



Preliminary Geologic Map of the Lewisburg Quadrangle, Benton, Linn, Polk, and Marion Counties, Oregon

2009

Open-File Report O-09-05

Preliminary Geologic Map of the Lewisburg 7.5' Quadrangle,
Benton, Linn, Polk, and Marion Counties, Oregon

By Thomas J. Wiley

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program through STATEMAP Award #08HQ400087. Additional funding came from the State of Oregon. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

PLATE 1

NOTICE
This map cannot serve as a substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from those shown on the maps.

MAP DISCUSSION

The Lewisburg quadrangle is located in the Willamette Valley of western Oregon and consists principally of a gently rolling plateau cut by the Willamette and Luckiamute Rivers, Soap Creek, Bowers Slough, and their tributaries. The easternmost ridge of the Coast Range extends into the western part of the quadrangle. Land use in the area is a mix of residential, rural-residential, and agricultural-silvicultural lands. Northwest of Albany the area is developing rapidly.

The geology was mapped using field observations, drillers' logs from hundreds of approximately located water wells, geochemical analyses of volcanic rocks, and interpretation of topography. The map was compiled digitally using both ArcMap™ and MapInfo™ GIS software with the U.S. Geological Survey's Lewisburg 7.5' topographic map as a base.

Bedrock geology in this area consists of Paleogene volcanic and marine sedimentary rocks with extensive late Neogene and Quaternary surficial deposits. The oldest rocks in the quadrangle are Eocene basalt flows of the Siletz River Volcanics, which are overlain by Eocene to Oligocene marine sedimentary rocks and Miocene(?) to Pleistocene fluvial terraces deposited by the ancestral Willamette River and its tributaries. Sedimentary rocks can be divided into two groups. Those associated with the Siletz River Volcanics contain volcanic lithic grains and little or no mica, while Tye and younger formations contain micaceous sedimentary or interlayered sequences of micaceous and non-micaceous sandstone and siltstone.

Quaternary surficial units include extensive deposits of silt and fine sand left by catastrophic outburst floods from Glacial Lake Missoula, terrace deposits cut into the Missoula deposits, and alluvium on the floodplains and in the channels of rivers and streams. Deposits of both shallow and deep-seated soil and rock landslides are abundant, as are alluvial fans deposited by numerous debris flows. Artificial fill is widespread in the form of road embankments, culvert fills, and dams for small impoundments but is not shown on the map.

Eocene rocks are locally faulted and folded. The Corvallis fault places Siletz River Volcanics to the west above the younger Tye Formation to the east. Within a mile or two of the fault the Tye Formation is tightly folded, and a marked angular unconformity separates it from the overlying Spencer Formation. Folds related to the Jefferson anticline are shown in the southeastern part of the quadrangle. The anticline extends eastward, across the Albany quadrangle and beyond the town of Jefferson, bringing bedrock to or near the surface across width of the Willamette Valley.

Some bedding attitudes reported by Vokes and others (1954) and Allison (1953) were repositioned to match the altitude, hillslope aspect, and drainage position shown on the published maps with similar settings on the 7.5' base map rather than matching their latitude and longitude. Where bedding attitudes on a newer publication appeared to have been compiled from an older publication the location shown in the older publication has been retained, or modified as described above, and the newer location ignored.

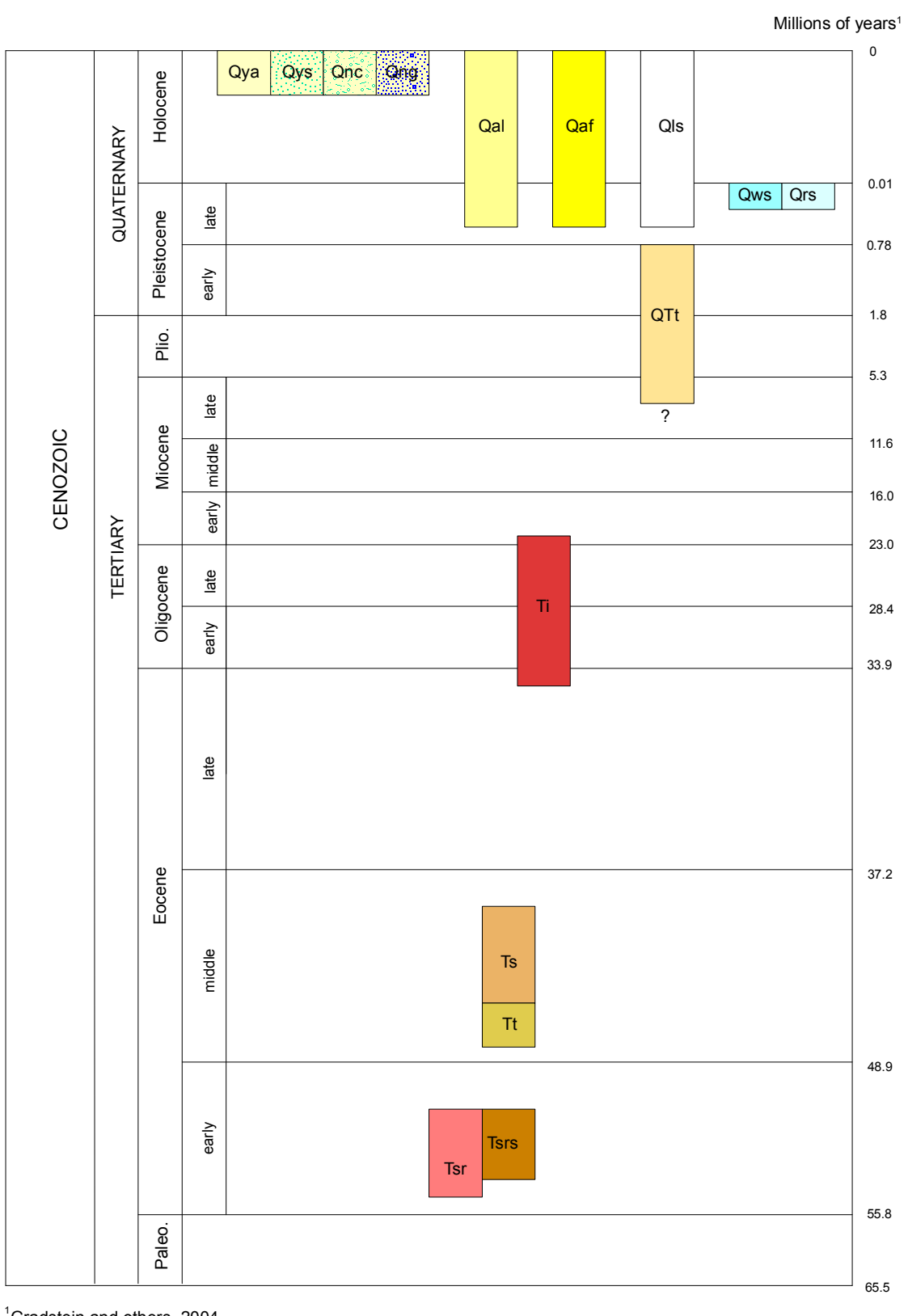
Information recorded by water well drillers has been used to help define the distribution of geologic units. Symbols placed at the approximate location of the wells are colored to indicate key lithologies reported by the driller.

