STATE OF WASHINGTON

DEPARTMENT OF NATURAL RESOURCES

BERT L. COLE, Commissioner of Public Lands
DON LEE FRASER, Supervisor

DIVISION OF MINES AND GEOLOGY

VAUGHN E. LIVINGSTON, JR., Acting Supervisor

Bulletin No. 63

GEOLOGY AND MINERAL RESOURCES OF KING COUNTY, WASHINGTON

By
VAUGHN E. LIVINGSTON, JR.

Prepared in cooperation with
UNITED STATES GEOLOGICAL SURVEY

STATE PRINTING PLANT OLYMPIA, WASHINGTON

1971

For sale by Department of Natural Resources, Olympia, Washington.

Price $4.50

Errata sheet for Division of Mines and Geology Bulletin 63,

"Geology and Mineral Resources of King County, Washington"

Plate 1. Geologic map of King County, Washington

Under EXPLANATION

"Oceola Mudflow" should read Osceola mudflow

CONTENTS

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS

TABLES

GEOLOGY AND MINERAL RESOURCES OF KING COUNTY, WASHINGTON

BY VAUGHN E. LIVINGSTON, JR.

INTRODUCTION

King County was the fourth county organized north of the Columbia River. The first settlement in the county was reportedly established in the Duwamish Valley during 1850 or 1851. On December 21, 1852, the county was established as a political subdivision, when the Oregon Territorial Legislature, meeting in Salem, Oregon, created it from the north part of Pierce County.

King, now Washington's most densely populated county, is rapidly increasing in population. As a result of this increase, the building industry and related industries such as services, supplies, transportation, and the mineral industries, are also increasing in economic importance and in land area covered. In planning the establishment of new industries, knowledge of the availability of minerals is imperative, and in locating industrial plants and other buildings it is most desirable to know the geology of the areas considered.

One of the many services performed by the Washington Division of Mines and Geology is the preparation and publication of reports pertaining to the geology and mineral industries of the state. The Division and its predecessor agencies have been preparing such reports since 1891, when the first State Geologist, G. A. Bethune, made his first annual report.

ACKNOWLEDGMENTS

The author is indebted to the many previous workers whose findings on King County geology and mineral resources are incorporated into this compilation. Throughout the report these people are credited individually for their contributions. Special thanks go to the mine and property owners who volunteered information and allowed the author to examine many of the mines and mineral processing facilities. Thanks are also given to the U.S. Bureau of Mines at Albany, Oregon, for statistics on King County mineral production, and to the Safety Division of the Washington State Department of Labor and Industries for early coal mine production statistics of King County. Howard Gower, James Vine, and A. A. Wanek, of the U.S. Geological Survey, are thanked for information on some of the silica sand and clays in the Green River area. The staff members of the Division of Mines and Geology who helped the author in the field and in the preparation of this report are also thanked for their cooperation and help.

SCOPE OF THE REPORT

This report is primarily a discussion of the individual mineral deposits in King County, but brief discussions of the geology and water resources are included. A tabulation of all reported metallic mineral properties (Table 28, pages 157 to 176) has been prepared, although the information on many of them is very sketchy. A list of patented claims is on pages 177 to 181, and an index of mineral properties is on pages 182 to 185. A geologic map of the county (Plate I, in pocket) has been compiled, and a comprehensive bibliography on the geology, mineral deposits, and mineral industries is included, on pages 186 to 200.

LOCATION

King County is approximately between 121° and 122°30' west longitude and 47° and 48° north latitude (Fig. 1). The county covers an area of 2,206 square miles (Wolcott, 1961, p. 85) and had a population of 1,005,300 in 1965. It is bounded on the west by Puget Sound and on the east by the Cascade Mountains— the crest of the range serving as the eastern border— and on the north by Snohomish County and on the south by Pierce County. It includes two of the largest islands in Puget Sound— Vashon and Maury— and two of the state's largest natural lakes— Washington and Sammamish.

FIGURE 1.— Location of King County, Washington.

CLIMATE

The climate of King County is far from uniform, mainly because of the differences in physiography and elevation between one part of the county and another. Seattle, which is near sea level, has a climate quite different from that of Snoqualmie Pass (elev. 3,020 feet), which is in the heart of the Cascade Mountains. The discussion on the climate of the county is based on data from three weather stations— Seattle, Snoqualmie Falls, and Snoqualmie Pass—which show the general climatic changes that take place from the western to the eastern part of the county.

