STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

# Geology and Mineral Resources Map of the Lakecreek Quadrangle, Jackson County, Oregon

1995

ISSN 0270-952X

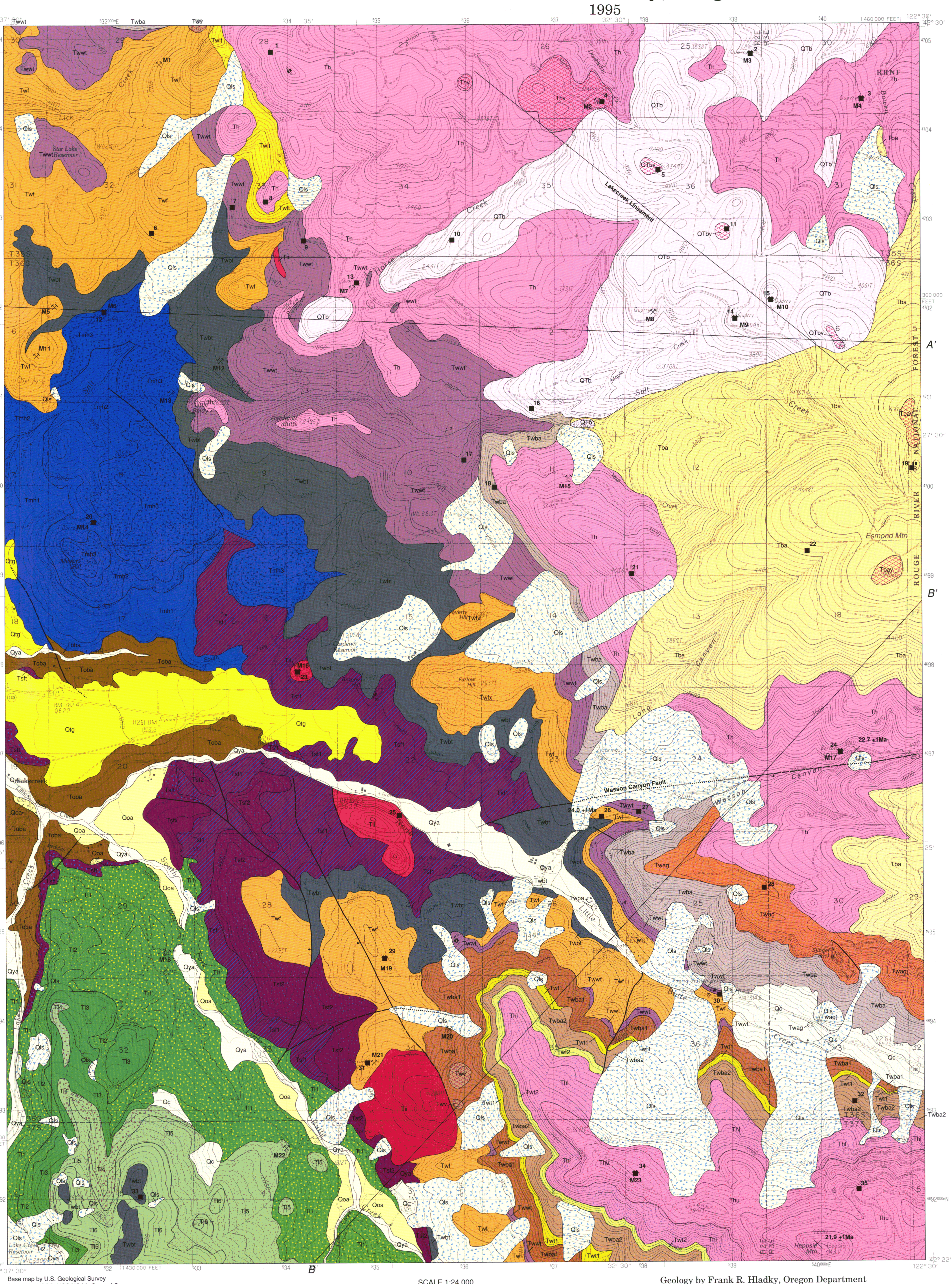
## GMS-88

Geology and Mineral Resources Map of the Lakecreek Quadrangle, Jackson County, Oregon

By F.R. Hladky

Funded in part by the National Geologic Mapping Program (STATEMAP) administered by the U.S. Geological Survey

## Plate 1



Base map by U.S. Geological Survey
Control by USGS, NOS/NOAA, State of Oregon
Projection: Lambert Conformal Conic
Grid: 1000-meter Universal Transverse Mercator, Zone 10
10,000-foot State Grid Ticks, Oregon, South Zone
UTM grid declination: 18 minutes east
1980 magnetic north declination: 18 degrees, 30 minutes east
Vertical datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum



QUADRANGLE LOCATION

SCALE 1:24 000

KILOMETERS

FEET

MILES

CONTOUR INTERVAL 40 FEET

Geology by Frank R. Hladky, Oregon Department of Geology and Mineral Industries

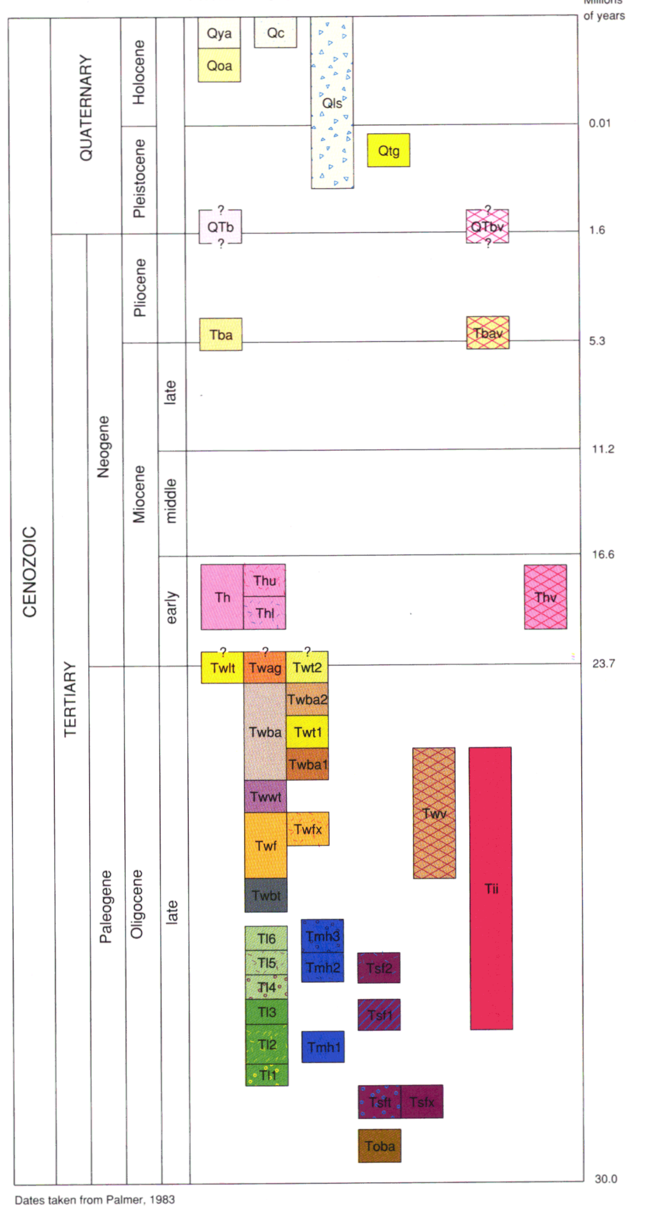
Reviewed by David R. Sherrod, U.S. Geological Survey, and Thomas J. Wiley, Oregon Department of Geology and Mineral Industries

Field work conducted 1993-1994

Cartography by Mark E. Neuhaus

The geologic information on this map is available in digital formats

### TIME ROCK CHART



Dates taken from Palmer, 1983

### EXPLANATION OF MAP UNITS

*(see accompanying text for full explanation)*

#### Surficial deposits

- Qya — Young alluvium (Holocene)
- Qc — Colluvium (Holocene)
- Qls — Landslide deposits (Holocene and Pleistocene)
- Qoa — Old alluvium (Holocene)
- Qtg — Terrace gravel (Pleistocene)

#### Quaternary or Tertiary volcanic rocks

- QTb — Olivine basalt and basaltic andesite (Pleistocene or Pliocene)

#### Tertiary volcanic rocks

- Tba — Olivine basaltic andesite (Pliocene and upper Miocene)
- Th — Heppsie Formation (lower Miocene)
  - Thu — Upper part
  - Thl — Lower part

Wasson Formation (lower Miocene? and upper Oligocene)

- Twlt — Lithic andesitic tuff (lower Miocene? and upper Oligocene)
- Twag — Flow agglomerate of Wells (1956) (lower Miocene? and upper Oligocene)
- Twt2 — Dacite tuff unit 2 (lower Miocene? and upper Oligocene)
- Twba — Basaltic andesite, undivided (upper Oligocene)
- Twba2 — Basaltic andesite unit 2 (upper Oligocene)
- Twba1 — Basaltic andesite unit 1 (upper Oligocene)
- Twt1 — Dacite tuff unit 1 (upper Oligocene)
- Twwt — White tuff of Wells (1956) (upper Oligocene)
- Twf — Lava flows of Wells (1956) (upper Oligocene)
- Twfx — Andesitic tuff breccia (upper Oligocene)
- Twbt — Buff tuff of Wells (1956) (upper Oligocene)

