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## MINERALIZATION IN THE NORTH-CENTRAL WESTERN CASCADES

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This is the second of a series of four articles prepared because of renewed interest by major mining firms in mineralized areas in the north-central Western Cascades; the general public's growing interest in geology, mineral collecting, and mining history; and the need for local planning groups to know what is in their planning units. These articles summarize information that has been published piecemeal concerning mineralization and mining in the area, showing what has been studied and what needs to be studied. This geologic jigsaw puzzle has many scrambled pieces that need to be put together before the picture becomes clear.

The first article, "A Geological Field Trip Guide from Sweet Home, Oregon, to the Quartzville Mining District," appeared in the June 1977 ORE BIN. This article presents an overview of published information on mineralization in the north-central Western Cascades. The third article, scheduled for an early summer 1978 ORE BIN, will provide a closer view of typical mineralization in the Western Cascades and will serve as an introduction to the last article in the series, "A Field Trip Guide to the Bohemia Mining District," to appear in a following ORE BIN.

### Location and Geography

Mineralized areas in the north-central Western Cascades have produced approximately \$8.9 million worth of metals at today's prices since 1858, when gold was first discovered in this region. Most production took place prior to 1920. The mineralized areas are fairly evenly spaced along a north-south line extending from Clackamas County on the north to the northern part of Douglas County on the south. The mineral deposits are in Tertiary volcanic rocks and are apparently associated with small Tertiary intrusive bodies.

The north-central Western Cascades (Figure 1) are located on the east side of the Willamette Valley. The Western Cascades are composed of old, deeply dissected, Tertiary volcanic rocks lying to the west of the younger High Cascades which, in Oregon, extend from the Columbia River on the north to the California border on the south. Because the

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High Cascades are composed of younger volcanic rocks, they have not been deeply eroded and have little known mineralization.

Summits in the Western Cascades rise to altitudes of 2,000 to 6,000 ft; relief ranges from 1,000 to 4,000 ft over a horizontal distance of 2 to 4 mi. No original upland surfaces are preserved; divides are sharp and valleys narrow. The stream pattern is dendritic (see Glossary at end of article), and streams drain toward the west. The highest ridges form divides between major drainage systems, and lower ridges slope toward the valleys. Valley walls are generally steep, and cliffs occur in many places. Glaciation has modified the higher summits.

Heavy forest cover of Douglas fir and hemlock is common, and timber productivity is excellent. The climate is generally mild and wet during winter months and dry in summer. The average annual rainfall is from 28 to 110 in, depending on elevation. Precipitation is greatest at higher elevations and is largely in the form of snow.

The location of mineralized areas that will be discussed in this article is shown in Figure 2. Granitoid intrusions are indicated on the same map.

#### History and Production

The discovery of placer gold in southern Oregon in 1851 stimulated interest in the prospecting of all streams in the Cascade Range. Small amounts of gold panned in the tributaries of Row River led to the discovery of a lode gold deposit at Bohemia in 1858; placer gold in the Molalla and North Santiam Rivers pointed the way to the North Santiam lodes in 1860. The Middle Santiam placers preceded the development of the Quartzville district, and in 1863 the discovery of placer gold in the McKenzie River led to the discovery of the Blue River lodes.

Interest in the Western Cascades languished after the first flurry of discovery until the 1890's, when the Lawler mine at Quartzville and the Musick, Champion, and Noonday mines of the Bohemia district became active. The major producing mine in the Blue River district, the Lucky Boy, reached its peak in the early 1900's. During this period, mining was with hand steel (Figure 3), and crushing was done by stamp mill (Figure 4) or arrastre (Figure 5). Gold was recovered with an amalgamation plate, a copper plate coated with mercury, that trapped any free gold touching it. Only free gold found in near-surface oxidized ore could be recovered by this system; and because this type of ore is never completely oxidized, only 50 percent of the total gold value present was ever recovered by early-day miners. Furthermore, these mining techniques were completely unsuited for recovering values in complex primary (unoxidized) sulfides. Selective flotation had not been developed; and gravity concentration, where tried, produced a complex concentrate of copper, lead, and zinc not desired by smelters.

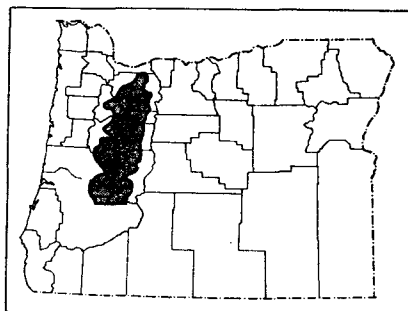


Figure 1. Location map of north-central Western Cascades, Oregon.