This map was prepared with support from the U.S. Geological Survey, StateMap Program.

REFERENCES

- Allison, I. S., 1953, Geology of the Albany quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 37, scale 1:62,500.
- Gradstein, F. M., Ogg, J. G., and Smith, A. G., eds., 2004, A geologic time scale 2004: London, Cambridge University Press, 610 p.
- Vokes, H. E., Myers, D. A., and Hoover, L., 1954, Geology of the west-central border area of the Willamette Valley, Oregon: U.S. Geological Survey Oil and Gas Investigations Map OM-150, scale 1:62,500.

TIME ROCK CHART



*Gradstein and others, 2004

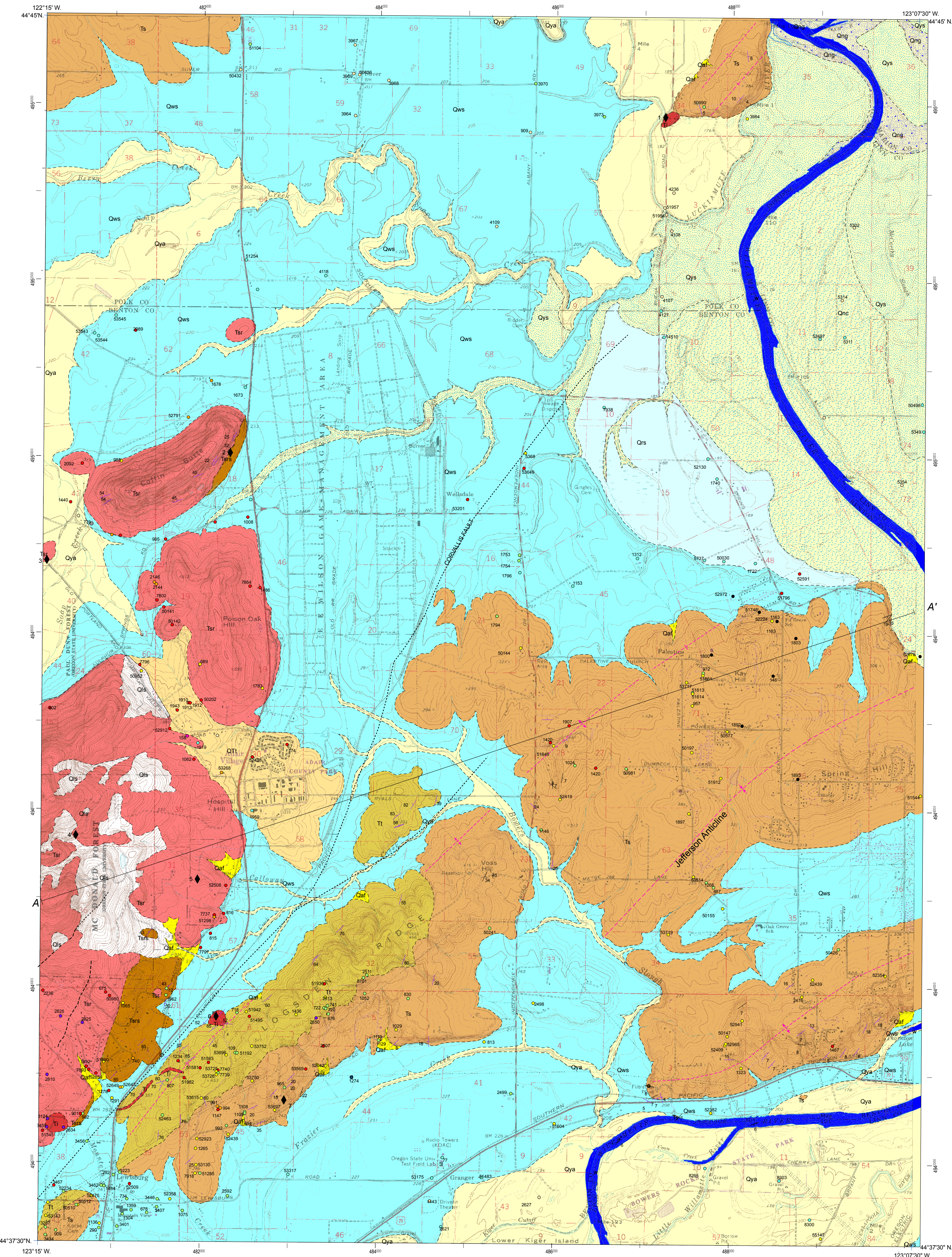
MAP SYMBOLS

- Bedding, labeled with dip; black this study, purple compiled (may have been moved to match elevation, aspect, and drainage of original mapped location)
- Bedding, approximate, labeled with dip; black this study, purple compiled
- Bedding, horizontal; black this study, purple compiled
- Contact, from left to right: certain, inferred, concealed
- Fault; inferred on left, concealed on right
- Coal bed, existence questionable, location inferred, cross section only
- Fold, inferred, existence uncertain; anticline on left, syncline on right
- Geochemical sample site, labeled with map number (see Table 1)
- Location of water well. Symbol color indicates important unit(s) in the well: red = "basalt", green = siltstone, claystone, or shale, yellow = sandstone, magenta = conglomerate, orange = "basalt" and sandstone, purple = "sandrock" (intrusive), black = coal, tan = alluvium, blue = blue clay. Add the appropriate four-letter county abbreviation (BENT, LINN, POLK, or MAR) to construct the Oregon Water Resources Department (OWRD) well log identification number.

EXPLANATION OF MAP UNITS

Note: "Recent" as used in this paper refers to surficial units that postdate settlement. See accompanying text report for complete map unit descriptions.

