KEITH AND OTHERS—MINERAL AND GEOTHERMAL RESOURCE POTENTIAL OF THE MOUNT HOOD WILDERNESS, OREGON

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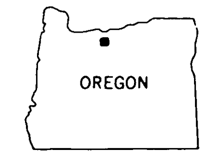


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# MINERAL AND GEOTHERMAL RESOURCE POTENTIAL OF THE MOUNT HOOD WILDERNESS, CLACKAMAS AND HOOD RIVER COUNTIES, OREGON

## SUMMARY REPORT

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## STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral and geothermal survey of the Mount Hood Wilderness, Mount Hood National Forest, Clackamas and Hood River Counties, Oregon. The area was established as a Primitive Area in 1931, and reclassified as a wilderness on June 27, 1940.

## SUMMARY

The potential for near-surface mineral resources in the Mount Hood Wilderness is low. Geochemical data suggest two areas of weak epithermal mineralization in the Zigzag Mountain part of the wilderness: (1) the Lost Creek-Burnt Lake-Cast Creek-Short Creek area on the north side of Zigzag Mountain where vein-type lead-zinc-silver mineralization occurs and (2) the Lady Creek-Laurel Hill area on the south side of Zigzag Mountain where the upper part of a quartz diorite pluton has associated propylitic alteration resulting in some porphyry-type copper, gold, silver, lead, and zinc mineralization.

Geothermal-resource potential for low- to intermediate-temperature (less than 248°F, 120°C) hot-water systems in the wilderness is moderate to high. Part of the wilderness is classified as a Known Geothermal Resources Area (KGRA), and two parts have been included in geothermal lease areas.

Rock and gravel sources are present within the wilderness; however, quantities of similar and more accessible deposits are available outside the wilderness. Deposits outside the wilderness are large enough to supply local demand in the foreseeable future.

## INTRODUCTION

During the summer of 1979 the U.S. Geological Survey and U.S. Bureau of Mines conducted field investigations to evaluate the mineral-resource potential of the Mount Hood Wilderness. Geologic mapping, geochemical sampling, geophysical surveys, and a study of known prospects, claims, mineralized areas, and exploratory geothermal drill holes were included in the field investigations (Keith and others, 1980, 1982a, 1982b; Robison and others, 1982; Williams and Keith, 1982).

Forty samples were assayed for gold, silver, copper, lead, and zinc (J. D. Causey, unpub. U.S. Bureau of Mines file report, 1981). The samples were also analyzed for 40 elements by semiquantitative spectrography. An additional 45 panned samples were run over a Wilfley[3] table and the concentrates analyzed for gold and silver. The results are on file at the U.S. Bureau of Mines Western Field Operations Center, Spokane, WA 99202.

Geochemical samples totaling 57 stream sediments, 69 panned concentrates, 12 unaltered rocks, and 26 altered rocks were collected at selected sites, and selected samples were analyzed by semiquantitative emission spectrography for 30 elements. Thirty-two stream sediment and 4 altered rock samples were analyzed for uranium by fluorometric determinations. Selected altered rock samples were analyzed for gold, copper, antimony, mercury, and arsenic by more precise methods. Complete analytical data is listed in Keith and others (1980).

### Location and geographic setting

The Mount Hood Wilderness, approximately 50 mi (80 km) east of Portland, Oregon (fig. 1), consists of about 47,100 acres (19,061 ha). Situated within the Mount Hood National Forest, the wilderness includes parts of Clackamas and Hood River Counties. Mount Hood, the highest peak in Oregon at 11,234 ft (3,425 m), is a Quaternary volcano in the central part of the wilderness.

The east side of the wilderness is bounded by Bluegrass Ridge with a maximum elevation of 5,608 ft (1,709 m). Zigzag Mountain, an east-west trending ridge reaching an elevation of 4,971 ft (1,515 m), makes up the western part of the wilderness.

The terrain is mountainous with steep-walled canyons heading at glaciers on Mount Hood and cirques on Zigzag Mountain. Dense lava flows interlayered with easily eroded volcanic debris and pyroclastic layers result in numerous waterfalls, cascades, and cold-water springs in the wilderness. Dense forest vegetation covers the terrain to timberline at an altitude of 6,000 ft (1,829 m) on Mount Hood, above which the volcano rises nearly barren of vegetation because of wind and ice as well as unstable recently deposited volcanic material. Lush undergrowth covers the forest floor in most of the wilderness below timberline because of the high precipitation during most of the year.