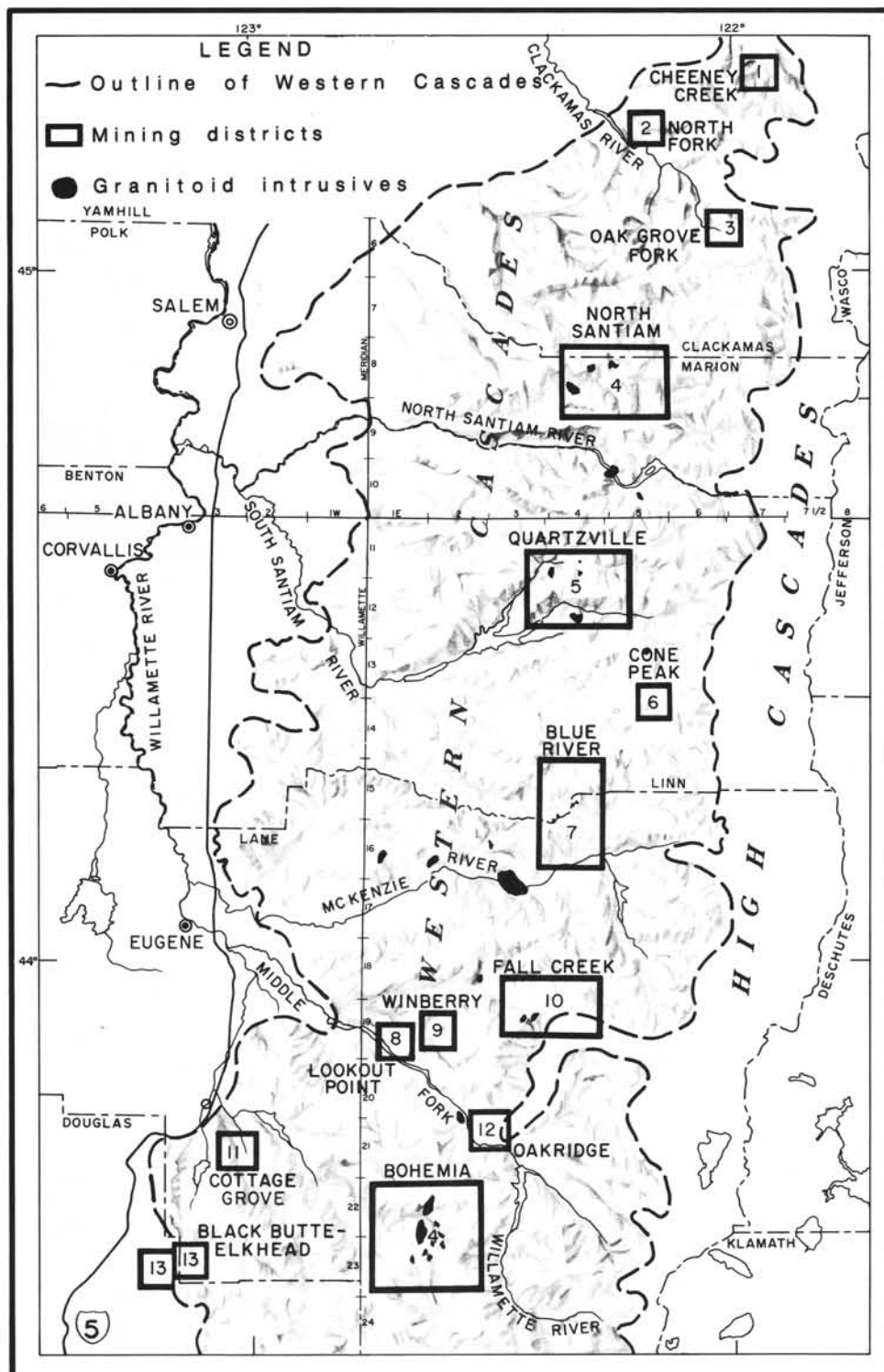
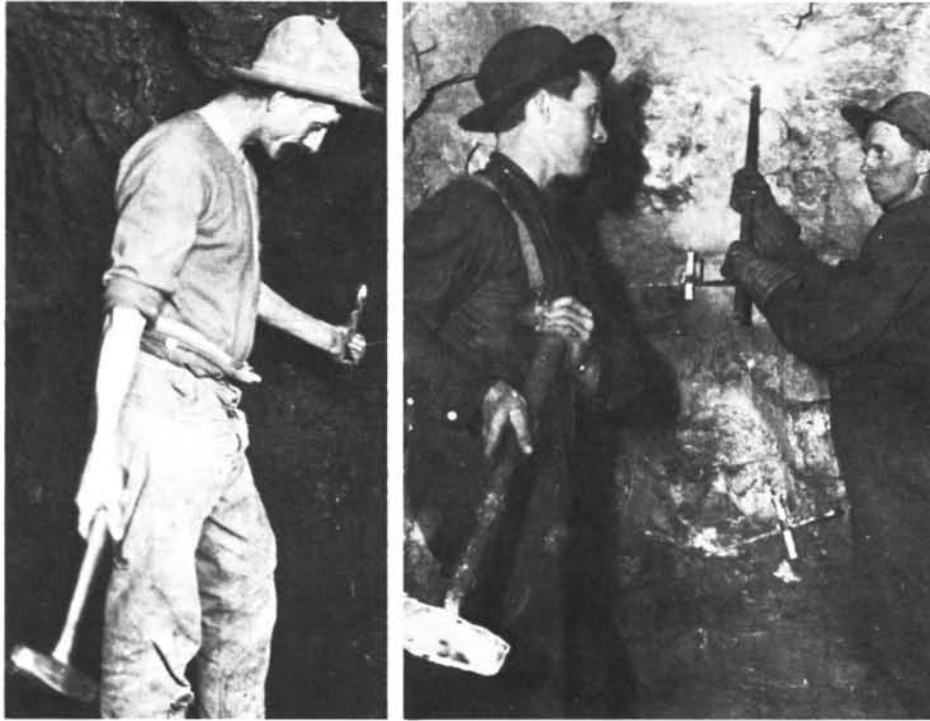
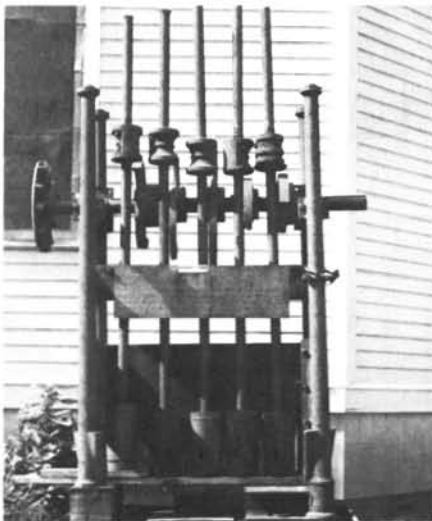


Figure 2. Mineralized areas in north-central Western Cascades, Oregon.  
Map by Kath Eisele.