Basaltic andesite of Lake Creek (upper Oligocene)

- Tl6 — Flow unit 6
- Tl5 — Flow unit 5
- Tl4 — Flow unit 4
- Tl3 — Flow unit 3
- Tl2 — Flow unit 2
- Tl1 — Flow unit 1

Basaltic andesite of Meyers Hill (upper Oligocene)

- Tmh3 — Flow unit 3
- Tmh2 — Flow unit 2
- Tmh1 — Flow unit 1

Volcanic rocks of the South Fork Little Butte Creek (upper Oligocene)

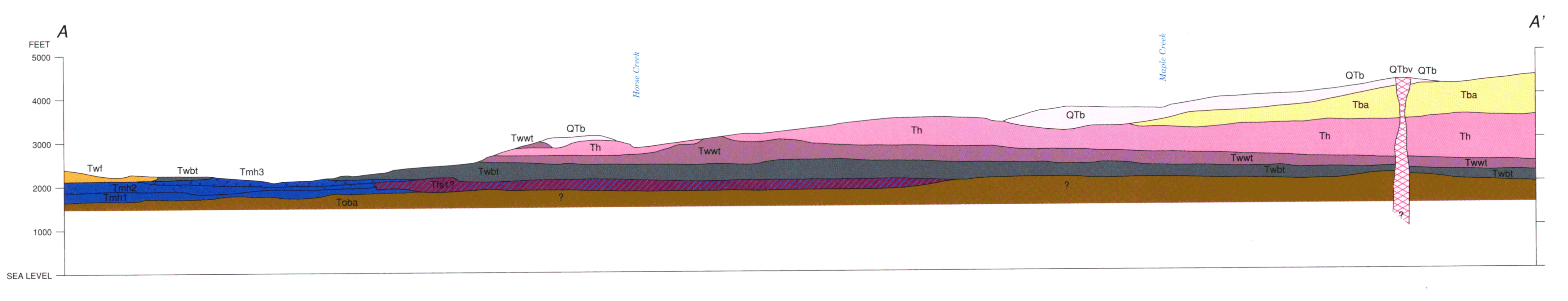
- Tsf2 — Basaltic andesite flow unit 2
- Tsf1 — Basaltic andesite flow unit 1
- Tsft — Dacitic tuff
- Tsfx — Tuff breccia
- Toba — Basaltic andesite of Little Butte Creek (upper Oligocene)

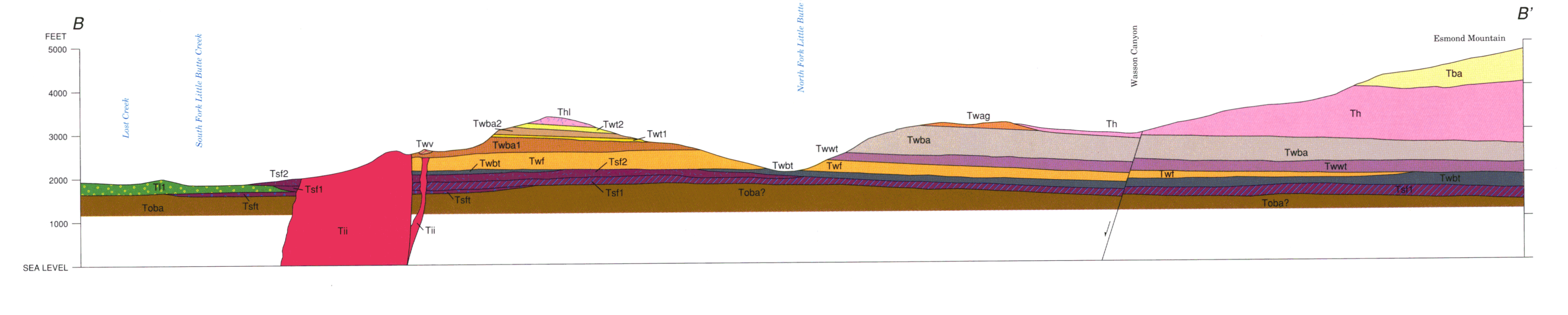
#### Vent deposits and intrusive rocks

- QTbv — Basaltic vent deposits (Pleistocene or Pliocene)
- Tbav — Basaltic andesite vent deposits (Pliocene and upper Miocene)
- Thv — Hypabyssal and vent rocks of the Heppsie Formation (lower Miocene)
- Twv — Basaltic to andesitic vent deposits of the Wasson Formation (upper Oligocene)
- Tii — Intermediate intrusive rocks (upper Oligocene)

### GEOLOGIC CROSS SECTIONS

Surficial units not shown.





### MAP SYMBOLS

- Contact -- Approximately located
- Fault -- Dashed where inferred; dotted where concealed; ball and bar on downthrown side
- Lineament
- Strike and dip of beds
- Strike and dip of beds -- Visual field estimate or 3-point calculation
- Strike and dip of dike
- Vertical dike
- Zone of lava invading tuff
- Landslide scarps
- Landslide boulder -- 3-10 m across; rock type indicated
- Sample or mine location -- Showing map number. Symbols superimposed where location is the same. Data listed in Tables 1 and 2
  - 34 — Sample location (Table 1)
  - M23 — Mine location (Table 2)
- 21.9 ±1Ma — Potassium-argon age sample site -- Showing age in millions of years (Ma). From Fiebelkorn and others (1983)

ISSN 0270-952X

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# Analytical Data, Lakecreek Quadrangle, Jackson County, Oregon 1995

## GMS-88

Geology and Mineral Resources Map of the Lakecreek Quadrangle, Jackson County, Oregon

