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WASHINGTON MINERAL DEPOSITS

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A wide variety of mineral deposits occurs in Washington. Incomplete records indicate that, from the first reported discovery of gold in 1858 through 1963, Washington's total cumulative mineral production is about $2 billion, of which about $341 million is in metallic minerals and about $1.7 billion in non-metallic minerals. All but 10 of the State's 39 counties have produced gold, silver, copper, lead, or zinc. However, by far the greatest part of the production of metals has been from the northern row of counties adjacent to the Canadian border - Pend Oreille, Stevens, Ferry, Okanogan, and Whatcom Counties - and the northern Cascade Mountains counties of Chelan and Snohomish. These are the principal areas of occurrence of Tertiary and Mesozoic intrusive rocks and pre-Tertiary metamorphic rocks.

The principal metals, in decreasing order of production value, are zinc, gold, lead, copper, silver, and uranium. Lesser amounts of tungsten, mercury, iron ore, antimony, manganese, molybdenum, and chromite have been mined.

The State of Washington can be broadly divided on the basis of rock types and structural features into the seven fairly distinct geologic areas that are described below, 1 to 7. See also Figure 12-1, to which numbers in brackets refer.

1. In the northeast is an area of slightly to moderately metamorphosed miogeosynclinal rocks of early Paleozoic age, with lesser amounts of eugeosynclinal metasedimentary rocks of late Paleozoic age and Precambrian metasedimentary rocks. In this area the structural trends are quite uniform to the northeast. The rocks are strongly folded. Dips are steep and in places the folds are overturned to the east. Both normal and thrust faults are numerous. Intruding the older rocks in the area are large batholiths such as the Kaniksu in northern Pend Oreille County, and the Colville and Loon Lake batholiths in northern and southern Stevens County. These intrusives are all thought to be Mesozoic, probably Cretaceous, in age. In western Stevens County are several small areas of Tertiary volcanic rocks. This northeastern area of Washington can be characterized as a zinc-lead province; most of the production of these metals has been from Cambrian limestones in northern Pend Oreille and Stevens Counties. Southern Stevens County also is the principal source of uranium in this State and has produced some copper and tungsten from quartz veins. The Tertiary volcanics in northwestern Stevens County have produced gold.

2. To the west in Ferry County is an area about 20 miles wide and 80 miles long north and south which is predominantly underlain by Tertiary volcanic rocks with minor sedimentary interbeds. In places these are intruded by Tertiary dacites and similar rocks. Much of this area lies within the north-northeast trending Republic graben. The Tertiary rocks in the Republic district (26, Fig. 1) are the hosts for some of the most productive gold deposits in the State.

3. Farther to the west in Okanogan County and the whole northern Cascade Mountains is a large area of pre-Tertiary low-, medium-, and high-grade metamorphic rocks which are intruded by both Mesozoic and early and late Tertiary quartz diorite and related rocks. These include schists, gneisses, migmatites, and granitic rocks. Greenstone and slightly metamorphosed sedimentary rocks, including minor fossiliferous limestones, are fairly widely distributed. Small areas are covered by sedimentary and volcanic rocks of recognized Tertiary and Mesozoic age. Structural trends in the metamorphic rocks are predominantly north-northwest. Several large thrust faults are recognized. Intrusive quartz diorites
and related rocks are of both Mesozoic and early and late Tertiary age. Several small to fairly large ultramafic rock masses are in the northern Cascades. Most of these are pre-Tertiary in age, but the Twin Sisters dunite mass, about 40 square miles in area, is believed to be Late Cretaceous or Paleocene in age. The northern Cascades is an area of high relief, and the rocks are deeply eroded. This area is primarily a copper province, and most of the copper production of the State has come from here. Many of the copper deposits have molybdenum as an accessory metal as, for example, the Star property about 6 miles west of Tonasket in central Okanogan County, where molybdenite occurs in a silicified pyritic stockwork in granitic rock. Directly overlying a large east-trending band of serpentinitized peridotite in the Cle Elum River-Blewett area of the Central Cascades is a series of nickelliferous iron deposits that were formed by laterization of the ultramafic rock.