- Qya** Young alluvium (Holocene) — Gravel, sand, silt, and clay deposited in active channels and on floodplains of rivers and streams. Locally divided to show:
 - Qys** Near channel gravel (Recent) — Gravel with minor sand, silt, and clay located along active and recently active channels of major streams. May be capped by thin sand layers on point bars.
 - Qws** Near channel sand, silt, and clay (Recent) — Sand, silt, and clay, typically as fining-upward sequences on the lowest floodplains along the channels of major streams. Thickness varies, but typically similar to the height of the floodplain above point-bar gravel.
 - Qsf** Young silt and sand (Holocene) — Sand, silt, and minor gravel forming extensive floodplain deposits flanking major streams. Typically occur as fining-upward sequences. Cuts into (post-dates) Willamette Silt (unit Qws). Gravel exposed in pools and low areas.
- Qrs** Reworked Willamette Silt (upper Pleistocene) — Reworked Willamette Silt (unit Qws) and mixtures of reworked Willamette Silt and younger fine-grained alluvium.
- Qws** Willamette Silt (upper Pleistocene, 12.7-15 ka) — Sandy silt and clay with rare pebbles, cobbles, and boulders. Sediment deposited by Missoula floods at elevations up to 400 ft (122 m) in valleys of the Willamette River and its tributaries.
- Qaf** Alluvial fan deposits (Holocene to upper Pleistocene) — Gravel and sand deposited by streams and debris flows. Typically define fan-shaped deposits located at the breaks in slope where steep drainages enter valleys. Should be considered possible sources of debris torrents during prolonged intense rainfall.
- Qls** Landslide deposits (Holocene to late Pleistocene) — Chaotically mixed rock fragments and blocks, soil, gravel, sand, silt, and clay displaced downslope by gravity.
- Qal** Alluvium (Holocene to upper Pleistocene) — sand, gravel, and silt deposited along streams. Generally shown in drainages that lie above the limits of Willamette Silt deposition.
- QTI** Terrace deposits (Pleistocene to Miocene?) — Deeply weathered, partly cemented valley margin sand and gravel deposits.
- Ts** Spencer Formation (middle Eocene) — micaceous sandstone and siltstone with minor fine-pebble conglomerate and grit.
- TI** Tye Formation (middle Eocene) — Micaceous turbidite sandstones and mudstone with minor conglomerate and shale. Typically micaceous with large detrital biotite grains; well bedded, often contains wood, leaf, and stem fragments; macrofossils rare.
- Tr** Siletz River Volcanics (lower Eocene) — Basalt and pillow basalt flows with less common mafic volcanic breccia and sedimentary or proclastic interbeds. Locally divided to show:
 - Tes** Sedimentary and/or volcanoclastic interbeds (lower Eocene) — Lithic volcanic sandstone and shale, tuffaceous sandstone and shale, foraminiferal sand, and conglomerate with volcanic clasts, interbedded lava flows and volcanic breccia. Little or no mica.
 - TI** Intermediate to mafic intrusive rocks (late Eocene to early Miocene) — Dikes and larger intrusive bodies ranging from granodioritic to basaltic compositions. May be vesicular or amygdaloidal, fine to coarse grained.



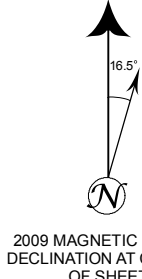
Base map by United States Geological Survey

Control by USGS, USCGS, and State of Oregon.

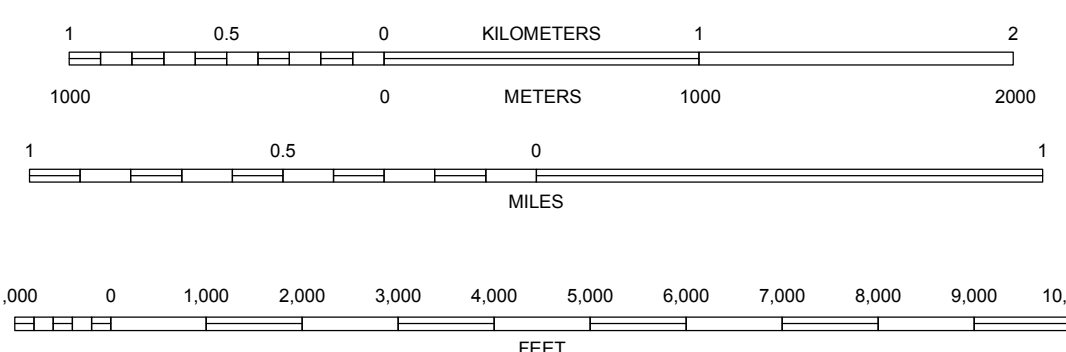
Topography compiled from aerial photographs taken 1967. Field checked 1999. Photorevised, 1998.

Universal Transverse Mercator Projection, zone 10. GRS1980 meter Universal Transverse Mercator grid ticks. 2000 Magnetic north declination 16.5 degrees east. Vertical datum - National geodetic vertical datum of 1929. Horizontal datum - 1987 North American datum.

Geologic data extended north and east to cover Lewisburg quadrangle projected on 1983 North American datum.



2009 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



Geology by Thomas J. Wiley, Oregon Department of Geology and Mineral Industries

Field work conducted during 2008-2009

Cartography by Thomas J. Wiley



QUADRANGLE LOCATION

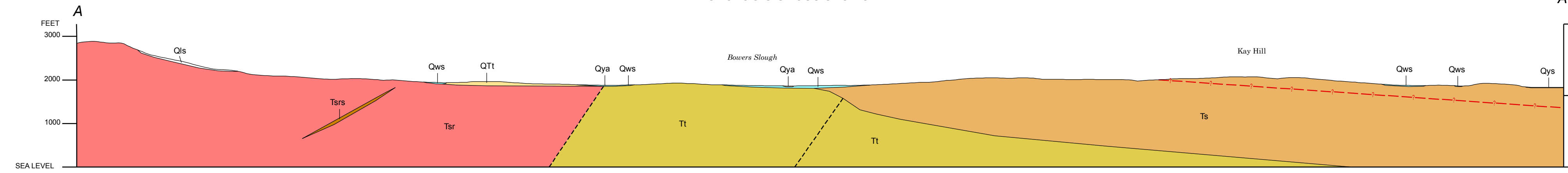
ADJOINING 7.5' QUADRANGLE NAMES
1. Astoria 2. Boring 3. Clatsop 4. Rainier 5. Rainier 6. Rainier 7. Corvallis 8. Astoria

Table 1. Whole-rock x-ray fluorescence (XRF) analyses for the Lewisburg 7.5' quadrangle, Benton, Linn, Polk, and Marion Counties, Oregon