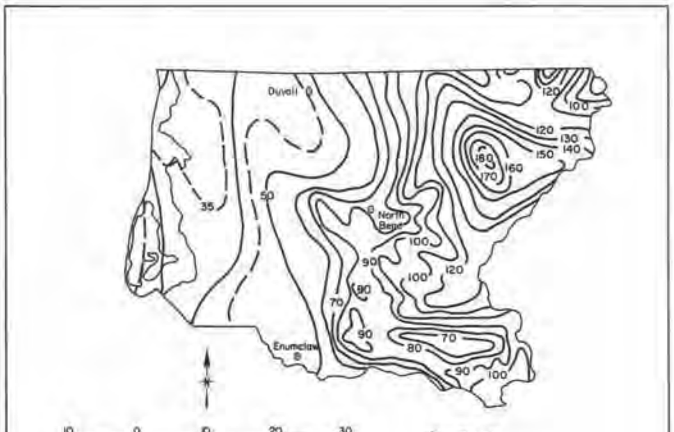


FIGURE 2.— Average annual precipitation in King County, Washington, using climatological data from 1930 to 1957. [From U.S. Weather Bureau River Forecast Center (Portland, Oregon), 1965.]

Seattle, at 47°36' north latitude and 122°20' west longitude, is about 90 miles from the Pacific Ocean. The city is situated on a hilly stretch of land that separates Puget Sound from Lake Washington, and its elevations range from 0 to 500 feet (Phillips, 1962). The climate is a mid-latitude, west coast marine type having dry days and pleasant temperatures during the summer, mild but rainy winters, and a small overall temperature range. A typical summer day has afternoon temperatures in the upper 70's and nighttime readings in the 50's. During winter, daytime temperatures are usually in the 40's and nighttime readings in the upper 20's or low 30's. Precipitation is usually light to moderate, and there are few really heavy downpours. Snowfall is light, varying between 8 and 15 inches a year. Usually the snow melts as it touches the ground. Over a 30-year period (1931-1960) average daytime temperature was 60°; the maximum reading was 100° in 1955, and the minimum reading was 11° in 1950. Normal precipitation is about 34 inches a year. On the average, 71 days a year are clear, 93 are partly cloudy, and 201 are cloudy.

Snoqualmie Falls is on the Snoqualmie River about 1 mile northwest of the city of Snoqualmie and about 25 miles east of Seattle. It is at 47°33' north latitude and 121°51' west longitude, and is at an elevation of 440 feet (Phillips, 1965). Snoqualmie Falls is at the western edge of the Cascade Range and 30 miles to the east the mountains reach elevations generally 5,000 to 8,000 feet, although a few peaks are as high as 10,000 feet. Snoqualmie Falls has a mid-latitude west coast marine climate similar to that of Seattle. Daytime temperatures during the summer are in the upper 70's, and nighttime readings are near 50°. Winter daytime temperatures are in the 40's, and during the night the temperatures fall below freezing. Mean yearly temperature is about 60°; the highest reading was 102° in 1960, and the lowest was -3° during 1950. Mean yearly precipitation is 60 inches, and mean yearly snowfall is 17 inches.

Snoqualmie Pass is 40 air miles southeast of Seattle on the crest of the Cascade Range. Highway U.S. 10 crosses the pass, which is the lowest route through the Cascades except for the Columbia River Gorge. The pass is at 47°25' north latitude and 121°25' west longitude and is 3,020 feet in elevation (Phillips, 1960). The winters are wet, especially on the west side of the pass, and the summers are dry. The average afternoon temperature in the summer is in the upper 60's, and the nighttime temperature is in the middle 40's. During the winter, daytime temperatures are around 32° and nighttime temperatures are between 15° and 20°. Yearly mean temperature is about 51°. The warmest day recorded at the pass was 101° in 1938, and the record low was -17° in 1943. Annual mean precipitation is 107 inches. Average snowfall is 420 inches a year.

As is readily apparent, the climate varies from mild in the western part of the county to more severe in the higher, eastern part. Precipitation increases and average temperatures decrease eastward. Figure 2 shows the average annual precipitation in King County.

