Geologic Map of the Orofino West Quadrangle, Clearwater, Lewis, and Nez Perce Counties, Idaho

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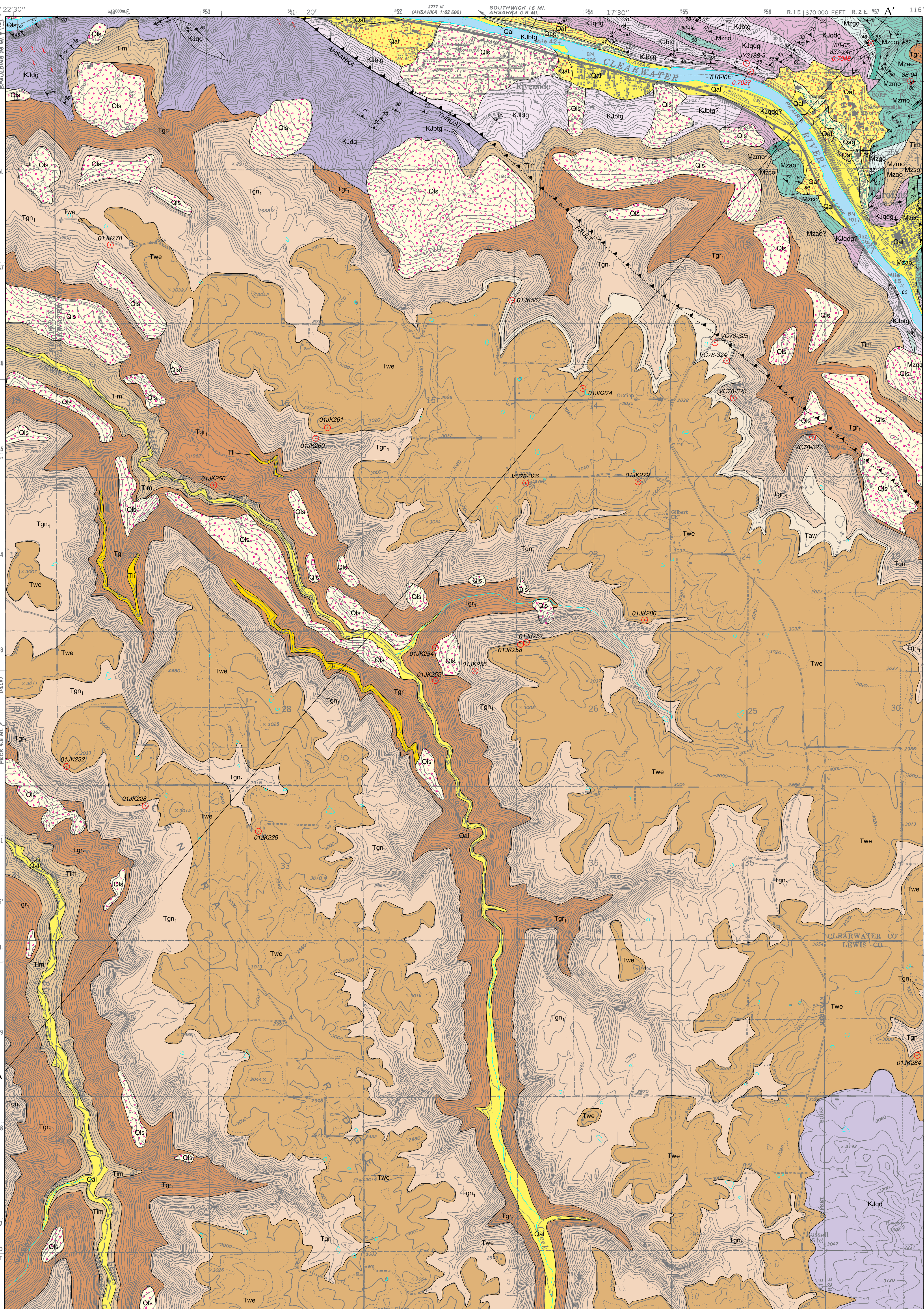
2005



Base map from USGS digital raster graphic 1994.

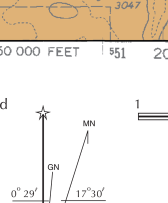
Topography by photogrammetric methods from aerial photographs taken 1966. Revised from aerial photographs taken 1990. Partial field check by U.S. Forest Service 1994.