Map Number	7.5' Quad	Field and Lab Number	UTM Easting (NAD 27)	UTM Northing (NAD 27)	Lithology	Feature	Map Unit	Oxides (wt. percent)														Trace Elements (parts per million)																		
								SiO ₂	TiO ₂	Al ₂ O ₃	FeO	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	LOI	Total	Fe ₂ O ₃ /T	Rb	Sr	Y	Zr	V	Ni	Cr	Nb	Ga	Cu	Zn	Co	Ba	La	Ce	U	Th	Sc	Pb
1	Lewisburg	409-7-4	487229	4953866	basalt	intrusive	TI	47.59	1.49	17.82	2.90	7.04	0.14	5.39	12.60	2.41	0.19	0.15	2.33	100.06	10.72	1.1	215	23.1	82	291	82	204	6.5	17.8	129	75	37	38	10	16	<0.5	<0.5	34	<1
2	Lewisburg	409-7-5	482311	4950045	basalt	lava flow	Tsr	46.02	2.45	14.03	4.26	9.28	0.25	5.68	12.04	2.40	0.15	0.26	3.31	100.13	14.57	<1.0	224	31.8	155	385	68	155	14.7	20.7	207	97	46	79	11	29	<0.5	0.6	35	1
3	Lewisburg	409-7-6	480236	4948824	basalt	lava flow?	Tsr	45.78	2.43	14.06	5.53	8.24	0.21	5.27	11.47	2.47	0.35	0.26	3.75	99.82	14.69	3.4	225	31.5	154	361	61	90	14.3	21.4	218	91	43	78	11	29	1.2	0.8	30	<1
4	Lewisburg	409-7-1	480580	4945706	basalt	lava flow	Tsr	45.77	2.69	13.30	6.48	6.68	0.22	6.36	11.29	2.33	0.36	0.27	4.03	99.78	13.90	5.0	204	37.4	152	362	163	131	13.9	20.4	204	91	68	87	11	31	<0.5	<0.5	31	<1
5	Lewisburg	409-7-2	481962	4945209	basalt	lava flow	Tsr	45.56	1.83	16.84	4.16	7.88	0.20	7.08	11.31	2.46	0.73	0.31	2.07	100.23	12.70	14.9	395	25.6	122	300	71	106	31.0	17.0	98	142	46	204	36	1.9	2.7	31	<1	
6	Lewisburg	109-30-1	482180	4943555	basalt	intrusive	TI	44.15	1.16	13.23	4.73	6.22	0.16	13.64	11.90	1.64	0.50	0.16	2.64	100.17	11.64	11.0	243	18.9	47	273	349	919	22.5	12.1	120	65	57	145	13	24	<0.5	<0.5	37	<1
7	Lewisburg	409-7-3	482054	4942711	basalt	intrusive	TI	46.35	3.14	13.79	9.96	4.93	0.17	3.35	5.45	3.27	1.08	0.44	5.92	99.85	15.44	27.0	162	47.4	230	290	4	22	16.2	24.5	31	142	28	293	16	54	1.0	2.6	39	<1
8	Arlie South	108-16-1	478564	4941560	basalt	lava flow	Tsr	43.83	1.64	14.53	6.06	5.37	0.18	8.84	11.09	1.89	0.47	0.21	6.11	100.22	12.03	1.2	219	26.5	91	334	110	259	8.7	17.1	148	83	48	25	7	18	<0.5	1.6	38	2

LOI is loss on ignition.

GEOLOGIC CROSS SECTION



Gently east-dipping dashed and queried red line represents approximate position of coal and charcoal intercepts in several nearby water wells.



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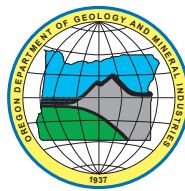
Software used: MapInfo Professional 8.0, ArcGIS 9.3, Adobe Acrobat 7.0.
Source file: Contact Tom Wiley regarding Lewisburg file.

State of Oregon
Department of Geology and Mineral Industries
Vicki S. McConnell, State Geologist

**OPEN-FILE REPORT
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BENTON, LINN, POLK, AND MARION COUNTIES, OREGON**

By
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2009

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NOTICE

The results and conclusions of this report are necessarily based on limited geologic and geophysical data. At any given site in any map area, site-specific data could give results that differ from those shown in this report. **This report cannot replace site-specific investigations.** The hazards of an individual site should be assessed through geotechnical or engineering geology investigation by qualified practitioners.

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MAP PLATE

Plate 1. Preliminary geologic map of the Lewisburg 7.5' quadrangle, Benton, Linn, Polk, and Marion Counties, Oregon

INTRODUCTION

A preliminary geologic map of the Lewisburg quadrangle (Plate 1) was prepared by merging new field data with data compiled from existing geologic maps and geologic interpretations of soil maps, water well logs, and topography. The map covers the western edge of the Willamette Valley and the easternmost ridge of the Oregon Coast Range. Access is from U.S. Highway 99W and Oregon State Highway 20. Off the main highways, access is from a system of county and forest roads. The area is drained by the main stem of the Willamette River in the south and by its tributaries the Luckiamute River in the northeast, Soap Creek in the north, and Bowers Slough. The City of Corvallis lies just south of the quadrangle and the smaller communities of Lewisburg and Adair Village lie within the map boundaries. Land use outside of residential and rural residential areas consists of timber production on steeper terrain and farming and grazing on the flats. Oregon State University's McDonald-Dunn Forest covers a large part of the mountainous terrain in the southwestern corner of the quadrangle.

Rocks in the larger Corvallis-Albany area reveal an early history of seafloor spreading and volcanism followed by deposition of marine sedimentary rocks, the most common of which is sandstone. The composition of the oldest sedimentary beds (unit Tsrs) reflects a nearby source of sand and gravel within the volcanic terrane. Younger sandstone (units Tt and Ts) is composed of far-traveled grains that originated in feldspar-, mica-, and quartz-rich terranes to the south and east. Sandstone deposition was punctuated

by tectonic events that folded, tilted, faulted, and rotated the strata. During periods of low sea level there were islands, shoals, or peninsulas that restricted interaction between local waters and the Pacific Ocean. Sills and dikes (sheet-like intrusions) of basalt, gabbro, diorite, and granodiorite formed in the sandstone layers when hot magma forced its way upward along zones of weakness. Eventually the land rose and the sea retreated, hills formed in the west, and a broad river valley formed to the east. The Willamette River system evolved in this valley even as volcanoes farther east erupted to form the Cascade Range. Alluvial fans formed at the mouths of major tributaries and were later eroded back to a few terrace remnants by the main stream. During the ice age, extraordinary floods brought on by bursting dams of glacial ice floated boulders and cobbles from Canada and Montana down the Columbia River and into the Willamette Valley, temporarily transforming it into a giant muddy lake. When the lake drained for the last time, a blanket of silt covered almost everything below 122 m (400 ft) elevation. As the river retreated from flood-swollen drainage ways to the lowest channels it began again to migrate back and forth across the valley floor, reworking the silt-covered floodplains and carrying sand, gravel, and silt to the sea.

Radiometric dates and fossil collections suggest that the oldest rocks in the area are about 50 million years old, marine sandstone beds are as young as about 40 million years old, intrusions are 30 to 35 million years old, and the youngest flood silt deposits are 10 to 12 thousand years old.

EXPLANATION OF MAP UNITS

Note: "Recent" as used in this paper refers to surficial units that postdate settlement.