TRANSPORTATION

King County has two international airports, one in Seattle (Boeing Field) and the other at the southern limits of the city (Seattle-Tacoma International Airport). The county is also the western terminus of Highways U.S. 10 and 410. Highway U.S. 2 also serves the county as an east-west travel route. Highway Interstate 5, the main north-south highway of the Pacific Coast, crosses the county near its western border. The county is served by four railroads: the Great Northern, which crosses the Cascade Mountains at Stevens Pass, in the northern part of the county; the Northern Pacific, which crosses the Cascades at Stampede Pass; the Chicago, Milwaukee, St. Paul and Pacific, which crosses the Cascades near Snoqualmie Pass; and the Union Pacific, which is limited to north-south haulage in the county. Elliott Bay, which fronts Seattle, is an excellent deep-water harbor for ocean-going ships, and the Port of Seattle affords adequate pier space and cargo transfer facilities.

INDUSTRIES

King County is the most industrialized as well as the most populous county in Washington, having a reported 1,668 manufacturing establishments in 1963 (Washington Dept. of Commerce and Economic Development, 1969, p. XI). This is more than three times the number in Pierce County, which is second in number of industries. Of the 1,668 manufacturing industries in the county, at least 659 process minerals, modify semifinished mineral products for their final use, or repair metal and nonmetal mineral items (Washington Dept. of Commerce and Economic Development, 1969, p. 1-15). Transportation products, such as aircraft, trucks, and ships, constitute the largest segment of the county's industry. The Boeing Company, primarily a manufacturer of aircraft, is the largest single industry in the county.

The abundant mineral resources of King County have made a prime contribution to the history and development of the county. In 1967 the county ranked first in mineral production in Washington, with a value of $17,570,000. Because of incomplete records, it is impossible to give the total value of minerals produced from King County. However, the data available, incomplete as they are, show more than $150 million in mineral production since about 1920. Sand and gravel, coal, clay, cement, stone, peat, and silica sand have all been produced continuously for many years. Expanding urbanization— construction of homes, industrial plants, roads, and similar building projects— provides the largest mineral market in the county. The most important minerals produced, in order of their value, are: sand and gravel, stone, coal, and clay.

LAND USE

Over 333,000 of the 1,365,760 acres of land in King County is federally owned. Most, but not all, of the federal land is open to prospecting and mineral location. Military reservations are closed to prospecting and mining, but Indian reservations are open to prospecting and mining by permit from the tribal councils. In King County, federal land open to the staking of mining claims corresponds roughly to the area shown as national forest on Figure 3; however, the Seattle watershed area on the Cedar River and the Tacoma watershed area on the Green River, although in the national forest, are closed to entry. All national forest land in the county is part of the Snoqualmie National Forest. About 56,600 acres of land in King County is State owned and is administered by the State Department of Natural Resources. Most of this land is open to prospecting and mine development through mineral lease from the Lands Division of the Department of Natural Resources.

In King County the general trend over the years has been toward a decreased amount of land available for mining. In the mountainous part of the county, national forest acreage has been withdrawn from mineral entry for recreational and administrative uses, and pressure is being exerted by various

