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# PRELIMINARY GEOLOGIC MAP OF THE EUGENE EAST AND EUGENE WEST 7.5′ QUADRANGLES, LANE COUNTY, OREGON

By

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# Preliminary Geologic Map of the Eugene East and Eugene West Quadrangles, Lane County Oregon

## Introduction

The Eugene-Springfield urban area is Oregon's second largest, and is home to a large and rapidly growing population. The adjacent cities of Eugene and Springfield have a combined 2000 population of over 190,000, and a growth rate over the preceding ten years greater than 20%. Population growth and development have also been rapid in the small towns and rural areas around the two major cities. Managing growth and development requires good geologic information for engineering, to manage landslide, flood and erosion hazards and to properly develop and regulate the heavily used groundwater resources. Existing geologic mapping for the area is poor, and new, detailed 1:24,000 scale maps complete with subsurface information are needed in the entire Eugene-Springfield urban area. In 2001, the Oregon Geologic Map Advisory committee selected the Eugene-Springfield urban area as a priority for new mapping. This map is the first product of a multi-year mapping study, carried out by the Oregon Department of Geology and funded by the State of Oregon and the U.S. Geological survey through the STATEMAP portion of the National Cooperative Geologic Mapping Program under assistance award #02HQAG2037. "*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*."

The study area is located (Figure 1) at the southern end of the Willamette Valley in western Oregon. The area is entirely within Lane County, and includes the confluence of three major rivers, the Middle Fork Willamette, Coast Fork Willamette and McKenzie. In addition to the heavily urbanized areas in Eugene and Springfield, the area includes intensively farmed lands in the Willamette Valley, and privately owned timberland and dense rural residential areas in the surrounding hills.

## Methods

This geologic map was prepared using a wide range of data, including existing mapping, new field observation, water well data, high-resolution topographic data, aeromagnetic data, geochemistry, geochronology, petrography and air photo interpretation.

The quadrangles are covered by numerous geologic maps, most of which are regional compilations at scales of 1:100,000 to 1:250,000 (Peck and others, 1964; Peck, 1960; Walker and Duncan, 1989; Yeats and others, 1991, O'Connor and others in press). All of these are largely based on the one original map of the area, which was published at 1:62,500 (Vokes and others, 1951). Little new fieldwork has been done since 1951. A MS thesis map at a scale of 1:62,500 covers the far NE corner of the map area (Lewis, 1950).

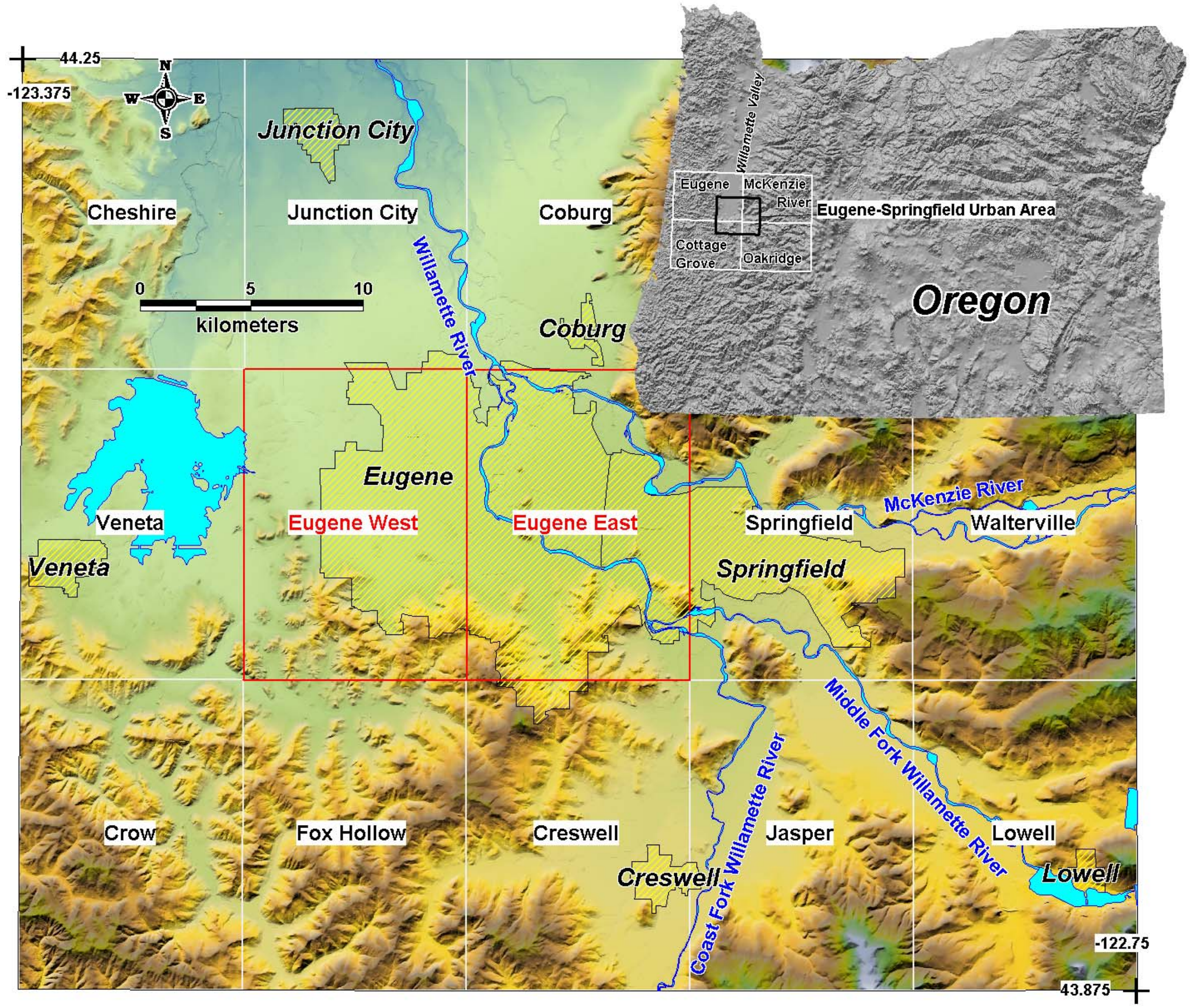


**Figure 1**. Eugene Urban Area Location Map. Red-bordered quadrangles presented in this report.

New field data was collected throughout the area. Although much of the geology is obscured by urbanization, thin soils and colluvium in the hilly areas allowed for fairly good exposures. Contacts were rarely observed, but it was relatively easy to find exposure that allows identification of lithology. Mapping was complicated by severe weathering or hydrothermal alteration of most of the rocks. Although the vast majority of the area is private land, it was possible to negotiate access for most parcels. The data map, which accompanies the geologic map, shows the traverses made and over 1200 GPS-located field stations. Field station locations along with brief notes are included in the data appendix. Outcrop photos are also included in the appendix, keyed to field stations. Several hundred samples were collected and described using a binocular microscope.

Over 1200 water wells were located using digital taxlot data and in some cases GPS. Unfortunately, the rocks in the area proved very challenging for well drillers to describe, and most of the logs provide limited stratigraphic information in bedrock areas. Well locations, along with location method and estimated spatial accuracy are provided in the data appendix. Logs for all the located wells are available online at the Oregon Water Resources Department.

The City of Eugene provided 2-foot contour mapping for about 75% of the map area. The contours, and digital elevation models derived from them were useful in identifying Quaternary features, dikes and contacts.

A high-resolution aeromagnetic map provided by Rick Blakeley of the USGS provided regional structural insights, but had little relation to details of surface geology in the quadrangles.

Selected volcanic rocks were analyzed for major and trace element chemistry by XRF. Analyzed samples are plotted on the map, and the chemical data presented in spreadsheet format in the data appendix. Samples were analyzed by XRD by Dr. Stan Mertzman at Franklin and Marshall College. The whole-rock analyses for major and trace elements were performed using a Phillips 2404 X-ray fluorescence vacuum spectrometer equipped with a 102 position sample changer. The Loss on Ignition (LOI) was determined by heating accurately pre-weighed amounts of sample rock powder to $950^{o}$ C for one hour, and then reweighing the sample to determine the relative percentage of weight gain and loss. The amount of ferrous Fe was titrated using a modified Reichen and Fahey (1962) method.

Two samples from within the quadrangle were submitted for $Ar^{39}/Ar^{40}$ dating at the Geochronology facility at Oregon State University. Results are pending.

The paleontology of the Eugene area, and the Eugene Formation in particular has been well studied and documented. No new paleontological studies were carried out for this map. Published fossil locations from Vokes and others (1951) and Hickman (1969) are plotted on the map. A data file linking the plotted points to sample locations in the references is provided in the appendix. Additional paleontologic data is presented in Retallack and others (In press).