- Qya Young alluvium (Holocene)**—sand, gravel, and silt deposited by modern streams. Deposits in volcanic dominated drainages contain sediment dominated by pebble gravel. Deposits in drainages dominated by weakly cemented sandstone bedrock contain sediment dominated by micaceous and quartzo-feldspathic sand. Drainages with mixed bedrock contain strikingly bimodal dark gray gravel and light-colored sand. Deposits of the Willamette River typically include floodplain sequences of sand and silt underlain by fining-upward sand and gravel facies interpreted as channel deposits. Locally divided to show units Qys, Qnc, and Qng.
- Qng Near channel gravel (Recent)**—Gravel with minor sand, silt, and clay located along active and recently active channels of major streams. May be capped by thin sand layers on point bars.
- Qnc Near channel sand, silt, and clay (Recent)**—Sand, silt, and clay, typically as fining-upward sequences on the lowest floodplains along the channels of rivers. Thickness varies but typically similar to the height of the floodplain above point-bar gravel.
- Qys Young silt and sand (Holocene)**—Sand, silt, and minor gravel forming extensive floodplain deposits flanking major streams. Typically occur as fining-upward sequences. Cut into (postdate) Willamette Silt (unit Qws). Gravel exposed in pods and low areas.
- Qrs Reworked (Willamette) Silt (upper Pleistocene)**—Silt and sand with a few pebble lags. Reworked Willamette Silt (unit Qws) and mixtures of reworked Willamette Silt and younger fine-grained alluvium. Probably includes small exposures of eroded Willamette Silt. Interpreted as fine-grained facies deposited by Holocene streams, including the Willamette River, where, although eroded into or through the Willamette Silt, they locally left behind sediment of similar or slightly modified composition. Exact age is uncertain, but the provenance and occurrence of this sediment on benches above incised modern streams may indicate deposition shortly after the floods. At that time the Willamette Silt largely covered the valley floor, streams were just beginning to cut into it, and other types of sediment were isolated from the system by the silt.
- Qws Willamette Silt (upper Pleistocene, 12.7–15 ka)**—Thin- to medium-bedded rhythmites of silt, sandy silt, and silty clay. Deposited by repeated Missoula (Bretz) floods when glacial dams in the upper Columbia River drainage failed catastrophically and generated floodwaters that temporarily filled the Willamette Valley. Individual rhythmites range from 0.1 to 1.0 m (4 to 39 in) thick (O'Connor and others, 2001); each is interpreted as the deposit left by a single flood event. Ice-rafted erratic pebbles and boulders with continental provenance occur at elevations as high as 122 m (400 ft) above sea level. Areas below about 76 to 91 m (250 to 300 ft) elevation were draped with a thick (3 to 6 m [10 to 20 ft]) blanket of silt by repeated floods (Gannett and Caldwell, 1998). Locally absent where removed by hillside erosion, receding floodwaters, or incision by younger channels. May include some gravel deposits where the velocity of receding floodwaters was sufficient to winnow away sand and silt or to move gravel. Locally the silt is overlain by younger floodplain deposits of Wisconsin (Tioga?) age (Allison, 1953). O'Connor and others (2001) report an age range of 12.7 to 15 ka. Because this unit largely blanketed topography, it created similar, distinctive soils that overlie many different surficial and bedrock units. Nearly identical soils top older alluvial fan units as well as bedrock hills. The following list of related soils have been given different names on the basis of subtle variations in weathering, mixing, and dissection: Amity, Coburg, Conser, Holcomb, Malabon, Willamette, and Woodburn (Langridge, 1987). Beneath the Willamette Silt older, buried, soils and weathered zones are often preserved at the top of the buried unit.
- Qaf Alluvial fan deposits (Holocene to upper Pleistocene)**—sand, gravel, boulders, and woody debris that form fan- or cone-shaped accumulations at slope breaks. These generally occur where the mouths of small streams and side canyons enter drainages of larger streams.

The risk of debris flows and fast-moving landslides is generally higher on areas underlain by alluvial fan deposits, particularly where such deposits ramp across a slope break at the foot of rugged terrain. Only deposits are shown on the map. Gullies, valleys, and canyons located upstream from alluvial fan deposits have a higher than average risk for fast moving landslides. Site-specific studies should be undertaken to determine actual risk.

- Qls** **Landslide deposits (Holocene to late Pleistocene)**— Boulders, gravel, sand, mud, and large coherent blocks of adjacent bedrock lithologies that have been transported down slope by gravity sliding. Landslides have been compiled from earlier publications with local additions and modifications based on new field work or inferred from topography.
- Qal** **Alluvium (Holocene to upper Pleistocene)**— sand, gravel, and silt deposited along streams. Generally depicted in drainages situated above the limits of Willamette Silt deposition (122 m [400 ft] elevation). Deposits in drainages dominated by weakly cemented sandstone bedrock contain sediment dominated by micaceous and quartzo-feldspathic sand. Drainages with mixed bedrock contain strikingly bimodal dark gray gravel and light-colored sand.
- QTt** **Terrace deposits (Pleistocene to Miocene?)**— sand, clay, gravel, and silt that is locally consolidated or cemented to form poorly indurated sandstone, claystone, conglomerate, and siltstone. Preserved locally along the western edge of the Willamette Valley; locally forms the bench on which much of Adair Village sits. Probably correlative to similar gravel deposits in the Lebanon-Albany area; assigned to the Leffler Gravel by Allison (1953). Outcrops consist of fine- to medium-grained basaltic pebble gravel and pebbly sandstone with volcanic clasts, many of which appear to have been derived from Siletz River Volcanics.

Water well drillers may log sandy parts of this formation as varieties of clay. Black, lithic coarse sand and black gravel are more consistently reported by water well drillers.

According to reports, many water wells spudded into this formation encountered intervals of “blue clay.” Blue clay is similarly reported from water wells that penetrate young sand and gravel sequences beneath valley fill. Elsewhere in the Willamette Valley intervals of “blue clay” have been reported from decomposed fine-grained sandstone, siltstone, and claystone that form the tops of fluvial fining-upward sequences in old alluvium and from drilled intervals known to be weathered Eocene bedrock (Spencer Formation) at the surface. Geologists working near Corvallis examined a thick interval of “blue clay” and interpret it as having been deposited in a lacustrine or low-energy fluvial environment. Near Buena Vista, thick weathered sections of Spencer Formation sandstone are similarly logged as “clay” by water well drillers, so care must be taken in assigning “clay” sequences reported from water wells to any particular formation.

Probably equivalent to older sand and gravel deposits preserved in benches east of Albany. Age based on stratigraphic position and the relationship between similar strata and young lava flows in the eastern part of the valley (M. L. Ferns, personal communication, 2008).

