State of Oregon
Department of Geology and Mineral Industries
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PRELIMINARY GEOLOGIC MAP OF THE ALBANY QUADRANGLE, LINN, MARION, AND BENTON COUNTIES, OREGON

By

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2006

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Text to Accompany:

Geologic Map of the Albany Quadrangle Linn, Marion, and Benton Counties, Oregon

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INTRODUCTION

New mapping in the Albany quadrangle (Figure 1) ties discontinuous bedrock exposures to lithologic and stratigraphic data from several oil and gas wells. Bedrock mapped exclusively as Spencer Formation by some authors is more complex, representing environments ranging from sandy non-marine to sandy neritic to silty middle bathyal. Variations in water depth and environment are correlated to transgressive and regressive events recognized in the Eugene, Fisher, and Spencer Formations in the Eugene area to the south. The presence of angular boulders of volcanic rock in marine conglomerate suggests deposition adjacent to nearby volcanic outcrops . . . . igneous rock in the quadrangle is not exclusively intrusive. Elsewhere, baked upper contacts confirm that several strata-bound igneous bodies are sills, not flows. Basalt-pebble conglomerate that crops out in the southwestern part of the quadrangle has a western source in Siletz River Volcanics on the hanging wall of the Corvallis fault. Strata mapped on either side of the projected trace of this fault parallel its northeasterly trend. These structures interrupt the regional north-northwest strike that dominates the geology in surrounding areas. The northeast-plunging Jefferson Anticline similarly parallels the fault and may indicate the presence of another splay at depth. However, rocks exposed up-plunge (northeast of the quad), have northwesterly strikes, suggesting a local angular unconformity. Surficial deposits define several generations of broad, coalescing, alluvial fans that interfinger with sand, gravel, and clay deposited by the Willamette River. Clay-rich deposits recognized in water wells drilled along the western side of the valley represent weathered or altered bedrock, weathered terrace deposits, or low-gradient-stream deposits of the ancestral Willamette River. Near the end of the Pleistocene the Missoula floods blanketed the quadrangle with Willamette Silt, only the highest hills rose above the floodwaters. In places the receding water and younger streams eroded through the silt, depositing gravel or revealing older gravel sequences. Elsewhere, the extent of Holocene stream deposits is conveniently bounded by preserved sequences of Willamette Silt.

The mapped distribution of surficial deposits is modified from soil maps and descriptions published by the U.S. Department of Agriculture (Langridge, 1987; NRCS, 2006; 2005).

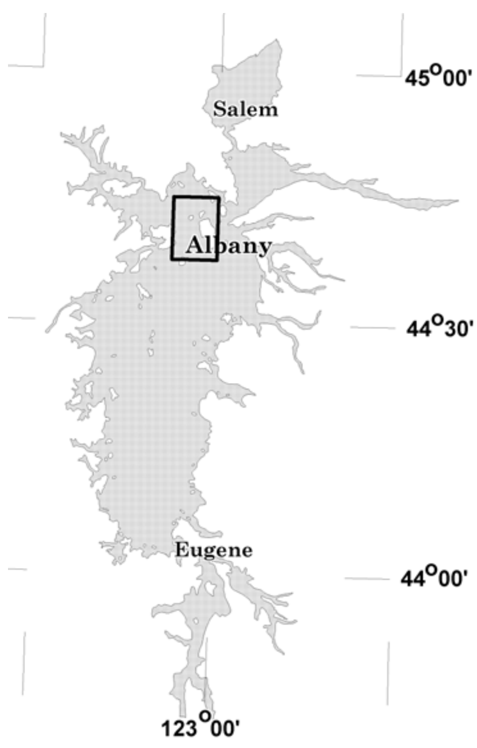

Figure 1. Location of the Albany quadrangle. Stippled pattern shows distribution of Willamette Valley fill.

EXPLANATION OF MAP UNITS

Surficial Deposits

m **Manmade fill (Historic)—**This unit is depicted where it has significant thickness or extent. Typical occurrences along roadways, railways, and rivers (dikes and levees) are not shown.

Qng **Near-channel gravel (Recent)—**Gravel deposited along and near modern channels of large streams and rivers. Locally includes unmapped areas of scoured bedrock and older alluvial units. Underlain by older alluvial units or bedrock. This unit forms a coarse-grained facies of the modern stream system, laterally equivalent to unit Qnc and to the youngest deposits that are assigned to units Qyg and Qys. Thickness is up to 15 m (50 ft).

Qnc **Near-channel gravel, sand, silt, and clay (Recent)—**Undivided gravel, sand silt, and clay deposited on low, near-channel floodways and floodplains. Commonly formed on the concave sides of river bends by the development of point bars. At greater distances from the main channel this unit is overlain by floodplain depoists of unit Qys. Typically underlain by channel gravel (unit Qng), but may be locally underlain by older alluvial units or bedrock. Thickness less than about 5 m (15 ft), locally greater where fine-grained sediment fills abandoned channels.

Qyg **Young gravel and sand (Holocene)—**Gravel exposed in patches that are typically round to oblong but locally irregular; distribution compiled from maps by Langridge (1987) and NRCS (2005, 2006) and locally modified for this report. Interpreted as gravel deposited along floodplain drainage channels and at breaches in natural levees (crevass splay deposits). Probably also includes exposures of older gravel where floodplain fines have been removed by erosion. Thickness less than 15 m (50 ft).