By F.R. Hladky

Plate 2

**Table 1. Whole-rock analyses, Lakecreek quadrangle, Jackson County, Oregon[1]**

| | | | | | | | | | | | Oxides (wt. percent) | | | | | | | | | | | | | Trace elements (ppm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Map no. | Laboratory no. | 1/4 | 1/4 | Sec. | T.(S.) | R.(E.) | UTM coordinates | Elev. (ft) | Lithology | Map unit | $SiO_2$ | $Al_2O_3$ | $TiO_2$ | $Fe_2O_3T$ | MnO | CaO | MgO | $K_2O$ | $Na_2O$ | $P_2O_5$ | $Cr_2O_3$ | LOI | SUM[3] | Rb | Sr | Y | Zr | Nb | Ba |
| 1 | BBG-221 | NW | SE | 28 | 35 | 2 | 4704863N 533812E | 3,940 | Basalt | Th | 48.5 | 16.1 | 1.70 | 12.0 | 0.15 | 8.77 | 5.19 | 0.81 | 3.05 | 0.52 | 0.03 | 2.55 | 99.5 | <10 | 540 | 21 | 130 | 36 | 391 |
| 2 | BBG-209 | NE | SE | 25 | 35 | 2 | 4704863N 539193E | 3,580 | Olivine basalt | QTb | 50.0 | 16.0 | 0.633 | 10.0 | 0.17 | 10.8 | 8.42 | 0.33 | 2.35 | 0.14 | 0.06 | 0.82 | 99.8 | <10 | 437 | 10 | 26 | 15 | 188 |
| 2 | BBG-209D[2] | NE | SE | 25 | 35 | 2 | 4704863N 539193E | 3,580 | Olivine basalt | QTb | 50.3 | 16.1 | 0.630 | 10.0 | 0.16 | 10.8 | 8.43 | 0.34 | 2.33 | 0.14 | 0.05 | 0.70 | 100.1 | <10 | 438 | 16 | 30 | <10 | 170 |
| 3 | BBG-208 | SW | SW | 30 | 35 | 2 | 4704360N 540421E | 3,180 | Basalt | Th | 50.0 | 16.7 | 1.32 | 10.5 | 0.16 | 8.99 | 6.66 | 0.69 | 2.93 | 0.36 | 0.02 | 1.75 | 100.2 | 21 | 524 | 15 | 111 | 23 | 334 |
| 4 | BBG-220 | SE | SE | 26 | 35 | 2 | 4704305N 537480E | 3,975 | Olivine basalt | Thv | 48.9 | 17.1 | 1.17 | 11.0 | 0.17 | 11.2 | 6.59 | 0.46 | 2.68 | 0.22 | 0.02 | 0.85 | 100.5 | <10 | 568 | 20 | 72 | 18 | 219 |
| 5 | BBG-219 | SE | NW | 36 | 35 | 3 | 4703548N 538157E | 4,280 | Basalt | QTbv | 50.0 | 17.4 | 0.717 | 10.5 | 0.18 | 10.7 | 4.90 | 0.39 | 2.38 | 0.14 | 0.05 | 1.85 | 99.3 | <10 | 444 | <10 | 25 | 17 | 218 |
| 6 | BBG-235 | SE | SE | 32 | 35 | 2 | 4702812N 532482E | 2,430 | Andesite | Twf | 52.6 | 17.4 | 1.10 | 9.40 | 0.13 | 8.71 | 2.54 | 1.12 | 2.87 | 0.41 | <0.01 | 2.95 | 99.5 | 20 | 589 | 16 | 102 | 21 | 1,620 |
| 7 | BBG-228 | NE | SE | 33 | 35 | 2 | 4703112N 533390E | 2,660 | Lapilli ash dacite tuff | Twwt | 62.1 | 15.0 | 0.779 | 4.84 | 0.07 | 2.81 | 1.12 | 2.14 | 3.07 | 0.18 | <0.01 | 6.50 | 98.8 | 62 | 319 | 43 | 220 | 16 | 768 |
| 8 | BBG-227 | NW | SE | 33 | 35 | 2 | 4703168N 533766E | 3,200 | Olivine basalt | Th | 50.5 | 17.3 | 1.02 | 9.87 | 0.16 | 9.63 | 6.54 | 0.85 | 2.68 | 0.24 | 0.01 | 1.20 | 100.1 | 15 | 660 | 16 | 78 | 22 | 277 |
| 9 | BBG-226 | SE | SE | 33 | 35 | 2 | 4702756N 534178E | 2,960 | Dacite vitrophyre clast | Twwt | 65.7 | 14.6 | 0.605 | 4.27 | 0.10 | 3.54 | 1.26 | 2.38 | 4.10 | 0.18 | <0.01 | 3.45 | 100.3 | 48 | 285 | 29 | 195 | 14 | 689 |
| 10 | BBG-229 | SE | SE | 34 | 35 | 2 | 4702756N 535848E | 3,440 | Olivine basalt | QTb | 50.0 | 15.6 | 0.618 | 10.2 | 0.18 | 11.0 | 9.12 | 0.30 | 2.28 | 0.13 | 0.09 | 0.20 | 99.8 | <10 | 399 | 13 | 11 | 12 | 141 |
| 11 | BBG-218 | SE | SE | 36 | 35 | 2 | 4702883N 538929E | 4,160 | Olivine basalt | QTbv | 50.7 | 16.3 | 0.704 | 9.90 | 0.17 | 10.6 | 7.98 | 0.43 | 2.57 | 0.16 | 0.04 | 0.35 | 100.0 | <10 | 503 | <10 | 23 | 24 | 196 |
| 12 | BBG-236 | SE | NW | 5 | 36 | 2 | 4701939N 531935E | 2,190 | Basaltic andesite | Tmh3 | 51.5 | 14.3 | 1.76 | 12.5 | 0.36 | 8.50 | 3.67 | 1.18 | 3.03 | 0.33 | <0.01 | 1.70 | 98.9 | 12 | 319 | 16 | 136 | 40 | 407 |
| 13 | BBG-225 | NW | NW | 3 | 36 | 2 | 4702238N 534757E | 3,040 | Andesite | Th | 57.7 | 16.6 | 0.879 | 7.19 | 0.11 | 6.60 | 3.12 | 1.47 | 3.68 | 0.26 | <0.01 | 1.60 | 99.4 | 42 | 568 | 19 | 118 | 24 | 545 |
| 14 | BBG-217 | SE | NE | 1 | 36 | 2 | 4701914N 539020E | 4,040 | Olivine basaltic andesite | QTb | 52.5 | 18.0 | 1.02 | 8.94 | 0.14 | 9.27 | 5.07 | 0.75 | 3.31 | 0.23 | <0.01 | 0.95 | 100.4 | <10 | 1,100 | <10 | 46 | 13 | 332 |
| 15 | BBG-216 | SW | NW | 6 | 36 | 3 | 4702087N 539422E | 4,200 | Olivine basalt | QTb | 50.7 | 16.1 | 0.650 | 10.0 | 0.17 | 10.7 | 8.54 | 0.35 | 2.36 | 0.15 | 0.05 | 0.70 | 100.5 | <10 | 458 | <10 | 21 | 24 | 173 |
| 16 | BBG-232 | NE | NW | 11 | 36 | 2 | 4700863N 536756E | 3,050 | Olivine basaltic andesite | QTb | 51.1 | 17.2 | 0.936 | 9.03 | 0.14 | 9.09 | 6.57 | 0.68 | 3.15 | 0.20 | 0.02 | 0.90 | 99.2 | <10 | 1,070 | <10 | 32 | 16 | 308 |
| 17 | BBG-234 | SE | NE | 10 | 36 | 2 | 4700193N 535985E | 2,870 | Coarse ash, andesite tuff | Twwt | 58.3 | 17.0 | 0.940 | 5.80 | 0.09 | 4.61 | 1.51 | 1.43 | 3.21 | 0.20 | <0.01 | 5.70 | 98.9 | 25 | 439 | 13 | 119 | 16 | 603 |
| 18 | BBG-233 | NW | SW | 11 | 36 | 2 | 4699995N 536335E | 3,100 | Andesite | Twba | 57.7 | 16.8 | 0.890 | 6.98 | 0.12 | 6.50 | 3.14 | 1.89 | 3.16 | 0.27 | <0.01 | 1.90 | 99.5 | 40 | 590 | 18 | 117 | 28 | 570 |
| 19 | BBG-215 | SW | NW | 8 | 36 | 3 | 4700228N 541025E | 4,800 | Basaltic andesite | Tba | 51.7 | 16.9 | 1.07 | 9.59 | 0.16 | 8.22 | 6.37 | 1.13 | 3.57 | 0.42 | 0.01 | 0.50 | 99.8 | <10 | 986 | 21 | 65 | 27 | 569 |
| 20 | BBG-240 | SE | SW | 8 | 36 | 2 | 4699584N 531812E | 2,040 | Basaltic andesite | Tmh2 | 53.3 | 15.5 | 1.57 | 11.8 | 0.17 | 7.56 | 3.40 | 1.05 | 3.21 | 0.29 | <0.01 | 1.35 | 99.3 | 20 | 345 | 11 | 129 | 23 | 384 |
| 21 | BBG-230 | NW | NW | 13 | 36 | 2 | 4699025N 537873E | 4,035 | Basaltic andesite | Th | 51.2 | 17.3 | 1.11 | 9.38 | 0.16 | 8.60 | 4.37 | 0.92 | 2.89 | 0.39 | <0.01 | 2.20 | 98.7 | 18 | 613 | 25 | 138 | 26 | 463 |
| 22 | BBG-214 | NE | NW | 18 | 36 | 2 | 4699279N 539837E | 4,840 | Olivine basaltic andesite | Tba | 52.1 | 17.2 | 1.10 | 9.49 | 0.16 | 8.34 | 6.27 | 1.16 | 3.55 | 0.42 | 0.01 | 0.30 | 100.3 | <10 | 1,030 | 21 | 76 | 16 | 679 |
| 22 | BBG-214D[2] | NE | NW | 18 | 36 | 2 | 4699279N 539837E | 4,840 | Olivine basaltic andesite | Tba | 52.1 | 17.2 | 1.10 | 9.49 | 0.16 | 8.34 | 6.27 | 1.16 | 3.55 | 0.42 | 0.01 | 0.30 | 100.3 | <10 | 1,030 | 21 | 76 | 16 | 679 |
| 23 | BBG-239 | SW | SW | 16 | 36 | 2 | 4697900N 534127E | 2,000 | Andesite | Tii | 56.4 | 16.1 | 0.750 | 8.41 | 0.13 | 8.15 | 4.35 | 1.38 | 2.65 | 0.16 | <0.01 | 1.50 | 100.1 | 30 | 419 | 24 | 92 | 21 | 459 |
| 24 | BBG-231 | SW | NE | 19 | 36 | 3 | 4697035N 540213E | 3,260 | Basaltic andesite | Th | 52.1 | 17.3 | 0.810 | 8.51 | 0.14 | 10.7 | 4.82 | 0.81 | 2.67 | 0.24 | <0.01 | 1.70 | 99.9 | <10 | 778 | 23 | 64 | 16 | 430 |
| 25 | BBG-237 | SE | SW | 22 | 36 | 2 | 4696310N 535279E | 1,900 | Columnar andesite | Tii | 56.8 | 16.2 | 0.767 | 6.81 | 0.12 | 7.62 | 4.34 | 1.03 | 3.21 | 0.25 | <0.01 | 1.90 | 99.2 | 20 | 625 | 10 | 68 | 15 | 445 |
| 25 | BBG-237D[2] | SE | SW | 22 | 36 | 2 | 4696310N 535279E | 1,900 | Columnar andesite | Tii | 56.8 | 16.2 | 0.767 | 6.81 | 0.12 | 7.62 | 4.34 | 1.03 | 3.21 | 0.25 | <0.01 | 1.90 | 99.2 | 20 | 625 | 10 | 68 | 15 | 445 |
| 26 | BBG-224 | SE | SE | 23 | 36 | 2 | 4696289N 537528E | 2,280 | Andesite | Twf | 57.4 | 15.9 | 0.769 | 8.27 | 0.15 | 7.78 | 3.93 | 1.48 | 2.83 | 0.16 | <0.01 | 1.40 | 100.2 | 39 | 381 | 17 | 100 | <10 | 469 |
| 27 | BBG-211 | SW | SW | 24 | 36 | 2 | 4696355N 537949E | 2,390 | Dacite crystal-vitric tuff | Twwt | 63.6 | 15.3 | 0.706 | 4.36 | 0.09 | 3.69 | 0.83 | 2.45 | 3.12 | 0.17 | <0.01 | 5.70 | 100.2 | 58 | 375 | 26 | 161 | 25 | 763 |
| 28 | BBG-210 | SE | NE | 25 | 36 | 2 | 4695503N 539365E | 3,360 | Basalt lapilli breccia | Twag | 50.2 | 18.2 | 0.763 | 9.27 | 0.15 | 11.1 | 4.25 | 0.37 | 2.28 | 0.18 | 0.02 | 3.40 | 100.3 | <10 | 543 | 18 | 29 | 15 | 186 |
| 29 | BBG-238 | SE | SW | 27 | 36 | 2 | 4694690N 535100E | 2,360 | Basaltic andesite | Twf | 54.9 | 15.6 | 1.52 | 10.9 | 0.17 | 7.82 | 2.91 | 1.27 | 3.21 | 0.33 | <0.01 | 1.85 | 100.6 | 32 | 391 | 17 | 141 | 16 | 552 |
| 30 | BBG-223 | NW | NE | 36 | 36 | 2 | 4694290N 538858E | 2,300 | Dacite crystal-vitric tuff | Twwt | 64.1 | 15.1 | 0.612 | 3.45 | 0.08 | 3.41 | 0.69 | 2.37 | 2.82 | 0.14 | <0.01 | 6.70 | 99.6 | 69 | 360 | 26 | 151 | 15 | 694 |
| 30 | BBG-223D[2] | NW | NE | 36 | 36 | 2 | 4694290N 538858E | 2,300 | Dacite crystal-vitric tuff | Twwt | 64.1 | 15.1 | 0.612 | 3.45 | 0.08 | 3.41 | 0.69 | 2.37 | 2.82 | 0.14 | <0.01 | 6.70 | 99.6 | 69 | 360 | 26 | 151 | 15 | 694 |
| 31 | BBG-242 | NE | SW | 34 | 36 | 2 | 4693523N 534919E | 2,250 | Andesite | Twf | 54.4 | 15.2 | 1.48 | 11.2 | 0.19 | 8.05 | 4.05 | 1.20 | 3.21 | 0.33 | <0.01 | 0.75 | 100.2 | 18 | 374 | 28 | 144 | 29 | 455 |
| 32 | BBG-222 | SW | SE | 31 | 36 | 3 | 4693118N 540380E | 2,760 | Andesite lapilli breccia | Twba2 | 53.0 | 17.4 | 0.834 | 8.08 | 0.11 | 6.99 | 1.56 | 0.49 | 2.46 | 0.18 | <0.01 | 7.85 | 99.1 | <10 | 669 | <10 | 37 | 10 | 320 |
| 33 | BBG-241 | NW | SE | 5 | 37 | 2 | 4692020N 532365E | 2,650 | Rhyolite vitrophyre | Twbt | 69.5 | 14.9 | 0.614 | 3.24 | 0.05 | 2.73 | 0.28 | 2.54 | 4.47 | 0.14 | <0.01 | 1.25 | 99.9 | 56 | 259 | 24 | 209 | 13 | 849 |
| 34 | BBG-213 | SW | NW | 1 | 37 | 2 | 4692284N 537924E | 3,770 | Basaltic andesite | Thu | 51.5 | 17.4 | 1.13 | 9.91 | 0.18 | 8.92 | 4.09 | 1.09 | 3.17 | 0.42 | 0.02 | 1.90 | 99.9 | 35 | 624 | <10 | 118 | 27 | 524 |
| 35 | BBG-212 | SW | NE | 6 | 37 | 3 | 4692117N 540421E | 4,040 | Basaltic andesite | Thu | 52.1 | 18.2 | 0.731 | 8.48 | 0.15 | 9.99 | 5.36 | 0.78 | 2.50 | 0.12 | <0.01 | 1.40 | 99.9 | <10 | 614 | <10 | 26 | 21 | 190 |