1927 North American Datum.

Projection and 10,000-foot grid ticks: Idaho coordinate system, west zone.

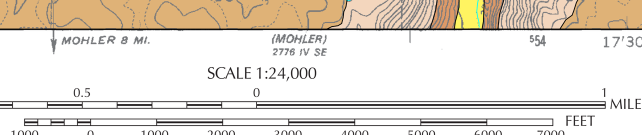
1000-meter Universal Transverse Mercator grid ticks, zone 11.

National geodetic vertical datum of 1929.



UTM Grid and 1994 Magnetic North Declination at Center of Map

SCALE 1:24,000



Contour interval 40 feet
Supplementary contour interval 20 feet

QUADRANGLE LOCATION

Field work conducted 1987, 1988, and 2001.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program.

Map reviewed by S.P. Reidel, Battelle, Pacific Northwest National Laboratory and S.A. Kattenhorn, Geological Sciences, University of Idaho.

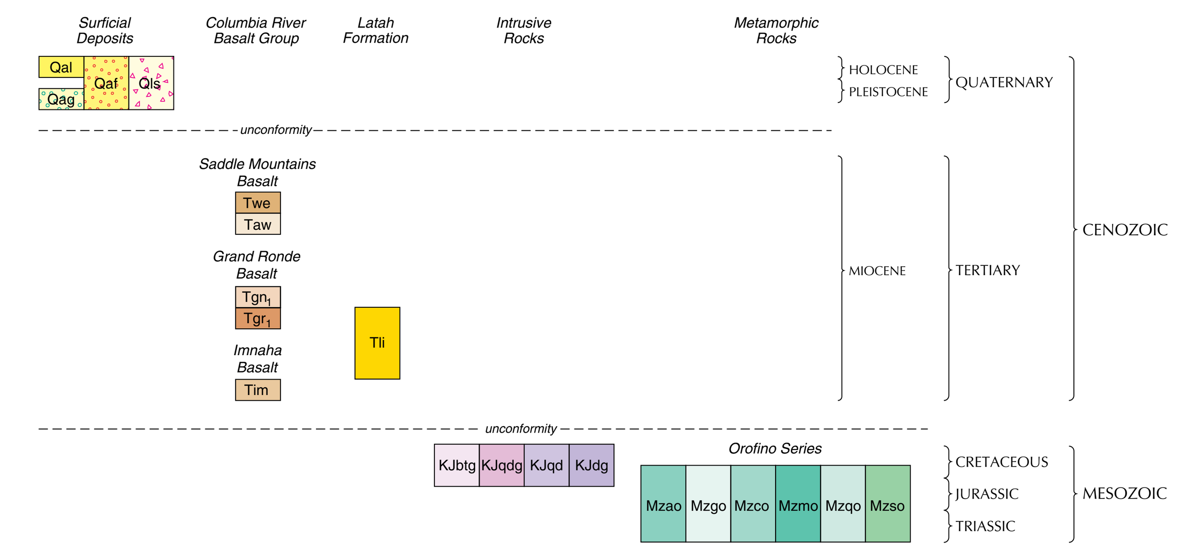
Digital cartography by Jane S. Freed, B. Benjamin E. Studer, and Loudon R. Stanford at the Idaho Geological Survey's Digital Mapping Lab.

Map edited by Roger C. Stewart.

Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run but not to the fading caused by long-term exposure to light.

Map version 2-4-2005.

CORRELATION OF MAP UNITS



INTRODUCTION

The geologic map of the Orofino West quadrangle is based largely on field work completed by Davidson in 1987 and 1988 and by Kauffman, Lewis, and Burmester in 2001. The work by Davidson (1990) was part of an $^{40}Ar/^{39}Ar$ thermochronologic and mapping study. Mapping of the prebasalt basement was supplemented with work by Hietanen (1962), Kopp (1959), and Shea (1970) and with reconnaissance mapping by Paul E. Myers (written commun., 1999) along the Clearwater River. Basalt mapping relied extensively on reconnaissance mapping and sampling in the area from 1978 to 1980 (Camp, 1981; Swanson and others, 1979a). Much of the surficial geology is from Othberg and others (2002).