- Ts** **Spencer Formation (middle Eocene)**— micaceous arkosic and lithic sandstone, siltstone, conglomerate, and claystone in sequences ranging from thin to thick bedded or massive. Sandstone ranges from thin interbeds to thick massive (bioturbated) sequences. Interpreted as deposited in shallow to deep(?) marine environments but the facies have not been mapped separately. Thick fine-grained sequences are generally interpreted as deep marine facies that accompanied sea level high stands, while sandy facies are interpreted as shallow water facies deposited during episodes of low sea level. Age of the formation is based on ages reported elsewhere in the Coast Range and correlation with the type area near Eugene (see Wiley [2006]). The upper contact in the Eugene area is dated at about 40 Ma where the Spencer Formation is overlain by the Fox Hollow Tuff of that age (Madin and Murray, 2006). A poorly defined horizon at which water wells intercept coal and coally material is indicated by a dashed red line on the cross section and by well symbols colored black on the map.

Near Lewisburg, strata mapped as the lower part of the Spencer Formation include shale and spheroidal-weathering siltstone and fine sandstone sequences that contain large foraminifera. It is not clear whether these sequences are continuous or preserved only locally, perhaps in basins defined by topography related to the unconformity. Because these rocks appear to rest above the local (?) unconformity that separates the Spencer and Tyee Formations they were included with the Spencer Formation. However, they may be correlative with other fine-grained formations that occur elsewhere at this stratigraphic level including the Yamhill and/or Lorane Formations. To the south these rocks underlie the hill on which the Corvallis Hospital stands (Corvallis quadrangle) and they were recognized in the Greenberry quadrangle near the intersection of Peterson Road and Cougar Lane. One or more thick sequences of fine-grained marine sedimentary rocks are present along this unconformity in the Flat Mountain quadrangle to the south where they are associated with many large landslides and intrusions.

In the Wren quadrangle, immediately to the west of Greasy Creek and the Corvallis fault, beds of Spencer Formation sandstone sit directly on Siletz River Volcanics. The same may be true in the area northeast of Coffin Butte where a few poorly constrained attitudes measured in this and adjacent quadrangles suggest that the intervening Kings Mountain, Tyee, and Yamhill Formations are likely to thin from northwest to southeast.

Spencer Formation locally contains scattered to abundant invertebrate fossils including pelecypods ranging from shell fragments to articulated whole shells in life position, gastropods, and foraminifera.

Tt Tyee Formation (middle Eocene)— Consists of micaceous sandstone and less common mudstone as turbidites. Sandstone ranges from fine to coarse grained and may contain abundant woody debris. Pebbly sandstone, conglomerate, coal beds, and mega-fossils are very rare or absent. Bed thickness ranges from thin bedded to massive or amalgamated. Sandstone is notably micaceous, most commonly with both biotite and muscovite, and typically arkosic, which distinguishes it from older lithic sandstone turbidites of the Kings Valley and Siletz River Formations. Age of the formation is based on ages reported elsewhere in the Coast Range and on correlations between the formations, global sea level curves, and nearby oil wells (Wiley, 2006).

West of the Lewisburg quadrangle the contact with the underlying Kings Valley Formation is marked by the sudden appearance of abundant mica. However, the contact is gradational in terms of the decreasing abundance of lithic volcanic grains. Other authors have reported an unconformity at the base of the Tyee Formation (Walker and Duncan, 1989) with micaceous sandstone deposited directly on mafic volcanic rocks of the Siletz River Formation. Where outcrops are too small to distinguish turbidite sequences, for example in amalgamated sandstone or thick mudstone sequences, the formation may be difficult to distinguish from the overlying Spencer Formation. In some areas mica content may help distinguish sandstone beds of the Tyee and Spencer Formations. The typical Tyee Formation sandstone contains more biotite, particularly more fresh-looking biotite, than Spencer Formation sandstone which typically has a larger percentage of muscovite and bleached biotite. Woody debris, leaf fragments, stems and reeds are common constituents of turbidite sandstone and shale. No fossil invertebrates were found that could be assigned to the Tyee Formation.

Tsr Siletz River Volcanics (lower Eocene)— Basalt and basaltic andesite lava flows and related rocks. Flows are typically augite-, plagioclase-, and/or olivine-phyric marine pillow lavas. They may be vesicular, amygdaloidal, or brecciated. Chemistry (Plate 1, Table 1) is either quartz or olivine normative. In some exposures pillowed intervals are sufficiently coherent to allow inference of paleohorizontal and estimate strike and dip.

Amalgamated basaltic pillow lavas form the lower part of the unit and are interpreted as submarine marginal ophiolite-type lavas. Lava flows in the upper part of the unit are locally interbedded with marine sandstone, siltstone, and less commonly tuffaceous rocks and conglomerate that are too thin, too poorly exposed, or too discontinuous to map separately. East of Blodgett, in the Wren quadrangle, the highest and presumably youngest of the lava flows assigned to this unit is composed of basaltic andesite; this composition suggests a major change in magma type and perhaps in plate tectonic setting accompanied the extinction of unit Tsr volcanoes. At several basalt quarries the tops of the headwalls reveal thin-bedded lithic sandstone and siltstone turbidite sequences that are generally not recognized in less perfect exposures. Locally these sandstone beds may contain abundant (30%) foraminifera tests. Where sedimentary rocks are extensive enough to be mapped separately, unit Tsr is divided to show unit Tsrs:

Tsrs Sedimentary rocks (lower Eocene)— Sandstone, siltstone, and less common tuff and conglomerate. Sandstone is typically lithic, with grains consisting of well-rounded mafic volcanic rock fragments. Sandstone may contain a large percentage of foraminifera tests.

The soil map of Benton County shows large areas of soil derived from sedimentary rock where only basalt was recognized in the field. Some of these areas undoubtedly contain thin sedimentary interbeds, and some lie downslope from areas underlain by sedimentary rock; however, it seems likely that in some cases soils derived from deeply weathered volcanic rock are similar to soils derived from sedimentary rock that was itself derived from weathered volcanic rock. Several water well logs report sandstone and siltstone in areas mapped as Siletz River Volcanics, and these are thought to represent sedimentary interbeds similar to those mapped in unit Tsrs. Unit Tsrs has been mapped to include wells with interlayered volcanic and sedimentary rocks, including lithologies described as volcanic conglomerate by water well drillers. Mapped transitions from lava flows of unit

Tsr to mixed flows, sedimentary rocks, pyroclastic rocks, and breccia of unit Tsrs are probably not as abrupt as is depicted on the map.

Ti Intrusive rocks (late Eocene to early Miocene)— Mafic to intermediate, fine- to medium-grained intrusive rocks range from gabbro to granodiorite and basalt to basaltic andesite. At least three intrusive suites are believed to be present. These include 1) small gabbro, basalt, and basaltic andesite intrusives of early Eocene age (circa 50 to 55 Ma) that may have served as feeders for lava flows of the Siletz River volcanics, 2) gabbro and related rocks associated with the Mary's Peak Sill (circa 30 to 33 Ma), and 3) quartz-bearing basaltic andesite, tonalite, and granodiorite dikes and sills that cut sedimentary rocks as young as the Spencer Formation and so are probably younger than about 40 Ma. (Oxford, 2006; Wiley, 2008).