[1]XRF analyses by XRAL, [2]Duplicate analysis, [3]Includes trace elements, 1,000 ppm = 0.1 percent

**Table 2. Mines and prospects, Lakecreek quadrangle, Jackson County, Oregon**

| Map no. | Name | 1/4 | 1/4 | Sec. | T.(S.) | R.(E.) | UTM coordinates | Elev. (ft) | Commodity | Map unit | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M1 | Call of the Wild | NE | SE | 29 | 35 | 2 | 4704711N 532553E | 2,960 | Copper | Twf | Malachite amygdules and veinlets |
| M2 | BLM borrow pit | SE | SE | 26 | 35 | 2 | 4704305N 537480E | 3,975 | Stone (basalt) | Thv | — |
| M3 | BLM quarry | NE | SE | 25 | 35 | 2 | 4704863N 539193E | 3,760 | Stone (basalt) | QTb | — |
| M4 | BLM quarry | SW | SE | 30 | 35 | 3 | 4704360N 540421E | 3,180 | Stone (basalt) | Th | — |
| M5 | Borrow pit | SW | NW | 5 | 36 | 2 | 4702000N 531386E | 2,280 | Stone (andesite) | Twf | — |
| M6 | Borrow pit | SE | NW | 5 | 36 | 2 | 4701939N 531935E | 2,190 | Stone (basaltic andesite) | Tmh3 | — |
| M7 | BLM quarry | NW | NW | 3 | 36 | 2 | 4702238N 534757E | 3,040 | Stone (andesite) | Th | — |
| M8 | BLM quarry | SW | NW | 1 | 36 | 2 | 4701965N 538106E | 3,870 | Stone (basalt) | QTb | Reclaimed |
| M9 | BLM quarry | SE | NE | 1 | 36 | 2 | 4701914N 539020E | 4,040 | Stone (basaltic andesite) | QTb | — |
| M10 | BLM quarry | SW | NW | 6 | 36 | 3 | 4702087N 539422E | 4,200 | Stone (basalt) | QTb | — |
| M11 | Borrow pit | NE | SE | 6 | 36 | 2 | 4701450N 531183E | 2,280 | Stone (andesite) | Twf | Trenches in andesite |
| M12 | Nichols Prospect | NW | SW | 4 | 36 | 2 | 4701380N 533250E | 2,040 | Manganese | Twbt | Not found |
| M13 | Homestake Claim | SE | SE | 5 | 36 | 2 | 4701020N 532705E | 2,300 | Manganese | Tmh3 | Not found |
| M14 | Meyers Hill borrow pit | SE | SW | 8 | 36 | 2 | 4699584N 531812E | 2,040 | Stone (basaltic andesite) | Tmh2 | — |
| M15 | Star F. Ranch | NW | SE | 11 | 36 | 2 | 4700100N 537162E | 3,450 | Manganese | Th | Not found |
| M16 | C2 Ranch borrow pit | SW | SE | 16 | 36 | 2 | 4697900N 534127E | 2,000 | Stone (andesite) | Tii | — |
| M17 | BLM borrow pit | SW | NE | 19 | 36 | 3 | 4697035N 540213E | 3,260 | Stone (basaltic andesite) | Th | Abandoned |
| M18 | C2 Ranch borrow pit | SE | SE | 29 | 36 | 2 | 4694762N 532609E | 1,760 | Stone (andesite) | Tl1 | — |
| M19 | C2 Ranch borrow pit | SE | SW | 27 | 36 | 2 | 4694690N 535100E | 2,360 | Stone (basaltic andesite) | Twf | — |
| M20 | Newstrom | SE | NE | 34 | 36 | 2 | 4693908N 535827E | 2,500 | Manganese | Twba1 | Not found |
| M21 | Nussbaum pit | NW | SW | 34 | 36 | 2 | 4693523N 534919E | 2,250 | Stone (andesite) | Twf | — |
| M22 | Flagg & Kirkland quarry | NW | NE | 4 | 37 | 2 | 4692560N 534000E | 1,920 | Stone (andesite) | Tl5 | — |
| M23 | BLM quarry | SW | NW | 1 | 37 | 2 | 4692285N 537918E | 3,760 | Stone (basaltic andesite) | Thu | — |

State of Oregon
Department of Geology and Mineral Industries
Donald A. Hull, State Geologist



# Geology and Mineral Resources Map of the Lakecreek Quadrangle, Jackson County, Oregon

1995

By Frank R. Hladky, Oregon Department of Geology and Mineral Industries

## INTRODUCTION

The Lakecreek 7½-minute quadrangle is located in the Western Cascades subprovince of the Cascade Range. Elevations range from 497 m (1,630 ft) on the west near the town of Lakecreek to 1,494 m (4,902 ft) on the east at the summit of Esmond Mountain. From the head of Lick Creek to Esmond Mountain a prominent northwest-trending ridge divides the Big Butte Creek drainage basin to the north from the Little Butte Creek basin. The herein named Lakecreek lineament, a topographic and volcanic feature, corresponds to the drainage divide. Wasson Canyon trims Esmond Mountain on its southeast side. The North and South Forks of Little Butte Creek flank Heppsie Mountain.

The quadrangle contains strata spanning 25 million years of volcanism and sedimentation. In late Oligocene and early Miocene time, basaltic and andesitic volcanoes of moderate height grew, lavas were erupted onto mountainous terrain and filled canyons, and dacitic pyroclastic flows from distant sources blanketed parts of the quadrangle. Volcanoes of early Miocene age and older became deeply eroded during a long hiatus in volcanic activity. Then in late Miocene and early Pliocene time, basaltic andesite lavas were erupted at Esmond Mountain. During Pliocene or Pleistocene time, basalt was erupted from a northwest-trending series of vents flanking Esmond Mountain. During Pleistocene time, the North Fork Little Butte Creek deposited terrace gravel across a wide plain. Broad uplift in the region caused the North Fork Little Butte Creek and its tributaries to subsequently incise the Pleistocene terrace. Mass wasting has continued to shape the landscape to the present.