*Figure 3. Hand steeling (drilling holes in rock with chisel and hammer). Left: Single jacking. Miner holds steel (chisel) in one hand and swings 6- to 8-lb hammer with other. Right: Double jacking. One miner holds steel; other miner swings 12- to 16-lb hammer. Photos courtesy Oregon Historical Society, Portland, Oregon.*



*Figure 4. Five-stamp mill, Cottage Grove Historical Museum. These heavy iron stamps (pestles), which rose and fell over a hundred times a minute, were used to crush ore.*



Figure 5. Arrastre used to grind friable gold and silver ore. Ore spread on floor was crushed by heavy stones chained to arms pivoting around central shaft. In this drawing, water provides power to turn shaft; in other cases, horses or steam could be used. Gold was then recovered, as it was from a stamp mill, by sluicibox and copper-mercury-coated plate.

The first recorded Western Cascades mercury production was from the Black Butte-Elkhead district in 1882, and production was more or less continuous from then until the 1960's. Mercury was discovered in the Oak Grove Fork area in 1923-1924, first mercury was produced in 1925, and latest production was in 1943.

The nature of the ore, technology, and economics of the times were all important factors determining the intermittent operation of the Western Cascades mining districts. Of the total production from the north-central Western Cascades, 47 percent came from the Bohemia district, 23 percent from Black Butte-Elkhead, 14 percent from Quartzville 13 percent from Blue River, 2 percent from North Santiam, and less than 1 percent from Oak Grove Fork (see Table 1).

#### Geology

The north-central Western Cascades in Oregon are underlain by a downwarped, 10,000-ft-thick pile of Tertiary volcanic rocks, consisting mainly of andesite with some basalt and rhyolite flow rock, extensive tuff beds, and lenses of lacustrine and fluvial sediments. The rocks,

Table 1. Summary of production of mining districts of Cascade Range from 1880 to the present <sup>1/</sup>

District	Mercury (flasks)	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)	Sept. '77 Value <sup>2/</sup>
Oak Grove Fork.....	172	—	—	—	—	—	19,780
North Santiam.....	—	454	1,412	41,172	40,700	110,063	148,487
Quartzville.	—	8,559	2,920	—	—	—	1,253,730 <sup>3/</sup>
Blue River..	—	7,727	17,162	267	—	—	1,196,773
Bohemia.....	—	28,285	9,567	14,831	120,816	5,550	4,192,634
Black Butte- Elkhead (est.)	18,000	—	—	—	—	—	2,070,000
Total:	18,172	45,023	31,061	56,260	161,516	115,613	8,881,404

<sup>1/</sup> Statistics taken from Brooks and Ramp (1968) and Brooks (1963)

<sup>2/</sup> Metal prices: mercury, \$115/flask; gold, \$145/oz; silver, \$4.44/oz; copper, \$0.64/lb; lead, \$0.31/lb; zinc, \$0.34/lb

<sup>3/</sup> Unreported production might raise production value another \$1,000,000

ranging in age from Eocene to late Miocene (see Figure 6), are folded into a series of anticlines and synclines with north- to northeast-trending axes. Northwest-trending faults occur in many of the mineralized areas of the Western Cascades. To the west, the volcanic rocks overlie or interfinger with Tertiary marine beds. Undeformed Pliocene and Pleistocene fluvial deposits and andesite and basalt flow rock are locally present. Small late Miocene to Pliocene granitoid intrusions occurring in the mineralized areas are believed to be the sources of mineralizing solutions.

### Stratigraphy

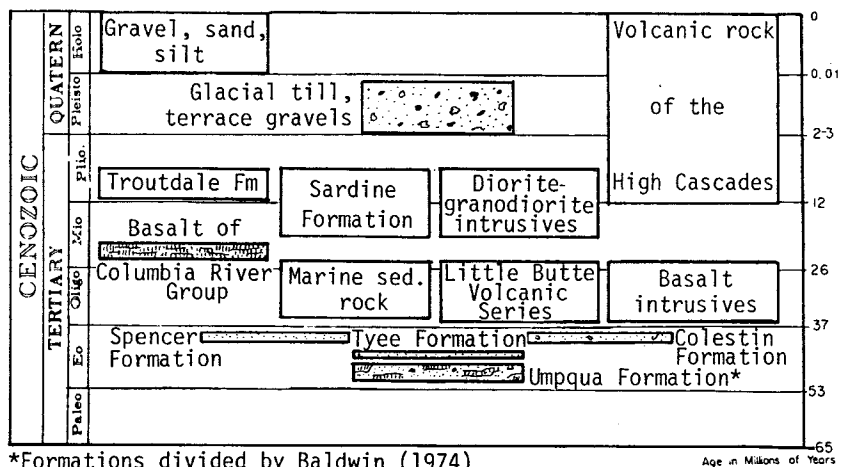
The following brief summary of the stratigraphy of the Western and High Cascades is derived largely from the work of Peck and others (1964), Griggs (1969), and Baldwin (1974). The time-rock chart (Figure 6) was developed by John Beaulieu, Oregon Department of Geology and Mineral Industries.

The oldest unit discussed in this article is 3,000 ft of flows, breccias, tuffs, and tuffaceous sandstones of the Eocene Colestin Formation. These nonmarine rocks crop out along the western edge of the Cascade Range, covering the eastern margin of older marine Eocene rocks.

The next oldest exposed unit in the area is the Oligocene and early Miocene Little Butte Volcanic Series, consisting of 3,000 to 15,000 ft of pyroclastic and flow rock. These rocks form the bulk of the Western Cascades south of the McKenzie River and crop out in the foothills and in axes of anticlines to the north. Tuffs, some of them welded, ranging in composition from andesite to rhyodacite, account for more than three-fourths of this unit; basalt and andesite flow rock and breccia make up



## GEOLOGIC TIME ROCK CHART



\*Formations divided by Baldwin (1974)

Age in Millions of Years

Figure 6. Time-rock chart for Western Cascades, Oregon. Stratigraphy by John Beaulieu, Oregon Department of Geology and Mineral Industries.

much of the remainder. Water-lain tuffs and conglomerate are present locally through the section. The thickest section of the Little Butte Volcanic Series, 15,000 ft, is exposed along the North Umpqua River. In the northern Western Cascades, where the base is not exposed, from 1,500 to 5,000 ft are exposed in eroded anticlinal cores. Intermittent subsidence of the volcanic pile as it accumulated is evident in the central part of the western margin, where the interfingering of marine rocks marks the last eastward incursions of the seas into the Western Cascades. Interbedded stream and lake deposits show that westward-flowing streams that drained the Cascades and the country to the east were dammed by volcanic material from time to time.