Basalt units were identified using hand sample characteristics, paleomagnetic signatures, geochemical signatures, and data from previous work. Representative samples of most basalt units were collected for analysis. These samples supplemented previous ones collected by V.E. Camp (written commun., 2002). Our sample locations and those of Camp are identified on the map. Analytical results are listed in Table 1. Samples were analyzed at Washington State University's GeoAnalytical Laboratory. Intrusive rocks are classified according to IUGS nomenclature using normalized values of modal quartz (Q), alkali feldspar (A) and plagioclase (P) on a ternary diagram (Streckeisen, 1976). Mineral modifiers are listed in increasing order of abundance for both igneous and metamorphic rocks.

DESCRIPTION OF MAP UNITS

QUATERNARY DEPOSITS

Qal **Alluvial deposits (Holocene)**—Mostly stream alluvium but may include some slope-wash and fan deposits. Primarily coarse channel gravels deposited during high-energy stream flow. Subrounded to rounded pebbles, cobbles, and boulders in a sand matrix. Moderately stratified and sorted. Includes intercalated colluvium and debris-flow deposits from steep side slopes.

Qaf **Alluvial fan deposits (Holocene)**—Poorly stratified, poorly sorted gravel in a matrix of granules, sand, silt, and clay. Gravel is composed of subangular pebbles, cobbles, and boulders. Fans form in canyon bottoms at the mouths of small tributaries to the major streams, many of which are steep debris-flow chutes.

Qls **Landslide and slump deposits (Pleistocene and Holocene)**—Poorly sorted and poorly stratified angular basalt fragments mixed with silt and clay. Landslide deposits include debris slides as well as blocks of basalt and sedimentary interbeds that have been rotated and moved downslope. Commonly form as a result of slumping of Latah Formation sediments.

Qag **Alluvial gravel (Pleistocene)**—Well-rounded pebble and cobble gravel of remnant point bars whose upper surface is about 80 to 100 feet above the Clearwater River. The gravel was deposited by the ancestral Clearwater River before the latest Lake Missoula Floods.

TERTIARY SEDIMENTS

Latah Formation

Tli **Latah Formation, sedimentary interbeds (Miocene)**—Sediment interbedded with basalt flows. Deposits include pebbles, cobbles, and clay, but typically consist of sand; locally contains tuff or arkosic tuff. Stratigraphically equivalent to the Ellensburg Formation in the Columbia Plateau in Washington (Swanson and others, 1979b).

COLUMBIA RIVER BASALT GROUP

The stratigraphic nomenclature for the Columbia River Basalt Group follows that of Swanson and others (1979b) and used in Reidel and Hooper (1989). In Idaho, the group is divided into four formations. From oldest to youngest, these are the Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Imnaha Basalt flows are exposed in the northern and western parts of the quadrangle above the Clearwater River and on the slopes of Big Canyon and Little Canyon creeks. Grande Ronde Basalt has been subdivided, from oldest to youngest, into the informal R_1, N_1, R_2, and N_2 magnetostratigraphic units (Swanson and others, 1979b). No basalts from the R_2 or N_2 units were identified in the map area. Exposures of the R_1 and N_1 Grande Ronde units occur along the canyon walls of Big Canyon and Little Canyon creeks and their tributaries and on the slopes above the Clearwater River. No Wanapum Basalt units were found in the quadrangle. Saddle Mountains Basalt units, from oldest to youngest, are undivided flows of the Asotin Member and Wilbur Creek Member and the basalt of Weippe. The undivided Asotin and Wilbur Creek unit is restricted to the northeast part of the map where it underlies the basalt of Weippe and overlies Grande Ronde N_1 basalt. The basalt of Weippe forms the capping unit over most of the upland surface. Interbedded within the basalt sequence are sediments of the Latah Formation.

Saddle Mountains Basalt

Twe **Basalt of Weippe (Miocene)**—Medium- to coarse-grained basalt with scattered to common plagioclase phenocrysts 2-5 mm long; abundant olivine crystals and clots generally visible to the naked eye. Reverse magnetic polarity, although field magnetometer readings are commonly conflicting and weak. Similar chemically to Pomona Member near Lewiston (Swanson and others, 1979a) and included in the Pomona Member by Camp (1981). Kauffman (2004) suggests the two units may not be coeval on the basis of paleomagnetic directions, although an age determination for the Weippe (12.9 ± 0.8 Ma; Kauffman, 2004) is not significantly different from the 12 Ma age reported for the Pomona Member by McKee and others (1977). Consists of one flow 50-100 feet thick. Forms the capping unit over much of the quadrangle and directly overlies either Grande Ronde N_1 Basalt or undivided flows of the Asotin Member and Wilbur Creek Member (*Taw*) depending on location.