## Explanation of Units

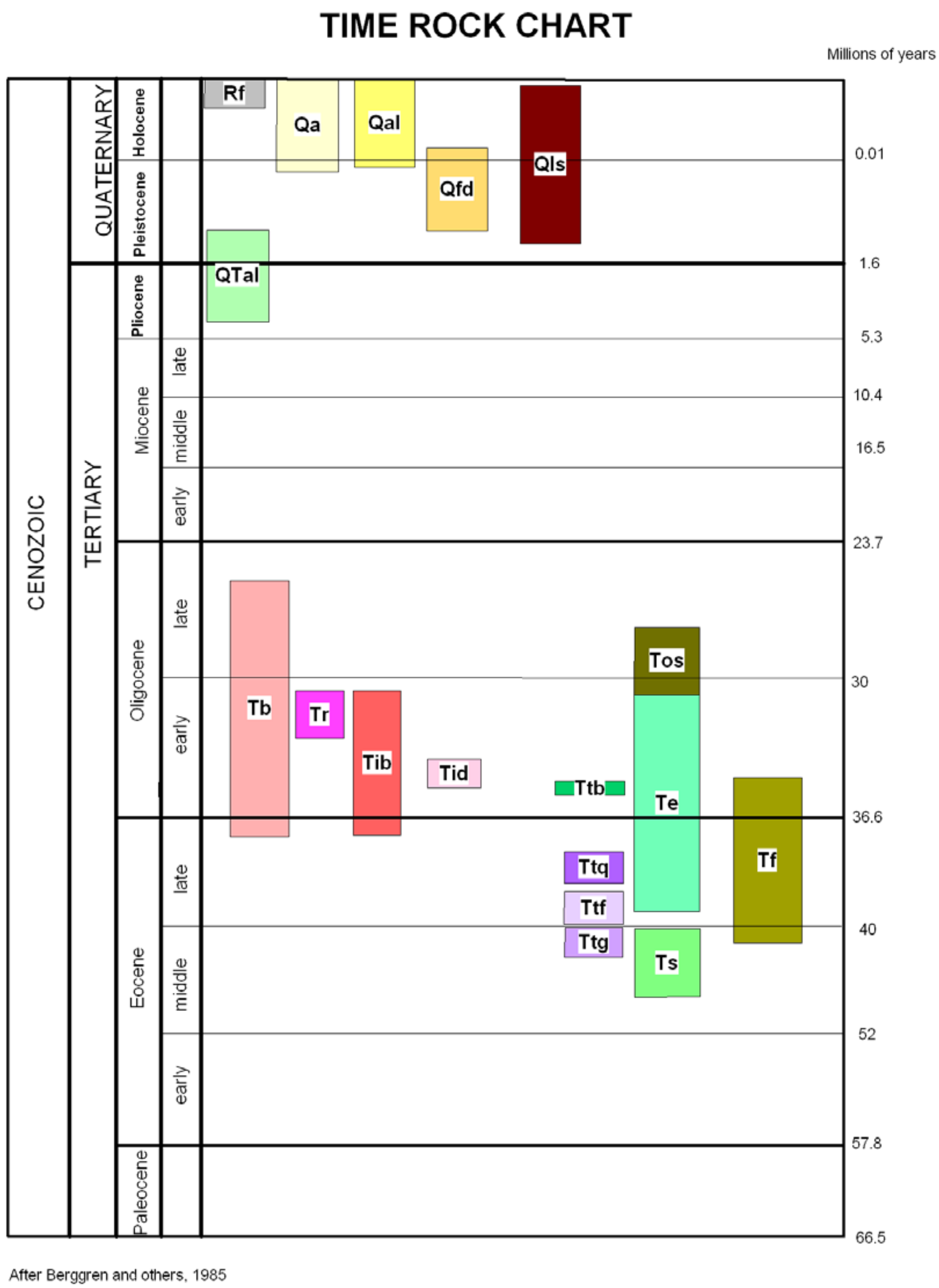


**Figure 2.** Time-rock chart showing age relations between units.

**Rf Artificial Fill—Recent**
Only mapped in un-urbanized areas where fill landforms are obvious on city of Eugene 2ft (0.6m) contour data. Recent fill is widespread in urbanized area.

**Qa Fine Grained Alluvium—(Holocene)**
Sand silt, clay and minor gravel deposited by local streams along the middle reach of Amazon Creek. Includes a distinctive 3-5 ft (1-1.6m) thick gray clay layer that contains pyroxene and hornblende crystals identical to those found in ash from the 6700 ka eruption of Mt. Mazama. (Personal Communication, Michael James and Karin Baitis, 2003). Thickness does not exceed 25 ft (8m).

**Qal Meander-belt Alluvium—(Holocene)**

Sand silt and gravel deposited in the active meander belt of the Willamette and McKenzie rivers. The meander belt is incised into the surface of the underlying fan-delta, and represents a shift from braided channel morphology during the most recent glaciation in the Cascade Range to incision and meandering during the current interglacial. Mapped by O'Connor and others (2001) as unit Qalc which they considered Holocene in age. They report C 14 ages from the Wildish Gravel pit (Section 8 T 17S R 3W) ranging from modern at the surface to 0.53 ka at a depth of 4 ft (1.2m) to 3.7 ka from a depth of 4m. Mapped on the basis of the relatively sharp edge to meander belt geomorphology, generally marked by a steep cutbank. The boundary is somewhat indistinct near downtown Eugene, where the river is cutting into bedrock in many places so that the edge of the meaner belt is not sharp.

**Qfd Fan-delta Alluvium—(Quaternary)**
A broad fan of sand and gravel deposited by the Willamette and McKenzie rivers in the head of the Willamette Valley. Fan-delta sediments range from silt to boulder gravel, but are predominantly sandy pebble-cobble gravel. Mapped by O'Connor and others (2001) as units Qg1 and Qg2, this study finds only one depositional landform in the form of a large subtle fan covering the center of the map area. Fan form based on high resolution DEM from 2 ft contour data shown in Figure 3. Exposures in gravel pits (O'Connor, and others 2001) include lahars and tuffs. Obsidian in lahar from about 90 ft (30m) below the surface returned an $Ar^{39}/Ar^{40}$ date of 418 +/-10 ka and 426 +/- 4 ka (O'Connor and others, 2001). In the northern part of the map area, gravel is up to 475 ft (145 m) thick (see data map on Geologic Map plate), but it is not obvious that this entire thickness is part of unit Qfd. It is possible that part of this gravel is a remnant of the older gravel unit QTal, and that incision after the deposition of QTal was modest. If that is the case the tuff and lahar ages may in fact be on unit QTal. Better dating of the gravels might establish whether there is an unconformity present.

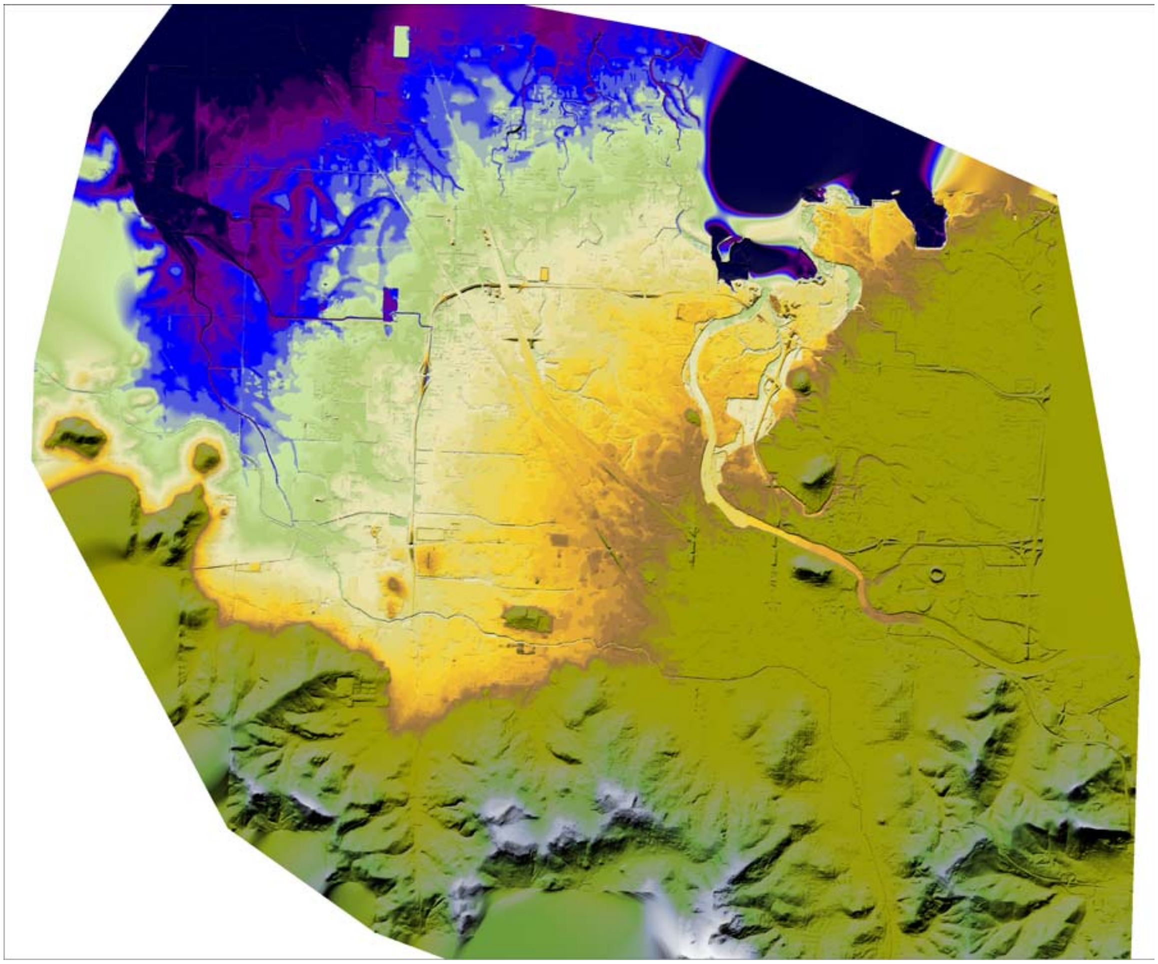

**Figure 3.** High resolution Digital Elevation Model of the Eugene area (roughly coincides with the map area). Based on 2 ft contour data from City of Eugene, color bands are at 5 ft intervals. Fan form is apparent in the blue though yellow bands. Areas of low resolution had no contour data.