Qys **Young silt, sand, and clay deposits (Holocene)—**Silt, sand, and clay deposited on extensive floodplains when river flows exceeded bank-full conditions. Includes small unmapped patches of gravel at the surface and more abundant gravel in the subsurface. Highest areas inundated only during the largest floods. Sediment accumulates by repeated drapings of mud and clay and by deposition from relatively slow currents along broad floodplain channels. Uppermost (youngest) layers are probably time equivalent to coarser grained valley facies including units Qng, Qnc, and Qyg. Typically underlain by stacked fining-upward sequences. Typically less than about 5 m (15 ft) thick but locally greater where mud fills abandoned channels.

Qal **Alluvium (Holocene)—**Gravel, sand, and silt deposited by Willamette and Santiam Rivers and tributary streams. Typically consists of one or more fining-upward sequences deposited during lateral migration of channel, point bar, and related facies of meandering streams (Willamette River) or similar, coarser-grained facies of high-sinuosity bedload streams (Santiam River). Where mapped along small streams this unit probably contains young channel and floodplain facies equivalent to units Qng, Qnc, and Qys. Although laterally extensive in the subsurface, exposures are limited to cutbanks due to burial by young floodplain deposits assigned to unit Qys. Typically deposited in areas where streams have cut through the older Willamette Silt, but may overlie that unit in places. Pseudo-terraces may result where alluvial fans that were once in equilibrium with a large stream on the far side of a valley were truncated when the stream migrated laterally toward the fan and removed its toe. Thickness less than 15 m (50 ft).

Similar deposits of Pleistocene age probably occur in the subsurface beneath parts of the Willamette Valley. Many water well logs report “blue clay” at depth beneath the western part of the valley, suggesting that such deposits may be finer grained than their Holocene equivalents. Gannet and Caldwell (1998) interpret the “blue clay” as a sandy, low-energy stream deposit. A long-lived low-energy stream system in the southern Willamette Valley might have resulted from low stream gradients equilibrated to the bedrock high along the Jefferson Anticline. Both the Willamette and Santiam Rivers have bedrock beds in the vicinity of the Jefferson Anticline. Water well logs do not reveal any older, lower, buried channel along the anticline.

Qrg **Reworked (Linn) gravel (Holocene)—**Consists of reworked Linn Gravel (unit Qli) and mixtures of reworked Linn Gravel and younger coarse-grained alluvium. Generally overlies coarse-grained beds of Linn Gravel. Probably includes small exposures of eroded Linn Gravel. The map pattern in the southeastern corner of the quadrangle suggests that receding floodwaters or younger Holocene streams, probably including one or both forks of the Santiam River, eroded through the cover of Willamette Silt to expose and rework the upper parts of Linn Gravel beds below.

Qrs **Reworked (Willamette) Silt (Holocene)—**Consists of 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 of Holocene streams, probably including the Willamette River and one or both forks of the Santiam River, that eroded through the Willamette Silt and left behind fine-grained fluvial facies of similar or slightly modified composition.

Qws **Willamette Silt (late 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 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 400 feet (122 m) above sea level. Areas below about 250 to 300 feet (76-91 m) elevation were draped with a thick (3-6 m, 10-20 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 overlain by younger floodplain deposits. Wisconsin (Tioga?) age according to Allison (1953). O'Conner and others (2001) report an age range of 12.7-15 ka. Because this unit largely blanketed topography to elevations as high as 400 feet above sea level, it created a similar, distinctive soil that overlies many different surficial and bedrock units. Nearly identical soils top each of the older alluvial fan units as well as bedrock hills. Although similar, the following list of related soils have been given different names based on 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 along the top of the buried unit.

Lebanon and Stayton Fans

Distal parts of the Lebanon and Stayton Fans (Piper, 1942; Gannet and Caldwell, 2001) interfinger along the eastern edge of the Albany quadrangle. Coarse-grained deposits that make up the fans are locally draped with up to 5 m of Willamette Silt but the fan morphology is still apparent in the topography. Allison (1953) divided the gravelly deposits associated with these fans into three units based on terrace height above base level and weathering of the clasts. Gannet and Caldwell (2001) assign these gravel units to the Willamette Aquifer and show them interfingering with silt and clay facies in the subsurface beneath the western part of the quadrangle

Qli **Linn Gravel (upper Pleistocene)—**Stratified gravel and sand deposits, widespread but shown only in areas from which younger Willamette Silt has been eroded. Reworked gravel is mapped as unit Qrg. Thought to underlie the Willamette Silt in most low-lying low-relief areas east of the Willamette River. May include younger gravel deposits, not mapped separately, where receding floodwaters flowed fast enough to deposit gravel beds that are coeval with the Willamette Silt. One such area is the bench north of Jefferson where the percentage and size of gravel clasts at the surface increases as you approach the mile-wide topographic low located northeast of "The Cliff" (UTM 497,250E, 4,951,800N). Locally, Linn gravel is probably truncated by, or interfingers with, older alluvium beneath unit Qys in the western part of the quadrangle. Renamed the Rowland Formation and divided into the coarse-grained Linn Member and fine-grained Diamond Hill

Member by Balster and Parsons (1969). Possibly Tahoe in age according to Allison (1953). McDowell and Roberts (1987) report a 36 to 28.5 ka age for the Diamond Hill Member.