In the northern part of the Western Cascades, middle Miocene basalt flow rock of the Columbia River Group crops out along the east and west fringes of the Cascade Range. Basalt of the Columbia River Group laps onto eroded edges of rocks of the older Little Butte Volcanic Series. The section of Columbia River Basalt exposed in the Columbia Gorge is more than 2,000 ft thick, but the flows generally pinch out at about the latitude of the North Santiam River. Basalt of the Columbia River Group is, however, exposed at intervals farther south along both the eastern and western margins.

The Sardine Formation is composed of flow rock, breccia, and tuff, mostly hypersthene andesite in composition, that conformably overlies the Columbia River Group in the northern part of the Western Cascades and unconformably overlies older volcanic rocks to the south. As presently mapped, the Sardine Formation, which is considered to be mostly middle to late Miocene in age, covers most of the northern part of the Western Cascades. Some correlative basalt and basaltic andesite flow rock exposed along the west-central margin of the Cascade Range is included in this unit. Locally along the North Santiam River, as much as 10,000 ft of section is exposed; but in most places, thickness is 3,000 ft or less.

During the middle to late Pliocene, a huge up-arching of the earth's crust, extending from Canada to California, began along the axis of what was presently to become the High Cascades. This great arch disrupted westward-flowing streams originating in eastern Oregon, forcing them eventually to flow northward to join the Columbia River. As the arch increased in height, it also uplifted the volcanic rocks of the Western Cascades, subjecting them to intense erosion and the development of a new drainage system. The ruggedness of the Western Cascades contrasts sharply with the much flatter slopes that are common in the High Cascades promontory upon which the younger Cascade peaks such as Mount Hood, Mount Jefferson, and the Three Sisters rest.

Pliocene conglomerate, mixed with sandstone, shale, tuff, and volcanic rock, is found along both margins of the Cascade Range for 30 to 40 mi to the south. Fluvial and lacustrine rock on the west side comprise the Troutdale Formation; the andesitic debris fan to the east forms the Dalles Formation. These units may be as much as 1,500 ft thick but are generally less.

The High Cascades are predominantly basalt and basaltic andesite, mostly in the form of lava flows that built up the chain of broad volcanoes that cover the eroded eastern margin of the Western Cascades, form the plateau, and underlie the narrow eastern slope of the Range. Eruptions of these rocks began early in the Pliocene and continued into the Holocene. Isolated volcanoes of the High Cascade type also developed in the Western Cascades (Treasher, 1942; Trimble, 1963). Some Western Cascade valleys were filled by many hundreds of feet of intracanyon flows from these Pliocene-Holocene volcanoes.

Quaternary deposits in the Western Cascades consist of gravel, sand, silt, and local glacial till in major stream valleys. Some of these deposits are gold bearing, but none have a history of production.

#### Intrusive rocks

Small bodies of intrusive rock, ranging in composition from rhyodacite to basalt, cut the volcanic rocks of the Western Cascades. The intrusions are related to the volcanic units and intrude rock ranging in age from Oligocene to late Miocene. Most granitoid rocks (including quartz diorite, granodiorite, and quartz monzonite) associated with mineralized areas are probably Miocene to Pliocene in age. Figure 2 shows their distribution in the Western Cascades. These intrusions are almost uniformly porphyritic in texture and are scattered throughout a narrow north-south belt. Some of the intrusions cover as much as 4 sq mi, but most are less than 1 sq mi. They are usually round to elliptical in plan and have nearly vertical margins.

#### Country-rock alteration/metamorphism

In the Western Cascades, most Miocene or older volcanic rocks have been partly or completely changed in composition and appearance by the intrusion of molten rock and associated heat and hydrothermal fluids. Three general types of country-rock changes have occurred (see Figure 7): rock farthest from intrusions has undergone zeolite alteration; rock somewhat closer has been altered propylitically; and rock closest to the intrusions has been subjected to contact metamorphism.

Zeolite alteration, the weakest and most widespread type of alteration in the Western Cascades, chemically breaks down (devitrifies) rel-

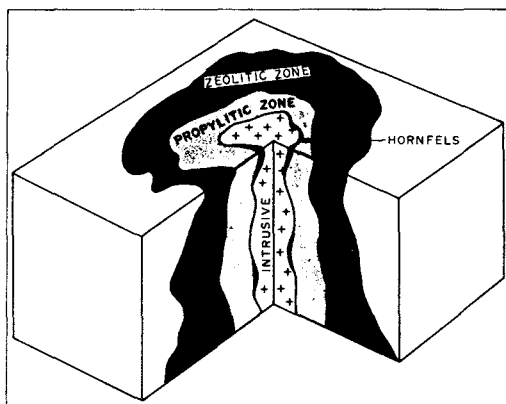


Figure 7. Country-rock alteration/  
metamorphism.

actively unstable volcanic glass in pyroclastic and lava flow rock, altering it to green clay and zeolites. Because flow rock does not contain much glass, even after alteration it may remain fresh in appearance. Pyroclastic rock, which contains more glass, is generally much more affected in appearance by alteration.

Propylitic alteration affects country rock more intensely. Propylitically altered rocks are generally greenish-gray in color. As they are altered, they become more brittle; when broken, they often develop a conchoidal fracture. A zone of propylitic alteration surrounding granitoid intrusions forms an apparently discontinuous, north-south trending band in the Western Cascades. Most of the mineralized areas shown in Figure 2 are associated with this alteration zone.