**Qls Landslide deposits—(Quaternary)**
Unconsolidated masses of rock and colluvium deposited by landslides. Age uncertain, likely Pleistocene or early Holocene, as slide morphology is typically subdued. Identified on basis of geomorphology: steep headwall scarp, hummocky surface, fan shaped run-out zone. In no instances was any outcrop or subsurface data available to confirm the landslide origin of these landforms, and site specific data collected from these sites could readily disprove their origin as landslides. There is little information bearing on the age of the slides, but most appear to be relatively topographically subdued and therefore fairly old.

**QTal older alluvium—(Pliocene ? –Pleistocene)**
Sandy silty pebble and cobble gravel and weak conglomerate deposited by the early Willamette River. Forms a terrace surface that stands 10-15 ft (3-5m) above the adjacent fan-delta surface. Only one exposure was observed, which consists of sand pebble-cobble conglomerate composed mostly of andesitic and dacitic lava clasts with a lithic-

feldspathic sand matrix and sand lenses (Figure 4). Roughly half of the clasts in this exposure were totally weathered to clay and crumbled completely when excavated. Felsdpar and lithic sand grains from this exposure were almost completely weathered to clay. Age uncertain, limited by the underlying Paleogene bedrock and overlying Pleistocene fan-delta deposits. O'Connor and others (2001) report a discordant $Ar^{39}/Ar^{40}$ of about 700-800 ka for obsidian from a site about 6 miles (10km) west of the map area.

**Figure 4**. Photograph of QTal gravels. Hammer point indicates profoundly weathered cobble.

**Tr rhyolite flow and breccia (Oligocene)**

Massive, cliff-forming unit cropping out prominently in the NE corner of the map. Typically chalky gray with abundant phenocrysts of plagioclase, lesser quartz and pyroxene, and trace biotite in a fine-grained crystalline matrix. Phenocrysts are subhedral to euhedral, rounded, seriate ≤ 3 mm, and variably altered. Fresh samples are dark gray, glassy. Locally brecciated. Thickness up to 525 ft (160 m). Age unknown, bounded by Spores Point Tuff below at 31.3 Ma and overlying Tb basalt with data pending. Chemistry in Table 1 (J).

**Tos volcaniclastic sedimentary rocks—(Oligocene)**

Volcaniclastic sedimentary rocks interbedded with volcanic flows in the Coburg Hills. Predominantly massive lahar and muddy pebble-cobble conglomerate and breccia; includes pebbly sandstone and mudstone. Locally includes carbonized plant material. Differentiated from underlying Eugene Formation sandstone and conglomerate by very poor sorting, angular clasts, lack of marine fossils or glauconite. Descriptively similar to

Fisher Formation rocks, though apparently of somewhat younger age. Age bounded by underlying Tuff of Spores Point (31.3 Ma) and overlying Tb lava flows (date pending).

**Tts Tuff of Spores Point—(Oligocene)**

Tan pumice-lithic plagioclase tuff exposed in the banks of the McKenzie River SW of Spores point. White-tan ash matrix with abundant rounded tan pumice to 2cm, with common plagioclase crystals to 1mm, common very fine magnetite, some brown cariously weathered pyroxene? Polymict lithics are common up to a 3-4 mm. Shown on map as a data point (EW-53) because it is too thin to map, and not exposed elsewhere in the quadrangle. Has been $^{40}Ar/^{39}Ar$ dated at 31.3 +/- 0.6 Ma by Retallack and others (in press).

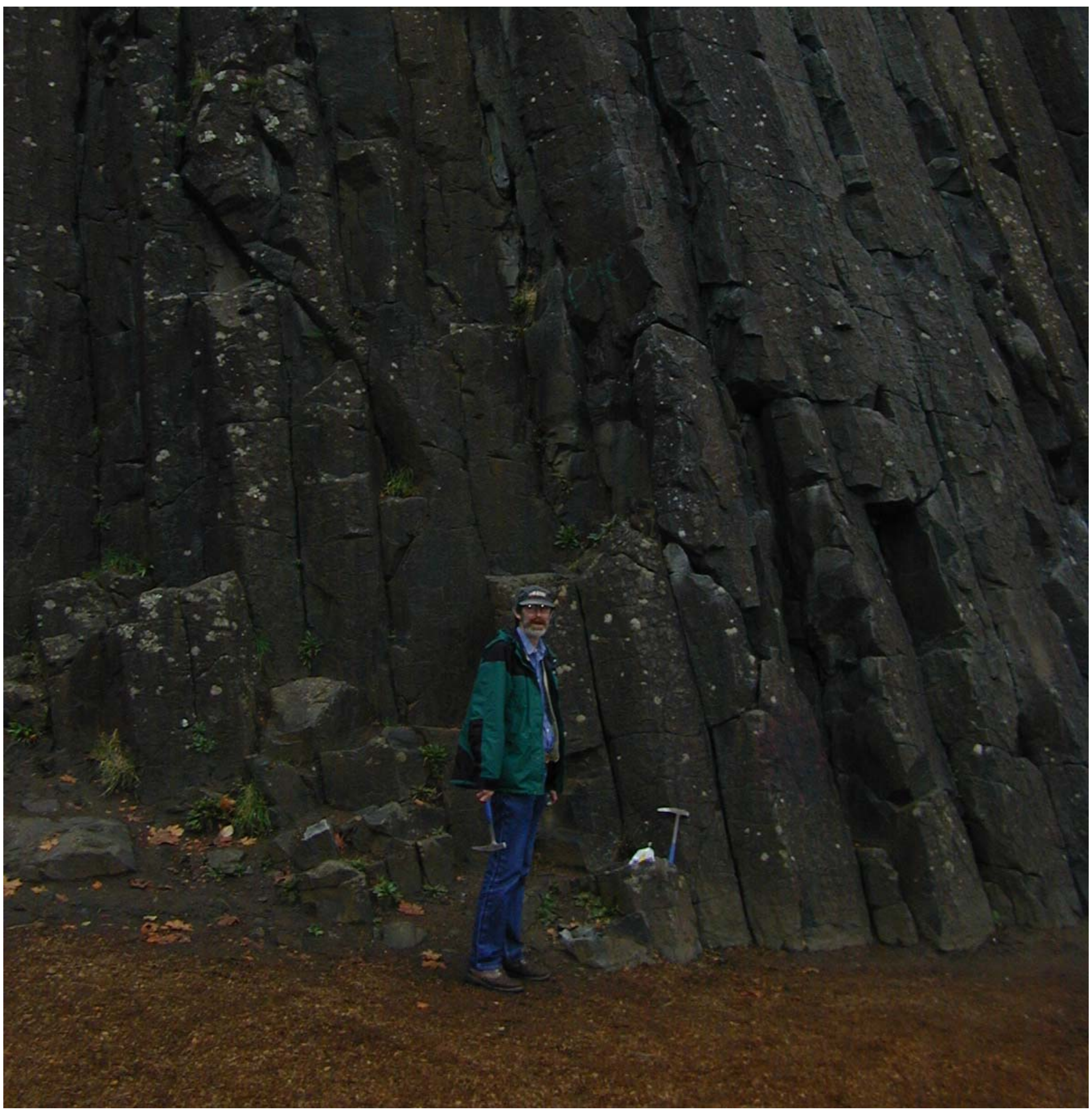

**Figure 5.** Columnar Basalt at Skinner Butte (EW 61, AE in Table 1)

**Tid dacite dike—(late Eocene-late Oligocene)**
Dark gray, very fine grained dike underlying Laurel Hill Cemetery in Glenwood. Outcrop along I-5 is scoriaceous to massive; at railroad tracks is columnar. Marine fossils within Eugene Formation at contact are pyritized. Chemistry in Table 1 (H).