Qle **Leffler Gravel (late Pleistocene)—**Stratified bench gravel, sand, and mud. Locally deeply weathered. Partly covered by Willamette Silt at low elevations. Thickness up to 50 feet (15 m). Probably truncated by, or interfingers with, older alluvium beneath unit Qys in the western part of the quadrangle. Although now preserved well above the valley floor, these deposits may represent a period during which the ancestral Stayton fan and North Santiam River were in equillibrium with an ancestral Willamette River located on the western side of the Willamette Valley and an ancestral South Santiam River a similar distance to the south. Such a relationship could help explain the elevation of the deposits above the modern channel of the North Santiam River. The 15-m rim along the southeastern side of Scravel Hill (section 25, T.10S, R.3W.) is formed of Leffler gravel over sandstone and was apparently cut by the Santiam River and filled with alluvium (18 feet [6 m] of mud reported in well logs) prior to deposition of the Willamette Silt. Springs and year-round ponds form a line along this contact suggesting that older bedrock and younger (Willamette Silt +/- Santiam River mud?) fill in this area have low permeability. Angular clasts of siltstone have been recognized within about 20 feet (6 m) of the bedrock contact and probably represent rip-up clasts derived from nearby bedrock. In soils and shallow road cuts, and in gopher, fence-post, and telephone-pole-hole ejecta this unit is often distinguished by the presence of resistant sub-rounded to rounded pebbles. Deeper, fresher cuts reveal that the formation consists predominantly of clast-supported gravel. Terrace and benchtop flats are preserved in many places including the low ridge between Scravel Hill and Knox Butte and the bench in the northeastern corner of the quadrangle. Benches are preserved approximately 50 feet above the tops of benches assigned to the younger Linn Gravel. Where thickness of Willamette Silt is less than plow depth, shallow cuts in terrace edges underlain by Leffler Gravel typically show more than ten percent hard rounded clasts. Overlain by Willamette Silt and dissected by younger streams. Probably Sherwin or Kansan in age according to Allison (1953).

Qla **Lacomb Gravel (early Pleistocene)—**Dissected high-terrace gravel and sand deposits that crop out on the southeastern side of Scravel Hill. These deeply sand and gravel deposits are preserved at elevations as high as 402 feet (123 m) above sea level and 190 feet (56 m) above the Santiam River. Thickness at Scravel Hill may be as much as 52 m (172 feet). In soils and shallow road cuts, and in gopher, fence-post, and telephone-pole-hole spoils this unit is often distinguished by the presence of a few scattered resistant sub-rounded to rounded pebbles. Overlies Tertiary bedrock. Overlain in places by Leffler and Linn Gravels and by Willamette Silt. Dissected by younger streams.

Deep, fresh cuts reveal that the formation consists predominantly of clast-supported gravel. Weathering of many of the unstable clasts, most notably of rounded sedimentary clasts derived from nearby Tertiary sedimentary units, has significantly increased the percentage of clay. Many clasts can be cut with a knife. Many of the siltstone clasts disintegrate when handled. Water-well drillers often log the formation as clay and, at greater depth, as clay with intervals of gravel. This suggests that the formation is slightly better preserved at depth, however, the presence of a high percentage of soft sedimentary clasts indicates that deposits in the Albany quadrangle are poorly suited for use as aggregate. Water wells drilled on the southeast slope of Scravel Hill suggest that the gravel lies directly on bedrock. Remnants are small enough that flattened fan or terrace morphology is not apparent. May be equivalent to the Pleasant Hill terrace that crops out in the southern Willamette Valley south and west of Eugene. Probably equivalent to the decomposed gravels unit mapped by Vokes and others (1954) along the western edge of the Willamette Valley. Predates and is mantled by deposits of Willamette Silt. Allison (1954) assigns this unit to alluvial fans derived from the several forks of the Santiam River but the unit is more widespread than just that drainage. No age is available for widespread soft, yellow-to-green-to-gray sedimentary clasts derived from the Eocene-Oligocene sedimentary section. May record uplift and erosion of the Salem Hills and/or Coast Range. An unmapped occurrence of similar gravel, one meter thick, was recognized in a foundation excavation a few hundred meters northeast of Plumstone quarry in North Albany (SE1/4, Section 36, T.11S., R.4W.). Distinguished from Leffler Gravel by percentage of deeply weathered clasts, deeply dissected landforms, higher maximum elevation, and higher elevation of underlying bedrock surface. Where thickness of Willamette Silt is less than plow depth, fields underlain by Lacomb Gravel display only scattered round pebbles.

Unconformity

Tkb **Basaltic Andesite of Knox Butte (Oligocene)—**Two flows of dark reddish brown, plagioclase-phyric basaltic andesite crop out on Knox Butte in the southeastern corner of the quadrangle. A few meters of sedimentary rock assigned to unit Teok separate the flows. Thickness of the blocky lower flow ranges from 50 to 58 feet (15 to 18 m) in water wells. The upper flow is thinner (perhaps 33 feet [10 m] thick), spheroidal weathering, and locally vesicular or amygdaloidal at its base; it was not reported from water wells, rather an interval of boulders is often reported. Small patches of sandstone, with laminations that parallel attitudes measured in the Knox Butte area, occur within the vesicular facies near the base of the upper flow. A thin section was prepared from rock taken from the middle part of the lower flow (Table 1, Map Number 8) and contains andesine and labradorite plagioclase phenocrysts to 8 mm; labradorite is rimmed by granular clinopyoxene. The sample's intersertal groundmass has oligoclase lath, clinopyroxene, and opaque oxides enclosing patches of devitrified glass. Swallow-tailed opaque oxide rods (to 0.8 mm by 0.08 mm) are distinctive and probably reflect the flow's high titanium content (3.5% TiO2).