Rock closest to intrusive bodies is affected most profoundly and may be contact metamorphosed into a dark, fine-grained, flinty rock called hornfels. The major effect of this type of alteration is the introduction or remobilization of silica (silification) and the formation of the following mineral assemblages: tourmaline-quartz, epidote-tourmaline, tourmaline-specularite-sericite, epidote-chlorite-magnetite (or pyrite), and quartz-sericite-pyrite. These mineral assemblages may occur in the total rock mass, along rock fractures, or as nodules within the rock mass. Such nodules have been found as far as 4,000 ft away from the intrusive body in the Bohemia mining district.

Within the Western Cascades, another type of metamorphic rock has also been found. Deposits of emery may have been formed as the result of contact metamorphism of ferruginous bauxite by mafic intrusions. Mineral assemblages occurring within the emery deposits include corundum-magnetite, mullite-cristobalite, and hercynite-mullite-crisobalite.

In this report, the term "wall rock" is applied to country rock that surrounds a mineralized vein or other mineralized zone. The alteration of wall rock by hydrothermal fluids will be discussed in the following section.

## Ore Deposits

### Base- and precious-metals mineralization

Areas of mineralization are more or less evenly distributed along a north-south line running through the center of the Western Cascade Tertiary volcanic rocks. Most of the sulfide mineralized areas are associated with small granitoid intrusive bodies that are believed to be genetically related to the mineral deposits. Sulfide minerals found in mineralized zones and veins in the Western Cascades include pyrite, sphalerite, chalcopyrite, and galena. The common noneconomic (gangue) minerals include quartz, calcite, and, in places, barite. The veins,

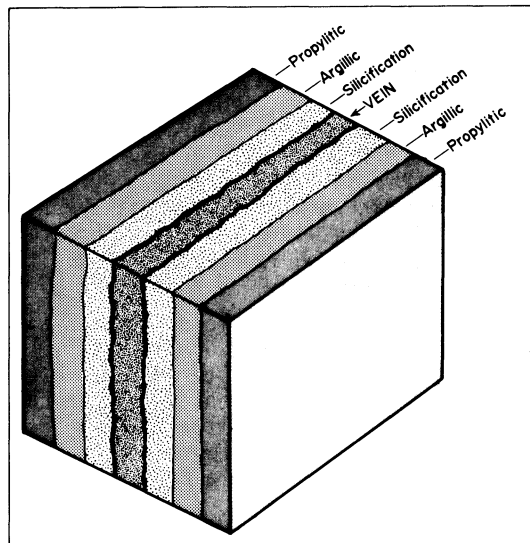


Figure 8. Stages of zoning in wall-rock alteration.

which cut across virtually all rock types including intrusions, generally strike northwest to west and dip steeply. Some veins found in the Bohemia district are more than 0.5 mi long and 20 ft wide.

In general, ore-bearing fluids change gradually in composition as they migrate from their sources. The spatial distribution of mineral deposition is known as zoning. Zoning patterns are shown by changes in mineralogy over a distance in both vertical and horizontal directions in mineralized areas. Most mineralized areas are zoned, both in wall-rock alteration and in vein minerals. Figure 8 shows the stages of zoning in wall-rock alteration, starting with the closest to the source: silica flooding (silicification), clay mineral (argillic), and propylitic.

Zoning is also shown by minerals in veins. Figure 9 is a generalized picture of vein-mineral zoning in both vertical and horizontal directions. Theoretically, the porphyritic-copper-molybdenum zone is the closest to or part of the granitoid intrusion, followed by copper vein minerals, followed by lead-zinc vein minerals, followed by iron-gold vein minerals, all surrounded by veins of gangue minerals. Figure 9 also shows a pipe-shaped body, called a breccia pipe, filled with fragmental rock, which can be a favorable locale for mineralization.

Veins within mineralized areas in the Western Cascades show this type of zoning. In the North Santiam district, a central zone of chalcopyrite veins is surrounded by a zone of complex-sulfide veins, which in turn is surrounded by carbonate veins. In the Quartzville district, a center zone of gold veins have lead-zinc veins around the periphery; in the Bohemia district, a central zone of large veins with abundant sulfides is surrounded by a zone of veins containing minor amounts of sulfides, and this zone in turn is surrounded by one with stibnite veins.

All past prospecting, mining, and geological studies in this region have concentrated on the veining systems of the districts. The economics of today call instead for the mining of massive orebodies. Evidence from the north-central Western Cascades suggests that copper-molybdenum porphyry-type orebodies such as that shown in Figure 9 may lie at depth. Because the mineralogy of veins is generally related to proximity to the copper-molybdenum-porphyry heart below, the targets for exploration companies should be zoning centers, zones of disseminated copper minerals, geochemical molybdenum anomalies, and breccia pipes (see Figure 9).

#### Other mineralization

Other types of mineralization occurring in the north-central Western

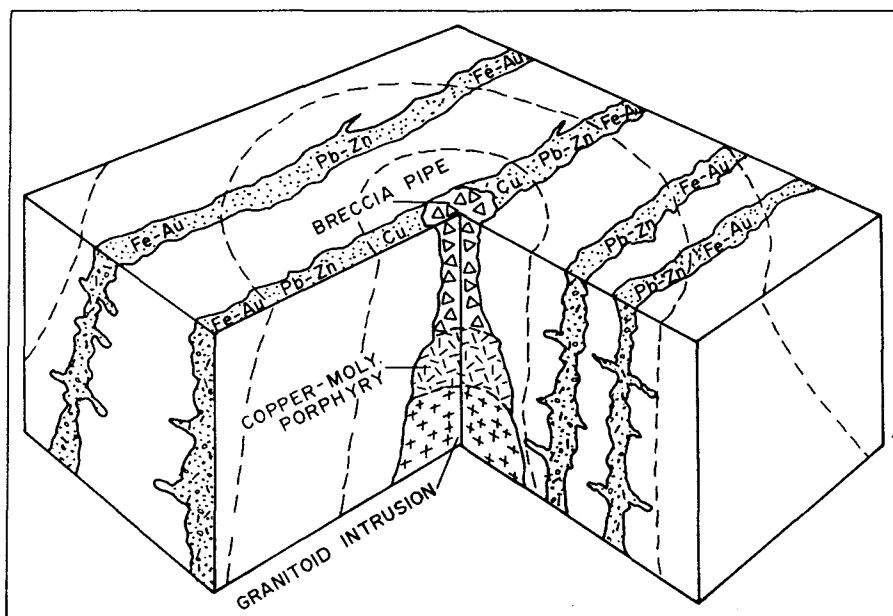


Figure 9. Vein-mineral zoning. Fe=iron; Au=gold; Pb=lead; Zn=zinc; Cu=copper; Moly=molybdenum.