Taw **Asotin Member and Wilbur Creek Member, undivided (Miocene)**—Fine-grained basalt with scattered plagioclase phenocrysts 1-5 mm long and a few olivine phenocrysts 1-3 mm in diameter. Upper part of flows commonly has abundant small spherical vesicles with a pale bluish lining. Both units have normal magnetic polarity. Consists of one or two flows with a total thickness of 100 to 200 feet. Restricted to the northeastern part of the quadrangle where the unit overlies Grande Ronde Basalt. Three sampled outcrops, two near the top of the Gilbert Grade and the other in a canyon to the northwest of the grade, have Asotin chemistry. Approximately 1 mile to the southwest of the sampled outcrops, the unit is absent, and the basalt of Weippe directly overlies Grande Ronde N_1 Basalt.

Grande Ronde Basalt

Tgn_1 **Grande Ronde, N_1 magnetostratigraphic unit (Miocene)**—Mostly fine-grained, dark gray to black, aphyric to plagioclase-microphyric basalt. Uppermost flows, however, are usually medium gray, medium grained, with plagioclase phenocrysts 2-5 mm long, or fine grained but with sugary texture and diktytaxitic in places. Normal magnetic polarity. Flows range in thickness from about 50 feet to several hundred feet. Thin flows are characterized by large stocky columns grading upward into vesicular flow tops commonly with crude columnar structure. Thick flows have a lower colonnade with columns 2-5 feet in diameter, and above that an abrupt change to a blocky, hackly thick entablature that becomes vesicular near the top. Entablature of one flow or series of flows forms cliffs along upper canyon walls. Locally a saprolite is developed on top of the N_1. Probably consists of four to six flows with a total thickness of about 500 feet.

Tgr_1 **Grande Ronde, R_1 magnetostratigraphic unit (Miocene)**—Typically dense, dark gray to black, fine- to very fine-grained aphyric to microphyric basalt. Less commonly medium-grained with scattered small plagioclase phenocrysts. Reverse magnetic polarity. Field magnetometer readings commonly inconsistent and weak, especially in flows near the R_1-N_1 contact; therefore, the mapped contact is within this stratigraphic zone of inconsistent magnetometer readings. Outcrop characteristics are similar to N_1 flows. Number of flows estimated at four to six. Thickness in Big Canyon and Little Canyon creeks is about 600 feet. Locally contains massive arkosic tuffaceous unit or sedimentary interbeds of the Latah Formation within or near the top of the sequence. Interbeds range from less than 10 to more than 60 feet thick and consist mostly of arkosic sand and silt but commonly contain zones of both quartz and quartzite pebbles. Interbeds are mapped (*Tli*) where exposed or indicated by sand grains in soils.

Tim **Imnaha Basalt (Miocene)**—Medium- to coarse-grained, sparsely to abundantly plagioclase-phyric to glomerophyric basalt; olivine common; plagioclase phenocrysts as large as 1 cm in length common; glomerocrysts as large as 3 cm in diameter are less common. Flows examined have normal polarity. Outcrops typically deeply weathered or degraded commonly forming grus-like detritus. Outcrops of fresh basalt are characterized by well-formed columns 1 to 3 feet in diameter and commonly fanning or radiating.

INTRUSIVE ROCKS

KJbtg **Biotite tonalite gneiss (Jurassic or Cretaceous)**—Fine- to medium-grained, well-foliated biotite tonalite gneiss. Contains 5-10 percent biotite and 1-5 percent epidote. Locally muscovite-bearing. Accessory allanite cores in some epidote grains. Epidote is conspicuous in hand specimens, and at least some is likely primary. Initial $^{87}Sr/^{86}Sr$ value is low (0.7037; Criss and Fleck, 1987) and is shown accompanying the sample number on the map. A muscovite $^{40}Ar/^{39}Ar$ plateau of 72.1 ± 0.3 Ma was obtained from muscovite tonalite northwest of Orofino (Table 2); it represents a cooling age (minimum age).

KJqdg **Quartz diorite gneiss (Jurassic or Cretaceous)**—Medium-grained, equigranular, well-foliated quartz diorite gneiss. Unit is deformed equivalent of *KJqd*. Contains 8-10 percent hornblende, 4-12 percent biotite, 1-2 percent epidote, and 1 percent apatite. This unit and the *KJbtg* unit are mapped in part on fabric and define the extent of the Orofino shear zone.

