Geologic Map of the Lewiston Orchards North Quadrangle and Part of the Clarkston Quadrangle, Nez Perce County, Idaho

Compiled and Mapped by
Dean L. Garwood and John H. Bush

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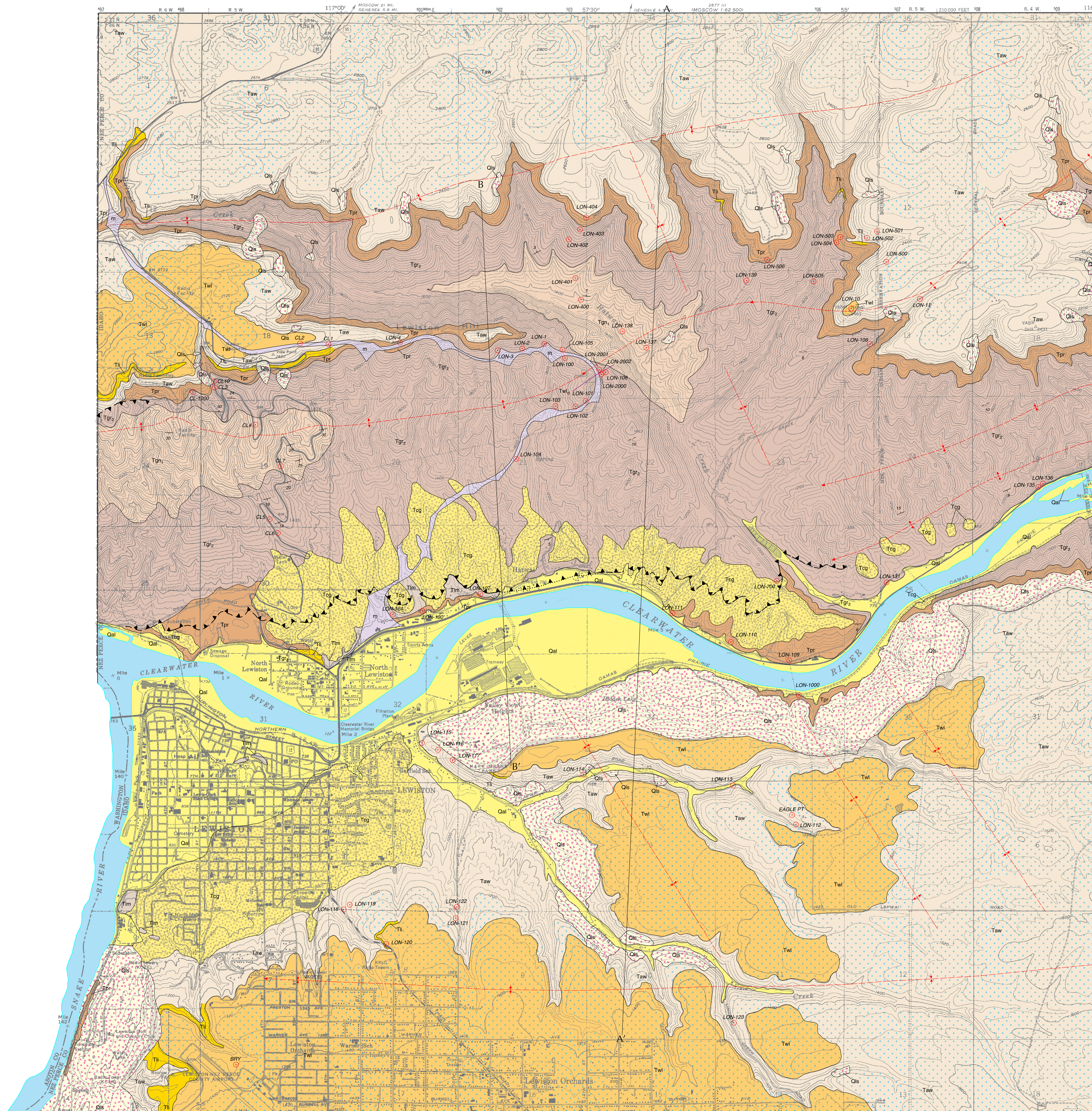

Base map from USGS digital raster graphic 1971 (Clarkston), 1972 (Lewiston Orchards North).

Topography by photogrammetric methods from aerial photographs taken 1966. Field checked 1967.

1927 North American Datum.

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

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

National geodetic vertical datum of 1929.

UTM Grid and 1971 Magnetic North Declination at Center of Map

SCALE 1:24,000

Contour interval 40 feet
Supplementary contour interval 20 feet

Field work conducted 2003.