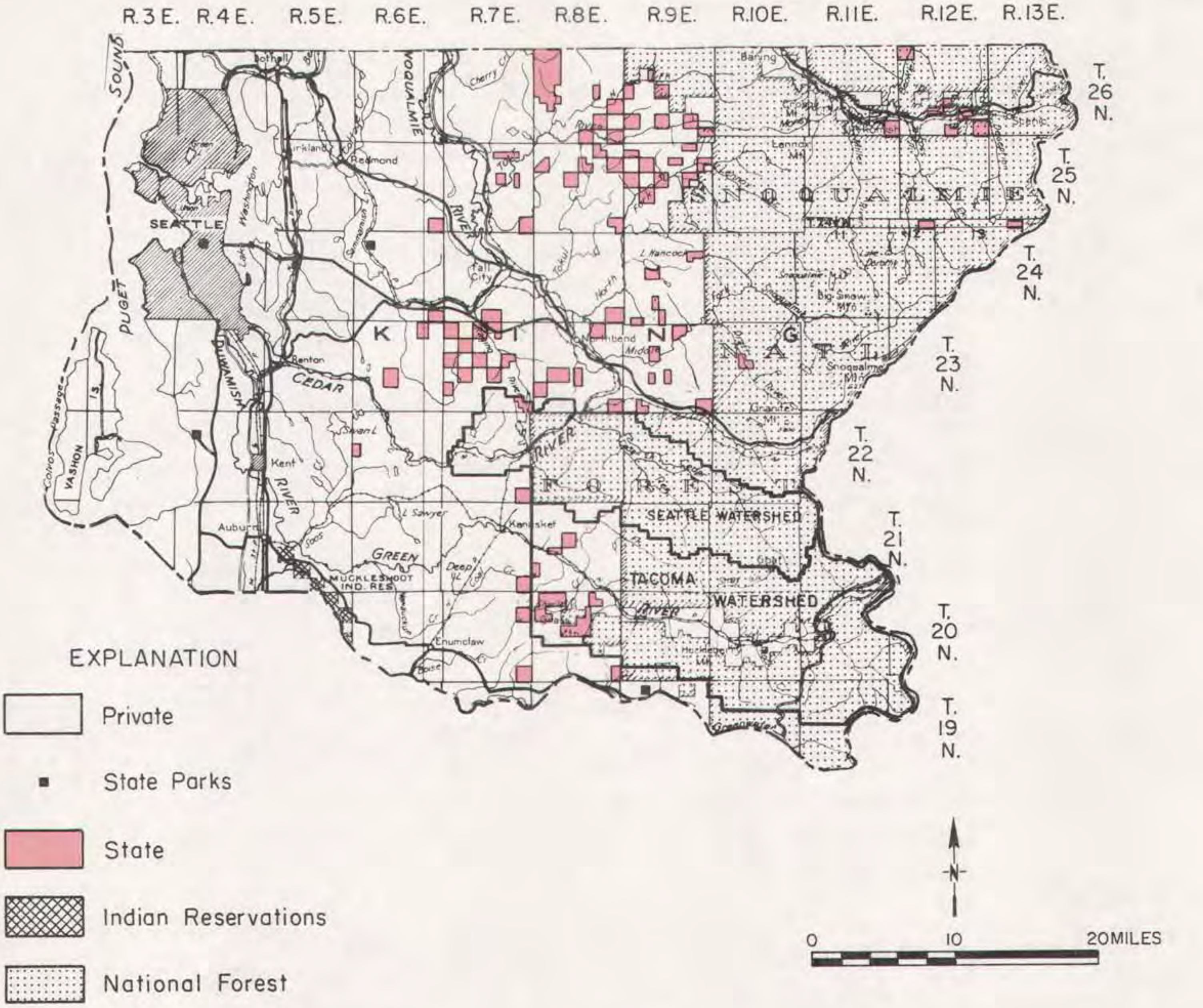


FIGURE 3.— Land ownership in King County, Washington.

organizations for more recreational withdrawals. Closure to mining of areas such as the Seattle watershed on the Cedar River and the City of Seattle's proposed closure of the Tolt and Money Creek drainages in addition to Tacoma's Green River watershed emphasize the changing land status. In the western part of the county, constant spreading urbanization is very rapidly changing the situation regarding land availability for mineral use.

Anyone interested in prospecting for and developing mineral resources must determine the ownership and availability of the mineral rights on the land to be investigated. A general guide to the status of mineral rights and landownership in Washington has been published by the Washington Division of Mines and Geology (Moen, 1962). Agencies having information concerning land status and those having regulatory powers over mining are shown in Table 1.

TABLE 1.— Sources of information relevant to mining and land status in King County, Washington