Deformation is minimal. Some of the rocks of prelate Miocene age tilt generally very shallowly along faults of very little displacement. Most of the rocks of early Miocene age and older dip very shallowly (less than 5°) to the east toward the axis of the High Cascades. Younger rocks dip away from their axes of eruption, commonly mantling topography. Volcanism has been concentrated along the Lakecreek lineament, producing the highest elevations there.

Crushed stone for road building is the principal economic mineral. A very small amount of copper has been produced. Manganese was found but has not been produced. Agate is abundant. Some dacite tuff beds may be potential sources of clay.

This report presents a detailed geologic map that was produced from extensive field examinations and photogrammetric plotting from aerial photographs. Field and aerial data were compared and rechecked in the field to determine unit contacts. Potassium-argon ages in this report have been plotted from data reported by Fiebelkorn and others (1983).

## EXPLANATION

### SURFICIAL DEPOSITS

Qya **Young alluvium (Holocene)**—Gravel, sand, and silt deposited along modern stream channels. Thickness varies, maximum about 8 m (25 ft)

Qc **Colluvium (Holocene)**—Angular to subrounded, unconsolidated gravel, sand, and silt forming substantial slope-mantling aprons in areas of greatest relief. Mapped where thickness exceeds about 6 m (20 ft)

Qls **Landslide deposits (Holocene and Pleistocene)**—Fragments of bedrock displaced downslope by gravity sliding. Arrows indicate direction of movement. No distinction made between active and inactive slides. Includes coherent slide block of stratified tuff breccia (unit Twag, labeled parenthetically) above Highway 140 (N½ sec. 31, T. 36 S., R. 3 E.). Thickness varies; mapped where thickness exceeds about 3 m (10 ft)

Qoa **Old alluvium (Holocene)**—Well-rounded unconsolidated gravel, sand, and silt. Exposures follow the modern channels but lie 3–18 m (10–60 ft) above them. Maximum thickness about 6 m (20 ft)

Qtg **Terrace gravel (Pleistocene)**—Well-rounded unconsolidated gravel and minor sand, silt, and clay deposited on a bedrock bench forming a terrace 24–37 m (80–120 ft) above Little Butte Creek. Forms broad terrace along Highway 140. Maximum thickness about 6 m (20 ft)

## QUATERNARY OR TERTIARY VOLCANIC ROCKS

QTb **Olivine basalt and basaltic andesite (Pleistocene or Pliocene)**—Light- to medium-gray, fine-grained, dense olivine basalt and basaltic andesite. Phenocrysts of olivine and pyroxene set against a light-gray, plagioclase-rich groundmass lend a speckled or salt-and-pepper appearance. Locally aphanitic. Phenocrysts consist of olivine, less than 10 percent, as large as 1.5 mm, typically with black pyroxene rims; and black augite, less than 5 percent, as large as 1.5 mm. Groundmass consists of microcrystalline subhedral plagioclase, light-gray glass, and very fine grained magnetite (smaller than 0.1 mm). Mafic minerals locally altered to red iddingsite and black magnetite. No internal paleosols or stratification were found, and subhorizontal partings are rare. These chemically and petrographically similar lavas are interpreted to have coalesced from multiple vents over a short period of time. Maximum thickness about 120 m (400 ft).

## TERTIARY VOLCANIC ROCKS

Tba **Olivine basaltic andesite (Pliocene and upper Miocene)**— Light medium gray to brownish-gray, dense, fine-grained olivine basaltic andesite. Phenocrysts of olivine (commonly fresh) as large as 1 mm typically form less than 5 percent of the rock. Microphenocrysts of plagioclase are mostly smaller than 0.5 mm. Slight alteration of larger plagioclase crystals produces a fine-grained oatmeal appearance. Groundmass consists of plagioclase microlites, brownish-gray or brown glass, and very fine grained magnetite that rarely clusters into 1-mm knots. Commonly weathers spheroidally. Potassium-argon ages from the adjacent Willow Lake quadrangle to the east range between 3 and 6 Ma (Medford Water Commission, 1990, p. C-2, E-1). Maximum thickness about 305 m (1,000 ft)

Th **Heppsie Formation (lower Miocene)**—Mostly medium-gray to dark-gray, fine-grained to very fine grained basaltic andesite with lesser basalt (commonly columnar) and platy andesite. Formed predominantly of plagioclase microlites, as much as 40 percent; dark-gray glass, as much as 35 percent; chlorophaeite (in basalt), as much as 10 percent; and very fine grained magnetite, less than 5 percent. Phenocrysts, where present, consist of pyroxene as large as 2 mm, less than 15 percent; olivine (fresh in basalt, corroded in basaltic andesite) as large as 0.5 mm, less than 10 percent; and plagioclase as large as 3 mm, less than 35 percent but mostly less than 10 percent. Rubbly and vesicular interflow zones common. In Wasson Canyon an andesite has a K-Ar age of 22.7±1 Ma (Fiebelkorn and others, 1983). Maximum thickness 670 m (2,200 ft). Locally divided into the following subunits:

Thu **Upper part**—Orange- and tan-weathering, medium dark gray, fine-grained to very fine grained basaltic andesite. Formed of phenocrysts of black pyroxene 1-2 mm, less than 10 percent, locally in glomeroporphyritic clots as large as 5 mm; plagioclase smaller than 1 mm, less than 10 percent; and dark-reddish-brown iddingsite smaller than 1 mm, less than 5 percent, in a groundmass of microlites, dark-brownish-gray glass, and magnetite. Locally platy. At Heppsie Mountain a basaltic andesite has a K-Ar age of 21.9±1 Ma (Fiebelkorn and others, 1983). Separated from underlying lower part by paleosol and rubbly autoclastic breccia that is exposed along Heppsie Mountain Road in NE¼ sec. 6, T. 37 S., R. 3 E. Maximum thickness about 335 m (1,100 ft)

Thl **Lower part**—Medium- to dark-gray, fine-grained to very fine grained basaltic andesite. Phenocryst assemblage includes pyroxene, plagioclase, and iddingsite. Thickness exceeds 150 m (500 ft)

**Wasson Formation (lower Miocene? and upper Oligocene)**—Divided in this report into:

Twlt **Lithic andesitic tuff (lower Miocene? and upper Oligocene)**—Tan to brown, altered, nonwelded, andesitic crystal-vitric-lithic tuff. Clasts partially and groundmass generally completely altered to clay. Clast abundance and grain size decrease abruptly southeastward. Maximum thickness about 150 m (500 ft)

Twag **Flow agglomerate of Wells (1956) (lower Miocene? and upper Oligocene)**—Reddish-brown basaltic lapilli breccia; argillically and limonitically altered. Interpreted to be near-vent agglutinate. Comprises clast-supported altered basalt pyroclasts in an altered but welded ashy basalt matrix. Clast-matrix boundaries vary from distinct to indistinct, typically the latter. Pyroclasts form more than 60 percent of the rock, are angular to subspherical, and range in size from 1 to 20 cm. Large-scale (typically greater than 5 m) planar stratification locally with scour-and-fill structure. Good sorting characterizes individual intervals. Local graded bedding. Limonite and clay after pyroxene smaller than 2 mm form less than 15 percent;

olivine remnants 0.5-1.5 mm form less than 5 percent; plagioclase 0.5-2 mm forms less than 15 percent. Groundmass consists of about 40 percent altered brown glass, 20 percent magnetite, 40 percent plagioclase microlites. Maximum thickness about 240 m (800 ft)

Twt2 **Dacite tuff unit 2 (lower Miocene? and upper Oligocene)**—Partially altered, nonwelded, dacitic crystal-vitric ash-flow tuff. Exposed between South and North Forks of Little Butte Creek. Separated from nearly identical tuff unit Twt1 by basaltic andesite lava flows of unit Twba2. Maximum thickness about 37 m (120 ft)

Twba **Basaltic andesite, undivided (upper Oligocene)**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite. Different flows may vary in composition from basalt to andesite. Maximum thickness about 270 m (900 ft). Where divided by tuff unit Twt1, locally subdivided into the following units:

Twba2 **Basaltic andesite unit 2 (upper Oligocene)**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite. Different flows may vary in composition from basalt to andesite. Locally includes reddish brown, limonitically and argillically altered andesitic lapilli breccia. Separated from unit Twba1 by tuff, unit Twt1. Maximum thickness about 120 m (400 ft)

Twba1 **Basaltic andesite unit 1 (upper Oligocene)**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite. Different flows may vary in composition from basalt to andesite. Separated from unit Twba2 by tuff, unit Twt1. Maximum thickness about 150 m (500 ft)

Twt1 **Dacite tuff unit 1 (upper Oligocene)**—Partially altered, nonwelded, dacitic crystal-vitric ash-flow tuff. Exposed between South and North Forks of Little Butte Creek. Separated from nearly identical tuff unit Twt2 by basaltic andesite lava flows of unit Twba2. Maximum thickness about 37 m (120 ft)