Tob **Basaltic Andesite, undivided (upper Eocene and Oligocene)—**Flows and possibly intrusive bodies of basalt and basaltic andesite located near the west bank of the Santiam River at Scravel Hill. Includes seriate to glomeroporphyritic plagioclase and olivine basaltic andesite with plagioclase phenocrysts to 1.5 cm (Table 1, Map Number 4), plagioclase phyric olivine basaltic andesite (Table 1, Map Number 5), and seriate plagioclase / olivine basaltic andesite (Table 1, Map Number 7). A 50-cm clast sampled from conglomerate at "The Cliff" on the Santiam River (Table 1, Map Number 1) is interpreted to be a weathered piece of petrographically identical rock collected from a thin flow remnant exposed to the southeast (Table 1, Map Number 4). Age is based on stratigraphic position above the last occurrence of planktonic forminifers *Globigerinatheka sp*. in the Wolverton 13-31 well located nearby.

Teok **Keasy Formation (upper Eocene and Oligocene)—**Marine siltstone and tuffaceous marine siltstone and mudstone with less common sandstone and rare pebbly sandstone and conglomerate. Poorly sorted sandstone from the southeast side of Knox Butte contains a mixture of subrounded to rounded volcanic lithic grains (to 2 mm in diameter, average 0.8 mm in diameter) and smaller, angular to subrounded quartz and feldspar grains (to 0.4 mm in diameter, average 0.2 mm) and glass shards in a fine grained (tuffaceous?) matrix. Very-fine-grained sandstone collected beneath the Santiam River bridge at Jefferson consists largely of subangular to subrounded grains of clear glass many of which have haloes (of brown devitrified glass) around tiny included crystals; other grains include volcanic lithic fragments, quartz, and feldspar all enclosed in a fine-grained (devitrified?) matrix. The formation is locally fossiliferous with fossils concentrated in scattered beds. Poorly to moderately indurated. Interpreted as a deep-water equivalent of the Eugene Formation. McKeel (1985) interpreted benthic foraminifera as representative of bathyal water depths for intervals in the American Quasar Petroleum Company Wolverton Number 13-31 well that have been assigned to the Keasy Formation for this report. The best road cuts are exposed on Knox Butte where the formation is dominated by cream to off-white colored siltstone. A few exposures occur on Scravel Hill.

Teoe **Eugene Formation (upper Eocene and Oligocene)—**Marine sandstone and tuffaceous sandstone. Typically arkosic and micaceous. Volcaniclastic or tuffaceous in the vicinity of volcanic units Tvsh and Tob. Combined thickness of deep-water (Keasy Formation) and shallow water (Eugene Formation) in the Wolverton Number 13-31 well is on the order of 2200 feet (670 m). Age based on the presence of upper Narizian and upper-lower Refugian foraminifers and the last occurrence of planktic foraminifers *Globigerinatheka index* and *Globigernitheka tropicalis* (McKeel, 1985) at about 34.2-34.3 Ma.

The Eugene Formation was originally named by Smith (1924) for tuffaceous marine sandstone that crops out in the Eugene area. There the formation is separated from similar marine strata of the older Spencer Formation by non-marine and volcanic rocks assigned to the Fisher Formation (Vokes and others, 1951; Retallack and others, 2004). The contact between the Eugene and Fisher Formations interfingers, reflecting local transgression and regression of the shoreline that may correspond to global sea level changes. During late Eocene and early Oligocene time water depths increased to the north (present coordinates), toward Albany. The non-marine Fisher Formation thins markedly northwest of Eugene and has not been recognized north of Cox Butte where it disappears beneath surficial deposits that cover the western Willamette Valley (Vokes and others, 1951). If the non-marine Fisher Formation simply disappears basinward then marine sandstone of the Eugene Formation would rest directly on similar sandstone of the Spencer Formation. At Albany, the contact between the Eugene and Spencer Formations is placed at the base of the Volcanics of Scravel Hill, which may be a northern equivalent to the Fisher Formation.

Vokes and others (1951) describe the southernmost exposures of the Eugene Formation in the Dorena Dam area (near Cottage Grove). They suggest that this location defines a significant transgression and highstand of the late Eocene sea. These beds crop out just a few hundred meters beneath the well dated 35 Ma Tuff of Bond Creek. Farther north, in its type area, marine strata of the Eugene Formation completely enclose the 35 Ma Tuff of Bond Creek (which crops out along the Willamette River south of Autzen Stadium). The 36-37 Ma age of maximum transgression (36.63 according to calculations by Retallack and others, 2004) overlaps with that of siltstone assigned to the Oligocene Keasy Formation (Schenk, 1927) that crops out north of Albany. An age of 35 Ma is roughly equivalent to the Narizian-Refugian boundary which is recorded by the last occurrence of the benthic foraminifer *Cibicides natlandi*,and the planktic foraminifers *Truncorotaloides sp.* (possibly *Acarina sp*.), *Globigerinatheka index* ,and *Globigerinatheka tropicalis?* between 1170 and 1360 ft (357-420 m) in the Wolverton 13-31 well (McKeel, 1985). Worldwide, the last known occurrences of these species range from 38.5 Ma for *Truncorotaloides* to 34.2 Ma for *Globigerinatheka tropicalis* (Pearson, 1998; as cited in Stewart and Pearson, 2000). Although no upper limit for the Eugene Formation has been defined in the well, the pre-*Cibicides natlandi* section is on the order of 1000 feet thick (305 m). Middle to upper bathyal water depths reported for benthic foraminifera found between 1150 (350 m) and 1700 (520 m) feet in the Wolverton 13-31 well are interpreted as coeval with highstand sandstone of the Eugene Formation in the Dorena Dam area west of Cottage Grove.