South and east of the wilderness are U.S. Highway 26 and Oregon State Highway 35, respectively (Fig. 1). Timberline and Mount Hood Meadows ski resorts abut the wilderness on the south slope of Mount Hood. Most of the north side is accessible from U.S. Forest Service spur roads off of the Lolo Pass road (F. S. Road N-12) or the Cloud Cap road (F. S. Road S-12) (map sheet). Numerous foot trails, including part of the Pacific Crest Trail, provide access through the wilderness.

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[2]U.S. Bureau of Mines
[3]Use of trade names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey or the U.S Bureau of Mines.

### Geologic Setting

The Mount Hood Wilderness is located along the crest of the High Cascade Range, which extends from northern California to British Columbia. The High Cascade Range is characterized by Pleistocene and Holocene volcanic activity, the major topographic features of which are large, predominantly andesitic stratovolcanoes and numerous smaller volcanoes and cinder cones. These volcanic rocks were extruded onto a parallel, eroded range of older Cenozoic, dominantly andesitic volcanoes that are presently referred to as the western Cascade Range. Mount Hood is one of the large, dominantly andesitic stratovolcanoes and is considered active because of reported ash events in 1859 and 1865 and because fumaroles are active in the 200- to 300-year-old vent and dome area (Crater Rock).

Zigzag Mountain, which constitutes the western part of the wilderness, is composed of lava flows and pyroclastic rocks erupted prior to the building of Mount Hood volcano and is considered to be part of the western Cascade Range. East-northeast- and north-northwest-trending regional structural patterns are present in the rocks of Zigzag Mountain.

### Mining Activity

There is no mining activity in the wilderness at present. The last indication of any prospecting activity within the wilderness was a claim staked in Lost Creek in 1948. On Laurel Hill, 0.6 mi (1 km) south of the wilderness, two claims were staked in 1966. No mining is known to have occurred in these areas.

Several rock and gravel sources are being or have been mined around the edge of the wilderness. The rock is used in road construction and repair. A gravel pit on the White River, on the lower south flank of Mount Hood, is presently being used.

### Geothermal Investigations

Beginning in 1976, geothermal temperature gradient and exploration holes were drilled near the northern and southern boundaries of the wilderness. The drilling was financed by the U.S. Department of Energy, U.S. Geological Survey, Oregon Department of Geology and Mineral Industries, and Northwest Geothermal Corporation.

Approximately 19,730 acres (7,985 ha) were leased for geothermal resources in the Old Maid Flat, Timberline Lodge, and Bluegrass Ridge areas, including about 9,600 acres (3,885 ha) in the wilderness. Exploratory drilling has been done adjacent to the wilderness. The two deepest geothermal exploration holes drilled west of Mount Hood were Old Maid Flat 1 (OMF 1; table 1, no. 8), which reached a temperature of 180°F (82°C) at a depth of 4,003 ft (1,220 m), and Old Maid Flat 7A (OMF 7A; Table 1, no. 7), which reached a temperature of 235°F (113°C) at a depth of 6,028 ft (1,838 m) (fig. 2; map sheet). Both had poor permeability and yielded inadequate quantities of hot water for a geothermal resource. The 4,003 ft (1,220 m) Pucci drill hole (Table 1, no. 18) on the south flank of Mount Hood just outside the wilderness reached a temperature of 170°F (76.7°C) at a depth of 3,706 ft (1,130 m). The well was tested briefly in summer 1981 and yielded 110 gallons per minute of water; the area may be considered for production of hot water for space heating of the new Timberline Day Lodge. Approximately 8,960 acres (3,626 ha) within the wilderness have been declared a KGRA by the U.S. Geological Survey (Oregon Geothermal Resources Minutes No. 4: Minutes of the Mineral Lands Classification Board, 24 February 1971).

## GEOLOGY, GEOCHEMISTRY, AND GEOPHYSICS PERTAINING TO MINERAL AND GEOTHERMAL RESOURCE ASSESSMENT

The geology of the area including the Mount Hood Wilderness was mapped by Wise (1969); Holocene volcanic activity and associated mudflow and pyroclastic deposits of Mount Hood volcano were described by Crandell (1980). The U.S. Geological Survey modified the previous mapping and did additional mapping, particularly on Zigzag Mountain (Keith and others, 1982b).