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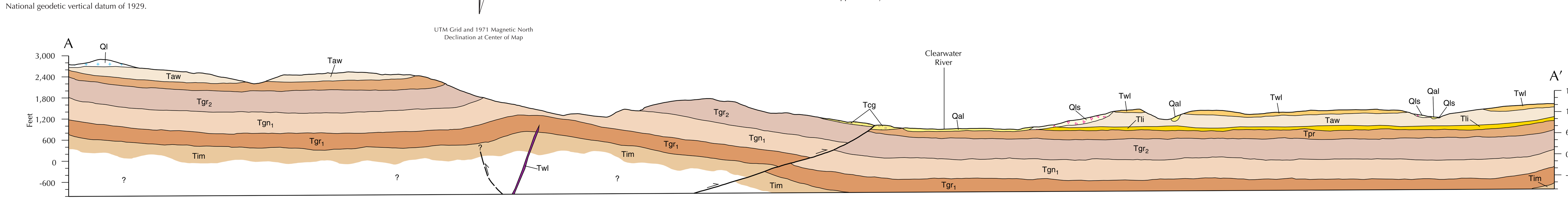
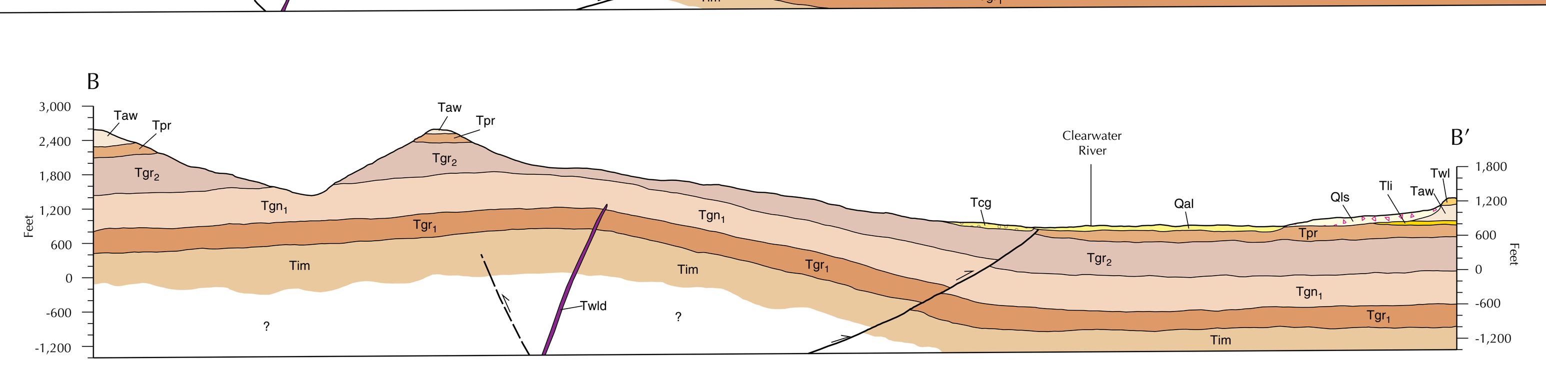
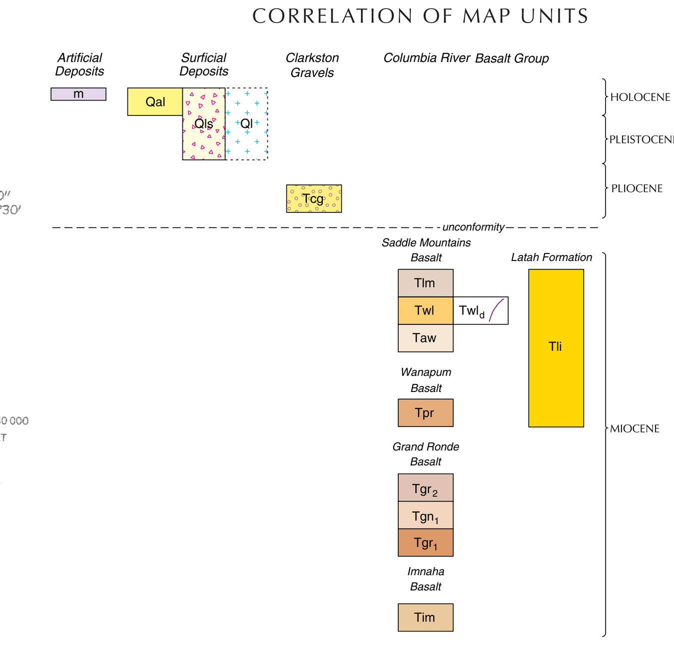
Digital cartography by Jesse S. Bird, Loudon R. Stanford and Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.

Map version 8-8-2005.





CORRELATION OF MAP UNITS



INTRODUCTION

The bedrock geologic map of the Lewiston Orchards North quadrangle and part of the Clarkston quadrangle represents a compilation of previous research and additional field work. Distribution of the loess of the Palouse Formation and some post-basalt gravel units are not illustrated in keeping with the emphasis on bedrock geology. However, alluvium, landslides, and Pliocene(?) Clearwater gravels are illustrated because their map patterns often help interpret bedrock structures. Continuous outcrops are not common and the contact lines are interpretive. Regional maps by Bond (1963), Newcomb (1970), Kehew (1976), Rember and Bennett (1979), Swanson and others (1979a; 1980), Hooper and others (1985), and Schuster (1993; 1997) were used in the compilation. In addition, maps of the "Lewiston structure" by Hollenbaugh (1959) and Camp (1976) were used for some details. The basalt chemistry was analyzed at the GeoAnalytical Laboratory at Washington State University (Table 1). Magnetic polarities were determined using a field fluxgate magnetometer and in places field readings were verified in the paleomagnetic laboratory of the Idaho Geological Survey.