Cascades are discussed later in this article in the sections describing the areas in which they occur. Native copper is found at Cottage Grove; mercury mineralization occurs in the North Fork, Oak Grove Fork, and Black Butte-Elkhead areas. Emery is found in the Cone Peak area, and barite occurs at both Lookout Point and Oakridge.

#### Mineralized Areas (see Figure 1)

##### Cheaney Creek, area 1

The Cheaney Creek area is located in Clackamas County, sec. 20, T. 3 S., R. 7 E. One hundred claims were staked by 1903, with workings totaling 87 ft of shaft and 400 ft of adit. Total reported production is 48 oz of gold. Mineralization appears as narrow gouge seams and thin seams of vein matter consisting of fragments of country rock altered to an aggregate of quartz and clay minerals on which are crusts of galena and sphalerite with quartz and dolomite. The country rock is a light-gray andesite that is only slightly altered (Callaghan and Buddington, 1938).

##### North Fork, area 2

The North Fork area is located in Clackamas County, secs. 7 and 8, T. 4 S., R. 5 E. Traces of mercury mineralization in the form of cinnabar are found in agglomerate and tuff of the Sardine Formation. Development consisted of a 30-ft adit and scattered open cuts. No production has been reported (Brooks, 1963).



Figure 10a. Oak Grove Fork. Country rock is brecciated basalt, cut by vein surrounded with alteration.



Figure 10b. Oak Grove Fork. Mine adit shows typical mine conditions today in this district.

#### Oak Grove Fork, area 3

The Oak Grove Fork area is located in Clackamas County, secs. 4 and 5, T. 6 S., R. 7 E. The mercury mineralization occurs as cinnabar in fissure veins of banded calcite and zeolite and as narrow fracture filling in the basalt adjacent to the veins. The country rock, basalt of the Columbia River Group, has been brecciated near the veins and altered by hydrothermal solutions to a dark, gray-green rock containing considerable clay and showing some limonite stains (Figure 10a). Reported mercury production from 1923 to 1943 was 71 flasks. The mining was through several adits (Figure 10b), with the ore transferred across the river by tramline (Brooks, 1963).

#### North Santiam, area 4

The North Santiam mining district (Figure 11) is located in Clackamas and Marion Counties, Ts. 7, 8, and 9 S., Rs. 3, 4, 5, and 6 E. Production of this complex-sulfide mineralized area is given in Table 1. Country rock of the Little Butte Volcanic Series has been intruded by small dacite-porphyry dikes and plugs. One quartz-diorite body is exposed at the Crown mine. Large areas of contact metamorphic alteration and zoning of the vein mineralization indicate the possibility of large, unexposed intrusive bodies. Zoning of vein mineralization appears to be better developed in the North Santiam district than anywhere else in the Western Cascades. Chalcopyrite-bearing veins from the Crown mine to and along the Little North Fork of the Santiam River form a central high-temperature zone that is succeeded in the section by pyrite-bearing veins





*Figure 11. Ruth mill, North Santiam district, built and operated in early 1930's. This mill, which had a very small production run, is no longer standing. Photo courtesy George Atiyeh.*

on Gold Creek that, in turn, give way to complex-sulfide veins in the Blende Oro mine and, farther east, in the Ruth mine. These complex-sulfide veins contain sphalerite with variable amounts of galena and chalcopryrite. An outer low-temperature zone is represented by a calcite vein on lower Elkhorn Creek and at the Ogle Mountain mine.

Reported development totals 16,344 ft of crosscuts, drifts, winzes, raises, and stopes. Twenty-five different mines and claims groups have been described (Oregon Department of Geology and Mineral Industries, 1951). Because of recent interest by major mining firms, most of the district has been staked with mining claims (Callaghan and Buddington, 1938; Brooks and Ramp, 1968).

#### Quartzville, area 5

The Quartzville district (Figure 12) is in Linn County, Ts. 11 and 12 S., R. 4 E. See Table 1 for production from this district. Mineralization has occurred in rocks of the Sardine Formation. Scattered dikes and plugs of dacite porphyry are also found in this district. Most of the veins contain mixed sulfides; pyritization (Fe-Au zoning, Figure 8) is widespread; and propylitic alteration is common.

Reported development of drifts, open cuts, shafts, crosscuts, and raises totals 10,688 ft. Twenty-five different mines and claims groups have been described (Callaghan and Buddington, 1938; Brooks and Ramp, 1968). Recently a large mining firm has developed a land base by claim staking. The Oregon Department of Geology and Mineral Industries has published a field trip guide to this district (Gray, 1977).



Figure 12. Small-scale weekend placer mining in Quartzville mining district. Children in foreground are panning for gold; child in background is using mechanical rocker. Photo courtesy Albany Democrat Herald.

