNNORMALIZED (in weight percent)

Sample no.	SiO_2	Al_2O_3	TiO_2	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Total
SV601	54.81	17.94	5.051	6.46	0.094	6.87	0.45	1.90	3.47	1.070	98.12
SV602	49.65	12.80	3.604	14.90	0.223	8.45	4.00	1.30	2.82	0.776	98.52
SV603	49.72	12.88	3.597	14.76	0.236	8.58	4.34	1.32	2.68	0.772	98.88
SV611	49.74	12.91	3.631	14.81	0.239	8.67	4.14	1.30	2.66	0.797	98.91
SV616	49.83	12.89	3.618	14.50	0.237	8.70	4.25	1.32	2.68	0.793	98.82
FR509	48.98	12.77	3.671	15.35	0.252	8.65	3.87	1.21	2.49	0.816	98.06
FR510	49.87	12.66	3.660	14.93	0.248	8.37	4.42	1.23	2.71	0.795	98.89

TRACE ELEMENTS (in parts per million)

Sample no.	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
SV601	10	2	50	595	1398	43	442	317	61	26.9	31	35	245	9	39	94	5
SV602	15	9	39	434	572	33	290	223	51	19.5	20	17	156	8	31	64	3
SV603	16	12	38	430	577	31	292	218	49	18.5	22	21	160	9	26	69	3
SV611	14	9	39	437	594	33	295	223	51	19.7	23	26	158	8	32	69	3
SV616	16	9	39	431	594	32	296	221	52	19.1	21	21	155	7	29	65	6
FR509	16	23	40	445	596	28	292	214	51	18.9	22	26	150	4	21	77	4
FR510	16	25	38	433	576	30	276	211	51	18.5	21	23	153	6	16	63	3

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