**Tib basaltic intrusive rocks—(late Eocene-late Oligocene)**
Sills and dikes of olivine and pyroxene bearing basalt. Basalt is gray to black and commonly has columnar joints (Skinner Butte (Figure 5), Judkins Point, Fisher Butte) or is massive. Petrographically, basalt typically has a groundmass of seriate plagioclase to 1-1.5mm and glass, with olivine and clinopyroxene phenocrysts to 2-3mm. Olivine and clinopyroxene are commonly altered or completely replaced by chlorite and smectite. Geochemically the intrusive rocks are all basalt, with major and trace element chemistry largely indistinguishable from unit Tb. Contact relations are rarely observed with the intrusive rocks, and the geometry and origin of many bodies is uncertain. Tib basalts are typically columnar jointed, non vesicular and relatively coarse grained, but there is no simple way to differentiate them from Tb basalts. It is possible that rocks mapped as Tib are canyon filling flows or invasive lobes of Tb flows. Intrusive bodies at Skinner Butte in downtown Eugene and Fisher Butte just W of the map area have little aeromagnetic signature suggesting that they are rootless. Geochemically Tib rocks are all tholeitic basalts (Figure 6, 7) (Table 1, Z-AF), except for EW-119 (Table 1, AA) which is a basaltic andesite.