All rocks exposed in the wilderness are of volcanic origin and are of Tertiary and Quaternary age. The oldest rocks are upper Miocene volcaniclastic rocks and andesitic lava flows of the Rhododendron Formation. Rocks of the Rhododendron Formation are propylitically altered at the contact zone with the relatively younger quartz diorite of Laurel Hill, and in the vicinity of Lost Creek-Cast Creek-Short Creek and Burnt Lake where thin, discontinuous sulfide-bearing quartz veins and faults were found (Keith and others, 1982a). Zeolitization of volcaniclastic layers in the Rhododendron Formation is widespread.

The quartz diorite intrusion of Laurel Hill also crops out just outside the southwest boundary of the wilderness. Potassium-argon determinations on the age of the intrusion are conflicting (11 m.y., Wise, 1969; 8 m.y., Bickerman, 1970), but the major time of intrusion was probably during late Miocene. Intrusive rocks have been encountered in several geothermal drill holes (Oregon Department of Geology and Mineral Industries, 1980; H. J. Meyer, oral commum., 1980; J. W. Hook, oral commun., 1980), indicating that the Laurel Hill pluton may be part of an intrusive complex and is more extensive than surface outcrops suggest. The quartz diorite of Laurel Hill is propylitically altered, and at the contact zone with the Rhododendron Formation both units are highly fractured and propylitically altered (Keith and others, 1982a).

Remnants of several locally propylitically altered plugs exposed in the vicinity of Zigzag Mountain (Wise, 1969; Keith and others, 1982b) are apparently feeder vents for upper Miocene andesite flows which overlie the Rhododendron Formation. The sources for upper Miocene andesite lava flows on the east side of Mount Hood volcano may be to the north (out of the map area). In general, upper Miocene andesite flows in the wilderness are fractured, faulted, broadly folded, and in most places at least slightly altered.

Deformation that accompanied the intrusion of the quartz diorite pluton of Laurel Hill and the subsequent extrusion of the upper Miocene andesite lava flows subsided by Pliocene time. Pliocene andesite lava flows were small and poured out of several centers that presently crop out around Mount Hood volcano. The Pliocene andesites are generally not fractured and altered as are the underlying andesites of late Miocene age.

The Sandy Glacier volcano of Pleistocene age (Keith and others, 1982b) is exposed on the west side of Mount Hood where it has been partly eroded by glaciation. Remnants of the well-developed cone are composed of basalt and andesite flows that dip east and southeast under Mount Hood. Aeromagnetic studies indicate that other Pleistocene volcanoes may have been buried by the Mount Hood volcano (Flanagan and Williams, 1982).

The lava flows forming the cone of Mount Hood volcano all have normal remanent magnetism so far as is known; therefore, construction of the present cone is considered to have begun less than 730,000 years B.P., the beginning of the latest time of normal magnetic polarity (Mankinen and Dalrymple, 1979). Andesitic lava flows from Mount Hood volcano poured out over the older volcanic rocks, and a huge cone grew to at least the present height, and probably higher by about 29,000 years ago (Crandell, 1980). Three sizable satellite vents on the north flank of Mount Hood erupted after the Mount Hood cone began building up, but prior to the end of Fraser Glaciation, about 15,000 years B.P. Three major postglacial eruptive periods were characterized by pyroclastic eruptions of hornblende dacite, mudflows, and a hornblende dacite dome extrusion (Crandell, 1980). Fumarolic activity has been continuous around the youngest (200-300 years) dome (Crater Rock) since emplacement. Minor eruptive activity was reported in 1859 and 1865 (Crandell, 1980) and may have deposited local thin ash layers on the slopes of Mount Hood.

The general east-northeast and north-northwest structural pattern in the Mount Hood area, especially in the upper Miocene rocks of the Zigzag Mountain area, is typical of the Cascade Range (Venkatakrishnan and others, 1980). On the southwest flank of Mount Hood, a fault zone trending N. 45° W. dips steeply to the northeast. A parallel inferred fault zone along Lost Creek is buried beneath block and ash material from Mount Hood volcano and is associated with sulfide-bearing quartz veins and propylitic alteration in the andesitic lava flows of late Miocene age.