KJqd **Quartz diorite (Jurassic or Cretaceous)**—Medium- to coarse-grained, equigranular, massive to foliated biotite-hornblende quartz diorite. Contains minor amounts of epidote and apatite.

KJdg **Diorite and gabbro (Jurassic or Cretaceous)**—Hornblende-rich diorite and gabbro. Primarily medium- to coarse-grained hornblende-plagioclase rocks with minor quartz. Includes small amounts of quartz diorite and hornblende gneiss (*Mzgo*?). See Hietanen (1962) for detailed descriptions.

OROFINO SERIES

Amphibolite-facies metasedimentary (and metavolcanic?) rocks first recognized near Orofino (Anderson, 1930; Hietanen, 1962). Commonly sulfide-rich with iron-stained exteriors. Lithologically varied at outcrop scale. Includes marble commonly associated with dark gray, fine-grained, garnet-diopside-hornblende gneiss of fairly uniform appearance. These metamorphic rocks appear to belong to the Wallowa accreted terrane assemblage, but they straddle the initial $^{87}Sr/^{86}Sr$ 0.704-0.706 line (Criss and Fleck, 1987) from Orofino to Kooskia. May be equivalent to parts of the Riggins Group (upper part of Squaw Creek schist?) exposed 100 km to the south and described by Hamilton (1963).

Mzao **Amphibolite (Mesozoic)**—Foliated or lineated plagioclase-hornblende rocks with less than 10 percent quartz. Locally contain garnet and biotite. Probably metaigneous rocks (metamorphosed mafic sills or lava flows). Described in more detail by Hietanen (1962). A hornblende $^{40}Ar/^{39}Ar$ plateau of 79.4 ± 0.5 Ma was obtained from the large amphibolite body north of Orofino (Table 2); it represents a cooling age (minimum age).

Mzgo **Hornblende gneiss (Mesozoic)**—Fine- to medium-grained hornblende gneiss that grades into biotite and muscovite-biotite gneiss and schist. Includes minor amounts of diopside-bearing calc-silicate rocks. Sample of biotite-quartz-plagioclase schist sampled by R. Fleck (personal commun., 2002; Criss and Fleck, 1987; sample 837-24F) has an initial $^{87}Sr/^{86}Sr$ ratio of 0.7048 calculated at 80 Ma; value is shown accompanying the sample number on the map. A muscovite $^{40}Ar/^{39}Ar$ plateau of 74.6 ± 0.2 Ma was obtained from a muscovite-biotite schist layer within the hornblende gneiss unit (Table 2).

Mzco **Calc-silicate rocks (Mesozoic)**—Calc-silicate gneiss and granofels containing various amounts of diopside, epidote, zoisite, clinozoisite, scapolite, calcite, amphibole, garnet, quartz, plagioclase, biotite, and wollastonite. Wide range of layering thickness and grain size; some very fine to medium grained and thinly layered (millimeter to centimeter scale); others coarse grained (skarnlike) and thickly layered (decimeter to meter scale). Hietanen (1962) reported An_{37-40} plagioclase compositions. The garnet is locally abundant, as much as half the rock, light brownish red, and mainly grossularite (Hietanen, 1962). Small grains of graphite rare.

Mzmo **Marble (Mesozoic)**—Tan-weathering, white to light bluish gray graphitic marble in discontinuous lenses. Layers are decimeter to meter scale, concentrated in sections as much as 20 m thick. Most layers are pure calcite (grains 0.5-5 mm in diameter) with only a few small grains of pyrite, tremolite, diopside, quartz, and sphene (Hietanen, 1962). Kopp (1959) reported plagioclase, mica, and graphite.

Mzqo **Quartzite (Mesozoic)**—Small exposure of biotite-plagioclase quartzite southwest of the Clearwater River in the eastern part of map. Contains about 10 percent biotite and 30 percent plagioclase.

Mzso **Muscovite-biotite schist (Mesozoic)**—Small area of poorly exposed muscovite-biotite schist near the eastern edge of the map, north of Orofino.