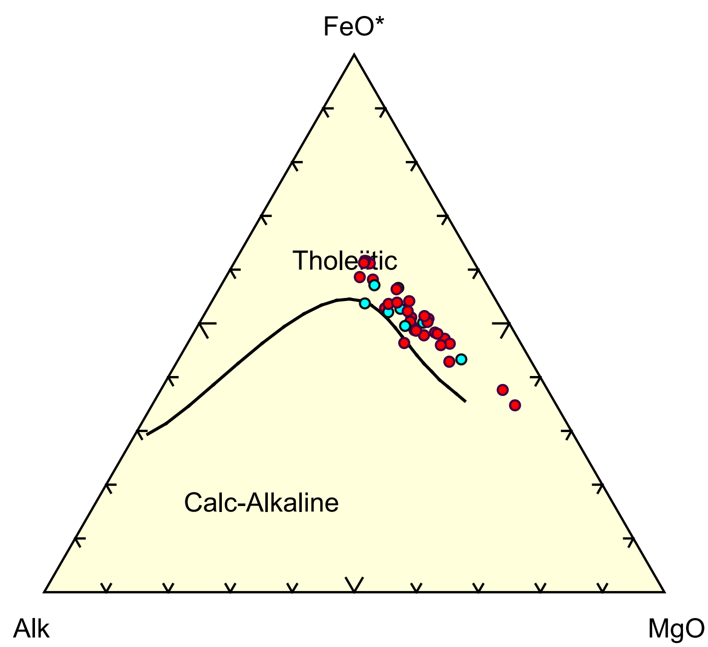


**Figure 6.** Irving and Barager AFM diagram. Red points unit Tb, blue unit Tib.

TABLE 1. GEOCHEMICAL DATA

| Code | Specimen | UTME_ 27_10 | UTMN_2 7_10 | Unit | SIO2N | TIO2N | AL2O3N | FE2O3N | FEON | MNON | MGON | CAON | NA2ON | K2ON | P2O5N | FEOTN | LOI_ | Rb | Sr | Y | Zr | V | Ni | Cr | Nb | Ga | Cu | Zn | Co | Ba | La | Ce | U | Th | Sc | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 03RM-132A | 499666 | 4874945 | Tb | 51.01 | 1.197 | 15.06 | 8.55 | 5.69 | 0.256 | 6.63 | 11.47 | 2.01 | 0.28 | 0.143 | 16.16 | 2.25 | 5.1 | 737 | 19.2 | 93 | 445 | 80 | 425 | 8.1 | 20.3 | 119 | 92 | 43 | 465 | 34 | 71 | 1.5 | 7.9 | 43 | 6 |
| B | 03RM-132B | 499666 | 4874945 | Tb | 50.70 | 1.362 | 16.43 | 4.38 | 6.52 | 0.180 | 6.54 | 9.57 | 2.43 | 0.54 | 0.300 | 12.90 | 0.12 | 6.2 | 292 | 19.5 | 88 | 238 | 196 | 498 | 7.8 | 16.9 | 92 | 74 | 49 | 67 | 7 | 18 | <0.5 | <0.5 | 30 | 4 |
| C | 03RM-139A | 496451 | 4884339 | Tb | 51.89 | 2.009 | 14.57 | 2.84 | 7.85 | 0.211 | 4.70 | 9.31 | 2.91 | 0.61 | 0.271 | 12.79 | 0.47 | 6.1 | 293 | 20.5 | 101 | 235 | 169 | 365 | 9.1 | 17.7 | 86 | 109 | 48 | 137 | 9 | 23 | <0.5 | 2 | 28 | 4 |
| D | 03RM-140 | 499044 | 4882370 | Tb | 50.86 | 1.814 | 17.73 | 0.20 | 7.01 | 0.181 | 3.76 | 9.86 | 2.66 | 0.39 | 0.222 | 8.81 | 0.76 | 5.9 | 299 | 20.6 | 95 | 179 | 51 | 156 | 8.3 | 19.2 | 85 | 59 | 26 | 100 | 10 | 23 | 0.5 | 1.5 | 25 | 4 |
| E | 03RM-204 | 497839 | 4874135 | Tb | 50.45 | 0.947 | 16.05 | 5.00 | 4.64 | 0.143 | 7.21 | 11.78 | 1.81 | 0.57 | 0.153 | 11.09 | 1.82 | 2.4 | 429 | 18.7 | 104 | 199 | 194 | 325 | 9.6 | 18 | 110 | 65 | 44 | 157 | 9 | 21 | <0.5 | 1.7 | 26 | 3 |
| F | 03RM-218 | 497918 | 4874824 | Tb | 50.54 | 1.619 | 16.47 | 8.59 | 3.61 | 0.165 | 5.31 | 9.61 | 2.60 | 0.87 | 0.433 | 13.58 | 3.02 | 10.8 | 455 | 33.1 | 247 | 220 | 50 | 120 | 21.6 | 20.9 | 90 | 109 | 36 | 231 | 24 | 48 | <0.5 | 3.3 | 29 | 6 |
| G | 03RM-238 | 494711 | 4872950 | Tb | 51.10 | 1.041 | 14.74 | 3.97 | 5.94 | 0.153 | 7.70 | 12.06 | 1.84 | 0.39 | 0.122 | 11.51 | 2.01 | 12 | 481 | 17.1 | 74 | 278 | 53 | 196 | 6.8 | 18.4 | 122 | 63 | 36 | 190 | 8 | 19 | <0.5 | 0.7 | 29 | 5 |
| H | 03RM-29 | 496462 | 4875705 | Tid | 65.99 | 0.724 | 14.52 | 10.17 | 2.05 | 0.060 | 1.49 | 3.70 | 3.50 | 1.45 | 0.161 | 13.76 | 0.52 | 11.4 | 475 | 36.6 | 302 | 202 | 34 | 75 | 25.2 | 22.2 | 81 | 108 | 31 | 370 | 25 | 52 | 0.7 | 1.2 | 25 | 4 |
| I | 03RM-351 | 497008 | 4884467 | Tb | 50.46 | 1.770 | 17.55 | 3.00 | 7.61 | 0.190 | 3.89 | 9.93 | 2.64 | 0.36 | 0.220 | 12.74 | 0.02 | 10.3 | 426 | 20.4 | 81 | 308 | 98 | 218 | 6.3 | 20.2 | 134 | 88 | 43 | 122 | 7 | 16 | 0.6 | 1.6 | 29 | 7 |
| J | 03RM-362 | 497889 | 4884119 | Tr | 73.44 | 0.394 | 14.19 | 2.08 | 0.40 | 0.050 | 0.15 | 2.54 | 4.56 | 1.67 | 0.081 | 2.79 | 0.89 | 38.3 | 189 | 33.4 | 255 | 31 | 3 | 5 | 15.5 | 16.3 | 8 | 41 | 3 | 467 | 31 | 63 | 1.7 | 4.8 | 10 | 7 |
| K | 03RM-38 | 498667 | 4881709 | Tb | 51.06 | 2.575 | 14.19 | 2.98 | 9.59 | 0.212 | 4.16 | 9.12 | 2.79 | 0.69 | 0.424 | 15.01 | 0.98 | 24.3 | 328 | 33.2 | 137 | 359 | 12 | 44 | 11.7 | 20.8 | 37 | 111 | 33 | 281 | 18 | 40 | 0.5 | 3.5 | 34 | 6 |
| L | 03RM-462 | 492742 | 4873344 | Tb | 48.61 | 0.735 | 12.04 | 3.40 | 6.22 | 0.171 | 15.63 | 9.54 | 1.27 | 0.52 | 0.101 | 11.39 | 0.66 | 9.1 | 382 | 11.6 | 53 | 218 | 447 | 1575 | 3.8 | 13.4 | 120 | 69 | 64 | 124 | 8 | 16 | 0.9 | 1.8 | 30 | 6 |
| M | 03RM-568 | 498307 | 4882161 | Tb | 50.73 | 1.816 | 17.62 | 2.74 | 7.06 | 0.171 | 3.69 | 9.73 | 2.70 | 0.45 | 0.221 | 11.71 | 0.36 | 7.8 | 331 | 22.2 | 119 | 235 | 99 | 234 | 11.8 | 19 | 96 | 71 | 38 | 158 | 13 | 28 | <0.5 | 1.1 | 27 | 3 |
| N | 03RM-612 | 495810 | 4873848 | Tb | 50.41 | 0.722 | 12.76 | 3.86 | 6.79 | 0.163 | 13.51 | 9.13 | 1.30 | 0.48 | 0.102 | 12.47 | 1.60 | 8 | 301 | 24.1 | 134 | 236 | 130 | 289 | 12.5 | 19.1 | 125 | 87 | 43 | 122 | 14 | 31 | <0.5 | 0.6 | 30 | 5 |
| O | 03RM-623 | 495206 | 4871313 | Tb | 50.62 | 1.329 | 16.20 | 4.38 | 6.45 | 0.152 | 6.43 | 10.19 | 2.32 | 0.66 | 0.233 | 12.66 | 1.40 | 9.7 | 481 | 24.7 | 97 | 299 | 83 | 115 | 8.1 | 21.1 | 188 | 86 | 41 | 155 | 10 | 25 | <0.5 | 0.6 | 29 | 5 |
| P | 03RM-64 | 495067 | 4875422 | Tb | 51.49 | 1.348 | 16.57 | 3.69 | 6.61 | 0.180 | 6.56 | 8.82 | 2.33 | 0.73 | 0.250 | 12.28 | -0.14 | 10.5 | 517 | 21.1 | 93 | 277 | 71 | 95 | 7.3 | 21.4 | 143 | 84 | 38 | 155 | 12 | 25 | <0.5 | 2 | 27 | 29 |
| Q | 03RM-71 | 495219 | 4874834 | Tb | 48.72 | 1.048 | 21.47 | 5.60 | 4.96 | 0.121 | 3.85 | 12.90 | 2.22 | 0.15 | 0.151 | 12.25 | 0.79 | 8.8 | 404 | 22 | 74 | 301 | 100 | 250 | 5.7 | 18.8 | 165 | 81 | 43 | 108 | 8 | 18 | <0.5 | 0.6 | 34 | 6 |
| R | 03RM-717 | 490801 | 4880636 | Tb | 49.37 | 1.456 | 15.96 | 3.94 | 6.66 | 0.168 | 7.35 | 9.80 | 3.28 | 0.68 | 0.199 | 12.04 | 4.53 | 11.2 | 530 | 19.2 | 87 | 297 | 27 | 66 | 6.8 | 20.3 | 132 | 76 | 30 | 188 | 9 | 23 | 0.7 | 2.6 | 31 | 7 |
| S | EW-19 | 487133 | 4872927 | Tb | 50.12 | 1.399 | 16.31 | 5.05 | 6.45 | 0.182 | 7.54 | 9.93 | 2.60 | 0.41 | 0.213 | 13.39 | 1.37 | 12.4 | 361 | 28.9 | 123 | 355 | 30 | 43 | 10.4 | 22.4 | 255 | 95 | 32 | 154 | 14 | 31 | 1.7 | 2.1 | 31 | 6 |
| T | EW-21 | 487626 | 4874104 | Tb | 48.52 | 1.489 | 16.18 | 1.63 | 7.48 | 0.194 | 8.66 | 9.95 | 2.42 | 0.34 | 0.173 | 10.85 | 1.92 | 5.9 | 526 | 14.2 | 65 | 324 | 59 | 212 | 5.8 | 18.8 | 136 | 79 | 37 | 150 | 7 | 18 | 0.6 | 1.7 | 35 | 6 |
| U | EW-24B | 488125 | 4874136 | Tb | 48.24 | 1.252 | 15.61 | 4.08 | 7.08 | 0.180 | 9.57 | 10.06 | 2.31 | 0.29 | 0.160 | 13.26 | 0.13 | 5.9 | 300 | 23.1 | 126 | 311 | 36 | 87 | 11.2 | 20.3 | 150 | 88 | 35 | 116 | 11 | 25 | <0.5 | 1.2 | 34 | 5 |
| V | EW-32 | 488821 | 4874535 | Tb | 49.76 | 1.471 | 17.09 | 2.72 | 6.76 | 0.162 | 6.98 | 10.27 | 2.73 | 0.41 | 0.223 | 11.20 | 1.41 | 9.4 | 423 | 10.6 | 56 | 226 | 314 | 1155 | 4.1 | 13.9 | 92 | 75 | 55 | 175 | 6 | 14 | <0.5 | 1.9 | 29 | 6 |
| W | EW-36 | 489850 | 4875295 | Tb | 49.18 | 1.113 | 17.42 | 3.48 | 5.47 | 0.216 | 8.26 | 10.44 | 2.37 | 0.26 | 0.165 | 10.31 | 2.93 | 10.1 | 494 | 12.8 | 59 | 245 | 93 | 309 | 4.3 | 17 | 87 | 66 | 36 | 151 | 10 | 20 | <0.5 | 1.5 | 30 | 5 |
| X | EW-462 | 500036 | 4893826 | Tb | 50.32 | 1.412 | 17.16 | 4.16 | 5.68 | 0.193 | 5.80 | 10.27 | 2.17 | 0.39 | 0.183 | 11.46 | 1.52 | 8.4 | 438 | 14.7 | 70 | 260 | 133 | 501 | 6.1 | 15.4 | 93 | 70 | 45 | 201 | 6 | 20 | 0.7 | 2.3 | 30 | 3 |
| Y | EW-60 | 498355 | 4876029 | Tb | 49.44 | 1.807 | 16.36 | 1.79 | 8.04 | 0.216 | 5.74 | 9.84 | 2.58 | 0.43 | 0.595 | 11.61 | 2.58 | 10.7 | 550 | 20 | 92 | 293 | 33 | 120 | 9.2 | 19.4 | 133 | 71 | 31 | 175 | 9 | 24 | <0.5 | 2 | 30 | 5 |
| Z | 03RM-429 | 492451 | 4881153 | Tib | 50.80 | 1.448 | 16.47 | 4.41 | 5.76 | 0.164 | 5.50 | 10.34 | 2.70 | 0.75 | 0.195 | 11.70 | 2.60 | 11.4 | 454 | 17.9 | 73 | 298 | 22 | 68 | 7.1 | 20.4 | 159 | 84 | 31 | 175 | 11 | 27 | <0.5 | 2.2 | 30 | 6 |
| AA | EW-119 | 484579 | 4874078 | Tib | 53.24 | 1.410 | 17.48 | 4.63 | 5.48 | 0.152 | 4.00 | 8.99 | 3.07 | 0.37 | 0.264 | 11.75 | 1.41 | 5.6 | 370 | 21.4 | 125 | 225 | 137 | 309 | 11.3 | 18.6 | 133 | 78 | 44 | 118 | 15 | 32 | <0.5 | 1.6 | 27 | 4 |
| AB | EW-167 | 483308 | 4874475 | Tib | 49.86 | 1.484 | 16.02 | 2.92 | 7.10 | 0.170 | 7.28 | 9.81 | 2.39 | 0.41 | 0.231 | 11.98 | 0.28 | 5.8 | 518 | 23.7 | 94 | 260 | 92 | 148 | 7.3 | 21.1 | 100 | 80 | 39 | 183 | 13 | 28 | <0.5 | 2.7 | 27 | 6 |
| AC | EW-59 | 495724 | 4876505 | Tib | 49.60 | 1.836 | 16.34 | 4.12 | 7.22 | 0.203 | 4.89 | 9.51 | 2.86 | 0.74 | 0.629 | 13.30 | 1.43 | 9.1 | 358 | 29.7 | 125 | 350 | 29 | 63 | 11.1 | 22 | 247 | 94 | 32 | 156 | 14 | 28 | 0.5 | 2 | 31 | 6 |
| AD | EW-592 | 479680 | 4878456 | Tib | 50.56 | 1.554 | 15.89 | 2.39 | 7.39 | 0.180 | 5.48 | 10.59 | 2.52 | 0.26 | 0.211 | 11.75 | 0.25 | 12.3 | 543 | 24.8 | 179 | 251 | 39 | 104 | 13.8 | 21 | 128 | 72 | 30 | 269 | 17 | 39 | <0.5 | 3.4 | 27 | 5 |
| AE | EW-61 | 492338 | 4878111 | Tib | 50.54 | 0.884 | 13.81 | 5.59 | 5.05 | 0.173 | 9.94 | 10.67 | 1.84 | 0.58 | 0.142 | 12.25 | 1.60 | 9.6 | 452 | 22.8 | 129 | 239 | 88 | 200 | 11.6 | 20.3 | 108 | 96 | 39 | 167 | 13 | 27 | 0.9 | 3.2 | 30 | 7 |
| AF | EW-62 | 492589 | 4879642 | Tib | 50.67 | 1.478 | 16.06 | 4.50 | 6.20 | 0.172 | 6.43 | 10.52 | 2.51 | 0.77 | 0.223 | 12.50 | 1.24 | 9.9 | 334 | 24.8 | 98 | 298 | 24 | 32 | 8 | 21.2 | 174 | 94 | 31 | 151 | 11 | 21 | <0.5 | 0.5 | 32 | 5 |