STRUCTURE

Lewiston Hill, a prominent topographic feature on the Lewiston Orchards North quadrangle, is part of a doubly plunging east-west-trending anticline with an undulating crest. The high elevations and intervening low areas generally represent northwest-trending cross folds. Fold geometry is complicated by folding during extrusion of the basalt sequence and by the presence of later northwest-southeast-trending low-amplitude, long-wavelength cross folds. The northwest-southeast folds illustrated are rarely visible in the field and were delineated by detailed correlation of individual units over long distances and by interpretation of map patterns. The anticline is part of the "Lewiston structure" which includes associated faulting.

Researchers agree on the presence of the Lewiston Hill anticline but disagree on the nature of the associated faulting. On the Lewiston Orchards North quadrangle Camp (1976) and Swanson and others (1980) depicted a major east-west fault a few hundred feet below and to the south of the crest of the Lewiston Hill. Hooper and others (1985) show this fault across the eastern part of the Clarkston 15 minute quadrangle. We do not show this fault on the Lewiston Orchards North quadrangle because detailed mapping across the projected fault zone using geochemical, paleomagnetic, and stratigraphic methods demonstrates that stratigraphic offset is less than 25 feet. Breccias, slickensides and minor faults present in highway cuts in the Lewiston Hill area are interpreted to be related to anticlinal deformation and the intrusion of basalt of Lewiston Orchards dikes.

On the western edge of the map the east-west fault shown by Hooper and others (1985) is illustrated near the Idaho-Washington boundary in the northwestern part of section 9, T.11 N., R.6 W. Faulting plays a more important role and the structure is more complex as the units are traced westward into Washington.

The thrust fault on the north side of the Clearwater River is exposed in a small cut in the middle of section 26, T.26 N, R.5 W. At that locality basalt from the R2 magnetostratigraphic unit of the Grande Ronde overlies Clearwater gravels which are late Pliocene(?) in age (Hooper and others, 1985; Othberg and others, 2003). Kehew (1976) described a similar exposure approximately one mile to the west. The fault dips to the north between twenty-five and thirty degrees (see cross-section).

DESCRIPTION OF MAP UNITS

ARTIFICIAL DEPOSITS

m — **Made ground (Holocene)**—Artificial fills composed of excavated, transported, and emplaced construction materials typically derived locally. Most notable is the new Lewiston Hill segment of Highway 95.

QUATERNARY DEPOSITS

Qal — **Alluvium (Holocene)**—Stream, slope-wash, and debris-flow deposits. In the plateau areas, composition commonly consists of reworked loess or mixtures of loess and basalt. Downstream from the plateau edges, basalt comprises most of the deposits until the drainages reach lower elevations where the deposits include incorporated parts of postbasalt sediments. Compositions are highly variable at the lower elevations because of the influence of several different types of river, slope-wash, and catastrophic flood sediments common to the Lewiston basin area. Composition of the surficial sediments is locally influenced by erosion of nearby Latah sediments and postbasalt Tertiary sediments. Though dominated by basalt, the Clearwater River contains sediments with a high percentage of prebasalt lithologies, reflecting headwater erosion through and beyond the eastern edge of the Clearwater embayment. Othberg and others (2003) subdivide the alluvium into several units.

Qls — **Landslide deposits (Holocene and Pleistocene)**—Highly variable rock and soil masses ranging from slumped coherent blocks to earth flows. The map pattern of this unit was modified from Othberg and others (2003). Slump blocks consist primarily of intact and broken sections of basalt and interbed sediments. Earth flows mainly consist of unstratified, unsorted gravel rubble in a clayey matrix derived from liquified Sweetwater Creek sediments (Othberg and others, 2003). Location of landslides is controlled by stratigraphic position of sedimentary interbeds and the hydrogeologic regime. The largest landslides occur where valley incision has cut through the Saddle Mountains Basalt sequence exposing sedimentary interbeds to steep topography. The landslides are not considered to be relic features that are stable today (Othberg and others, 2003). The landslide debris can be highly unstable when modified, either because of natural changes in precipitation or artificial modifications such as cuts, fills, and changes in surface drainage and ground-water infiltration.

Ql — **Loess deposits (Holocene and Pleistocene)**—Silty and clayey loess of the Palouse Formation. Remnants of the Palouse hills occur in the north part of the quadrangle. The map pattern of this unit was taken from Othberg and others (2003).

TERTIARY SEDIMENTS

Tcg — **Clearwater Gravels (Pliocene?)**—Primarily mainstream channel gravel and sand deposits that form a highly dissected terrace. This unit was modified from Othberg and others (2003). Terrace surface remnants, from east to west, range from 1,080 feet to 1,050 feet in elevation; an alluvial fan facies forms remnant slopes graded to the terrace. Gravel clast lithologies, foreset cross-bedding, and cobble imbrication indicate a source and current direction similar to the present Clearwater River (Hooper and others, 1985; Othberg and others, 2003). The gravels and sands are more weathered than typical Quaternary deposits, showing yellow to brown iron oxides in the matrix, local cementation, and softening of some gravel clasts. Recent field observations by Othberg and others (2003) suggest a complex facies in this unit, reflecting interaction of mainstream and tributary sources. These deposits and their stratigraphic relationships are exposed uphill from the site described by Kuhns (1980), in the POE Asphalt gravel pit in North Lewiston, and three miles to the east in a gravel pit adjacent to Groundcovers, Inc. (Othberg and others, 2003). As described by Kehew (1977), Hooper and others (1985), and Othberg and others (2003), the Clearwater Gravel, and its downstream correlative Clarkston Heights Gravel, represent a major aggradational event in which an ancestral valley was filled to an elevation of about 1,150 feet.