4. Erosion in the southern Cascades has penetrated the cover of Tertiary andesites and basalts in only a few places, exposing only the uppermost parts of Tertiary plutons and stocks. The volcanic rocks in the southern Cascades are moderately folded along predominantly northwest axes. To date only small "showings" of copper and minor gold, lead, and zinc have been found associated with the known intrusives. Most of these are in the Mt. St. Helens and Washougal districts (3 and 2). Most of the mercury production from Washington — about $700,000 — has come from Tertiary sedimentary rocks in the Morton district (4, Fig. 1) in the west-central part of the southern Cascades. The mercury mineralization was localized by permeable sedimentary beds and impermeable gouge zones along faults.

5. The Olympic Mountains in the northwestern part of the State is an area of Tertiary and Mesozoic shales and sandstones. The central area is surrounded on the north, east, and south by a horseshoe-shaped band of outward dipping beds of Tertiary sedimentary rocks, at the base of which is a thick sequence of submarine basalts of middle Eocene age. In the basalts are minor interbeds of argillaceous limestone, with which are associated deposits of manganese silicates with minor manganese oxides (1). No igneous rocks other than the basalts and minor diabase are known in the Olympics. Apparently the manganese was derived from the basaltic lava and was concentrated on the sea floor at the time the lavas were extruded on the ocean bottom.

6. West of the western flanks of the Cascade Mountains are the Puget Sound Lowland and the Willapa Hills, which are underlain by marine and nonmarine sandstone and shale and flows of basalt and andesite of Tertiary age. These rocks are folded along predominantly northwest-trending axes. Excellent shows of oil and gas have encouraged exploration for these resources over a period of many years, but, to date, no commercial production has resulted.

7. The whole southeastern part of Washington, comprising at least a third of the area of the State, is covered by a thick series of basalt flows, largely of Miocene age, but including some continental sedimentary beds and basalt flows of Pliocene age. The flows and beds in this area are mostly low-dipping to flat-lying, except for a series of west and northwest-trending anticlines in the western part of the area. These rocks contain no deposits of metallic minerals but are the source from which diatomite and pumicite have been produced.

Gold

Lode gold has been mined as the principal product from approximately 116 mines, the largest of which have been the Knob Hill, Gold King, and Holden mines, in the Republic, Wenatchee, and Railroad Creek mining districts (26, 6, and 18), respectively. Other significant production has come from the Blewett, Mount Baker, Slate Creek, Monte Cristo, and Oroville-Nighthawk mining districts (7, 20, 21, 12, and 23) in the northern Cascade Mountains and from the Orient district (27) in Stevens County. Cumulative production through 1956 has been $78,302,463.

Probably somewhat less than half the gold production has come as a co-product or byproduct of base-metal mining. Early production included placer gold in fairly large amounts, but in recent years very little placer production has been recorded.