Vein-type epithermal mineralization occurs in the Rhododendron Formation in the Lost Creek-Burnt Lake-Short Creek-Cast Creek area on the north side of Zigzag Mountain (Keith and others, 1982a; J. D. Causey, unpublished U.S. Bureau of Mines file report, 1981). Quartz veins in steeply dipping shear zones were emplaced along with sulfides at the end of shearing activity. Irregular, discontinuous veins are generally not more than one inch wide. Propylitic alteration with chlorite, illite, calcite, laumontite, prehnite, and hematite has pervaded the andesite lava flows that host the quartz veins. The north-northwest-trending quartz veins contain sparse amounts of galena, sphalerite, chalcopyrite, and pyrite (Beeson and others, 1980) sufficient to show anomalous concentrations of silver, lead, zinc, and arsenic in the geochemical sampling. East-northeast, steeply dipping normal faults that cut the ridges between Lost Creek and Horseshoe Creek are filled with quartz- and pyrite-cemented breccia and abundant weathered iron hydroxide.

The drainage of Lady Creek on the south side of Zigzag Mountain also has anomalous concentrations of lead, zinc, and silver in geochemical samples. The quartz diorite of Laurel Hill crops out at the south end of Lady Creek just outside the wilderness but probably underlies the Lady Creek drainage in the wilderness. Subvertical, discontinuous mineralized veins at the west contact zone of the quartz diorite pluton contain anomalous concentrations of gold, arsenic, and copper in addition to lead, zinc, and silver.

Rocks of the summit and crater area of Mount Hood volcano have been extensively altered by fumarolic activity. Secondary minerals deposited by acid fumaroles include native sulfur, iron oxide, and opal-cristobalite. Anomalous mercury and boron concentrations found in the summit rocks are not unusual at vents of active volcanoes.

Geophysical data support geological observations and interpretations in the wilderness. Mount Hood volcano is the dominant topographic feature and obviously is the dominant feature on both the aeromagnetic and the Bouguer gravity maps (Williams and Keith, 1982). Flanagan and Williams (1982) interpret the aeromagnetic data as indicating several older, volcanic cones, similar to Sandy Glacier volcano, buried beneath the flanks of Mount Hood volcano.

The gravity survey reveals the presence of a dense intrusive body with a diameter of 3 mi (5 km) beneath Mount Hood volcano (Williams and Keith, 1982). The body extends into the edifice of the volcano where it appears to decrease in size to a diameter of about 0.6 mi (1 km). Gravity data also show a low over the quartz diorite intrusion of Laurel Hill and over Zigzag Mountain. One interpretation is that the pluton complex is more extensive at depth than the surface outcrops indicate. This supports the hypothesis that the upper Miocene pluton complex may be responsible for the mineralization in the Zigzag Mountain area.

Electromagnetic and magnetotelluric surveys are interpreted by Goldstein and others (1982) as indicating buried intrusive bodies beneath the south and southeast flanks of Mount Hood volcano.

The geological setting, geophysical data, and mineralization observed are typical of epithermal base and precious metal deposition associated with Cenozoic andesitic volcanism as described by Boyle (1979) and Sillitoe (1977, 1981). This type of mineralization characteristically is related to subaerial volcanism and is associated with propylitic or advanced argillic alteration.

Vein-type epithermal mineralization, probably associated with nearby small intrusive bodies usually of late Miocene age, is found along the western Cascade Range (Callaghan and Buddington, 1938). In Oregon, mineralized areas tend to be small and generally not of ore grade, although a few of the larger deposits were mined on a small scale in the past for gold and base metals (Callaghan and Buddington, 1938).

Porphyry deposits in the western Cascade Range in Washington and British Columbia generally are associated with apparently larger, more deeply eroded plutons, many of which contain deposits of copper and molybdenum; however, producing mines are known only in British Columbia (Field and others, 1974; Hollister, 1978, p. 117-122). This type of mineral deposit occurs throughout the Circum-Pacific Belt including British Columbia-Yukon (Canada), Taiwan, Japan, New Zealand, Mexico, and Nevada (United States) (Boyle, 1979; Sillitoe, 1981).