Latah Formation

Several of the basalt units are separated by sediments that belong to the Latah Formation. In places, these sediments are laterally continuous but overall are too thin or too discontinuous to trace across the entire quadrangle. The sediments change thickness and composition over short distances. They tend to thicken in synclinal areas and are generally thin or absent in anticlinal areas. Rare exposures occur in recent roadcuts and quarries.

Tli — **Latah Formation sedimentary interbeds (Miocene)**—Clay, silt, sand, and gravel deposits that in places separate basalt flows. The most notable Latah unit is the Sweetwater Creek interbed of Bond (1963). The interbed overlies the uppermost Priest Rapids flow throughout most of the quadrangle. It is as much as 241 feet in thickness (unpublished well data) and consists of intercalated sand, silt, clay, and ash-rich strata with local gravel stringers. Gaylord and others (1989) describe the Sweetwater Creek interbed for the Lewiston basin and conclude that deposition resulted primarily from fluvial and mixed fluvial-lacustrine sedimentation. These sediments, along with the Wilbur Creek and Asotin flows of the Saddle Mountains Basalt, thicken westward toward the center of the Lewiston syncline and thin northward toward the Genesee quadrangle. Natural exposures of Latah sediments are rare and occur primarily in recent roadcuts and quarries. Therefore they are shown where exposed and not as continuous units. The Sweetwater Creek interbed shown in the cross section is based on well logs.

COLUMBIA RIVER BASALT GROUP

The stratigraphic nomenclature for the Columbia River Basalt Group is based on that presented by Swanson and others (1979b). In Idaho, the group is divided into four formations: from base upward, these are the Imnaha, Grande Ronde, Wanapum, and Saddle Mountains. Imnaha Basalt is not exposed on the quadrangle, but is interpreted to occur at depth as shown on the cross section. The Grande Ronde can be subdivided into four magnetostratigraphic units (Swanson and others, 1979b). Of these, only flows of the N_1 and R_2 Grande Ronde units are exposed in the map area. Grande Ronde R_1 flows are interpreted to underlie the area as shown in the cross section. The only Wanapum Basalt unit on the quadrangle is the Priest Rapids Member. Saddle Mountains Basalt units include undivided flows of the Asotin and Wilbur Creek members, the basalt of Lewiston Orchards of the Weissenfels Ridge Member, and the Lower Monumental Member. Chemistry, stratigraphic position, lateral tracing, and magnetic polarity were used to map the units in the field.

Saddle Mountains Basalt

Tlm — **Lower Monumental Member (Miocene)**—Dense, fine-grained basalt with microphenocrysts of olivine that are readily visible with a hand lens. The basalt has a normal magnetic polarity (Choiniere and Swanson, 1979) and has been isotopically dated at 6 Ma (McKee and others, 1977). Occurs as erosional remnants along the Snake and Clearwater rivers and was emplaced as a channel fill. Characterized by its generally consistent hackly entablature jointing.

Twl, Twl_d — **Basalt of Lewiston Orchards, Weissenfels Ridge Member (Miocene)**—Medium- to coarse-grained basalt with microphenocrysts of plagioclase and olivine in an intergranular groundmass with minor glass; remanent magnetic polarity is normal (Hooper and others,). This unit is generally considered to consist of one flow. However, Hooper and others (1985) suggested the possibility of a second flow on the Clarkston quadrangle.

Taw — **Asotin Member and Wilbur Creek Member, undivided (Miocene)**—Consists of fine- to coarse-grained basalt that is sparsely plagioclase phyric and has a normal magnetic polarity. Although not consistent, the basalt of the Asotin Member tends to be denser than that of the Wilbur Creek. The lowermost basalt, generally the Wilbur Creek, overlies the Sweetwater Creek interbed of Bond (1963). Outcrops of these two members dominate the exposures south of the Clearwater River. No feeder dikes have been identified (Schuster and others, 1997).

Reidel and Fecht (1987) have shown that flows from these two members locally mixed at the surface to form the Huntzinger flow in the Pasco basin, indicating nearly simultaneous eruption. Chemical analyses from this study supports this idea. Wilbur Creek flows generally have higher TiO_2 and lower MgO than Asotin flows. In the Lewiston basin, the Asotin overlies the Wilbur Creek, which contains an upper subunit called the basalt of Lapwai (Reidel and Fecht, 1987). Analyses from this study show a range of chemistry with "mixed" chemistry being the basalt of Lapwai. Most workers attempted to delineate between the Asotin and Wilbur Creek Members and correlate between outcrops (Swanson and others, 1979a; Swanson and others, 1980; and Hooper and others, 1985). Chemically, the two members can be distinguished (Camp and others, 1984). Where there are good outcrops the flows can be distinguished using stratigraphic and chemical data. However, the basalts in these members were emplaced over irregular surfaces and our research showed that they cannot be correlated from locality to locality as laterally continuous units over long distances.