Gold deposits include free gold and auriferous sulfides in quartz veins in rocks ranging from Tertiary sedimentary and volcanic rocks to Precambrian metamorphic rocks. Some deposits occur within silicified and pyritized breccia zones in Tertiary volcanics and in older rocks. Most of the lode gold deposits are associated with granitic rocks of Tertiary age, but some appear to be related to Late Cretaceous batholiths, and a few in southern Pend Oreille County may be related to Precambrian igneous rocks.
In the Republic district (26) the gold occurs with small amounts of pyrite in low-temperature quartz-calcite veins in Tertiary volcanic and intrusive rocks. Most of the gold occurs in a series of east-dipping veins in a belt 6 miles in length in which the veins trend in a northerly direction south of Republic, then turn north-northwest near Republic, and bend to the northeast in the north end of the belt. The ore carries about 4 ounces of silver for each ounce of gold. At the Gold King mine in the Wenatchee district (6), gold occurs with very minor amounts of pyrite in quartz veins in a silicified zone near the axis of a northwest-trending anticline in nonmarine sandstone of the Swauk-Fernow Formation of probable Paleocene age. Several small bodies of Tertiary intrusive igneous rocks crop out in the vicinity of the mine and along the same anticlinal axis. The Swauk district has had a small amount of lode gold production from similar deposits and some production from placer deposits. The Holden mine in the Railroad Creek district (18) had a production of 612,778 ounces of gold during its 20 years of operation. In the Blewett district (7) gold occurs in quartz veins in serpentinized peridotite that is intruded by Mount Stuart Granodiorite of Mesozoic age. At the First Thought mine in the Orient district (27) in Stevens County, gold occurs in a wide silicified and pyritized breccia zone in acid volcanic rocks of Tertiary age. Gold in the Mount Baker district (20) occurs as free gold, tellurides, and with pyrite in quartz veins that cut pre-Tertiary metamorphic rocks. To the east, in the Slate Creek district (21), gold is found in breccia zones and quartz veins in tightly folded Cretaceous sedimentary rocks just north of a large mass of granitic rock of Tertiary age. In the Monte Cristo, Silverton, Silver Creek, Miller River, Conconully, Oroville-Nighthawk (12, 14, 11, 9, 22, 23), and several other mining districts of the State, gold is associated with pyrite and arsenopyrite and with silver, copper, lead, and zinc minerals in quartz veins and in shear zones in both Tertiary and Mesozoic granitic rocks and adjacent sedimentary, volcanic, and metamorphic rocks.

Silver

Silver is reported to have been mined as the principal product from 38 mines, but most of the production has been a byproduct of the gold and base metal mines in the State. Total silver production of the State from 1866 through 1956 has been $12,265,109.

Of the few mines that were operated in the early days primarily for their silver content, the Old Dominion mine in the Colville district (30) of central Stevens County was probably the largest. It is reported to have produced more than $2 million from low-dipping fracture zones in Cambrian Old Dominion Limestone near its contact with Cretaceous granitic rock. The highest silver values here, as well as at most of the other silver producers in Washington, were near the surface in highly oxidized zones.

At another important producer, the Deer Trail mine (33) in southern Stevens County, the ore occurs in quartz veins in the Precambrian Edna Dolomite near its contact with a large lobe of the Cretaceous Loon Lake batholith. In the Nespelem and Sheridan districts (35 and 24), silver occurs in stephanite, argentite, pyargyrite, galena, pyrite, chalcopyrite, and tetrahedrite in veins and narrow shear zones about equally distributed between the Colville Granite of Mesozoic age and the upper Paleozoic (?) metasedimentary rocks of the Covada Group that are intruded by the granite. In the Covada district the same formations contain lead-silver-zinc veins. In the Ruby-Conconully district and the Oroville-Nighthawk district (22 and 23) to the north, the silver deposits are found at or within a short distance of the contact between older metamorphic rocks and granitic rocks of the Similkameen batholith of Mesozoic age. In these districts galena is the most abundant ore mineral; associated minerals are pyrite, sphalerite, chalcopyrite, and tetrahedrite. Oxidation has affected the veins to only shallow depths. Although Snohomish County has more silver occurrences than any other county in the State, very few, if any, of these mines were worked primarily for the silver content of their ore. Most of the ores are complex and have relatively low silver values. These deposits also are associated with Tertiary plutonic rocks.

Copper

Twenty-four mines in the State are reported to have produced copper as their principal product. Copper occurrences are distributed throughout northeastern Washington, from the Canadian border southward in the Cascade Mountains to the central part of the State, and in a few small areas in the southern Cascades. Cumulative production through 1963 has had a value of $43,412,918.