Agency	Address	Information
Washington State:		
Department of Commerce and Economic Development	General Administration Bldg. Olympia, WA 98501	Industrial promotion.
Department of Employment Security	Employment Security Bldg. Olympia, WA 98501	Employment laws, rules, and regulations.
Department of Health		
Division of Air Quality and Radiation Control	1510 Smith Tower Seattle, WA 98104	Air pollution regulations.
Department of Labor and Industries	General Administration Bldg. Olympia, WA 98501	Industrial safety regulations, coal mine inspector's reports.
Department of Natural Resources		
Lands Division	P. O. Box 168 Olympia, WA 98501	Prospecting permits for State-owned land, mineral and oil and gas leases on State-owned land.
Division of Mines and Geology	P. O. Box 168 Olympia, WA 98501	Geology, mineral resources, oil and gas drilling permits, oil and gas well records, mining laws, oil and gas laws, biennial reports of mining activity, mining property inspection, ore buyers, production statistics, mineral identification service.
Pollution Control Commission	P. O. Box 829 Olympia, WA 98501	Water pollution regulations.
Department of Water Resources	General Administration Bldg. Olympia, WA 98501	Water rights, water resources, water well data, geology.
King County:		
Assessor	King County Courthouse Seattle, WA 98104	Land-ownership maps, location of patented claims. Aerial photographs of the county can be purchased, with clearance from the Assessor's office, from Walker Associates, 310 Prefontaine Bldg., Seattle, WA 98104
Engineer	King County Courthouse Seattle, WA 98104	Road access, load limits, bridge capacities, county maps.
Planning Department	King County Courthouse Seattle, WA 98104	General information concerning business, industry, recreation, zoning; data on projected population growth and direction of urban expansion.
Recorder	King County Courthouse Seattle, WA 98104	Chronological file of mining claim records, including proof of labor for annual assessment work, copies of location notices, transfers of claim ownership. Claims indexed alphabetically by year.
Seattle Area Industrial Council	215 Columbia Street Seattle, WA 98104	General information concerning industry and business.

TABLE 1.— Sources of information relevant to mining and land status in King County, Washington— Continued

Agency	Address	Information
United States Government:		
Bureau of Land Management	729 N.E. Oregon Street Portland, OR 97232	Records of patented claims, patent procedures, mining laws, land withdrawals.
	680 Bon Marche Bldg. Spokane, WA 99201	
Bureau of Mines	W. 222 Mission Avenue Spokane, WA 99201	Geology, property inspection, mine operation, ore preparation.
	909 First Avenue Seattle, WA 98104	
	P. O. Box 70 Albany, OR 97321	
Forest Service	P. O. Box 4137 Portland, OR 97208	Aerial photographs of forest land, mining claims in forest, regulation of surface rights.
	905 Second Avenue Seattle, WA 98104	
Geological Survey	656 U.S. Courthouse W. 920 Riverside Ave. Spokane, WA 99201	Geology, topographic maps, aerial photographs.
	Federal Center Denver, CO 80225	
	Washington D.C. 20242	
Office of Minerals Exploration	656 U.S. Courthouse Spokane, WA 99201	Government loans for mineral exploration.
Private companies:		
H. G. Chickering, Jr. Consulting Photogrammetrist, Inc.	1190 West 7th Avenue Eugene, OR 97402	Aerial photographs.
Kroll Map Company, Inc.	816 Second Avenue Seattle, WA 98104	Mine maps, land ownership maps.
Metsker Maps	111 S. 10th Avenue Tacoma, WA 98444	Land ownership maps.
	1222 Third Avenue Seattle, WA 98101	
Walker Associates	310 Prefontaine Bldg. Seattle, WA 98104	Aerial photographs of the county.

Until the mineral is needed, the land could be used for parks or open-space area. After the mineral has been mined, the land should be rehabilitated and rezoned for its highest use. This procedure may not conform with some of the zoning concepts of today, but if we are to keep our valuable minerals available and still utilize the land both before and after the minerals have been extracted, new thinking and new practices are needed.

A mine operator should no longer think in terms of opening a pit or quarry, working it out and then leaving without rehabilitating it. While working his property he should place fences around the operation; observe setback and screening regulations; try to minimize dust and noise and avoid pollution of water; and, in general, make his operation fit into the community as well as possible. When he has finished working an area, he should leave gently contoured slopes in the pits for appearance, safety, and proper drainage. New pits and quarries that are opened should operate under a planned program, so that as parts of the property are worked out they are restored to a condition that is suitable for other uses.