Wanapum Basalt

Tpr — **Priest Rapids Member (Miocene)**—Medium- to coarse-grained basalt with microphenocrysts of plagioclase and olivine in a groundmass of intergranular pyroxene, ilmenite blades, and minor devitrified glass. Distinguished from overlying Saddle Mountains Basalt flows by its reverse polarity and distinctive chemistry (Table 1). This unit was previously identified and described by Wright and others (1973) and Swanson and others (1979a; 1980). Mapping of this unit east and northeast of the Lewiston Hill shows that it thickens and thins in relation to the folding in that area. Northeast of the hill and north of the steepest plunge of the fold, the Priest Rapids is more than two hundred feet thick, consists of two flows, and rests on a poorly developed saprolite atop thick R_2 flows of the Grande Ronde that have very large well-developed columns in thick units. In the Lewiston Hill area near the highest crest of the anticline, the Priest Rapids thins to less than 150 feet, consists of one flow, and overlies a well-developed saprolite atop R_2 flows that locally consist of thin flow units with small poorly developed columns. These changes in flow unit thickness and column configuration are interpreted to have been caused by thinning over the developing anticline in the Lewiston Hill area. The same Priest Rapids and R_2 flows were ponded and developed into thicker flow units in the area northeast of the crest, probably due to intersection of the east-west-trending anticline with a northwest-southeast-trending syncline.

Grande Ronde Basalt

Tgr_2 — **Grande Ronde, R_2 magnetostratigraphic unit (Miocene)**—Two to three fine-grained to very fine-grained reverse magnetic-polarity flows of Grande Ronde chemical type (Wright and others, 1973; Swanson and others, 1979a; Reidel and others, 1989). Locally, the uppermost basalt unit is abundantly plagioclase-microphyric. Our comparisons suggest that the uppermost unit correlates to the Meyer Ridge unit and the lower flows to the Wapshilla Ridge unit of Reidel and others (1989). The entire sequence is at least 600 feet in thickness. The R_2 flows in the map area form the uppermost surface of the Grande Ronde Basalt, which is deeply weathered to saprolite at most locations. Red flow tops are common.

Tgn_1 — **Grande Ronde, N_1 magnetostratigraphic unit (Miocene)**—Several fine-grained aphyric, normal magnetic polarity flows of Grande Ronde chemical type (Wright and others, 1973; Swanson and others, 1979a; Reidel and others, 1989). The unit is dominated by the intermediate to high MgO and relatively low TiO_2 flows described by Reidel and others (1989) and may correlate to their China Creek unit. The base of the unit is not exposed in the map area.

Tgr_1 — **Grande Ronde, R_1 magnetostratigraphic unit (Miocene)**—Typically dense, dark gray to black, fine- to very fine-grained aphyric to plagioclase-microphyric basalt. Reverse magnetic polarity. Not exposed in the map area. Described from deep water wells for Lewiston and shown on cross-sections.

Tim — **Imnaha Basalt (Miocene)**—Medium- to coarse-grained, sparsely to abundantly plagioclase-phyric basalt; olivine common; plagioclase phenocrysts and glomerocrysts as large as 3 cm not uncommon. Not exposed in the map area. Estimated position and thickness shown on cross-sections.

Table 1. Major oxide and trace element chemistry of basalt samples collected on the Lewiston Orchards North and Clarkston quadrangles.