Twwt **White tuff of Wells (1956) (upper Oligocene)**—Coarse-ash and lapilli-ash, extensively altered (vitric component is virtually all clay), nonwelded to partially welded, dacitic lithic-crystal-vitric ash-flow tuff. One of the five analyses of unit Twwt (Laboratory no. BBG–234, Map no. 17, Table 1), corrected for loss on ignition, fell marginally into the andesite field of Le Bas and others (1986). Unit Twwt generally contains 10–15 percent pumice lapilli. Quartz and feldspar crystals (coarse ash) less than 10 percent, magnetite less than 5 percent, biotite trace. Poorly to moderately sorted, fine-ash vitric component is predominant. Typically unstratified. Clastic zones contain black dacite vitrophyre blocks as large as 20 cm. A 6-m-high outcrop along Salt Creek north of Gardener Butte (SE¼ SE¼ sec. 4, T. 36 S., R. 2 E.) reveals a planar-stratified, fining-upward sequence, grading from block-and-ash tuff to coarse-ash tuff. Unit Twwt probably represents multiple pyroclastic flows and more than one cooling unit. Thins southward, and exposures become increasingly sporadic south of the North Fork Little Butte Creek. Maximum thickness about 180 m (600 ft)

Twf **Lava flows of Wells (1956) (upper Oligocene)**—Brown-weathering, medium dark gray to dark-gray, fine-grained andesite and aphanitic basaltic andesite, commonly platy. The andesite contains plagioclase less than 2 mm, less than 20 percent; black pyroxene smaller than 1.5 mm, less than 15 percent; green olivine smaller than 1.5 mm, less than 5 percent. Groundmass composed of dark-gray glass with subordinate plagioclase microlites. Includes vesicular and rough-textured zones commonly with argillic and limonitic alteration along vesicles and cracks. Potassium-argon age of 24.0±1 Ma in Wasson Canyon (Fiebelkorn and others, 1983). Maximum thickness about 240 m (800 ft). Identification based on descriptive text ("Geology of the Medford Quadrangle, Oregon-California") by Wells (1956), rather than on unit label in his map explanation (see "Geologic Summary" below)

Twfx **Andesitic tuff breccia (upper Oligocene)**—Reddish-brown andesitic tuff breccia at Fallow Hill and Poverty Hill. Gradational with flows of unit Twf. Maximum thickness about 110 m (350 ft)

Twbt **Buff tuff of Wells (1956) (upper Oligocene)**—Brown to pink, coarse-ash and lapilli-ash, unwelded to welded, dacitic to rhyolitic, crystal vitric ash-flow tuff. Contains scattered accidental lithics as large as 1 cm. Thins and welding diminishes to the southeast. Includes black basal vitrophyre in sec. 5, T. 37 S., R. 2 E. Maximum thickness about 180 m (600 ft)

**Basaltic andesite of Lake Creek (upper Oligocene)**—Lava flows of brown-weathering, medium dark gray to dark-gray basaltic andesite. Contains fine-grained pyroxene (less than 20 percent), plagioclase phenocrysts as large as 5 mm (less than 15 percent), and minor olivine in a groundmass of plagioclase microlites and dark-gray glass. Subhorizontal partings typically spaced 1 m (3 ft) or more apart. Paleosols (e.g., in NE¼ sec. 4, T. 37 S., R. 2 E.) or autoclastic breccias separate flows, commonly marked by a pronounced break in slope. Maximum thickness about 270 m (900 ft). Divided into the following individual or composite flows on the basis of superposition:

Tl6 **Flow unit 6**

Tl5 **Flow unit 5**

Tl4 **Flow unit 4**

Tl3 **Flow unit 3**

Tl2 **Flow unit 2**

Tl1 **Flow unit 1**

**Basaltic andesite of Meyers Hill (upper Oligocene)**—Lava flows of brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite composed of fine-grained (smaller than 0.25 mm) pyroxene and plagioclase (less than 20 percent), set in a groundmass of plagioclase microlites and dark-gray glass. Brecciated to platy. Autoclastic breccias separate flows, commonly marked by a pronounced break in slope. Maximum thickness about 180 m (600 ft). Divided on the basis of superposition into the following composite lava flow units:

Tmh3 **Flow unit 3**

Tmh2 **Flow unit 2**

Tmh1 **Flow unit 1**

**Volcanic rocks of the South Fork Little Butte Creek (upper Oligocene)**—Divided into the following composite lava flows and individual tuffs:

Tsf2 **Basaltic andesite flow unit 2**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite composed of fine-grained pyroxene and plagioclase set in a groundmass of plagioclase microlites and dark-gray glass. Subhorizontal partings typically spaced 1 m (3 ft) or more apart. Autoclastic breccias separate unit from underlying unit Tsf1, commonly marked by a break in slope. Maximum thickness about 60 m (200 ft)

Tsf1 **Basaltic andesite flow unit 2**—Brown-weathering, medium dark gray to dark-gray, fine-grained basaltic andesite composed of fine-grained pyroxene and plagioclase set in a groundmass of plagioclase microlites and dark-gray glass. Subhorizontal partings typically spaced 1 m (3 ft) or more apart. Maximum thickness about 60 m (200 ft)

Tsft **Dacitic tuff**—Reddish-brown to yellow, fine- to coarse-ash, partially welded dacitic vitric ash-flow tuff. Vitric component commonly substantially altered to clay, forming a thick bentonitic zone. Contains some lapilli-rich horizons. Maximum thickness about 30 m (100 ft)

Tsfx **Tuff breccia**—Brown-weathering, light-yellow, fine-grained dacitic? blocks in a groundmass of similar composition. Unit, including clasts, is thoroughly altered to clay. Proximal facies of unit Tsft. Maximum thickness about 30 m (100 ft)

Toba **Basaltic andesite of Little Butte Creek (upper Oligocene)**—Orange brown weathering, brownish medium gray, fine-grained basaltic andesite mapped beneath the tuff of the volcanic rocks of the South Fork Little Butte Creek. Unit Toba is locally brecciated and bleached to a pale yellow south of the town of Lakecreek, but elsewhere the unit is intact. Maximum exposed thickness about 45 m (150 ft)

## VENT DEPOSITS AND INTRUSIVE ROCKS

QTbv **Basaltic vent deposits (Pleistocene or Pliocene)**—Light-gray and locally red (hematitically altered) vesicular basalt. Vesicles commonly interconnected. Exposures line up along a trend of N. 50° W. along the ridge top between Esmond Mountain and Doubleday Creek

Tbav **Basaltic andesite vent deposits (Pliocene and upper Miocene)**—Brownish-gray to medium dark gray vesicular basaltic andesite and tuff breccia. Slightly argillically altered. Unit Tbav is vent facies in secs. 7, 8, and 18, T. 36 S., R. 3 E., of the olivine basaltic andesites at Esmond Mountain (unit Tba)

Thv **Hypabyssal and vent rocks of the Heppsie Formation (lower Miocene)**—Medium-gray, porphyritic, plagioclase-rich basalt and vesicular basaltic andesite. Mafic minerals smaller than 1.5 mm and less than 5 percent; olivine as much as 2 percent and iddingsitized with or without pyroxene rims; black pyroxene comprises less than 3 percent. Groundmass contains about 60 percent plagioclase microlites, about 30 percent glass, and 10 percent very fine grained magnetite. Exposed at head of Horse Creek

Twv **Basaltic to andesitic vent deposits of the Wasson Formation (upper Oligocene)**—Red and reddish-brown basaltic and andesitic lapilli tuff and tuff breccia southeast of Lakecreek in SE¼ sec. 34, T. 36 S., R. 2 E., and at the head of Lick Creek in NE¼ sec. 29, T. 35 S., R. 2 E. Consists of basaltic or andesitic blocks and bombs in a coarse-ash and lapilli matrix of similar composition. Characteristically weathers to a very rough surface with irregular cavities. Marks vents for basalt, basaltic andesite, and andesite of Wasson Formation (units Twf and Twba)

Tii **Intermediate intrusive rocks (upper Oligocene)**—Light medium gray to medium dark gray, fine- to coarse-grained andesite. Columnar and glassy in SW¼ sec. 22, T. 36 S., R. 2 E. Elsewhere medium- to coarse-grained, porphyritic, and slightly argillically altered. Forms large, resistant rock mass in SW½ sec. 34, T. 36 S., R. 2 E., that contains no partings and characteristically deteriorates by spalling chips that are generally smaller than 1 cm

## STRUCTURE

Minimal deformation characterizes the structure of the Lakecreek quadrangle. Small-displacement faults have slightly tilted and offset volcanic units. The regional dip of rocks of early Miocene and older age is very shallowly eastward, toward the axis of the High Cascades. The magnitude of regional tilting is less than 5° on the basis of the mapped orientation of widespread, horizontally deposited ash-flow tuffs. Rocks of late Miocene and younger age dip radially from the axes of volcanic accumulation (cross sections A-A' and B-B').

North of Highway 140, vent-facies rocks of early Miocene age and younger line up along a trend of N. 50°–55° W. and correspond to the drainage divide between Big Butte Creek and Little Butte Creek. Vent-facies rocks of unit QTbv northwest of Esmond Mountain line up along a trend of N. 50° W., including a short northwest-trending linear vent in the center of sec. 6, T. 36 S., R. 3 E., and two additional vents in sec. 36, T. 35 S., R. 2 E. Exposures of unit Tbav at the head of Horse Creek and the vent facies of unit Tbav at Esmond Mountain also broadly parallel the trend of N. 50° W.