MAJOR STRUCTURAL FEATURES

The Ahsahka thrust of Davidson (1990), exposed west of Ahsahka, immediately north of the map area, marks a major change in deformational style, metamorphic grade, and $^{40}Ar/^{39}Ar$ ages in the region. Although poorly exposed in the Orofino West quadrangle, it forms the southwest margin of the northwest-striking Orofino shear zone (Payne and McClelland, 2002; Payne, 2004), a 6 km-wide, northeast-dipping, ductile (gneissic) shear zone from Orofino southeast to the Kooskia area. Mesozoic rocks southwest of the shear zone lack the pervasive gneissic foliation but are cut by numerous northeast-dipping ductile shear zones. To the north, the Ahsahka thrust is characterized by an approximately 250 m-wide zone of moderately to steeply northeast-dipping banded gneiss consisting of both mafic hornblende-rich bands and more felsic tonalite bands (Davidson, 1990). Rocks of the Ahsahka thrust and the Orofino shear zone are pervasively foliated to form mylonite gneiss, much of which is relatively coarse grained and probably recrystallized (blastomylonite). Lineations are only locally developed in the Orofino area (Davidson, 1990). Consistent offsets of late-stage pegmatite dikes across amphibolite bands provide evidence for NE over SW sense of shear (thrusting) in the shear zone.

SYMBOLS

Contact: approximately located.

Thrust fault: teeth on upper plate; approximately located; dotted where concealed.

52 Strike and dip of foliation.

Strike of vertical foliation.

80 Strike and dip of mylonitic foliation.

65 Bearing and plunge of lineation, type unknown.

Mylonite.

02RL802 Sample location and number.

0.7034 Initial $^{87}Sr/^{86}Sr$ ratio (from Criss and Fleck, 1987).

Gneissic foliation (cross section only).

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Table 1. Major oxide and trace element chemistry of basalt samples collected in the Orofino West quadrangle

Sample number	Latitude	Longitude	Unit name	Map unit	Major elements in weight percent										Trace elements in parts per million																
					SiO_2	Al_2O_3	TiO_2	FeO*	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
01JK228	46.4256	-116.3559	Grande Ronde N_1	Tgn_1	55.58	14.43	2.286	10.79	0.173	7.99	3.86	1.34	3.16	0.391	7	29	35	386	713	31	344	177	44	10.6	23	7	132	10	19	63	6
01JK229	46.4232	-116.3405	Weippe	Twe	52.10	14.76	1.839	10.54	0.187	11.13	6.22	0.54	2.45	0.236	33	68	42	304	301	10	243	129	31	12.4	19	47	93	5	16	38	1
01JK232	46.4293	-116.3666	Weippe	Twe	51.74	14.50	1.814	10.92	0.198	10.94	6.69	0.55	2.42	0.234	32	67	39	315	315	12	243	128	30	12.6	19	50	89	3	22	53	1
01JK250	46.4558	-116.3466	Grande Ronde R_1	Tgr_1	54.38	13.92	2.171	12.02	0.184	7.99	4.40	1.40	3.19	0.336	21	46	39	336	510	35	317	178	38	13.5	18	68	108	7	33	47	5
01JK252	46.4374	-116.3164	Grande Ronde R_1	Tgr_1	54.39	14.07	2.163	11.68	0.198	8.14	4.32	1.59	3.10	0.338	15	41	34	332	557	39	331	182	38	13.1	20	57	107	13	19	42	8
01JK254	46.4405	-116.3164	Grande Ronde N_1?	Tgn_1	56.88	13.55	2.222	12.18	0.190	6.69	2.92	1.91	3.14	0.326	3	18	33	356	704	54	308	201	41	15.6	22	6	122	20	28	56	7
01JK255	46.4383	-116.3110	Grande Ronde N_1	Tgn_1	54.80	14.16	1.831	11.73	0.200	8.34	4.25	1.39	2.99	0.314	8	27	36	334	535	30	317	158	38	12.0	18	21	107	12	12	45	6
01JK257	46.4410	-116.3040	Weippe	Twe	51.65	14.66	1.825	11.09	0.190	10.87	6.46	0.54	2.48	0.240	31	66	30	300	275	11	237	129	30	12.8	19	48	88	6	19	26	4
01JK258	46.4408	-116.3048	Weippe	Twe	52.17	14.60	1.811	10.91	0.177	10.92	6.32	0.48	2.38	0.232	33	68	36	301	300	10	245	128	29	12.4	19	45	92	5	16	52	3
01JK260	46.4602	-116.3327	Grande Ronde N_1	Tgn_1	55.35	13.76	2.191	11.65	0.222	7.86	3.98	1.48	3.12	0.382	10	30	41	395	626	36	323	166	37	10.7	21	7	122	10	6	52	2
01JK261	46.4612	-116.3311	Weippe	Twe	51.65	14.38	1.818	11.32	0.191	10.71	6.64	0.56	2.50	0.241	34	62	41	288	263	10	234	129	30	13.7	19	47	89	3	31	43	0
01JK274	46.4649	-116.2963	Weippe	Twe	51.30	14.27	1.815	11.56	0.240	11.10	6.37	0.59	2.51	0.236	32	62	33	283	281	8	241	125	28	12.9	20	46	87	0	13	44	0
01JK278	46.4784	-116.3607	Grande Ronde N_1	Tgn_1	54.90	13.83	2.202	12.07	0.213	7.88	3.95	1.44	3.14	0.379	7	29	40	366	630	31	331	161	38	10.6	22	6	118	10	29	36	3
01JK279	46.4561	-116.2888	Weippe	Twe	51.76	14.50	1.814	11.12	0.191	10.96	6.32	0.58	2.51	0.243	35	66	39	291	452	11	247	123	30	13.5	19	47	91	7	30	34	4
01JK280	46.4431	-116.2879	Weippe	Twe	51.84	14.72	1.872	10.75	0.194	10.99	6.18	0.58	2.61	0.253	33	69	38	280	414	11	245	128	32	15.0	20	52	92	9	18	60	7
01JK284	46.4021	-116.2508	Weippe	Twe	51.70	14.55	1.862	11.10	0.191	10.79	6.42	0.59	2.54	0.247	31	65	42	299	288	12	230	129	31	14.0	21	48	92	9	7	44	5
01JK567	46.4732	-116.3060	Asotin	Taw	49.99	16.18	1.384	9.58	0.159	11.37	8.40	0.47	2.30	0.158	131	288	30	249	208	8	242	101	24	10.5	20	79	73	3	1	38	2
**VC78-321	46.4603	-116.2650	Grande Ronde N_1	Tgn_1	54.48	15.17	1.83	11.29	0.20	8.01	4.22	1.46	2.84	0.31																	
**VC78-323	46.4640	-116.2758	Grande Ronde N_1	Tgn_1	54.17	15.15	2.23	10.24	0.21	7.77	3.92	1.48	2.29	0.35																	
**VC78-324	46.4675	-116.2767	Asotin	Taw	50.31	16.79	1.33	7.47	0.17	10.87	8.24	0.38	2.07	0.17																	
**VC78-325	46.4692	-116.2783	Asotin	Taw	50.34	16.92	1.47	7.71	0.17	10.76	7.70	0.44	2.08	0.21																	
**VC78-326	46.4560	-116.3041	Weippe	Twe	51.30	15.43	1.80	9.15	0.20	10.71	6.14	0.50	2.33	0.24																	

* Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO.
** Samples collected by V. Camp in 1978. Analytical results used with permission (Camp, written commun., 2002).
All analyses performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

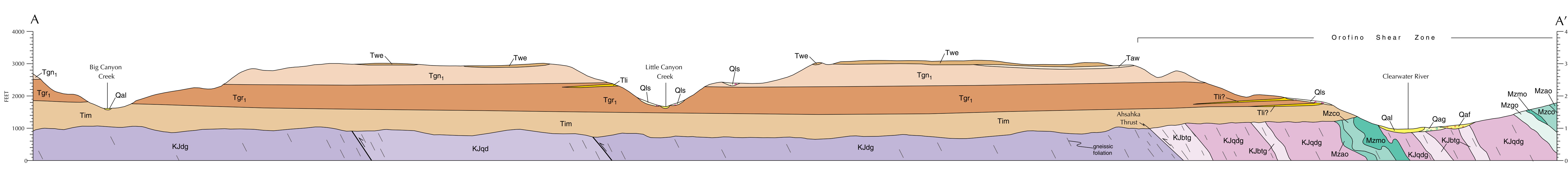

Table 2. $^{40}Ar/^{39}Ar$ plateau ages of prebasalt basement rocks in the Orofino West quadrangle

Sample number	Map unit	Rock name	Mineral	Age (Ma)	1 sigma (Ma)	Source
88-04	Mzao	Garnet amphibolite	Hornblende	79.4	0.5	Davidson (1990)
88-05	Mzgo	Muscovite-biotite schist	Muscovite	74.6	0.2	Davidson (1990)
JY3188-3	KJbtg	Muscovite tonalite	Muscovite	72.1	0.3	Davidson (1990)

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