Between Eugene and Eagle Point the preserved welded parts of the Tuff of Bond Creek have an average thickness of about 400 feet. This tuff undoubtedly formed a blanket that covered much of western Oregon. It must have dramatically altered the provenance of sands carried by the region's streams. Pyroclastic rocks predominate in the latest Eocene and earliest Oligocene section in the western Cascade Range in southern Oregon. Above this stratigraphic level sedimentary rocks in the Albany area exhibit a prominent tuffaceous component. For example, a sample of very fine-grained sandstone collected below the Santiam River railroad bridge at Jefferson consists largely of grains of volcanic glass.

Tvsh **Volcanics of Scravel Hill (late Eocene)—**This unit consists of multiple flows of porphyritic basaltic andesite that are interlayered with sandstone and siltstone beds. The lavas crop out in the Scravel Hill area and on nearby Hale Butte and Hill 365'. Although locally well exposed in quarries and roadcuts, these layers are difficult to track where weathered or buried by Willamette Silt. Several well logs report "basalt" or "volcanic" intervals more than 180 feet (54.9 m) thick. Well logs also define several areas where one or more volcanic or intrusive layers have been encountered. Although most of the wells have not been located more precisely than to tax-lot centroid, it is apparent that "basalt" is encountered in bands that parallel bedding in sedimentary rock that wraps around the nose of the east-northeast plunging Jefferson Anticline. Two or three "basalt" layers are reported at each of two different stratagraphic horizons, one beneath the northern slope of Scravel Hill and one beneath the eastern slope of Scravel Hill (unit Tob). Quarry exposures reveal unbaked sandstone beds that conformably overlie flow tops. Baker (1988) reports locally derived volcanic grains are common in sedimentary rocks examined in cuttings taken immediately above volcanic intervals.

Basaltic andesite that crops out along the western shoulder of Scravel Hill may be related to the volcanics of Scravel Hill but its outcrop pattern cuts across strike. Exposures in the quarry at the southern end of the hill confirm an intrusive origin for these rocks and they have been assigned to unit Ti.

Tey **Yamhill Mudstone (middle Eocene)—**A three-hundred-foot interval of marine mudstone is reported from oil wells drilled in and near the Albany quadrangle (Baker, 1988; McKeel, 1985). In outcrops and in wells this mudstone unit appears to be overlain and underlain by sandstone of the Spencer Formation. Baker (1988) refers to this mudstone as the "Upper Yamhill mudstone" and McKeel (1985) showed a stratigraphic column with a thick composite unit of mudstone, siltstone, and sandstone assigned to the "Upper Yamhill" of Bruer. McKeel (1985) reports foraminifera recovered from cuttings of the mudstone originally inhabited upper middle bathyal to middle bathyal depths. In this report, this episode of relatively deep water in the Albany area is correlated to the maximum transgression of the marine Spencer Formation south of Eugene that occurred prior to eruption of the 40 Ma Fox Hollow tuff (Retallack and others, 2004; Madin, in press). The presence of sections dominated by fine-grained facies of the Yamhill Formation farther to the north and sections composed entirely of shallow marine sandstone of the Spencer Formation farther to the south support this interpretation.

Tes **Spencer Formation (middle and late Eocene)—**Shallow marine sandstone, pebbly sandstone, conglomerate, siltstone, claystone, and coal. Sandstone ranges from volcaniclastic to arkosic in composition. Volcaniclastic facies are dominated by coarse sandstone, pebbly sandstone, and conglomerate with mafic (basaltic?) grains derived from the Siletz River Volcanics that crop out a few miles to the west. Arkosic sandstone facies contain quartz, feldspar, and mica grains interpreted to have a source in the Tyee Formation that crops out to the southwest. Overall, the grainsize is predominantly medium sand. More arkosic facies are more common toward the top of the unit, above the Yamhill mudstone, more lithic facies occur near the base of the unit. Coarse-grained sand and pebbles are predominantly of volcanic rock and medium- to fine-grained sand is dominated by quartz and feldspar grains. This relationship between grainsize and protolith can even be seen in thick graded beds that are predominantly lithic at the base and arkosic at the top. Mica grains include muscovite, bleached biotite, and fresh biotite. The presence of marine fossils and coal associated with graded, cross-bedded to hummocky or swaley cross-bedded, to parallel laminated sandstone suggests deposition on a marine delta / shelf at depths ranging down to storm wave base.