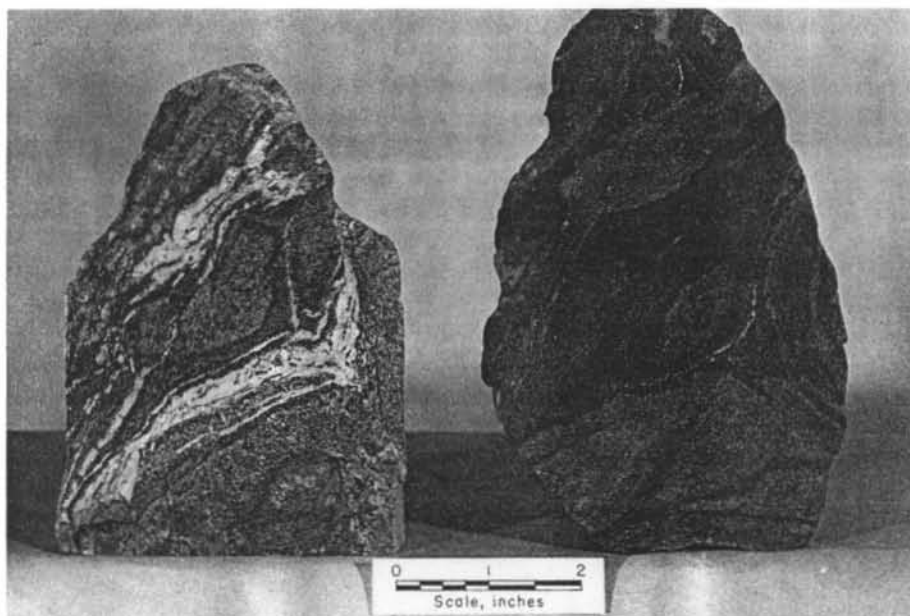
#### Cone Peak, area 6

The Cone Peak emery deposit is located in Linn County, sec. 30, T. 13 S., R. 6 E. The mineralogy of the emery is reported by White and others (1968). Emery is a high-temperature, contact-metamorphic rock (Figure 13a) that is used as an abrasive. Some assays show as much as 70 percent  $Al_2O_3$ . Along with the aluminum, every sample assayed shows anomalous values in one or more of the following: copper, zinc, nickel, chromium, vanadium, and silver.

These rocks appear to lie at the contact between the Western and High Cascades. Bauxitic material overlying the Western Cascade rocks may have been fused into emery by a High Cascade feeder dike. Development has been limited and consists of discovery shafts and one open pit from which less than 300 tons of hand-sorted emery have been mined (Figure 13b).

#### Blue River, area 7

The Blue River mining district (Figure 14) is located in Linn and Lane Counties, Ts. 15 and 16 S., R. 4 E. Production is given in Table 1. The complex-sulfide mineralization occurs in volcanic rock of the Sardine Formation. Two groups of dioritic dikes and plugs surrounded by narrow contact metamorphic rock (hornfels) occur, one northeast of Gold Hill and the other on the south fork of Tid Bit Creek.



*Figure 13a. Flow banding in Cone Peak contact-metamorphosed emery.*



*Figure 13b. Small-scale mining operation at Cone Peak emery deposit. Only mechanical equipment used is gasoline-driven conveyer and dump truck.*



*Figure 14. Blue River. Typical early-day miner and adit. Photo courtesy Oregon Historical Society, Portland, Oregon.*

Some vein zoning is present. The vein in the center of the district, the Lucky Boy, contains pyrite, sphalerite, galena, chalcopryite, and tetrahedrite, with quartz the dominant gangue mineral. Calcite is predominant in a few veins on the edges of the district. Pyrite veins without other sulfides occur between the other two zones. All of the veins in the area strike north to northwest and generally dip steeply. Reported development work for the district totals 15,400 ft (Callaghan and Buddington, 1938; Brooks and Ramp, 1968).

#### Lookout Point, area 8

The Lookout Point barite, pyrite, and quartz mineralized area (Figure 15) is located in Lane County, secs. 20, 21, and 27, T. 20 S., R. 2 E.



*Figure 15. Lookout Point.  
Note size of barite  
crystals lining vug  
that is large enough  
to accommodate man.  
Photo courtesy Leo  
Paschelki.*

North of the Lookout Point Reservoir, a small open vein of barite, with crystals up to 6 in across, occurs in rocks of the Little Butte Volcanic Series. The vein has been mined for crystals from an open pit and from a 60-ft adit driven 30 ft below the open pit.

A group of pits on a steep hillside about 600 ft above the south bank of the Middle Fork of the Willamette River at Black Canyon exposes a seam containing a small lens of quartz that has been brecciated and cemented with comb quartz. Pyrite occurs both disseminated and in bands in the quartz lens. No production has been reported (Callaghan and Buddington, 1938; Leo Paschelki, personal communication, November 1, 1977).

#### Winberry, area 9

The Winberry area is located in Lane County, T. 19 S., R. 2 E. Pyrite and gold mineralization occurring in Little Butte Volcanic Series rocks does not appear to have been very intense, but a small gold content has been reported. The country rock contains limonite and other oxidized iron minerals, and unconfirmed reports suggest the presence of some copper mineralization. Reported development totals 50 ft of adit (Smith, 1938).

#### Fall Creek, area 10

The Fall Creek mining district is located in Lane County, T. 19 S.,

Rs. 3 and 4 E. Gold and pyrite mineralization was discovered in 1901, and one mine was worked in a small way for several years. Ore was ground in a five-stamp mill, but the amount recovered was not recorded. Little Butte Volcanic Series rocks have been intruded and mineralized by diorite and dacite-porphyry plugs and dikes. Gold occurs in quartz veins and in zones without any apparent structure. Gold in quartz veins is associated with comb and cockade quartz. Pyrite is apparently the only sulfide present in the district. A total of 1,040 ft of adit has been driven (Callaghan and Buddington, 1938; Brooks and Ramp, 1968).

#### Cottage Grove, area 11

The Cottage Grove native copper deposit, located in Lane County, sec. 19, T. 21 S., R. 2 W., was discovered in 1940. Mineralization occurs as thin sheets of native copper occurring along fractures in rocks of the Coolest Formation. The sheets of copper are rarely more than 0.04 in (1 mm) thick and 0.4 to 0.8 in (1 to 2 cm) in diameter; commonly they have been altered to malachite. This deposit has had no reported production. Development work included 244 ft of drill hole, 53 ft of shaft, and two or three open pits (Smith, 1938).