On small-scale geophysical gravity and magnetic maps of the region (Diggles, 1991, Plates 6 and 10), it is possible to draw a broad trend of N. 50°–55° W. that passes through the Lakecreek quadrangle. The same feature is identifiable on the small-scale digital landform map of the United States (Thelin and Pike, 1991). The trend extends from a few kilometers northwest of the Lakecreek quadrangle to the southeast into northern California. For the Lakecreek quadrangle, the width of the trend is poorly constrained on these small-scale maps. In this quadrangle, the lineament covers the area between the South Fork Little Butte Creek and the drainage divide that separates the Big Butte Creek basin from the Little Butte Creek basin.

Local aeromagnetic data (Blakely, 1986) display a broad, elongate trend of N. 55° W., as measured from a magnetic high centered at Esmond Mountain to a magnetic high centered at the head of Lick Creek. The trend of the aeromagnetic data is aligned upon the drainage divide between Big Butte Creek and Little Butte Creek. The magnetic highs may reflect hypabyssal intrusions concentrated in the subsurface, and certainly, at least at Esmond Mountain, reflect centers of volcanic accumulation. The field evidence supports the interpretation that volcanic vents were active at the head of Lick Creek in late Oligocene time (unit Twv) and at Esmond Mountain in late Miocene time (unit Tbav) and perhaps earlier.

The topography and alignment of volcanic vents and aeromagnetic highs determined in this study trend N. 50°–55° W. and extend northwestward and southeastward from Esmond Mountain, thereby defining the Lakecreek lineament. At the longitude of Mount McLoughlin, the Lakecreek lineament is several kilometers south of Mount McLoughlin. The Lakecreek lineament is parallel to but several kilometers south of the Mount McLoughlin zone, which passes north of Mount McLoughlin, as postulated by Lawrence (1976; also Kienle and others, 1981). Lawrence interpreted the Mount McLoughlin zone as a major right-lateral shear zone displacing the High Cascades as much as 15–20 km. Subsequent workers (Smith and others, 1982; Sherrod and Pickthorn, 1992) found no evidence in the field to substantiate the claim of several kilometers of right-lateral offset.

The width and nature of the Lakecreek lineament is poorly constrained at the scale of the small-scale regional maps. At the scale of the Lakecreek quadrangle, however, the Lakecreek lineament is manifested by elevated topography, the alignment and accumulation of volcanic rocks, and rough association with graphic aeromagnetic data. Volcanic rocks have been erupted along the Lakecreek lineament in the Lakecreek quadrangle and accumulated to their greatest elevation there.

The fault herein referred to as Wasson Canyon fault offsets rocks a maximum of about 60 m (200 ft) (cross section B-B'). The fault is not exposed in the canyon filled with colluvium but is inferred on the basis of offset contacts.

The canyon of the North Fork Little Butte Creek was identified as an east-southeast-trending lineament (Kienle and others, 1981). However, the underlying structure of this lineament is masked by incision of the stream bed and mass wasting of the slopes. The head of the canyon originates in the high plateau of the High Cascades. This plateau was repeatedly covered by Pleistocene ice sheets (Carver, 1972; Smith, 1983). Although Carver (1972) found that west of the High Cascades in southern Oregon valley glaciers extended to elevations as low as 3,600 ft (1,100 m), no evidence was found to indicate that glaciers advanced down the canyon of the North Fork Little Butte Creek as far as the Lakecreek quadrangle.

Faults of northwest, north-northwest, and north-northeast trends are identified within the quadrangle. The faults typically have only a few meters displacement. Eastward tilt of less than 5° was observed in the field on some fault blocks south of Highway 140 (secs. 27 and 28, T. 36 S., R. 2 E.). The faults east and north of the town of Lakecreek (in secs. 18, 20, 21, and 28, T. 36 S., R. 2 E.) cut rocks of pre-middle Miocene age. The faults are marked by well-defined lineaments in low-level aerial photographs.

At Slinger Rock, in the canyon of the North Fork Little Butte Creek, shallowly rooted faults are accommodating the rotation of the tuff breccias of unit Twag. In one case a large, coherent block of stratified tuff breccia (unit Twag) has calved away from the canyon wall to rest above Highway 140 (N½ sec. 31, T. 36 S., R. 3 E.).

## GEOLOGIC SUMMARY

The classification of igneous rocks in the quadrangle follows the method of Le Bas and others (1986), superseding the method of Streckeisen (1979) used previously (Hladky, 1993). To determine the rock classification, major oxide analyses were corrected for loss on ignition, normalized to 100 percent, and plotted on the total alkali-silica diagram of Le Bas and others (1986). Where geochemical analyses were lacking, rock names were applied by visually comparing unanalyzed rocks with analyzed rocks with a binocular microscope.

This map presents the geology of the quadrangle in greater detail than earlier maps. As a consequence, several informal units and their subunits have been added. Units below the Wasson Formation are here identified as basaltic andesite of Little Butte Creek, volcanic rocks of the South Fork Little Butte Creek, basaltic andesite of Meyers Hill, and basaltic andesite of Lake Creek. These units had been previously mapped by Wells (1956) as Roxy Formation or by Smith and others (1982) as unit Tb2. For a map of the present level of detail, the Roxy Formation encompasses too many lava flows from too many sources. In addition, Wiley and Smith (1993) demonstrated that the type locality for the Roxy Formation is an intrusive rock and perhaps not suitable to the formation's original designation.

This report also further subdivides the Wasson Formation, for which it was possible to map multiple dacite tuffs because of extensive interbedded lavas.

Units above the Wasson Formation are also mapped in greater detail. I have redefined the Heppsie Andesite of Wells (1956) as the Heppsie Formation, utilizing the nomenclature of Le Bas and others (1986). The Heppsie Formation consists predominantly of basaltic andesite but also contains basalt and andesite, as defined by Le Bas (1986).

The outcrops within the Lakecreek quadrangle expose a record of geologic history from late Oligocene time onward. Volcanism and erosion have been the dominant processes shaping the geology and geomorphology of the quadrangle.

The oldest rocks in the quadrangle are basaltic andesite lava flows, the basaltic andesite of Little Butte Creek (unit Toba). The unit is locally brecciated and altered south of the town of Lakecreek, but elsewhere the sequence is intact. Lateral and vertical exposures within the quadrangle are insufficient to determine source, distribution, or lithologic diversity of the unit. A K-Ar age of 9.42±1 Ma near the town of Lakecreek (Sutter, 1978; also Fiebelkorn and others, 1983) is questionable because of its indeterminate location (descriptive location data differ from those indicated by latitude and longitude). For stratigraphic reasons the age would have to be from an intrusion or intracanyon flow. Attempts to locate intracanyon flows near the sample location were unsuccessful.

The products of basaltic andesite and dacite volcanism have been repeatedly intermingled in the map area. The first dacitic eruption to affect the quadrangle produced a small volume of dacite tuff that contains both fine (unit Tsft) and coarse (unit Tsfx) facies. Its precise source cannot be determined because of overlying basaltic andesite flows, but it is believed to have come from the area east of the present confluence of the North and South Forks of Little Butte Creek. This dacite tuff is overlain by a series of mostly basaltic andesite lava flows (units Tsf1 and Tsf2), which may have come from this area, but whose sources are overlain by rocks of the Wasson Formation. The dacite tuff and overlying lava flows are assigned to the volcanic rocks of South Fork Little Butte Creek. Units Tsf1 and Tsf2 indicate that after the small dacite eruption, basaltic andesite lavas were erupted in the vicinity. The map pattern of unit Tsf2 indicates that some amount of relief was developed on the surface of unit Tsf1 prior to the eruption of unit Tsf2.

A series of basaltic andesite flows that was also deposited on an irregular surface during late Oligocene time probably had sources north and east of Meyers Hill and has been informally named after that locality. Available mineralogical and geochemical data are insufficient to distinguish between the basaltic andesite of Meyers Hill and other basaltic andesite in the quadrangle. The Meyers Hill unit is subdivided on the basis of geomorphology, mostly on the basis of aerial photographs that show the approximate locations of contacts.

Another unit that was erupted during late Oligocene time was lava that originated from south and west of the quadrangle, here referred to as the basaltic andesite of Lake Creek. Six lava flows or composite flows can be recognized on aerial photographs and in the field.

The numerous eruptions of pre-Wasson Formation basaltic andesite in the area produced an undulating terrain. This terrain was largely covered by the first (unit Twbt) of a series of extensive dacite to rhyolite ash-flow tuffs within the Wasson Formation. The age of this lowest Wasson tuff is unknown. An overlying andesite lava flow in Wasson Canyon, also of unknown source, has a K-Ar age of 24.0±1 Ma (Fiebelkorn and others, 1983). A late Oligocene caldera complex (potential eruptive source) exists 30 km (20 mi) to the north in the Elk Creek drainage (Hladky, 1993). This caldera complex is suspected to be the source for the white tuff (unit Twwt) of the Wasson Formation. The white tuff pinches out southward, indicating a source north, northwest, or northeast of the quadrangle. Correlation with tuffs of the McLeod quadrangle (Hladky, 1993) awaits additional mapping and dating. Tuffs higher in the Wasson Formation (units Twt1 and Twt2) are thought to have emanated from the south, because they thicken in that direction, pinching out in the map area near Highway 140.