Volks and others (1954) report an angular unconformity with slight to 50° discordance between the Spencer Formation and the underlying Tyee Formation in the hills northeast of Lewisburg. Farther northwest the Yamhill Formation lies between the Spencer and Tyee Formations. Coal-bearing strata are reported from outcrops at Spring Hill and from water wells in the southwestern part of the quadrangle. This horizon may correspond to the coal-bearing horizon that Vokes and others (1951) describe near the contact between the Spencer and Fisher Formations west of Eugene. McKeel (1985) reports Narizian stage foraminifera.

Vokes and others (1954) report the following combined fauna from four localities (37, 38, 39, and 40) collected on the south side of Spring Hill: *Acila (Truncocila) decisa* (Conrad), *Nuculana cowlitzensis* (Weaver and Palmer), *Brachidontes cowlitzensis* (Weaver and Palmer), *Thracia* sp., *Crassatella dalli* (Weaver), *Venericardia clarkii* (Weaver and Palmer), *Pitar californiana* (Conrad), *Pitar eocenica* (Weaver), *Tellina cowlitzensis* (Weaver), *Tellina* cf. *T. castacana* Anderson and Hanna, *Gari columbiana* (Weaver and Palmer), *Solena (Eosolen) columbiana* (Weaver and Palmer), *Spisula bisculplurata* Anderson and Hanna, *Teredo* sp., *Dentalium stramineum* Gabb, *Calyptraea diegoana* (Conrad), *Turritella uvasana* (Conrad) *stewarti* Merriam, *Perse sinuata* (Gabb) *aragoensis* (Turner), and *Exilia dickersoni* (Weaver).

Vokes and others (1951) report the following species are similarly present in the Spencer Formation in the southern Willamette Valley: *Acila decisa* (Conrad), *Nuculana cowlitzensis* (Weaver and Palmer), Brachidontes cowlitzensis (Weaver and Palmer), Crassatella dalli (Weaver), *Venericardia clarkii* (Weaver and Palmer), *Pitar californica* (Conrad), *Pitar (Lamelliconcha) eocenica* (Weaver and Palmer), *Tellina castacana* (Anderson and Hanna), Gari columbiana (Weaver and Palmer), *Solena (Eosolen) columbiana* (Weaver and Palmer), *Dentalium stramineum*

(Gabb), *Calyptraea diegoana* (Conrad), *Turritella uvasana* var. cf. *T. stewarti* (Merriam), and *Perse sinuata* (Gabb).

Vokes and others (1954) report only one animal to species level (*Acrilla dickersoni* (Durham)) that occurs in both the Eugene and Spencer Formations. None of the species that they collected from the Eugene Formation in the southern valley (Vokes and others, 1951) were subsequently reported from strata in southwestern part of the Albany quadrangle or the southeastern part of the Lewisburg quadrangle (Vokes and others, 1954).

Tet **Tyee Formation (middle Eocene)—**sandstone and shale in graded beds interpreted as turbidites. Separated from the Yamhill and Spencer Formations by an angular unconformity. Includes the Lorane Shale where it is present. Probably older than about 47 Ma (Bukry and Snavely, 1988, as cited in Yeats and others, 1992). Depicted on cross section only

Intrusive rocks

Ti **Mafic intrusion (late Eocene to Oligocene)—**mafic sill(?) on Scravel Hill and other intrusive dikes and sills too small to depict on the map. Exposures include those on Scravel Hill, in North Albany, and along the Calapooya River.

Geologic History

The stratigraphic section that can be assembled for the Albany quadrangle using outcrop data alone is rather incomplete. This report defines geologic units using a combination of outcrop and borehole data (McKeel, 1984, 1985; Baker, 1988; OWRD GRID database).

Geologic nomenclature for Paleogene units is particularly problematic. This stems from the location of the Albany quadrangle between the type areas of the middle to late Eocene Yamhill Formation on the north and the Lorane Shale, Spencer, and Eugene Formations to the south. Not surprisingly, one or more sections of strata in this area have been variously referred to as “upper Yamhill” (Bruer and others, 1984; McKeel, 1985), “lower Spencer” (Baker, 1988), or “Miller Sand” (Bruer and others, 1984; McKeel, 1985; Baker, 1988). Unit assignments are made on the basis of lithology, best available ages, and stratigraphic position relative to water depth maxima and minima in the Paleogene sea.

The stratigraphy of the southern Willamette Valley records repeated sea level fluctuations in an Eocene-Oligocene basin that was deeper in what is now the Albany area and shallower in the Eugene area. Coeval deep marine, shallow marine, and non-marine facies appear to have transited back and forth across the basin as sea level rose and fell. In shallower parts of the basin near Eugene sea level low stands were accompanied by erosion that resulted in unconformities or disconformities in the geologic record. Water depth estimates are based on interpretations of depositional environments and on depths reported for benthic foraminifera assemblages (McKeel, 1985). They define at least three transgressive-regressive cycles.

The oldest (late Ulatisian?) transgression recorded here culminated in deposition of 200 meters of “deep water” Lorane Shale above the Tyee Formation in the Spencer Creek area west of Eugene (Turner, 1937; Vokes and others, 1951; Gandera, 1977; Ryu and others, 1992; Murray, in press). Ryu and others (1992) observed that the Baughman and Hubbard Creek members of the Tyee Formation “sky out to the north” so a disconformity may be present locally between the two formations in the Eugene area. Although Vokes and others (1951) describe the Lorane shale as a basal member of the Spencer Formation, other authors have since described an angular unconformity separating the two units (Gandera, 1977; Ryu and others, 1992; Murray, in press). Age, position, and lithologic similarities suggest that 600 meters of fine- to medium-grained facies of the Yamhill Formation reported from gas wells in the central Willamette Valley (McKeel, 1985) is at least partly equivalent to the Lorane shale. McKeel (1985) indicates that this sea level high stand persisted into Narizian time, ending at about the onset of late Eocene time (ca. 49 Ma). These rocks do not crop out in the Albany quadrangle but are present in the subsurface.