Long-range planning will help to protect our mineral deposits from being wasted through non-use, and will insure that land from which the minerals have been removed is reclaimed. To make long-range planning work properly, there must be an integrated program that calls for the complete cooperation of all parties concerned. Mineral land can be used for many purposes, such as wildlife preservation, recreation, lumbering, grazing, and farming, until such time as the minerals are needed. Good planning must include careful zoning to set aside mineral lands and to establish the requirements for the proper utilization of these lands. Permits may be issued that establish provisions for rehabilitation of the land. Operators should be willing to cooperate with planners and civic officials and be eager to maintain good relations with neighboring citizens. Planners should be reasonable in their zoning restrictions and should look upon mining operations not as nuisances but as essential elements in the local economy.

Solid waste disposal.— The increase in population and industrialization has also increased the variety and amount of waste products that must be disposed of, and King County is currently having difficulty finding good waste-disposal sites. The danger of pollution to surface water or ground water from nonputrescible waste probably is fairly low. The danger from putrescible material is high, and great care should be taken to evaluate potential sanitary landfill sites if this type of material is to be disposed of. When putrescible refuse becomes saturated, a leachate is produced that has a high concentration of dissolved minerals, and that also acts as a transporting agent for bacterial pollutants. If the leachate gets into surface water, dilution and dispersion are effective mechanisms that reduce the contaminants. In ground water, however, because there is no turbulence and the flow is slow, dilution and dispersion of the leachate is a slow and inefficient process. If ground water is percolated through material such as silt or dirt, the bacteria may be filtered out; however, the chemical contaminants are not removed. Percolation through clay probably reduces the concentration of some undesirable elements through ion exchange, similar to the process employed by household water softeners, but the amount of total solids exchanged by this process is probably not very great.

Sanitary landfills should be situated on relatively impermeable material, so that movement of the leachate will be slow. Clay, glacial till, and silt are the most effective materials for filtering out the biological contaminants in the leachate. Sites where sand and gravel occur are generally unsuited for sanitary landfill because of their high permeability.

Table 2 (on page 10) summarizes the criteria for evaluating sanitary landfill sites where putrescible waste is to be disposed of.

Slope failure.— Like land use competition and solid waste disposal, problems regarding slope failure are increasing in King County. Such situations as roads built across slide zones, failure of slopes in roadcuts, settling of the ground under building foundations, and earth slumps in residential areas require the expenditure of large sums of money each year to correct or maintain.

The unconsolidated pre-Vashon deposits (Q on Plate 1) are the most susceptible to slope failure. Landslides in this unit occur extensively along the Cedar and Green Rivers and along the shores of Puget Sound in the vicinity of Alki Point and Duwamish Head. Table 3 (in pocket) is a summary of the general engineering properties of the different rock units in the county.

Ground Water

The best sources of ground water in King County are aquifers in outwash material of the Salmon Springs Drift and the Vashon Drift in the southwestern part of the county, and unnamed gravels and Vashon Drift in the northwestern part of the county. Other sources are some of the older unconsolidated formations, but these are not as reliable as the younger units.

Water is also produced from rocks of Tertiary age in the west-central part of the county. Liesch and others (1963, p. 28) reported that more water is being taken from these rocks than is being put back into them by natural recharge through precipitation. As a result, there has been a steady decline in the water levels of wells in rocks of Tertiary age.

Surface Water

A review of surface water runoff for King County is shown on Figure 5. Eight major river systems drain King County. From north to south they are the Skykomish, Tolt, North Fork of the Snoqualmie, Middle Fork of the Snoqualmie, South Fork of the Snoqualmie, Cedar, Green, and Greenwater-White Rivers. These rivers are shown on Figure 5 along with smaller tributary streams that have gauging stations on them. As mentioned above, three of these streams furnish municipal water to Seattle and Tacoma.

Runoff in King County varies tremendously, depending on the time of year, frequency of storms, amount of precipitation, and temperature. Flooding has been common along the lower courses of some of the streams, and, as a result, flood-control measures have been taken. Dikes have been built along some streams, and on the White River a flood-control dam was constructed at Mud Mountain near Enumclaw. Some surface water is used for irrigation, but the amount can probably be considered negligible.

PREVIOUS WORK

The first geologic work in King County apparently was done by I. I. Stevens in connection with surveys to find a rail route across the Cascade Mountains. Unfortunately, none of his geologic work was published. In 1886 Bailey Willis reported on the coalfields of Washington Territory. He briefly mentioned the Newcastle, Renton, and Cedar River areas (on p. 760), and described the Green River coalfield (on p. 767) in more detail. Several papers, such as those of J. R. Browne (1869, p. 572-573), Ruffner (1889, p. 90-170), and Hodges (1897, p. 36-48), described some of the geology and mineral deposits in a cursory way, but it was not until 1899 (Willis and Smith) that the first detailed report was published. This is a report on the Tacoma 30-minute quadrangle, which covers the southwestern part of the county as well as part of Pierce County.