Of a total of 122,000 tons of copper produced in Washington from 1860 through 1961, about 107,911 tons came from the Holden mine during the 20-year period it operated, from 1938 through 1957. The Holden ore body consisted of a zone of sulfide disseminations 20 to 75 feet wide, 2,500 feet long, and 2,500 feet deep in a high-grade metamorphic zone of sheared schist and amphibolite in an overturned
isoclinal fold that has a northwest-trending axis and a dip of about 70 degrees to the southwest. The ore shoot was parallel to the enclosing foliated metamorphic rocks and pitched about 60 degrees to the east. The ore body was cut by numerous post-ore dikes associated with the nearby Tertiary Cloudy Pass pluton and by some possibly older dikes. The Glacier Peak (Miners Ridge) property (17), only about 8 miles to the west, contains more than 20 million tons of low-grade copper ore in one or more bodies. At this property, chalcopyrite and molybdenite are disseminated in the Cloudy Pass pluton of Tertiary age near its contact with migmatitic gneiss; some of the ore is also in the gneiss. Here, as well as at several other copper properties in the Cascades, the ore occurs along a northeast lineament that crosscuts the prevailing northwest regional trends of the range (A. R. Grant, personal communication, 1965). Also here, as in other places in the Cascades, the sulfides are associated with deuterically altered intrusive rock that has been enriched in potash by the addition of secondary biotite and potash feldspar. About 8 miles to the south, on Phelps Ridge in the Chiawawa district (16) of Chelan County, the Red Mountain (Royal Development) property has chalcopyrite in a breccia zone as much as 250 feet wide at the contact of gneiss and a dioritic stock. At a number of localities in the central and northern Cascade Mountains are found breccia pipes having values in copper and, in places, molybdenite. These are more or less vertical zones that are roughly circular or elliptical in plan view. They are in Tertiary volcanics and in intrusive rocks as well as pro-Tertiary rocks. The Quartz Creek copper prospect on the Middle Fork of the Snoqualmie River in King County represents this type of deposit, and some investigators consider the Sunrise deposit in Snohomish County to be a breccia pipe also. Recent exploration has shown extensive copper mineralization associated with Snoqualmie plutonic rocks in the headwaters area of the Middle Fork of the Snoqualmie River (8). Here the copper occurs in breccia pipes, stockworks, disseminations, fracture fillings, and veins in alteration areas of potash enrichment. At the Mineral Creek property in the Snoqualmie district (8), Kittitas County, chalcopyrite, pyrite, bornite, molybdenite, and pyrrhotite occur as a stockwork in granodiorite, and the same minerals occur in a 500-foot breccia contact zone between Tertiary rhyolite and basalt. The Sunset mine in the Index district (10) of Snohomish County for several years was the leading copper producer in the State. The deposit consisted of a series of lenses of copper are along a northwest-trending shear zone in Tertiary quartz diorite. Chalcopyrite and bornite were the principal ore minerals, occurring in places as solid, massive lenses with little or no quartz gangue.

West of the crest of the Cascade Mountains most of the copper deposits are in a narrow irregular belt that extends southward from the Darrington area in northern Snohomish County to Snoqualmie Pass in King County on the south. In this belt, which includes the Darrington, Silverton, Sultan Basin, Monte Cristo, Silver Creek, and Index districts (15, 14, 12, 11, and 10), the ore deposits occur in and near granitic rocks of late Tertiary age.

East of the crest in the Cascades also, many of the copper deposits are associated with Tertiary granitic rocks, but farther to the east, in Okanogan, Ferry, Stevens, and Pend Oreille Counties, copper deposits—mostly complex ores in quartz veins—are related to Mesozoic granitic rocks. At the United Copper and nearby properties in the Chewelah district (3) of Stevens County, copper-silver-quartz veins are parallel to the schistosity of enclosing phyllite of probable Precambrian age. The mineralizing solutions apparently were derived from a diorite pluton of probable Cretaceous age that is exposed more than a mile to the south of the mine. At the Lone Star property in Ferry County, just south of the Canadian border about 4 miles west of Danville (25) chalcopyrite is disseminated and in veinlets along the foliation of schistose serpentinized dacite in a zone 50 feet wide in the hanging wall of a diabase dike.