In the Albany area 650 m (2100 feet) of nonmarine and shallow marine sandstone overlie the fine-grained deep-water sequence described above. This sandstone has been variously referred to as Spencer, upper Yamhill, Miller Sand, and lower Spencer. In the Eugene area 800 to 1000 meters of similar sandstone is assigned to the Spencer Formation (Vokes and others, 1951) and the included, now abandoned, Comstock formation of Turner (1938). Lower to lower upper Narizian ages (McKeel, 1985) from gas wells in the Albany area are at least party equivalent to the age of the Spencer Formation in the Eugene area where it predates the 40 Ma Tuff of Fox Hollow (Madin, in press). West of Eugene, the angular unconformity at the base of the Spencer Formation (Top of Lorane Shale) suggests that significant erosion (subaerial exposure?) occurred prior to deposition of Spencer Formation sandstone.

McKeel (1985) shows 30- to 100-meters of mudstone in the Albany area that resulted from a mid-Narizian, episode of deep-water (middle bathyal) sedimentation. He reports that this unit was deposited above the uppermost occurrence of the foraminifera *Cassidulina globosa* and below the uppermost occurrence of *Gyroidina "scalata"*. A correlative deep-water facies has not been recognized in the Eugene area. However, the maximum landward (southward) extent of the Spencer Formation probably occurred during a period of high sea level. Maximum landward extent of the Spencer Formation predates the 40 Ma Fox Hollow tuff and post-dates the uppermost Ulatisian-lower Narizian age of the unconformity between the Lorane Shale and the Spencer Formation and is consistent with a mid-Narizian high stand between 40 and 41 Ma.

The ca. 40 Ma contact between the Spencer formation and the Fisher Formation in the Eugene area is gradational, with nearshore facies giving way to beach and nonmarine facies upsection. The northernmost occurrence of non-marine facies near Fern Ridge Reservoir records the sea level low stand. Farther north, in the Albany area, beds of shallow marine sandstone were deposited at the same time.

Sometime between 37 and 39 Ma sea level began to rise again, with the maximum southward penetration of marine facies recorded at Dorena Dam south of Eugene (36.63 Ma, Retallack and others, 2004). This appears to correspond to an upper Narizian age transition from shallow water sandstone to middle bathyal silty mudstone in the Albany area. Deposits of the 35 Ma Tuff of Bond Creek are enclosed by non-marine rocks at Dorena Lake and by marine Eugene Formation in Eugene, so by that time the shoreline had retreated northward, to a position south of Eugene and north of Dorena Dam. Benthic foraminifera similarly record a change from middle bathyal to inner neritic depths at the end of the Narizian. The position of the shoreline continues to oscillate and generally retreat northward through the Oligocene and into the Miocene. Near Albany marine conditions occurred as late as the early Miocene (Scotts Mills Formation, Miller and Orr, 1988) following deposition (and partial erosion resulting in an unconformity) of the non-marine Little Butte Volcanic Series.

Flows of Miocene Columbia River Basalt crop out just north and east of the quadrangle and some of the same flows are reported from the coast, far to the west of the quadrangle. Beeson and others (1985, 1989) suggest that some of the flows passed through the Albany area and have been removed by subsequent erosion.

Quaternary deposits in the Willamette Valley include broad coalescing alluvial fans (unit Qli), Missoula flood deposits (unit Qws), and floodplain (unit Qys) and channel (units Qnc and Qng) facies of major streams. The glacial flood deposits drape across older topography at elevations up to about 400 feet, burying older alluvium, bedrock, and soils. In places the flood deposits have been reworked (Unit Qrs), buried, or stripped away (unit Qrg) by younger streams or receding floodwaters. Water well lithology logs show that much of the extensive Willamette River floodplain (unit Qys) is underlain by repeated fining-upward gravel-sand-silt sequences related to lateral migration of streams. Finer-grained (lower gradient?) facies are reported from the subsurface beneath the western part of the valley. Pleistocene gravel sequences are preserved in dissected terraces (unit Qle) and higher isolated remnants (unit Qla).

Structural Geology

Large folds and faults disrupt bedrock beneath the Albany quadrangle and surrounding areas. Although extensive Quaternary surficial deposits limit bedrock exposures in the Albany quadrangle proper, several bedrock trends are apparent when the geology of surrounding areas is considered. The principle structure is a deformed segment of the regional homocline that lies between the Coast Range and the Cascade Range. From Washington to California, the easternmost outcrops of Paleogene sedimentary strata define a roughly north-south trending, east-dipping homocline. To the west these strata generally overlie tectonostrati-graphic terranes of the northern Klamath Mountains and Siletzia. To the east the Paleogene section (and thin early Miocene sedimentary sections) is buried by volcanic and volcaniclastic rocks of the ancestral Cascade Range and Columbia River Basalt flows. North of the Klamath Mountains the Tyee Formation and younger strata form an overlap sequence that ties Siletzia to North America.