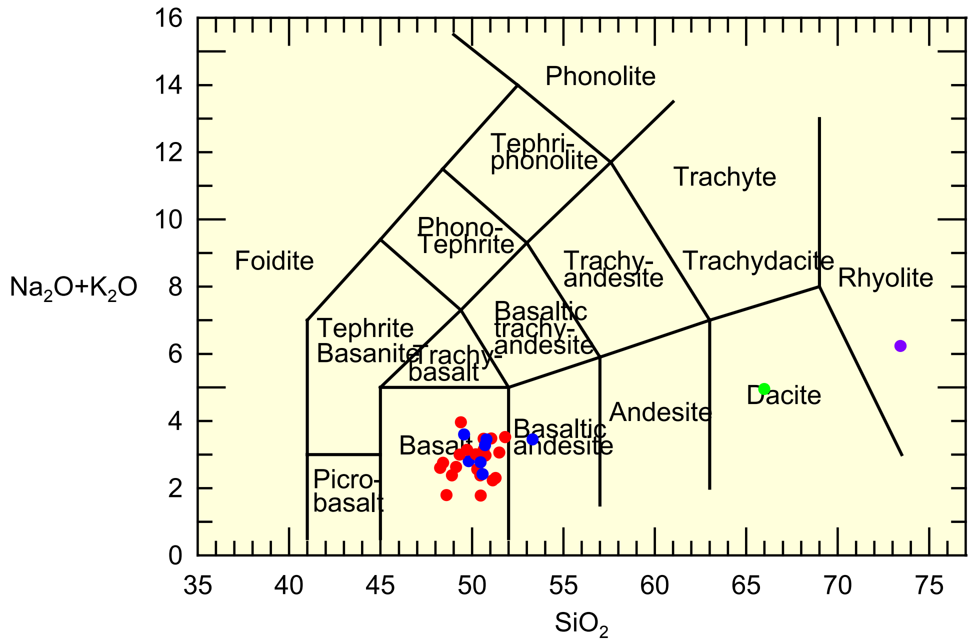


**Figure 7**. Le Bas and Streckeisen TAS classification for volcanic rocks in map area. Red points unit Tb, blue Tib, Green Tid and purple Tr.

**Ttb Tuff of Bond Creek (late Eocene-early Oligocene)**

White or light tan, massive to bedded. Varies from coarse-grained to porcelaineous. Coarse-grained rocks are predominantly plagioclase, with lesser quartz, trace biotite and opaques. Mafic volcanic lithics and pumice common in outcroppings south of the map area are sparse or lacking. Plagioclase and quartz are anhedral to subhedral, typically broken, ≤ 1mm. Plagioclase exhibits albite and Carlsbad twinning, and oscillatory zoning. Biotite is green pleochroic or brown. At least 25 m (90 ft) thick at Masonic Cemetery; the Willamette River exposure consists of approximately 0.5m of well-indurated, coarsely-crystalline plagioclase and quartz with trace biotite, overlain by at least 1 m of white, porcelaineous rock with rare biotite(?). Radiometric age of a sample collected at the Willamette River outcrop is 34 ± 0.8? 0.2? ($Ar^{39}/Ar^{40}$ on a plagioclase separate; Retallack and others, in press).

**Te Eugene Formation—(late Eocene-early Oligocene)**

Shallow marine sandstone and siltstone with local/minor thin conglomerate beds. Predominantly thick bedded to massive arkosic sandstone with glauconite and some mica, some is tuffaceous with matrix composed of glass shards. Typically tan to brown, locally weathered or hydrothermally altered to a soft massive white sandstone composed entirely of quartz, white clay and mica. Similar sandstone has been called the Wallace Butte sandstone (Schenk, 1928) for exposures at Wallace Butte, but in this mapping the sandstone has been found at several locations and varying stratigraphic positions, and is likely to be solely the result of weathering or alteration of the typical Eugene Formation sandstone. Locally strongly cemented with carbonate or FeO. Locally interbedded with Fisher Formation rocks at a scale to fine to map. Commonly fossiliferous, see Vokes and others (1951), Hickman (1969) for species lists.

**Ttq Tuff of Quaker Rd. (late Eocene-late Oligocene)**
Severely weathered white to yellow lithic rich tuff exposed in a few small cuts and excavations exposed in Section 2, T18S R4W. Appears to have been deposited in the marine environment, though contacts were not observed.

**Tb basalt flows and volcaniclastic sedimentary rocks--(late Eocene-late Oligocene)**
Numerous flows of olivine-clinopyroxene bearing basalt. Basalt is typically black to gray where fresh, but is commonly weathered or hydrothermally altered (Figure 8) to soft white, pink or light gray clay. Locally interbedded with sandy or pebbly claystone, sandstone and polymict volcaniclastic conglomerate or lahars very similar to Fisher Formation rocks. Typically spheroidally weathered. Basalt typically weathers to produce thick colluvium with abundant subangular basalt fragments to boulder size and a dark brown to dark gray soil. Local interbeds of brick red, silty or sandy claystone in the southern part of the map area are probably paleosols. Many of the bodies east of Amazon Creek appear to have been deposited as canyon filling flows. Petrographically, basalt typically has a groundmass of seriate plagioclase to 1-1.5mm and glass, with olivine and clinopyroxene phenocrysts to 2-3mm. Olivine and clinopyroxene are commonly altered or completely replaced by chlorite and smectite. Geochemically, the basalt flows are all tholeitic basalt, Lux (1982) reports whole rock K/Ar dates of 32.4 +/- 0.8 Ma and 35.3 +/- 0.9 Ma from basalt at 40$^{th}$ and Donald street, and 30.3 +/- 1.1 Ma for basalt at the Springfield Butte quarry. $^{40}Ar/^{39}Ar$ date pending for basalt directly above unit Tos in NE corner of map area. Geochemically the flow rocks are all basalt, with major and trace element chemistry largely indistinguishable from unit Tib (Figures 6,7, Table 1, A-G, I, K-Y)

**Tf Fisher Formation--(late Eocene-late Oligocene)**
Volcaniclastic sedimentary rocks and tuffs. In the map area, predominantly massive lahars and muddy pebble-cobble conglomerate. Also includes pebbly claystone, siltstone and sandstone. Sandstone typically composed of lithics and eu-subhedral plagioclase. Typically severely weathered or hydrothermally altered with most lithics replaced by clay, zeolite cement, and locally with hydrothermal epidote. Weathering of this unit generally produces thin colluvium and soil, an outcrops are relatively common even on flat surfaces.

**Figure 8.** Severely weathered or hydrothermally altered basalt. 3"x5" sample bag for scale. Round dark mass in upper center is remnant of less-weathered corestone**.**

**Tth Tuff of Fox Hollow—(middle Eocene)**

Massive plagioclase-lithic welded tuff. Typically cream or pinkish, but also green, reddish orange, white and purple. Matrix is typically recrystallized to a fine aggregate of feldspar (?), but relic glass shards are visible in some specimens. Plagioclase phenocrysts typically abundant, up to 3mm long, zoned and twinned, and euhedral or rounded euhedra, some broken. Plagioclase ranges from quite fresh in some specimens to up to 50% altered to sericite and carbonate in others. Lithics are typically abundant, up to 1cm in diameter, and are a polymict assortment of lavas, pumice occurs locally. Rare very fresh specimens have euhedral clinopyroxene phenocrysts up to 1mm in length, most samples have pyroxene-shaped masses of brown or green clay with fine magnetite or pyroxene shaped voids that suggest relict pyroxene phenocrysts (Figure 9). Retallack and others (in prep) report quartz in this unit, but none was observed in numerous thin sections, including sections stained for K-Feldspar and plagioclase. Age is 41.0 +/-0.06 Ma based on a plagioclase separate $^{40}Ar/^{39}Ar$ date reported by Retallack and others (in prep). Thickness up to 150 feet (50m).