Sample number	Latitude	Longitude	Unit name	Map unit	Normalized major elements in weight percent										Unnormalized 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
BRY	46.38124	-117.01616	Lewiston Orchards	Twl	49.68	14.35	2.543	12.15	0.190	11.41	6.24	0.44	2.41	0.589	49	259	44	323	499	8	242	184	44	20.5	21	50	121	3	15	74	1
CL1	46.46259	-117.00107	Asotin	Taw	50.58	16.04	1.413	9.16	0.156	11.41	8.23	0.51	2.33	0.167	130	284	35	251	156	8	242	105	24	11.5	19	92	75	4	6	44	1
CL2	46.46269	-117.00573	Lewiston Orchards	Twl	49.49	15.08	2.170	10.84	0.205	11.13	7.71	0.40	2.47	0.507	74	269	39	274	382	3	249	153	37	19.9	16	50	103	6	13	59	3
CL3	46.4577	-117.01966	Grande Ronde R_2	Tgr_2	55.43	13.86	2.554	11.97	0.192	7.33	3.26	1.86	3.08	0.466	2	27	24	386	890	48	323	191	40	14.8	21	20	132	10	31	65	5
CL4	46.4535	-117.01301	Grande Ronde N_1	Tgn_1	55.49	14.00	2.001	10.95	0.215	7.96	4.19	1.51	3.32	0.375	5	32	35	387	529	32	329	164	39	12.3	22	42	127	8	13	41	4
CL5	46.44284	-117.01068	Grande Ronde R_2	Tgr_2	55.51	13.70	2.452	12.13	0.197	6.93	3.33	2.12	3.18	0.463	8	21	30	367	753	53	313	204	40	13.4	20	28	132	9	21	63	7
CL6	46.44128	-117.00934	Grande Ronde R_2	Tgr_2	55.04	13.77	2.350	11.99	0.214	7.53	3.68	1.77	3.20	0.458	17	28	36	378	699	42	322	183	40	13.1	20	43	133	7	25	50	6
CL7	46.44881	-117.00884	Grande Ronde N_1	Tgn_1	54.38	13.79	2.304	12.38	0.216	8.00	3.95	1.46	3.09	0.439	8	37	34	380	574	35	338	163	40	12.2	21	28	129	8	13	58	5
CL10	46.45839	-117.0198	Grande Ronde R_2	Tgr_2	53.56	14.31	1.725	11.66	0.194	9.12	5.13	1.20	2.83	0.276	22	84	35	316	481	28	304	140	39	11.7	20	57	105	3	25	41	4
CL-1000	46.45721	-117.02319	Grande Ronde R_2	Tgr_2	53.80	14.80	1.649	9.90	0.178	9.96	5.54	0.95	2.96	0.263	38	128	40	309	469	16	307	131	31	10.9	20	66	100	3	16	24	5
LON-1	46.46273	-116.96586	Grande Ronde R_2	Tgr_2	56.67	13.91	2.374	10.73	0.185	7.13	3.31	1.82	3.42	0.462	0	18	37	354	688	46	332	194	44	15.3	24	10	134	5	20	59	8
LON-2	46.46303	-116.9689	Grande Ronde R_2	Tgr_2	55.35	13.79	2.532	11.81	†0.35	7.07	3.48	1.72	3.42	0.469	8	18	40	399	665	45	307	186	44	14.2	18	19	127	7	27	55	5
LON-3	46.46283	-116.97357	Grande Ronde R_2	Tgr_2	54.89	14.37	1.760	10.62	0.184	8.70	4.96	1.15	3.08	0.285	20	76	44	329	437	29	286	142	33	11.7	22	56	106	3	22	37	5
LON-4	46.46269	-116.98898	Priest Rapids	Tpr	50.70	13.62	3.232	13.13	0.238	9.18	5.20	1.10	2.82	0.783	30	91	41	363	488	25	283	179	46	17.1	20	27	137	1	1	63	3
LON-10	46.46659	-116.9156	Lewiston Orchards	Twl	48.71	15.09	2.211	12.19	0.200	11.38	6.83	0.44	2.44	0.514	77	266	37	288	452	6	254	156	34	18.7	18	49	101	2	14	52	2
LON-11	46.46767	-116.90436	Asotin	Taw	50.08	16.20	1.422	9.45	0.156	11.37	8.31	0.54	2.30	0.180	123	291	33	246	231	8	243	104	24	10.6	18	76	76	3	19	25	5
LON-100	46.46195	-116.96162	Grande Ronde R_2	Tgr_2	55.16	13.89	2.004	11.54	0.222	7.95	4.21	1.47	3.15	0.392	2	31	35	387	607	35	331	163	41	12.7	22	52	129	4	18	53	6
LON-101	46.45677	-116.96007	Grande Ronde R_2	Tgr_2	55.17	13.74	2.077	12.23	0.184	7.35	4.19	1.40	3.32	0.335	0	30	32	353	535	37	312	163	33	12.7	21	6	122	3	18	34	7
LON-102	46.45614	-116.96169	Grande Ronde R_2	Tgr_2	54.96	14.44	1.721	10.64	0.177	8.78	4.89	1.11	3.02	0.260	4	33	36	300	417	27	330	143	30	11.0	21	30	105	5	14	38	1
LON-103	46.45545	-116.96402	Grande Ronde R_2	Tgr_2	54.98	13.84	2.018	12.12	0.220	7.88	4.07	1.35	3.14	0.392	1	32	38	366	577	38	334	165	41	12.9	23	48	124	6	26	44	6
LON-104	46.44973	-116.97032	Grande Ronde R_2	Tgr_2	54.62	13.64	2.126	12.78	0.208	7.49	4.12	1.33	3.32	0.362	0	30	35	349	514	34	311	160	36	12.5	24	10	121	6	11	44	6
LON-105	46.46234	-116.96205	Grande Ronde R_2	Tgr_2	54.73	13.86	2.162	12.01	0.202	8.06	4.26	1.32	3.03	0.360	2	33	34	362	507	34	325	160	37	12.9	21	11	120	6	9	43	5