The Lost Creek-Burnt Lake-Cast Creek-Short Creek and the Lady Creek-Laurel Hill geochemical anomalies can be explained by either epithermal vein-type or porphyry-type mineralization which occurs at the upper part of the quartz diorite pluton or pluton complex. In fact, the mineralization is probably at the interface where the top of a pluton fractured and intruded rocks of the Rhododendron Formation resulting in fracture filling and quartz veins with associated propylitic alteration and local zeolitization of the country rock. Therefore, the two areas of geochemical anomalies may be related to a buried quartz diorite intrusive complex which crops out at Laurel Hill on the south side of Zigzag Mountain and displays there a porphyry-type mineralization; the same intrusive complex may be much deeper on the north side of the mountain where the surface outcrops have vein-type mineralization because of upward fracturing and mineralization of overlying volcanic rocks.

Although the Zigzag Mountain area contains epithermal mineralization, the areas are small and typical of many along the Western Cascades. Mineralized veins are thin, short, and discontinuous, and the actual abundance of base and precious metal-bearing minerals is not great.

Heat for geothermal energy may be derived from an intrusive body beneath the Mount Hood volcano, identified from the gravity survey (Williams and Keith, 1982). The active fumaroles are an obvious surface manifestation of a heat source at depth, as are the young volcanic products. Outward from the crater area of the volcano, heat may emanate from a magma chamber that geophysical (gravity) evidence indicates mushrooms outward at depth (D. L. Williams, written commun., 1982).

The N. 40° W. striking faults such as are along Sandy River and Lost Creek may serve as barriers for lateral convective fluid flow and thus could localize a source of hot water (less than 248°F, 120°C) for geothermal energy. Tests on two holes, OMF 1 and OMF 7A (fig. 2; table 1, nos. 8 and 7, respectively), drilled outside the wilderness adjacent to one of the faults, however, did not have favorable flow of hot water. Pucci drill hole (fig. 2; table 1, no. 18), which bottomed at 4,003 ft (1,220 m) in Pliocene lava flows (Gannett and Bargar, 1981), penetrated permeable rock that may yield sufficient hot water for local space heating. The wilderness is in an area of high regional heat flow (Blackwell and Steele, 1979) which could be a source of conductive geothermal systems if rock permeability was sufficient to allow hot water to move.

## MINING DISTRICTS AND MINERALIZED AREAS

### Lost Creek District

The only mining district that includes part of the wilderness is the Lost Creek District. Clackamas County records indicate that claims were staked in the Lost Creek-Cast Creek-Short Creek area in 1909. Minor activity was also recorded in 1910 and 1948. No evidence of any mining was found, and no production has been recorded.

The "Lost Creek Lode" mentioned on mining claim location notices probably refers to poorly exposed, narrow quartz veins in altered, northwest-trending fractures in upper Miocene andesites and tuffs in the Lost Creek drainage. A few sites were found where sphalerite, galena, and chalcopyrite occur in the quartz veins. There is little potential for economic mineral deposits along these northwest-trending structures in the vicinity of Burnt Lake. The veins appear to be narrow, irregular, and discontinuous.

### Zigzag District

The Zigzag district includes the area around Laurel Hill. Underlain by an upper Miocene quartz diorite-quartz monzonite pluton, Laurel Hill is an area that may have low potential for mineral deposits. Propylitic alteration and associated copper sulfides in the overlying Rhododendron Formation indicate a possible resource. Because the pluton appears to underlie the Mount Hood andesite flows in the wilderness, there is low potential for a porphyry-type copper deposit near Laurel Hill.

### Other Areas

The Mount Hood andesite flows exposed along the Ramona Falls Trail on the northwest flank of Mount Hood contain small amounts of secondary copper minerals. Chrysocolla and malachite coatings of fracture surfaces were found in talus, and on vertical joints in the flow. While no near-surface ore deposit is known, these minerals indicate that a copper deposit may occur at depth.

## GEOTHERMAL AREAS

Two possible heat sources for geothermal systems throughout the Mount Hood Wilderness exist: a high regional heat flow and a magma chamber or intrusive body beneath Mount Hood volcano. Geothermal systems in the wilderness may be conductive or convective.

Low-temperature (less than 194°F, 90°C) geothermal systems occurring throughout much of the wilderness may be a result of localized (fault-controlled) convective systems, or of hot water conductively heated by high regional heat flow. Blackwell and Steele (1979) identified an anomalously high geothermal gradient and regional heat flow in the area of the Mount Hood Wilderness. However, the hydrologic cycle of the area is not well understood, so the details of the geothermal systems are not yet known.