Additional intrusions were depicted on an earlier map compiled by Yeats and others (1991). Many of those intrusions were mapped on the basis of magnetic anomalies. In some of these areas the only intrusive rocks seen during this study were thin (approximately 20 cm) strongly magnetic mafic dikes that cut across sedimentary country rock in orientations parallel to the long axes of the magnetic anomalies. A small intrusive depicted by Allison (1953) on the steep west bank of the Willamette River at the northern edge of the quadrangle was not recognized during a river traverse. Those rocks may be hidden by vegetation that postdates the earlier investigation.

Color, grain size, and induration contrasts between intrusive and sedimentary rock are much more pronounced than the contrast between mafic intrusions and basalt flows. The paucity of mapped intrusions in the Siletz River Formation may be due to this lack of contrast. Tertiary intrusive rocks are probably more widespread than is shown on the map.

GEOLOGIC HISTORY

The geology of the area records an episode of widespread volcanic activity that occurred about 50 million years ago, during Paleocene and early Eocene time. The volcanic rocks are predominantly marine pillow lavas of the Siletz River Volcanics. They crop out from the Roseburg area to the south northward into Washington State. The oldest lavas in the suite are Paleocene, but at this latitude lavas older than Eocene have not been reported. The uppermost lava flow, mapped in the northwest quarter of the Wren quadrangle, is a basaltic andesite that is considerably more silica rich than older basaltic lavas (see Plate 1, Table 1). In some places, thin intervals of foraminiferal, tuffaceous, or lithic sandstone and siltstone lie between successive lava flows. The sedimentary interbeds become more common and generally thicker higher in the section. Eventually, volcanism waned and was followed by deposition of thick marine clastic sequences. Although nonmarine sandstone facies and subaerial lava flows have been reported from the Siletz River Formation elsewhere in the Coast Range, none were recognized here. Where the lava flows have been quarried they can be seen to contain thick pillowed intervals. When volcanic activity ended, sediment similar to that deposited between the lava flows accumulated in a thick sequence of sandstone and mudstone turbidites known locally as the Kings Valley Siltstone (Vokes and others, 1954; not mapped in the Lewisburg quadrangle), part of the Umpqua Group. These rocks locally contain conglomerate and waterlaid block and ash tuff. A dramatic change in the type of sandstone deposited occurs above the Kings Valley Formation when an influx of mica, quartz, and feldspar overwhelmed

tuffaceous and lithic-volcaniclastic sediment sources. The mica-rich sandstone that resulted probably had a source in a dissected arc terrane to the south in the Klamath Mountains or eastward on the continent itself. The oldest of these micaceous rocks form sandstone and mudstone turbidites that are interpreted as submarine fan deposits and assigned to the Tyee Formation. Some time after deposition of the Tyee Formation local deformation occurred, resulting in an unconformity. Near faults, beds assigned to the Tyee Formation are locally steeply dipping or overturned and younger beds are only moderately deformed.

A thick sequence of lithic sandstone lies above the Tyee Formation in oil wells drilled in the Willamette Valley but similar strata were not seen in the Lewisburg quadrangle and were only seen in a few small outcrops in the Corvallis quadrangle (Baker, 1988; Wiley, 2006, 2008). Moderately deformed micaceous sandstone and siltstone assigned to the Spencer Formation unconformably overlies the Tyee Formation. Younger, little deformed, nonmarine sedimentary rocks (unit QTt) crop out near Adair Village. Ice age Bretz Flood deposits including Willamette Silt and widely scattered ice- or root-wad-rafted exotic clasts mantle topography below about 122 m (400 ft). These silt deposits thicken into the Willamette Valley and thin up-slope to merge with soil derived from bedrock at higher elevations. Postglacial streams migrated laterally across the valleys, reworking older surficial units and depositing sand and gravel along active channels and finer alluvium on broad flood plains and in abandoned channels.

STRUCTURAL GEOLOGY

When greatly simplified, the structure in this area is that of a broad, gently northeast-plunging anticline with a core of Eocene pillow basalt overlain by younger Eocene sedimentary rocks. This simple structural model is complicated by the Corvallis fault, minor folds, and several small intrusions. The folds and faults are largely consistent with shortening along northwest-southeast axes. More easterly strikes are increasingly common in strata younger than the Tyee Formation. The timing of intrusions suggests a change in the structural regime occurred between about 35 and 30 Ma (Oxford, 2006).

The Jefferson anticline extends from Lewisburg to Jefferson and either refolds or is a more easterly trending east-

plunging extension of the larger regional anticline described above. It is not well defined in the Lewisburg quadrangle and appears to consist of a pair of anticlines offset from the single fold mapped in the Albany quadrangle to the east (Wiley, 2006). These folds are indicated by reversals in dip direction but exposures are generally too poor to accurately map fold axes. (See Yeats and others [1991, 1996] for a different depiction of fold axes and intrusions.) The folds typically parallel northeasterly trends of larger structures but, locally, bedding strikes parallel to northwest-trending faults or intrusion margins.

The northeast-trending, steeply northwest-dipping Corvallis fault cuts across the southeastern limb of the anticline

in the Philomath-Corvallis-Lewisburg area. The fault and associated folds are the most prominent geologic structures in the Lewisburg quadrangle. The valley that follows the fault and the dips of nearby beds suggest that dips on fault planes range from vertical to steeply west dipping. The apparent throw is down-to-the-east with older Siletz River Volcanics cropping out west of the fault and younger Tyee and Spencer Formations cropping out east of the fault, suggesting a thrust or reverse fault. To the south, in the Wren quadrangle, the dips of overturned beds near the fault are as low as 65 degrees to the west, suggesting a similar dip for the fault. However, some evidence suggests strike-slip movement. Strike-slip offset along the fault is indicated by the presence of subhorizontal slickensides (A. R. Niem, personal communication, 2007) and by apparent offset of Siletz River—Tyee—Spencer Formation contacts. In a detailed study of the fault in the Corvallis area, Goldfinger (1990) described evidence for a strike-slip component in the offset. Goldfinger's detailed mapping suggests left-lateral offset. The presence of northeast-trending, short wavelength, en echelon, left-stepping folds along the fault (as mapped by Yeats and others [1991]) also suggests a left-lateral strain component. Although the apparent offset of Eocene contacts across Benton and Polk Counties is right lateral, this relationship might also be explained by the

eastward plunge of the Jefferson anticline. The presence of micaceous fossiliferous Spencer Formation sandstone west of Greasy Creek in the Wren quadrangle suggests that much of the deformation and offset along the fault is older than the Spencer Formation. Dips in Spencer Formation on either side of the fault are to the south-southeast and rarely exceed 35 degrees while older beds of the Tyee Formation have more northerly strikes and are often overturned.