South and west of Albany the homocline has a north-northeasterly trend. But beneath the Albany quadrangle bedding rotates clockwise and forms northeast-trending folds, the largest of which is the Jefferson Anticline. This northeasterly trend is very nearly parallel to the Corvallis fault and suggests that that fault extends beneath a wide zone covered with alluvium in the northwestern corner of the Albany quad. Bedrock attitudes on either side of this zone parallel the Corvallis fault. North of the quadrangle Eocene strata are involved in a series of east-northeast trending folds while Oligocene and Miocene beds have more north-northwesterly trends, suggesting an unconformity sometime after the Eocene.

Although it lies north and east of the Albany quadrangle, one of the best-defined horizons mapped across the bends is the basal contact of the Columbia River Basalt Group. These lava flows are flat lying or gently west dipping, yet they appear to have filled middle Miocene topography that mimicked the older east-plunging folds. Beeson and others (1985) suggest that these folds form the southwestern extension of the Yakima fold belt. Based on the presence, absence, and thickness of various flows belonging to the Frenchman Springs Member of the Wanapum basalt, they suggest that several of the northwest-trending structures in the Willamette Valley were active during Frenchman Springs time. The distribution of Oligo-Miocene marine strata beneath the Columbia River Basalt suggests that a topographically controlled northeast-trending shoreline (drowned valley?) was already present during high sea level stands.

At deeper stratigraphic levels the anticline that forms the southern bend coincides with the Corvallis Fault. As currently mapped (Bela, 1979; Walker and MacLeod, 1991), Eocene stratigraphy varies dramatically across this fault. Arkosic sandstone dominates the section north of the fault while more lithic-rich sandstone with beds or basal layers of pebbly sandstone and conglomerate occur south of the fault. The Yamhill and Kings Valley Formations are thousands of feet thick in areas northwest of the fault, but have not been mapped to the southeast (Although Bela, 1981, shows Yamhill Formation east of the fault on a cross section that is based on well data from the northwest corner of the Sidney quadrangle. To the northwest Walker and McLeod (1991) show Yamhill Formation and Spencer Formation deposited directly on Siletz River Volcanics. The outcrop pattern of the Yamhill Formation suggests that it pinches out or changes in dramatic fashion as it approaches the fault from the northwest. South of the structure the Tyee Formation directly overlies the volcanic rocks or is faulted against them. Because the structure affected deposition of the Yamhill and Tyee Formations it probably predates the regional homocline. Subsequent tilting during formation of the homocline explains the northeasterly plunge of many folds. Evidence for activity from Eocene through Oligocene time suggests that this is either a long-lived or periodically reactivated structure. A left-lateral component for the Corvallis fault is suggested by the steepness of the fault plane, the style of deformation in the Tyee and Spencer Formations, the northeast-trending en echelon pattern of the large folds, and juxtaposition of markedly different stratigraphic sequences.

The early history of the Willamette Valley is not well constrained. Gannett and Caldwell (2001) place the northern part of the valley—north of the Salem Hills—in a structural low defined by a broad north-trending syncline that folds Columbia River Basalt. They draw the central and southern parts of the valley as a depression connecting local sub-basins developed on an older (middle Miocene?) east-dipping homocline. Beeson and others (1985) describe southwest-trending topographic lows that trend parallel to older folds like the Jefferson Anticline and predate eruption of Columbia River Basalt. They suggest that basalt flows turned southwestward in the vicinity of Mount Hood and followed these low areas toward the Albany area, across the modern trend of the valley. During the Eocene, marine facies of the Eugene Formation occur as far south as Dorena Dam where they lie well below the 35 Ma Tuff of Bond Creek (a thick ash flow that filled a broad lowland(?) extending as far south as Eagle Point, near Medford). Eocene Spencer Formation sandstone and conglomerate record a source in the Siletz River Volcanics to the west, suggesting the existence of a somewhat restricted or protected basin. The scarcity of planktonic forams is similarly related to deposition in a restricted or protected Eocene-Oligocene basin by McKeel (1985).

Water Wells

An attempt was made to improve the locations of water wells listed in the GRID on-line database maintained by the Oregon Department of Water Resources (OWRD). The accompanying spreadsheet lists the wells and their GRID numbers and other information including major lithologies and depth to bedrock. Using the four letter county abbreviation and well number, a scan of the original well log can be downloaded from the OWRD website. These data can be manipulated to show many aspects of the subsurface geology including bedrock type (see the figure titled Albany Area Water Wells on the map sheet), depth to bedrock, bedrock elevation (when used in concert with a digital elevation model), thickness of gravel bearing sediment, depth to first gravel, thickness of surface fines (including Willamette Silt), and depths to key bedrock horizons including volcanic rocks, conglomerate, and lignite/coal beds. These data are not be adequate to distinguish Willamette Silt from older buried alluvial silt sequences. This can only be done on a well-by-well basis where the original information on the driller's log is sufficiently detailed.

Natural Gas

The east-northeast-trending anticline in the southwestern part of the Sidney quadrangle has been tested by at least five unproductive oil and gas wells (Bela, 1981). These wells drilled into the Spencer Formation in an area between Roby Hill and the Willamette River, about two miles north of the northwest corner of the Albany quadrangle. The deepest of these, Portland Gas & Coke's Wiedehker 1 well, reached a depth of 3617 feet with shows of natural gas. This anticline lies parallel to the Jefferson anticline in the Albany quadrangle.

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