The KGRA, encompassing sections 16 through 22 and 27 through 33, T. 2 S., R. 9 E. Willamette Meridian, includes the summit area of Mount Hood volcano which has fumaroles at temperatures up to 194°F (90°C). An intermediate-temperature hot-water convection system with a small vapor-dominated component exists at the fumarole area. Brook and others (1979) estimate a small reservoir (3 $km^3$) with a temperature of 251.6°F (122° C) ± 22°F (12°C).

Fourteen holes have been drilled to depths of from 433 to 6,208 ft (132 to 1,837 m) outward from the flanks of the volcano near the border of the wilderness (table 1; Robison and others, 1982). The average geothermal gradient obtained from these holes is about 60° C/km, indicating that hot water for local uses may exist at reasonable drilling depths throughout the wilderness. Most of the wilderness can be considered to have moderate to high potential for a hot-water system (less than 248°F, 120°C) geothermal resource.

## ASSESSMENT OF MINERAL AND GEOTHERMAL RESOURCE POTENTIAL

Neither the examination of geology and claims nor a geochemical survey revealed widespread indications of substantial, near-surface mineral resources in the Mount Hood Wilderness. There are two areas of recognized, although low, mineral potential (fig. 2): the Lost Creek-Burnt Lake-Cast Creek-Short Creek area and the Lady Creek-Laurel Hill region. Rock samples from quartz veins and altered zones near Lost Creek contain subeconomic amounts of zinc, lead, silver, and copper. Propylitic alteration is accompanied by localized anomalous amounts of copper, molybdenum, lead, zinc, silver, and gold in the quartz diorite of Laurel Hill 0.6 mi (1 km) south of the wilderness. The values obtained indicate low potential for a mineral deposit extending into the wilderness.

A geothermal system exists in the wilderness and has potential to be developed as an energy resource. With the exception of the areas near Laurel Hill on the south side of the wilderness and Clear Branch on the north side, anomalously high temperature gradients were observed in drill holes situated around the wilderness (table 1). The wilderness is in an area of high regional heat flow. Fumarolic activity in the crater area of Mount Hood volcano indicates that heat is still being generated by the volcano. Most of the wilderness is considered to have medium to high potential for a low- to intermediate-temperature (less than 248°F, 120°C), hot-water geothermal resource.

Mercury, boron, and native sulfur found in rocks from the vent area of Mount Hood volcano are not considered a potential resource since their concentrations are consistent with those usually found in active volcanic vents. The concentrations are too low to warrant economic interest.

Zeolites are present in hydrothermally altered rocks throughout the wilderness, but they are not species useful for commercial purposes nor are they present in sufficient minable quantities to be considered a resource.

Large quantities of rock and gravel sources are present within the wilderness, however, large quantities of similar and more accessible deposits are available outside the wilderness.

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TABLE 1.--Thermal measurements from geothermal test holes in the vicinity of Mount Hood, Oregon; see map sheet for test hole locations.

(Modified from Robison and others, 1982)

| Well number | Total well depth | | Maximum Temperature | | Maximum Temperature Depth | | Gradient 1/ | Interval | |
|---|---|---|---|---|---|---|---|---|---|
| | Feet | Meters | °F | °C | Feet | Meters | °C/km | Feet | Meters |
| 1 --------- | 720 | 220 | 51 | 10.3 | 712 | 217 | -- | -- | -- |
| 2 -------- | 1020 | 311 | 51.6 | 10.9 | 1020 | 311 | -- | -- | -- |
| 3 --------- | 499 | 152 | 46 | 7.5 | 262 | 80 | -- | -- | -- |
| 4 --------- | 299 | 91 | 55 | 12.8 | 295 | 90 | 47 | 115-279 | 35-85 |
| 5 -------- | 2001 | 610 | 140 | 60.0 | 1985 | 605 | 85 | 623-1985 | 190-605 |
| 6 --------- | 495 | 151 | 55 | 13 | 492 | 150 | 68 | 246-492 | 75-150 |
| 7 (CMF 7A) | 6028 | 1838 | 235 | 113 | 6028 | 1837 | -- | -- | -- |
| 8 (CMF 1) | 4003 | 1220 | 180 | 82 | 4003 | 1220 | 55 | 3281-3937 | 1000-1200 |
| 9 -------- | 1319 | 402 | 738 | 23.2 | 860 | 262 | 63 | 98-860 | 30-262 |
| 10 -------- | 430 | 131 | 51 | 10.8 | 430 | 131 | 76 | 246-430 | 75-131 |
| 11 -------- | 940 | 287 | 54 | 12 | 940 | 287 | 19.8 | 492-940 | 150-287 |
| 12 -------- | 410 | 125 | 50.4 | 10.2 | 410 | 125 | 24.0 | 164-394 | 50-120 |
| 13 ------- | 1739 | 530 | 79.7 | 26.5 | 1739 | 530 | 35 | 1509-1739 | 460-530 |
| 14 -------- | 197 | 60 | 47.1 | 8.4 | 197 | 60 | 13 | 33-197 | 10-60 |
| 15 ------- | 1165 | 355 | 52.9 | 11.6 | 1148 | 350 | -- | -- | -- |
| 16 -------- | 377 | 115 | 41 | 5 | 131 | 40 | -- | -- | -- |
| 17 ------- | 1381 | 421 | 52 | 11 | 755 | 230 | -- | -- | -- |
| 18 (Pucci) | 4003 | 1220 | 170 | 76.7 2/ | 3706 | 1130 | 67 2/ | 1837-3706 | 560-1130 |
| 19 ------- | 1001 | 305 | 60.4 | 15.8 | 951 | 290 | -- | -- | -- |