Figures 6 and 7 are indexes to published geologic mapping in King County. Smith and Calkins (1906) mapped the Snoqualmie 30-minute quadrangle, which covers the area around Snoqualmie Pass.

Evans (1912) described the geology and coalbeds in the county. Bretz (1913) described the glacial geology of the Puget Sound area and mentioned specifically some of the glacial features in King County. W. S. Smith (1915, 1916b, 1917) mapped and described the rocks around Skykomish, in the northeastern corner of the county. Weaver (1916b) discussed the Tertiary rocks in selected areas in the north-central and central parts of the county. Later (1937), he described the Tertiary stratigraphy of the western part of the county.

Warren and others (1945) mapped the coalfields of the county and included a brief description of rocks. In 1949 Mackin made an engineering geology report on the West Seattle area. Purdy (1951) described the antimony occurrences in Washington; the report includes discussions of several mines in King County. In 1956 Crandell and Waldron reported on a Recent volcanic mudflow that blankets the drift plain around Enumclaw. Rigg (1958) mapped and described the peat bogs of Washington, 46 of which are in King County. Crandell and Gard (1959) mapped the Buckley $7\frac{1}{2}$-minute quadrangle.

Foster (1960) mapped the area around Snoqualmie Pass. Beikman and others (1961) prepared a report on the coal reserves of Washington that includes detailed information on King County coal. Waldron (1961) mapped the Poverty Bay $7\frac{1}{2}$-minute quadrangle. Vine (1962a) mapped the Maple Valley and the Hobart $7\frac{1}{2}$-minute quadrangles,