LON-106	46.45936	-116.95625	Grande Ronde R_2	Tgr_2	55.99	14.37	2.118	9.81	0.191	8.17	4.15	1.66	3.14	0.404	5	29	33	333	590	42	342	165	36	13.5	22	23	121	2	31	37	5
LON-107	46.43439	-116.97625	Lower Monumental	Tlm	50.39	13.70	2.976	14.13	0.226	8.70	4.99	1.46	2.77	0.657	6	36	23	329	477	32	346	180	35	27.9	20	7	136	3	44	82	5
LON-108	46.46259	-116.91256	Grande Ronde R_2	Tgr_2	54.98	13.80	2.540	12.13	0.197	7.31	3.63	1.82	3.14	0.458	6	29	26	404	678	47	318	185	40	14.7	21	15	131	12	25	50	8
LON-109	46.42686	-116.92578	Priest Rapids	Tpr	50.07	13.40	3.239	13.77	0.236	9.16	5.40	1.12	2.80	0.797	36	104	40	373	448	27	280	196	45	16.7	21	43	138	7	5	53	0
LON-110	46.42896	-116.93532	Priest Rapids	Tpr	49.74	13.44	3.199	14.05	0.239	9.21	5.33	1.24	2.77	0.794	36	106	42	370	437	27	285	187	45	16.7	19	39	136	1	8	57	3
LON-111	46.43219	-116.94487	Priest Rapids	Tpr	50.37	13.53	3.276	13.55	0.235	9.34	5.03	1.08	2.78	0.808	32	106	48	372	713	31	305	185	45	16.6	22	43	138	7	15	61	8
LON-112	46.40834	-116.92472	Asotin	Taw	50.11	16.13	1.420	9.46	0.160	11.31	8.28	0.49	2.46	0.176	124	280	29	244	191	12	241	107	22	11.1	18	87	80	5	3	30	0
LON-113	46.41274	-116.93497	Lapwai	Taw	52.83	14.96	1.729	10.59	0.164	9.41	5.82	1.35	2.74	0.404	61	119	32	280	615	28	268	201	37	15.0	19	44	104	11	21	69	1
LON-114	46.41401	-116.95943	Wilbur Creek	Taw	53.56	14.55	1.847	11.16	0.166	8.79	4.94	1.59	2.91	0.477	40	72	31	276	755	36	281	228	41	17.6	22	35	117	10	38	50	8
LON-115	46.41757	-116.9858	Asotin	Taw	51.32	16.73	1.492	8.99	0.155	11.77	6.50	0.43	2.42	0.192	124	281	35	257	261	11	262	110	26	10.9	17	80	78	6	40	40	13
LON-116	46.41679	-116.98318	Asotin	Taw	50.53	16.06	1.518	9.49	0.155	11.14	7.75	0.67	2.48	0.210	116	245	31	254	227	14	250	121	26	11.0	18	84	78	3	8	24	7
LON-117	46.41562	-116.98078	Asotin	Taw	50.44	16.25	1.461	9.43	0.152	11.43	7.76	0.42	2.47	0.185	113	277	30	257	219	8	246	108	24	9.9	15	75	80	1	12	36	10
LON-118	46.39876	-116.99859	Wilbur Creek	Taw	55.31	15.06	1.976	9.69	0.160	8.79	3.87	1.73	2.86	0.539	23	44	36	295	1005	44	309	255	44	18.4	20	25	126	12	40	73	1
LON-119	46.3993	-116.9976	Asotin	Taw	50.72	16.51	1.461	9.67	0.150	11.48	7.11	0.37	2.34	0.187	113	277	38	255	542	7	278	112	27	9.7	18	160	74	1	9	33	0
LON-120	46.39485	-116.99167	Lewiston Orchards	Twl	49.41	14.30	2.542	12.00	0.198	11.25	6.77	0.57	2.37	0.590	62	259	39	319	376	10	243	185	42	21.1	19	72	116	4	14	71	1
LON-121	46.39778	-116.98028	Asotin	Taw	49.75	16.18	1.441	10.03	0.158	11.33	8.23	0.36	2.34	0.184	122	280	31	255	206	4	252	108	25	9.5	19	64	80	0	13	28	2
LON-122	46.39905	-116.98014	Asotin	Taw	50.19	16.20	1.442	9.56	0.153	11.37	8.09	0.50	2.30	0.183	128	278	35	246	222	10	255	109	26	10.0	19	92	81	0	8	27	2
LON-123	46.38595	-116.9349	Lapwai	Taw	52.32	14.89	1.712	11.13	0.168	9.49	6.05	1.25	2.60	0.389	67	129	28	251	580	28	265	192	37	14.5	19	50	106	6	34	64	4
LON-124	46.43209	-116.99053	Lower Monumental	Tlm	50.30	13.85	2.982	13.74	0.228	8.83	5.11	1.55	2.74	0.674	16	40	36	325	487	33	347	181	36	26.0	22	18	139	5	21	69	6
LON-130	46.43248	-116.98573	Priest Rapids	Tpr	50.20	13.66	3.297	13.28	0.230	9.41	5.38	1.21	2.52	0.800	39	102	36	361	489	24	289	181	47	15.2	20	46	144	1	30	58	3
LON-131	46.43566	-116.90988	Grande Ronde R_2	Tgr_2	53.84	14.29	1.777	11.32	†0.25	8.71	5.36	1.16	3.00	0.284	24	79	41	323	473	28	294	143	33	11.1	19	64	108	3	15	38	6
LON-400	46.46762	-116.95978	Grande Ronde N_1	Tgn_1	56.30	13.99	2.104	11.06	0.198	7.51	3.74	1.61	3.15	0.335	8	22	28	349	668	40	324	187	41	13.3	23	34	126	7	10	53	4
LON-401	46.47007	-116.9607	Grande Ronde N_1	Tgn_1	54.65	13.68	2.225	12.41	0.216	7.77	3.89	1.76	3.00	0.410	8	36	40	388	582	38	309	159	37	10.8	21	30	121	7	23	62	7
LON-402	46.47442	-116.96176	Grande Ronde R_2	Tgr_2	55.97	13.83	2.402	11.20	0.213	7.17	3.43	2.09	3.22	0.487	6	24	30	347	766	48	323	196	43	13.5	24	24	143	7	18	55	6