It is not clear whether bedding attitudes in the southwestern corner of the Lewisburg quadrangle are affected by the south limb of the Jefferson Anticline. There, the anticline trend is parallel to many of the small folds along the Corvallis fault, suggesting that the two sets of features resulted from a similar strain regime. In the Albany quadrangle the bedrock high produced by the Jefferson Anticline bisects the Quaternary basin fill along the Willamette River, suggesting that the high and the strain regime that formed it are relatively young. Such a strain regime is also consistent with northwest-trending right-lateral offset like that seen where the Corvallis fault is cut by the Philomath fault to the south.

Small intrusions range from basalt to gabbro. Many of these form resistant hills and ridgelines, particularly where they intrude sedimentary rock. Intrusions were most commonly mapped near the Corvallis fault.

GEOLOGIC HAZARDS

Landslides depicted on the geologic map were compiled from hazard studies by Bela (1979) and Wang and others (2001) and were modified where appropriate on the basis of new field work. Oregon State University's McDonald Forest kindly provided a light detection and ranging (lidar) based bare-earth digital elevation model that was used to update landslide mapping in the forest.

A few small alluvial fans were mapped, generally on the basis of the topography depicted on the 7.5-minute quadrangle maps. Where these alluvial fans lie at the mouths of steep-sided canyons there may be significant risk of fast-moving landslides such as debris flows. In terms of location, the risk is highest at the apex of the fan. In terms of timing, the risk of fast-moving landslides is increased during episodes of intense rainfall that occur after soils have been

saturated by fall and early winter rainfall. Intense rainfall in this area is more than 2.85 inches in 24 hours (Wiley, 2000).

The author strongly recommends that landowners intending to build on lots underlain by or adjacent to areas mapped as unit Qaf or Qls have a site-specific geologic investigation conducted by a registered geologist or engineer before building pads or foundations are designed.

Earthquake hazards are discussed by Wang and others (2001). Some folding mapped in the Corvallis area parallels the Jefferson anticline and may be of similar age. In the Albany quadrangle the Jefferson anticline bisects Willamette Valley fill and may be as young as Quaternary (Wiley, 2006). Large folds such as these are often formed in tandem with large faults known as blind thrusts that may not break the surface but that nonetheless pose a seismic risk.

ROCK NAMES AND ANALYTICAL PROCEDURE

Igneous rock names are based on major element chemistry (Table 1 of Plate 1). The ratio between normalized total alkali and silica (International Union of Geological Sciences standard fields) is used to assign rock names to fine-grained igneous rocks and is adapted according to the "ANOR" method of Streckheisen and Le Maitre (1979) to assign names to coarse-grained feldspathoid-free intrusive rocks.

Stanley A. Mertzman (Department of Geosciences, Franklin and Marshall College, Lancaster, Pennsylvania) provided XRF analyses for samples listed in Table 1. Analyses were completed using the following procedures:

The original rock/mineral powder is crushed, using aluminum oxide milling media, until the entire sample passes through a clean 80-mesh sieve. Then, 3.6 g of lithium tetraborate and 0.4 g of rock powder are mixed in a Spex Mixer Mill. The powder is transferred to a 95% Pt-5% Au crucible and three drops of a 2% solution of Lil are added. The mixture is then covered with a 95% Pt-5% Au lid (which will later act as a mold) and heated for 10 minutes. After being stirred and thoroughly convected, the molten contents of the crucible are poured into the lid to cool. A Philips 2404 X-ray fluorescence vacuum spectrometer equipped with a 102-position sample changer and a 4-KW Rh X-ray tube is used for automated data acquisition and reduction. The major elements are determined via this technique together with Cr and V.

Working curves for each element of interest are determined by analyzing geochemical rock standards, data which have been synthesized by Abbey (1983) and Govindaraju (1994). Between 30 and 50 data points are gathered for each working curve; various elemental interferences are also taken into account, e.g., SrK β on Zr, RbK β on Y, etc. The Rh Compton peak is used for a mass absorption correction. Slope and intercept values, together with correction factors for various wavelength interferences, are calculated and then stored on a computer.

The X-ray procedure determines the total Fe content as Fe₂O₃T. The amount of ferrous Fe is titrated using a modified Reichen and Fahey (1962) method, and loss on ignition is determined by heating an exact aliquot of the sample at 950°C for one hour.

Trace element analysis is accomplished by weighing out 7 g of whole rock powder and adding 1 g of high-purity microcrystalline cellulose, mixing for 10 minutes, and pressing the sample into a briquette. Copolywax powder is substituted for cellulose when the whole rock SiO₂ content is >55 weight percent. Data are reported as parts per million (ppm). The elements measured this way include Rb, Sr, Y, Zr, Nb, Ni, Ga, Cu, Zn, U, Th, Co, Pb, Sc, Cr, and V. La, Ce, and Ba amounts have been calibrated using an L X-ray line and a mass absorption correction.

ROCK AND MINERAL RESOURCES

Aggregate Resources

Basalt from the Siletz River Formation is widely mined for road metal, fill, riprap, and decorative rock. In the Lewisburg quadrangle such rock has been produced for many years from the basalt quarries on Coffin Butte. Small quarries have been developed in many of the smaller intrusions. Historically, round rock (river gravel) has been mined in pits developed along old channels of the Willamette River. Several of these are now part of Bowers Rock State Park.

Energy Resources

Sequences of sedimentary rock in these three quadrangles are generally too thin to generate or to trap significant accumulations of oil or gas. No coal beds were encountered during fieldwork, but "coal" and "charcoal" (possibly lignite?) are reported on water well drillers' logs in the Kay Hill area in the eastern part of the quadrangle (see cross section A-A').

WATER WELLS

An attempt was made to locate water wells and other drill holes that have well logs archived by the Oregon Water Resources Department (OWRD). Very few wells were actually visited in the field. Instead, approximate locations were estimated using tax lot maps, street addresses, and aerial photographs to plot locations on the map. The accuracy of the locations ranges widely, from errors of 0.5 mile possible for wells located only by section and plotted at the section centroid to a few tens of feet for wells located by address or tax lot number on a city lot with bearing and distance from

a corner. At each mapped location the number of the well log is indicated. This number can be combined with the first four letters of the county name, together known as the Well Log ID number, to retrieve an image of the well log from the OWRD website [http://apps2.wrd.state.or.us/apps/gw/well_log/Default.aspx], e.g., BENT 5473). The symbol color shown at each well site indicates key lithologies reported on the log that were used to aid in preparation of the geologic map (See Plate 1).

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Mark Ferns provided help assembling earlier published maps. Bob Murray volunteered his time and insights while accompanying the author on several traverses. Oregon State University Forests staff provided lidar-based digital elevation models.

Because good outcrops may be short-lived, widely separated, or quickly overgrown, older geologic maps cited herein should be consulted for alternative interpretations.

Water well logs archived on the Oregon Department of Water Resources website provided additional data points.

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