1/Where temperature profiles are not linear, gradients are not useful for heat-flow analysis.

2/J. H. Robison, written comm., 1981.

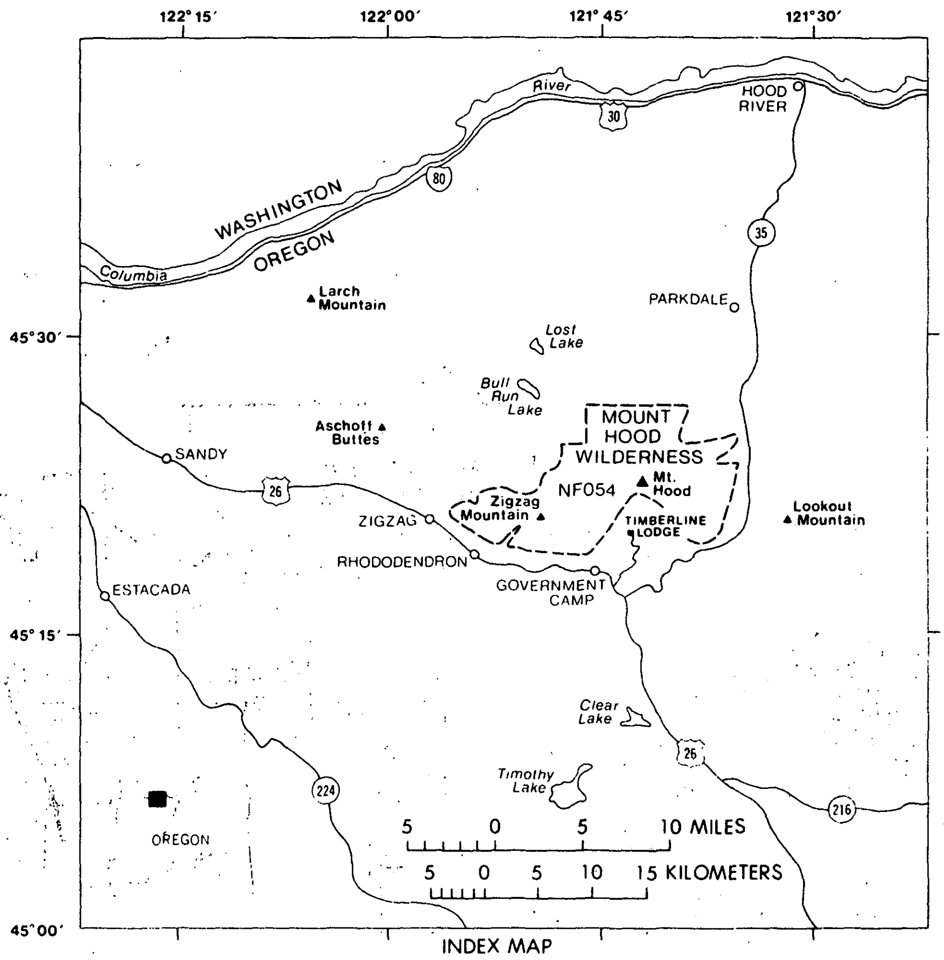


Figure 1. Index map showing the location of the Mount Hood Wilderness (NF054) and major geographic features, Clackamas and Hood River Counties, Oregon