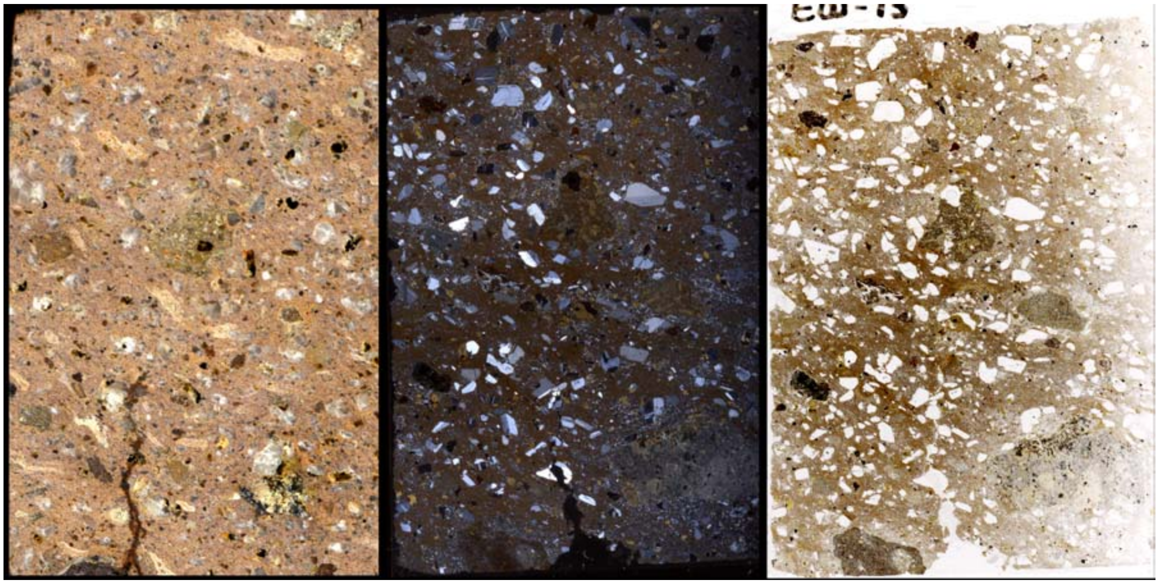

**Figure 9**. Tuff of Fox Hollow. Thin section billet (left), thin section with crossed nicols (center) and thin section in plane-polarized light (right). All 1 inch (2.5cm) wide.

**Ttg  Tuff of Gimpl Hill Rd. (late Eocene-late Oligocene)**
Thin deposit of pyroxene bearing plagioclase-lithic tuff. Recrystallized ash matrix shows shapes of relict glass shards. Common polymict lava lithics to 1cm, with abundant fresh euhedral plagioclase to 2mm. Pyroxene occurs as 1-2mm irregular grains intergrown with plagioclase, and as euhedral green needles up to 2mm long. $^{40}Ar/^{39}Ar$ plagioclase separate date pending.

**Ts  Spencer Formation—(middle-late Eocene)**
Predominantly thin bedded micaceous arkosic sandstone with siltstone interbeds. Massive sandstone beds, beach cobble conglomerate and coal beds occur near the top of the sequence in the far SW corner of the map.

**Structure**
The first order structure of the area is gently NE dipping homocline. The oldest rocks are exposed in the SW corner of the Map area, and get generally younger to the NE. Within this regional structure however are numerous complications, predominantly faults. Strikes and dips were generally difficult to measure, and usually only small (meter scale) exposures were available. In the Spencer Formation, measured attitudes appear to conform well to contact behavior. Fisher Formation rocks are typically massive, and rarely provided strikes and dips from even small exposures. In the Eugene Formation strikes and dips measured over a relatively small area varied widely, commonly disagree with attitudes inferred from contact behavior. It is likely that there is significant channeling and soft sediment deformation in the relatively shallow water Eugene Formation s well as deformation associated with emplacement of basalt flows and intrusions.
Numerous faults were mapped in the SW quadrant of the map. Most were mapped on the basis of apparent stratigraphic offset, in many instances coupled with subdued topographic expression. The fault plane was exposed only on the Hawkins Hill Fault.

The sense of motion was derived from stratigraphic relations, and dips inferred to be 60-70 for NW trending faults and vertical for E-W trending faults.
The NW trending faults include the Murray Hill, and Gimpl Hill Faults which have NE side down and SW side down throw respectively. In both cases vertical offset is 100-200 ft (30-60 m). These faults cut all of the Paleogene rocks, but show no evidence of Quaternary motion.
The E-W trending faults include the W 11th, Hawkins and Willow Creek Faults, and are typically N side up with vertical offset of a 100-200 ft (30-60 m). The Hawkins Hill fault plane was exposed just S of Hawkins Hill reservoir (Field stations EW342-346)