#### Oakridge, area 12

The Oakridge pyrite and barite mineralized area is located in Lane County, secs. 5 and 6, T. 21 S., R. 3 E. Pyrite is the only sulfide present, and no gold values have been reported. The Little Butte Volcanic Series country rock has been extensively altered; some alteration zones have been silicified and pyritized, and others have been altered to aggregates of clay minerals and cherty quartz. Quartz vugs are filled with barite crystals averaging 0.4 in (1 cm) in length (Callaghan and Buddington, 1938).

#### Black Butte-Elkhead, area 13

The Black Butte-Elkhead mercury mineralized area (Figure 16), located in Douglas and Lane Counties, T. 23 S., Rs. 3 and 4 W., occurs in rocks of



*Figure 16. Black Butte mercury retort. Tramline in upper left transported ore downhill from mine to retort. Cinnabar containing mercury and sulfur was heated in rotary kiln to drive off sulfur. Free mercury left behind was condensed as quicksilver. Photo courtesy Daniel Mills.*



the Colestin Formation. Production is described in Table 1. The principal ore zone lies along a normal fault. Subordinate faults are distributed through a wide zone both above and below the main fault, and the intervening rocks are extensively brecciated and altered. Veinlets of quartz, calcite, and dolomite are thickly massed in the fault zone; as they are more erosion resistant than the surrounding rock, they are responsible for the butte's standing above the surrounding countryside. Cinnabar occurs as irregular veinlets and disseminations scattered throughout most of the brecciated and altered country rock. The grade of ore is highest in material that was silicified and brecciated prior to the introduction of cinnabar.

The Black Butte mine was developed with adits distributed over a vertical interval of about 1,300 ft. The principal ore shoot has been worked from surface outcrops to the 1,100-adit level, a vertical distance of about 850 ft. Average recovery from the ore has been about 3.5 lb mercury/ton.

Mercury mineralization at the Elkhead deposit occurs in amygdaloidal basalt overlain by a series of interbedded sandstones and shales of the Colestin Formation. The higher grade mineralization lies along the north-eastward-trending contact of basalt and an overlying layer of tuffaceous sandstone. Both the basalt and the sandstone are intensely fractured, hydrothermally altered, and cut by numerous thin iron ribs. Alteration

has been more intense in the sandstone, and limonite veinlets are more abundantly developed in the sandstone than in the basalt. The veinlets appear to have been originally composed of intermixed silica and siderite, but, because of oxidation of the siderite, only limonite and silica generally remain. A little cinnabar occurs within 25 to 30 ft of the mined-out contact as disseminations and occasional veinlets in the altered sandstone, which assays less than 1 lb mercury/ton. Development work for both mines totals an estimated 6,000 ft of drifts, crosscuts, raises, and stopes (Brooks, 1963).

#### Bohemia, area 14

A description of the Bohemia mining district (Figure 17) will be published in the early summer of 1978, and a field trip guide to Bohemia will appear in a following ORE BIN. Production figures from the Bohemia district are given in Table 1.

#### Acknowledgments

The authors thank all the people who helped in the preparation of this series of articles. Special thanks are extended to Harold Barton of Cottage Grove, who served as guide and source of invaluable information.



*Figure 17. Bohemia Mountain, with Bohemia City in lower right-hand corner. One Musick mine dump is to left of the city; another is in center of photo. Photo courtesy Ray Nelson.*

## Glossary

(This glossary defines geological terms that may be unfamiliar to the reader. For information on minerals discussed in this article, readers are urged to consult any standard mineralogy text.)

- adit - mine entrance.
- amygdaloidal basalt - basalt in which small holes called vesicles have been filled with secondary minerals such as zeolites, calcite, or forms of silica.
- breccia - angular rock fragments; rock composed of angular fragments.
- cockade quartz - quartz deposited in successive crusts around vein breccia fragments.
- comb quartz - quartz crystals growing perpendicular to vein walls.
- country rock - the rock into which a mineral deposit or intrusion is emplaced.
- crosscut - small passageway driven at right angles to direction of main workings in a mine.
- dendritic - branching.
- drift - horizontal underground passage in a mine.
- extrusive rock - igneous rock that has cooled rapidly on the surface of the earth.
- ferruginous - containing iron.
- flotation - method of mineral separation in which froth created in water floats some finely crushed minerals and allows others to sink.
- fluvialite - produced by action of a stream or river.
- friable - said of rock or mineral that crumbles naturally or is easily broken or pulverized.
- granitoid - a textural term applied to rock that has cooled underground slowly enough to have formed relatively large crystals.
- hydrothermal fluids - hot-water solutions circulating within the earth.
- intrusive rock - igneous rock that has cooled slowly under the earth's surface.
- lacustrine - produced by lakes.
- lode - a narrow fissure, crack, or vein in country rock filled with a mineral deposit.
- placer mine - mine operation that extracts free gold from river deposits.
- porphyritic - crystalline rock containing some crystals that are larger than the rest.
- pyritized - converted to pyrite by simple replacement or alteration or both.
- pyroclastic - produced by explosion or aerial ejection of material from a volcanic vent.
- raise - a vertical or inclined opening driven upward in a mine.
- riffle - the lining in the bottom of a sluicibox, made of blocks or slats of wood, or stones, arranged in such a way that spaces are left between them.
- rocker - a sluicibox in which a mixture of water and gold-bearing sand and gravel are agitated in such a way that the gold is separated from the sand and gravel.
- sluicibox - long, inclined trough containing riffles in the bottom to provide a lodging place for heavy minerals as water and mineral-bearing river sand and gravel flow through the box.
- stope - an excavation from which ore has been removed in a series of steps by working horizontally in a sequence of workings, one on top of another.

tuff - rock composed of very small particles of compacted pyroclastic material.

vug - small cavity in rock, usually lined with mineral incrustation.

winze - a vertical or inclined opening that has been sunk downward, connecting two levels in a mine.

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Information from prior work by Ashley, Prostka, Bateman, Vallier, Wolff, Corcoran, Wagner, Imlay, Carlat, and Calkins was incorporated into the mapping.

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