The tuffs of the Wasson Formation are commonly separated by basaltic to andesitic lava flows and mafic tuff breccias that record the construction of local stratovolcanic piles at Lick Creek, Wasson Canyon, and Heppsie Mountain. The lowest andesite lava (unit Twf) in the Wasson Formation has a K-Ar age of 24.0±1 Ma (Fiebelkorn and others, 1983). Unit Twf has a coarse clastic facies, unit Twfx, in the vicinity of Farlow Hill, in SE¼ sec. 15, T. 36 S., R. 2 E., probably indicating proximity to an eruptive source. South of Highway 140, Wasson lava (unit Twf) crops out as thick flow sequences, but proximal facies were not found. Vent-facies tuff breccia is found at the head of Lick Creek (unit Twv).

A sequence of basalt to andesite flows (unit Twba) was erupted upon the pumiceous white tuff (unit Twwt) and accumulated to its greatest thickness at Wasson Canyon. Between Wasson Canyon and Highway 140, the lava grades upward into an extensive pile of tuff breccia (unit Twag) that pinches out rapidly to the north and south. South of Highway 140 in SE¼ sec. 34, T. 36 S., R. 2 E., basaltic tuff breccia (unit Twv) indicates gas-charged eruptions approximately coeval with the eruption of effusive lavas of unit Twba1. South of the highway and away from an inferred paleohigh at Wasson Canyon, a dacite tuff separates flows of Twba, allowing division of the lava into subunits Twba1 and Twba2. The tuff (unit Twt1) originated from outside the area and was deposited upon the lower flanks of the growing basalt and basaltic andesite volcano but not in the area of maximum accumulation near Wasson Canyon. North of Wasson Canyon, lavas of unit Twba pinch out. The extensive pile of lavas of the lower Miocene Heppsie Formation (units Th, Th1 and Th2) overlies units Twba and Twag. Prior to the eruption of lavas of the Heppsie Formation, another dacite ash-flow tuff (unit Twt2) swept over low-lying areas of the southeastern part of the quadrangle.

In early Miocene time, basalt to andesite lavas of the Heppsie Formation (units Th, Th1, and Th2), were erupted over an area extending from Heppsie Mountain to Lick Creek. Basaltic andesite (unit Th) in Wasson Canyon has yielded a K-Ar age of 22.7±1 Ma, and basaltic andesite at Heppsie Mountain (unit Thu) has yielded a K-Ar age of 21.9±1 Ma (Fiebelkorn and others, 1983). Exposures in the area of Gardener Butte and in sec. 4, T. 36 S., R. 2 E., indicate that these lavas flowed down canyons. At one location in NE¼ sec. 4, T. 36 S., R. 2 E., these lavas injected themselves into soft underlying tuff. At Heppsie Mountain, it was possible to subdivide the basaltic andesite of the Heppsie Formation, using geomorphic criteria in aerial photographs. Hypabyssal basalt and vesicular basaltic andesite near the head of Horse Creek (unit Thv) are interpreted to be some of the intrusive and vent facies of the early Miocene volcanoes of the Heppsie Formation.

Erosion cut deeply into the early Miocene volcanoes during a 10-million-year hiatus. In latest Miocene and early Pliocene time, basaltic andesite volcanism (unit Tba) resumed from several fissures in the Esmond Mountain area, forming a broad, thick basaltic andesite shield volcano. Several canyon-filling lavas were produced.

In Pliocene or Pleistocene time, eruptions of high-alumina basalt (unit QTb) began along the northwest flank of Esmond Mountain. The basalt was erupted from several vents along a northwest-trending axis at the present ridge crest, approximately parallel to the trend of some of the early Miocene and late Oligocene volcanoes. The basalt of unit QTb was erupted over a short period of time and coalesced into broad flow fronts that funneled down canyons.

During Pleistocene time, the North Fork Little Butte Creek aggraded gravel across a broad plain. Subsequent uplift in the region has caused the North Fork Little Butte Creek and its tributaries to incise their beds, stranding terrace gravel (unit Qtg). Terrace gravel of the same elevation is not found in the valley of South Fork Little Butte Creek, presumably because the valley was narrow and the creek reworked the Pleistocene gravel.

Extensive mechanical and chemical weathering, moderate topographic relief, and interbedded tuff and lava contribute to the mass wasting of rocks of the Western Cascades and High Cascades in southern Oregon. As a result, landslide deposits and colluvium are widespread within the quadrangle.

## GROUND-WATER RESOURCES

Ground-water resources in the Lakecreek area are largely unstudied (Doug Woodcock, Oregon Water Resources Department, and Larry Menteer, Jackson County Watermaster's Office, personal communication, 1994). Springs commonly emanate from lava interflow zones and along tuff-lava contacts. Surface-water diversions, mainly for irrigation but also for domestic use, are numerous in the quadrangle, and probably recharge aquifers at lower elevations. Rocks at the eastern edge of the quadrangle were included in a study of the geohydrology of the Big Butte Springs system (Medford Water Commission, 1990). Big Butte Springs supplies most of Medford's municipal water needs. The report indicates that units found at Esmond Mountain (sec. 18, T. 36 S., R. 3 E., elev. 4,902 ft), such as Tba and QTb, have less infiltration potential and less permeability than the younger and less weathered Pleistocene lava flows of Mount McLoughlin, but have higher infiltration potential and permeability than older and more deeply weathered rocks of early Miocene and older age. In addition, pyroclastic strata are typically less permeable than lava flows. Rocks along the east edge of the quadrangle north of Esmond Mountain transmit a small portion of the water that supplies the Big Butte Springs system (Medford Water Commission, 1990).

## MINERAL RESOURCES

Rock material is the most utilized mineral resource within the Lakecreek quadrangle. The U.S. Bureau of Land Management (BLM) has several rock quarries and borrow pits in the quadrangle to support road building (Table 2). In addition, the C2 Ranch maintains several small (less than about 1 acre) borrow pits for road building purposes on its approximately 10,000 acres of land. Other private borrow pits are located on the map. The rock types utilized are basalt, basaltic andesite, and andesite, both extrusive and hypabyssal varieties. Although one BLM quarry (mine site M7) has a 24-m (80-ft) highwall, most quarries and borrow pits are typically less than 8 m (25 ft) deep with sloped or benched highwalls. The total disturbed area in the Lakecreek quadrangle is about 30 acres. Total rock production is unknown. Rock resources outside quarry perimeters are vast.

In addition to rock materials, the quadrangle has produced copper ore from the Call of the Wild mine (mine site M1) also known as the Grand Cove prospect (Callaghan and Buddington, 1938; Oregon Department of Geology and Mineral Industries, 1943). The workings reportedly consisted of an open cut 18 m (60 ft) long and 3 m (10 ft) deep and a shaft 9 m (30 ft) deep. Only the open workings remain. Exposed mineralization today consists of a zone 2 m high by 2 m wide (6 ft by 6 ft) of altered basalt with thin veins, encrustations, and amygdules of malachite (hydrous copper carbonate). The total amount of ore produced is unknown (Callaghan and Buddington, 1938).

The Lakecreek quadrangle was also an area of manganese prospecting during World Wars I and II (Libbey and others, 1942). No known manganese production data exist for the quadrangle (Gray, 1993). Attempts to locate the manganese prospects were unsuccessful.

Agates and quartz crystals are abundant in the quadrangle in the units beneath the Wasson Formation, particularly south of North Fork Little Butte Creek. They are typically found scattered about the ground and in the soil overlying bedrock and are commonly concentrated in dry gulches or ephemeral streams. Permission should be obtained from landowners before exploring for these materials.

In addition, the Lakecreek quadrangle has potential for clay resources because of the occurrence of numerous weathered tuff beds.

## GEOCHEMISTRY

### Sampling methods

Rock samples were collected and analyzed for combined major and minor oxides and trace elements to determine their compositions (Table 1). Samples were analyzed by X-Ray Assay Laboratories (XRAL) of Don Mills, Ontario, Canada. The suite of samples analyzed does not constitute a complete sampling of all the rock types found within the quadrangle.

### Sample preparation

The components of the agate mill, consisting of pot, ring, and puck, were either lined with or composed of agate. Samples were placed in a clean pot. The pot was then placed into a vibratory mill for about two minutes depending on the sample hardness. The pot was air cleaned between samples and wiped out with a cloth. Silica cleaner was run between samples to eliminate any possible cross-contamination.

### Chemical analysis (whole-rock)

A 1.3-gram sample, after roasting at 950°C for one hour, was fused with five grams of lithium tetraborate and cast into a 40-mm button. The button was analyzed on a Philips PW1600 simultaneous X-Ray fluorescence spectrometer. This system is calibrated using more than 40 reference materials. Loss on ignition (LOI) is measured by weighing before and after roasting. Instrument precision on most elements is better than 0.5 percent of the reported value.

## ACKNOWLEDGMENTS

I am grateful for the critical reviews by David R. Sherrod (USGS, Vancouver) and Thomas J. Wiley (DOGAMI). Sincere thanks are also extended to Bob Marlow (BLM, Medford) for lending color aerial photographs of the Lakecreek area; to Gary Bohren and Matthew Thorburn (USGS, Vancouver), who made possible my photogrammetric compilations on their PG-2 plotters; to Doug Woodcock (ODWR), Larry Menteer (Jackson County Watermaster's Office), and Robert C. Jones (Medford Water Commission) for information and reports regarding water resources; to Bill Young (C2 Ranch) and Chuck Bruce (Cascade Ranch) for kindly providing access to their large land holdings; and to the many friendly residents of Lakecreek who provided helpful information and access. This map was funded in part by the National Geologic Mapping Program (STATEMAP) administered by the U.S. Geological Survey.

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