LON-403	46.47554	-116.95992	Grande Ronde R_2	Tgr_2	53.77	14.37	1.789	10.91	0.232	9.32	5.14	1.21	2.94	0.302	27	85	36	322	517	25	304	142	34	10.1	17	60	109	1	20	48	6
LON-404	46.47691	-116.95893	Priest Rapids	Tpr	49.98	13.64	3.259	13.55	0.241	9.38	5.35	1.20	2.61	0.791	38	105	39	371	554	26	293	179	45	15.1	23	45	141	5	28	68	7
LON-500	46.47187	-116.90988	Asotin	Taw	50.79	16.64	1.422	8.80	0.156	11.49	7.70	0.48	2.34	0.181	127	288	21	241	249	9	250	106	25	10.0	20	80	80	0	12	26	3
LON-501	46.47529	-116.91136	Asotin	Taw	50.37	16.34	1.502	9.30	0.160	11.36	7.94	0.47	2.35	0.200	119	275	31	242	243	7	248	113	26	9.6	18	79	83	4	24	47	3
LON-502	46.47456	-116.91299	Asotin	Taw	50.34	16.22	1.483	9.41	0.161	11.14	8.12	0.61	2.32	0.197	121	256	29	256	257	10	245	114	27	9.1	18	86	85	3	13	18	2
LON-503	46.47466	-116.91737	Priest Rapids	Tpr	50.19	13.49	3.278	13.53	0.241	9.24	5.38	1.22	2.65	0.793	39	105	35	374	528	26	287	181	45	15.7	19	38	144	2	19	48	5
LON-504	46.47407	-116.918	Priest Rapids	Tpr	50.30	13.63	3.262	13.24	0.245	9.36	5.33	1.23	2.63	0.783	44	107	36	376	554	25	288	180	46	14.9	22	52	140	4	27	53	4
LON-505	46.46967	-116.92175	Grande Ronde R_2	Tgr_2	55.22	14.11	1.869	11.18	0.221	8.33	4.37	1.35	3.03	0.321	6	30	32	337	507	30	316	151	36	11.1	21	40	116	3	14	58	5
LON-506	46.47212	-116.92932	Priest Rapids	Tpr	50.27	13.49	3.291	13.42	0.235	9.26	5.34	1.25	2.61	0.833	38	101	35	374	533	25	283	188	47	15.9	24	33	144	3	28	63	3
LON-135	46.44641	-116.88506	Grande Ronde R_2	Tgr_2	56.25	14.36	2.083	9.67	0.207	8.09	4.18	1.56	3.21	0.393	9	34	43	405	611	34	336	166	41	10.9	23	59	131	3	19	47	3
LON-136	46.4468	-116.88429	Grande Ronde R_2	Tgr_2	55.11	13.99	2.026	11.36	0.216	8.10	4.31	1.45	3.06	0.371	9	29	36	359	549	38	307	152	35	11.2	22	29	123	8	10	47	4
LON-137	46.4622	-116.94911	Grande Ronde R_2	Tgn1	56.64	13.88	2.078	10.83	0.198	7.47	3.70	1.78	3.08	0.333	6	22	34	356	627	40	310	185	40	12.4	22	34	129	6	29	50	3
LON-138	46.46405	-116.953	Grande Ronde R_2	Tgn1	56.26	13.83	2.090	10.94	0.194	7.73	3.89	1.64	3.13	0.296	9	27	31	336	584	42	306	175	35	11.0	20	39	124	10	19	54	5
LON-139	46.46977	-116.93271	Grande Ronde R_2	Tgr_2	54.58	14.59	1.811	9.86	0.207	9.31	5.12	1.28	2.95	0.295	22	84	34	330	504	26	306	142	34	10.4	20	64	111	5	33	48	3
LON-700	46.43585	-116.92705	Grande Ronde R_2	Tgr_2	55.04	14.19	2.054	11.29	0.204	8.15	4.12	1.38	3.22	0.375	11	32	31	353	604	31	320	155	37	10.5	22	31	122	5	18	50	3
LON-1000	46.42295	-116.92423	Priest Rapids	Tpr	49.79	13.28	3.218	14.10	0.241	9.13	5.72	1.12	2.61	0.780	47	105	44	380	502	24	278	179	45	15.1	22	42	134	5	24	52	3
LON-2000	46.45863	-116.95726	Lewiston Orchards dike	Twld	49.74	14.25	2.687	11.82	0.190	11.14	6.69	0.65	2.23	0.611	55	225	43	352	435	12	247	190	43	21.7	19	59	118	5	22	80	1
LON-2001	46.4587	-116.95748	Grande Ronde R_2	Tgr_2?	54.31	14.57	1.782	11.18	0.183	9.13	4.79	0.76	2.96	0.332	13	29	36	319	454	24	327	138	33	10.5	20	28	103	7	19	47	5
LON-2002	46.45882	-116.95702	Lewiston Orchards dike	Twl_d	49.38	13.61	3.156	12.83	0.217	10.93	5.98	0.67	2.47	0.756	48	191	42	333	594	21	248	227	50	25.8	20	67	130	5	36	76	2
EAGLE PT	46.40941	-116.92536	Asotin	Taw	50.06	16.45	1.375	9.13	0.155	11.41	8.55	0.45	2.25	0.161	138	294	26	231	195	7	244	97	24	9.2	18	82	79	0	13	26	2

* Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO.

SYMBOLS

- Contact: approximately located.
- Axial trace of fold: dotted where concealed; arrow indicates plunge direction.
- Anticline.
- Syncline.
- Monocline, synclinal bend: shorter arrow on steeper limb
- Thrust fault: teeth of upper plate.
- 45 — Strike and dip of basalt flows.
- 20 — Inferred strike and dip of basalt flows.
- LON110 — Sample location and number.

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