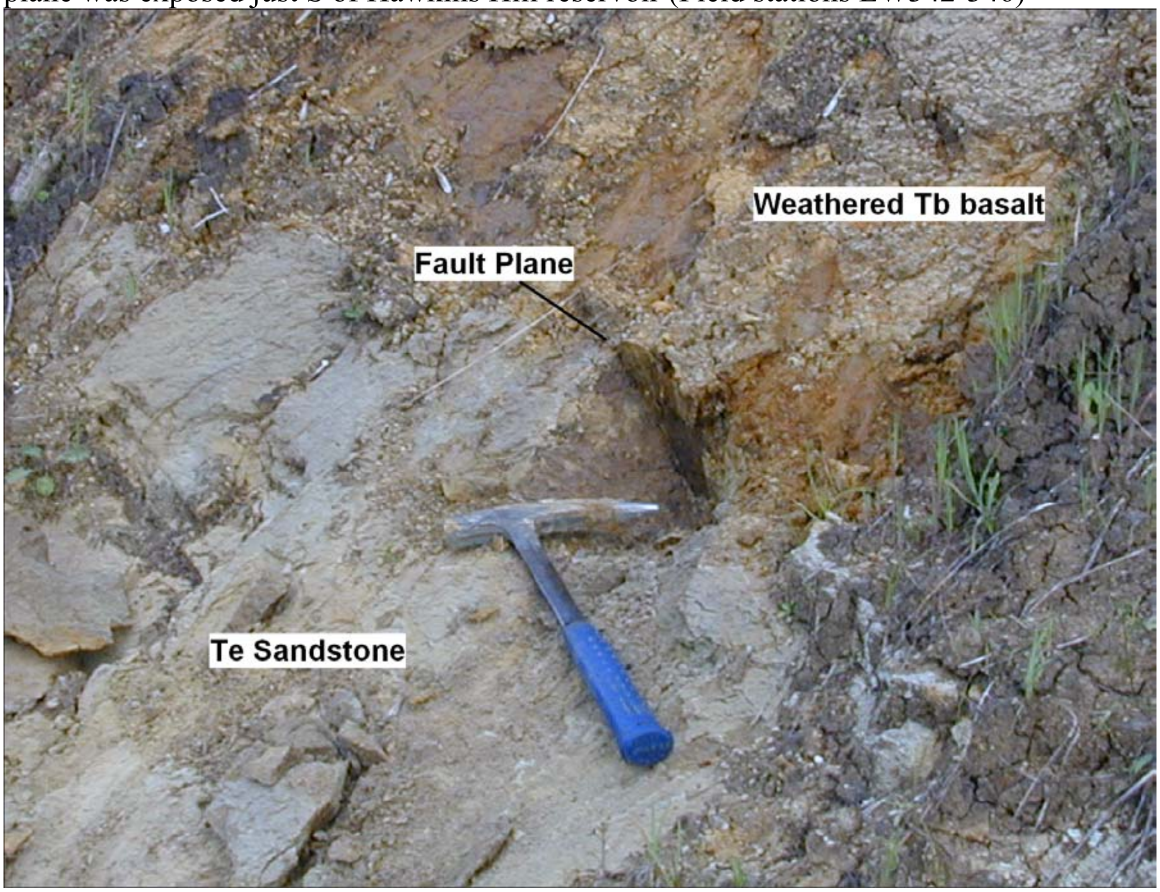


**Figure 10**. View looking East, exposed fault Plane on Hawkins Hill Fault.

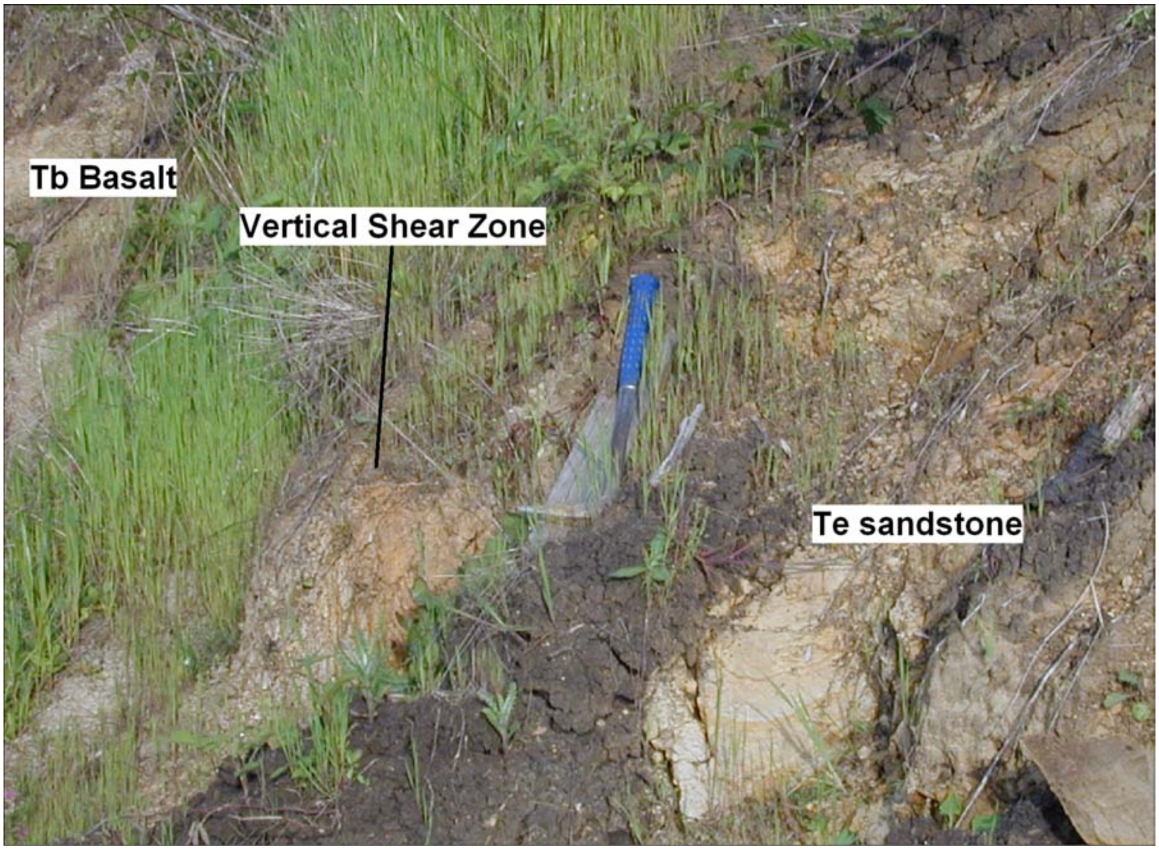

**Figure 11**. View looking east exposed fault plane on Hawkins Hill Fault, Photo a few meters east of figure 10.

where it consists of numerous closely spaced vertical shear zones and faults with 60-70 degree S dip. This style of faulting is suggestive of some strike slip component, but the poor exposures of the fault and lack of slickensides leaves room for doubt.

The W 11th Fault shows evidence for strike slip displacement. The tuff of Fox Hollow is exposed S of the fault, where it is at least 50 ft (15m) thick and overlies over 100 ft (30 m) of Fisher Formation. On the north side of the fault, the tuff is only a few meters thick, is anomalously glassy, and is interbedded with fossiliferous marine sandstones. These two exposures are separated by about 100 ft (30m) vertically and a few hundred feet horizontally, yet their depositional environments are radically different. This suggests that substantial horizontal slip has occurred on the fault, but there is no evidence for the sense.

The consistent N side up displacement of the E-W trending faults suggests that the southern Termination of the Willamette Valley here may be due to the faulting. The E-W faults have uplifted and exposed relatively easily eroded Spencer and Eugene Formation sandstones in the Valley, juxataposed against the overlying basalt flows and Fisher formation. All of the E-W faults offset all of the Paleogene rocks, but none appear to have any Quaternary motion.

No faults were mapped in the east half of the area. This may be due to the absence of faults, or the absence of easily mapped marker horizons. Most of the bedrock in the east half of the map is uniform Eugene Formation, with channel filling basalts and basalt intrusions. None of these lend themselves to locating faults. In the SW corner of the map, fault identification was highly dependent of the widespread and easily recognized Tuff of Fox Hollow.

**Geologic History**

The geologic history exposed in the map begins in the late Eocene with the deposition of Spencer Formation sandstones in the moderately deep to shallow waters. The provenance of the sandstone suggests that the basin was receiving sediment from a plutonic/metamorphic source, perhaps the Klamath Terrane to the south or the Idaho Batholith to the east. The Spencer changed as relative sea level fell, with the deposition of beach cobbles, massive beach sands and lagoonal coal right at the top of the unit. At least locally, the Spencer gives way abruptly to the subaerial volcaniclastic Fisher Formation, with thin lahars, tuffs and coarse lithic and euhedral plagioclase sandstones immediately overlying the shallow water Spencer deposits. This change probably resulted primarily from regional sea level changes instead of displacement of the marine environment by an advancing front of volcaniclastic deposits because the marine Spencer appears to have been shoaling before any Fisher rocks were laid down. The Tuff of Gimpl Hill closely marks this transition in the far SW corner of the map, where it occurs a few feet above the last of the Spencer.

Further north in the map area, there may have a been a somewhat different scenario. N of the W 11$^{th}$ fault, the Fisher appears to pinch out, and the Tuff of Fox Hollow is deposited directly on Spencer? Sandstones and overlain by Eugene? Sandstones. This suggests that this part of the basin never got shallow enough to allow thick deposits of Fisher rocks and the Spencer transitions directly to Eugene, and there are both Spencer and Eugene rocks that are age equivalent to the Fisher.

In the SW quadrant of the map, substantial thicknesses of Fisher lahar, conglomerate tuff and sandstone were deposited. These deposits appear to have been thickening to the west, as the Tuff of Gimpl Hill and overlying Tuff of Fox Hollow are separated by only a few tens of feet along Gimpl Hill Rd. but are apparently separated by hundreds of feet in the far SW corner of the map. This, coupled with apparent thinning to the north as described above suggests that either the source vents or the river system delivering the volcaniclastics were to the south. Near the top of the Fisher the distinctive Tuff of Fox Hollow was deposited around 41ma, leading to a period when Eugene Formation shallow water sandstones were being deposited along with basalt flows and Fisher sediments. These transitions may not have involved significant regional sea level change, and may simply reflect deposition along the strandline, with local Fisher and basalt deposition in channels. It is notable however that despite the common close relations between the marine Eugene and the basalt flows, there is very little evidence of lava-water interaction in the form of pillows, pelagonite tuffs or hyaloclastites. This may argue for local seal level excursions that left the Eugene formation dry and exposed to channeling and burial by basalt flows. Towards the top of the Eugene Formation, the number of basalt flows appears to decrease, although the section is marked by the Tuff of Bond Creek at 34 Ma (?) and Tuff of Spores Point at 31 Ma. In the far NE corner of the map the Eugene Formation is overlain by terrestrial volcaniclastic sediments very similar in appearance to the Fisher Formation, which are in turn overlain by more basalt flows. Previous workers have interpreted this as a transition to the Little Butte Volcanics; a formation defined hundreds of kilometers to the south. If pending radiometric ages show little difference between theses rocks and the Fisher Formation at Eugene, it may make more sense to map them as Fisher.

The lava flows that overlie the uppermost volcaniclastic sediments include a unique rhyolite flow and breccia, apparently interbedded with the basalt. No vent has been found for this or any other lavas in the map area.

The early Oligocene rocks in the NE corner of the map area represent the end of until perhaps the Pliocene, when the early Willamette Valley had developed and valley fill gravels of unit QTal formed a terrace across the valley. This terrace was subsequently incised to a depth of tens of feet to hundreds of feet, before being refilled during the Pleistocene by fan-delta gravels deposited by a braided ice age Willamette River. At the end of the ice ages, the Willamette began to incise into the fan delta surface as it shifted from braided to meandering, and is now cutting further into the bedrock and fan delta gravels and leaving a swath of modern alluvium. After the deposition of the fan delta, small alluvial deposits formed around its edges, locally accumulating tephra from the eruption of Mt. Mazama that formed Crater Lake.

**Acknowledgements**

Thanks are due to Dr. Greg Retallack of the University of Oregon for introductory field trips and helpful discussions, and to Bill Clingman of LCOG for digital data, field assistance and valuable discussions and to Michael James of James Geoenvironmental Services and Karin Baitis of US BLM for filed trips and unpublished data on the Mazama ash in Eugene.

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## Appendix Contents (Data Files on CD)
## All coordinates in UTM Zone 10 NAD 27

**Geochemistry**

| | |
|---|---|
| XRF_Methods.txt | Discussion of analytical methods |
| Eugene EW Geochem.xls | Geochem Data in Excel spreadsheet format, with coordinates. |

**Field Locations**

Field Data.xls Field data, brief notes in Excel spreadsheet format with coordinates

**Well Locations**

Well_data.xls Well locations with coordinates, OWRD Log ID number in Excel Spreadsheet Format. Location error estimated, xy in meters, z in feet. Located by tl (taxlot), gps (GPS reading in field), owrd (USGS-OWRD data file), intrsxn (street intersection).

**Photographs**

Outcrop and specimen photos in .jpg format, keyed to locations in Field_Data.

**Petrography**

Scanned thin sections and polished thin section billets as .jpg files keyed to Field_Data.xls

**Paleontology**

Fossil_locations.xls Excel spreadsheet of fossil locations with coordinates, keyed to Vokes and Hickman publications.

**GIS Files**

Eugene_EW_Polygons.tab, .shp Geology polygons labeled with unit Id, in Mapinfo Tab and Arcinfo Shape file format.

Eugene_EW_faults.tab, .shp Geology polygons labeled with unit Id, in Mapinfo Tab and Arcinfo Shape file format.