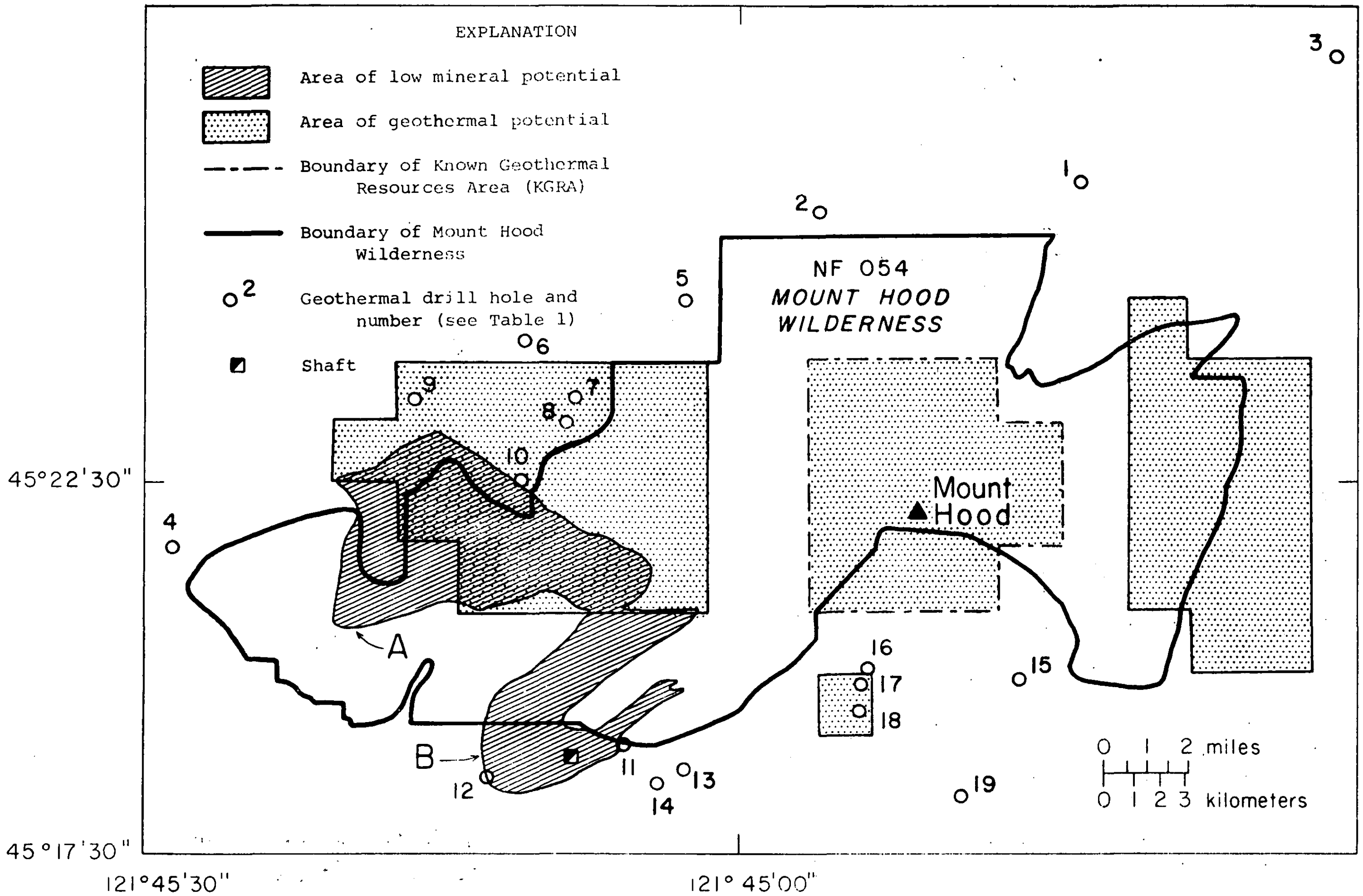


Figure 2. Map showing the location of potential mineral and geothermal resources and geothermal exploration holes in the Mount Hood Wilderness area, Clackamas and Hood River Counties, Oregon. A is the Lost Creek-Burnt Lake-Cast Creek-Short Creek area; B is the Lady Creek-Laurel Hill area.