Zinc and Lead

Zinc has been mined as the principal product at 25 mines in the State, and lead at 36 mines. Total cumulative production of zinc through 1963 has had a value of $109 million, and lead, $52 million.

Thousands of zinc and lead occurrences, usually in quartz veins, are distributed throughout most of the areas in which copper, gold, and silver are found in northeastern Washington and in the Cascade Mountains, but most of the production has come from the replacement deposits of zinc and lead in the Metaline district (29) in northern Pend Oreille County. Other important production has come from similar deposits in the Northport (28) and other districts in northern Stevens County. Eight deposits of complex ores in the Cascade Mountains have produced a little more than 1,400 tons of lead, having a value of about $500,000; most of this came from the Kaaba mine in the Nighthawk district (23). About 21,000 tons of zinc was recovered as a byproduct of copper-gold production at the Holden mine (18) in Chelan County during the years 1943 to 1957. In the western Cascades many of the zinc-lead deposits are associated with Tertiary granitic rocks, but most of the deposits in eastern Washington that can be related to igneous sources are associated with Mesozoic granitic rocks.
In the Metaline district, zinc occurs with lesser amounts of lead as large low-grade replacement deposits of disseminated sulfides in Metaline Limestone of Middle Cambrian age, generally in a zone less than 500 feet stratigraphically below the overlying Ordovician Ledbetter Slate. The ores are in the graben bounded by the Slate Creek and Flume Creek faults. The mineral composition of the ores is simple, sphalerite and galena being the common minerals. Galena appears to be concentrated near the peripheries of the ore bodies. Generally the gangue is dark-gray jasperoid formed by silicification of limestone. Most of the ores occur in breccia zones in the carbonate rocks. Production from the Pend Oreille mine in recent years has shown a ratio of about 3 parts of zinc to 1 part lead, and the ore contained about 9.95 ounce of silver for each 1 percent of lead. Although the closest outcrops of the quartz monzonite and granodiorite of the Kaniksu batholith of Cretaceous age are several miles distant from the largest known ore bodies, it has been suggested that the zinc-lead deposits are related to this batholith and that metallization took place during a late stage of its intrusive history.

Although one of the large mines in the Metaline district (29), the Grandview, was closed down in recent months, the possibility of developing significant new reserves in the district is considered to be very good.

In the Northport district (28) in northern Stevens County most of the larger zinc-lead ore bodies are also in the Metaline Limestone; some are near the overlying Ordovician slate, but others are far below the top of the limestone formation. The ore bodies are not veins but are roughly tabular replacement deposits that are parallel or nearly parallel to bedding planes. Ore is localized along bedding-plane shears in several mines. Many deposits seem to be related to major or minor faults, and at some deposits, such as those at the Van Stone and Deep Creek mines, Mesozoic granite crops out nearby. A small amount (about 25,000 tons) of lead has been produced from 1916 to the present time from nearly vertical chimneys or pipes in Metaline Limestone in the Gladstone Mountain area in the eastern part of the Northport district. In plan view the chimneys are roughly circular or ellipsoidal. They appear to be localized in breccia. The ore minerals are cerussite and galena.

Uranium

Uranium has been reported in many localities in Washington, but most of the production has come from one property, the Midnite mine (34), in southern Stevens County. Here autunite and other secondary minerals and uraninite and coffinite occur in Precambrian metasedimentary rocks and Mesozoic granitic rocks at and near their contact. Small production has come from Tertiary tuffs and lake beds in southern Stevens County and from autunite-filled joints and open fractures in alaskite and pegmatite associated with biotite-quartz monzonite of probable Cretaceous age in Spokane County (A. E. Weissenborn, oral communication, 1964).

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Reference Cited

Figure 12-1

Map showing granitic and ultramafic rocks, structural trend lines and locations and products of mining districts in Washington.