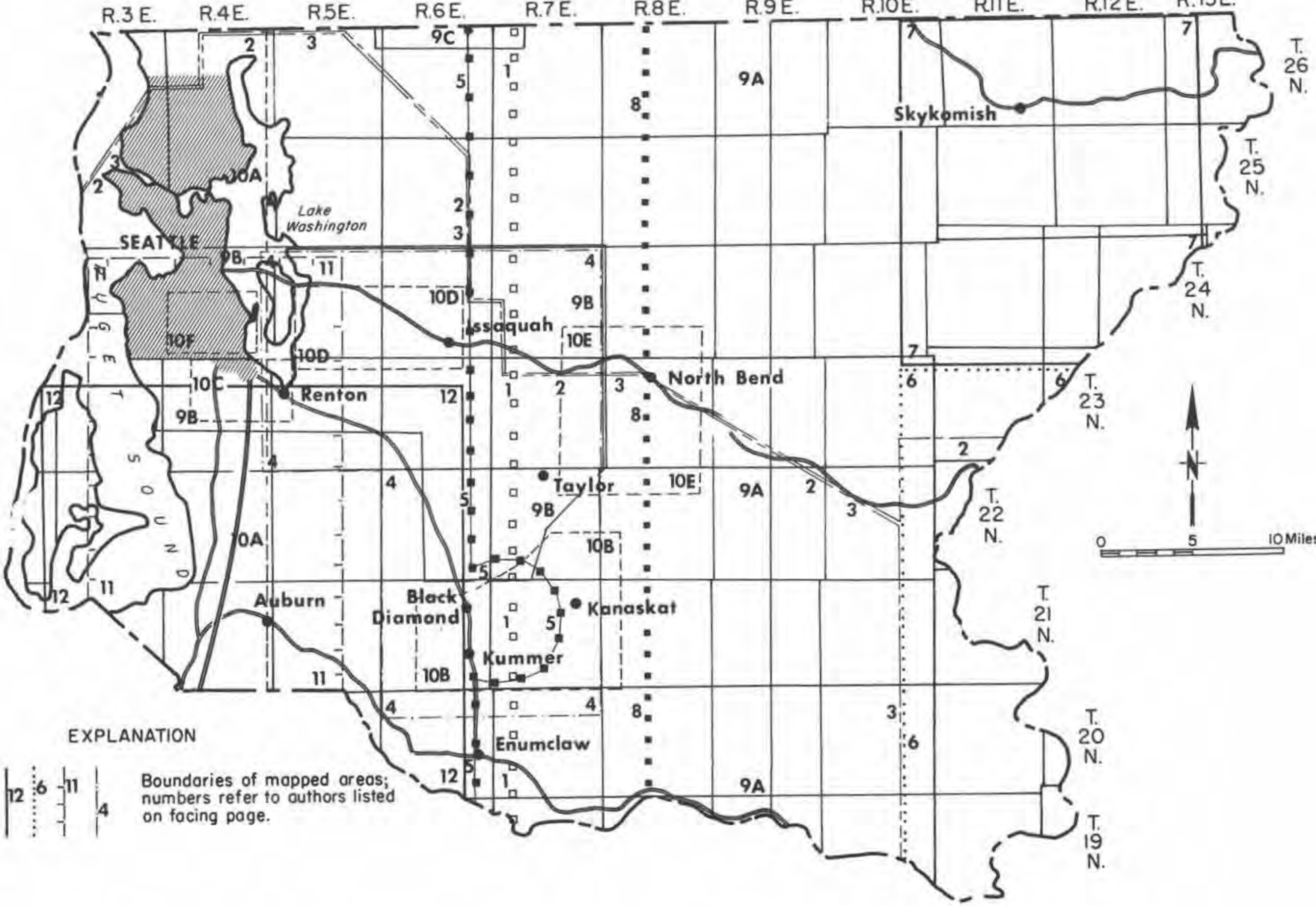


FIGURE 6.— Index to geologic mapping in King County, Washington, published before 1940.

AUTHORS OF GEOLOGIC MAPPING SHOWN ON FIGURE 6

1. Bretz, J H., 1913, Glaciation of the Puget Sound region: Washington Geol. Survey Bull. 8, 244 p. [Pls. XXII, XXIV.]

2. Campbell, M. R.; and others, 1915, Guidebook of the western United States, Part A— The Northern Pacific route with a side trip to Yellowstone Park: U.S. Geol. Survey Bull. 611, p. 184-196. [Sheet 27.]

3. Diller, J. S.; and others, 1915, Guidebook of the western United States, Part D— The Shasta Route and Coast Line: U.S. Geol. Survey Bull. 614, p. 9-15. [Sheet 1.]

4. Evans, G. W., 1912, The coal fields of King County: Washington Geol. Survey Bull. 3, 247 p. [Pl. I.]

5. Smith, G. O., 1902, Coal Fields of the Pacific Coast: U.S. Geol. Survey 22d Ann. Rept., pt. 3, p. 473-513. [Pl. XXXI.]

6. Smith, G. O.; Calkins, F. C., 1906, Description of the Snoqualmie quadrangle [Washington]: U.S. Geol. Survey Geol. Atlas, Folio 139, 14 p.

7. Smith, W. S., 1915, Petrology and economic geology of the Skykomish Basin: School of Mines Quarterly [Columbia Univ., N. Y.], v. 36, p. 154-185. [Fig. 1.]

8. Weaver, C. E., 1912b, A preliminary report on the Tertiary paleontology of western Washington: Washington Geol. Survey Bull. 15, 80 p. [Pl. A].

9. Weaver, C. E., 1916b, The Tertiary formations of western Washington: Washington Geol. Survey Bull. 13, 327 p. [9A— Pl. 2; 9B— Pl. 4B; 9C—Pl. 4D.]

10. Weaver, C. E., 1937, Tertiary stratigraphy of western Washington and northwestern Oregon: Univ. of Washington Pubs. in Geology, v. 4, 266 p. [10A— Pl. 3; 10B— Pl. 9B; 10C— Pl. 10A; 10D— Pl. 10B; 10E— Pl. 10C; 10F— Pl. 12A.]

11. Willis, Bailey, 1898b, Drift phenomena of Puget Sound: Geol. Soc. America Bull., v. 9, p. 111-162.

12. Willis, Bailey; Smith, G. O., 1899, Description of the Tacoma quadrangle [Washington]: U.S. Geol. Survey Geol. Atlas, Folio 54, 10 p. [Pl. 7.]

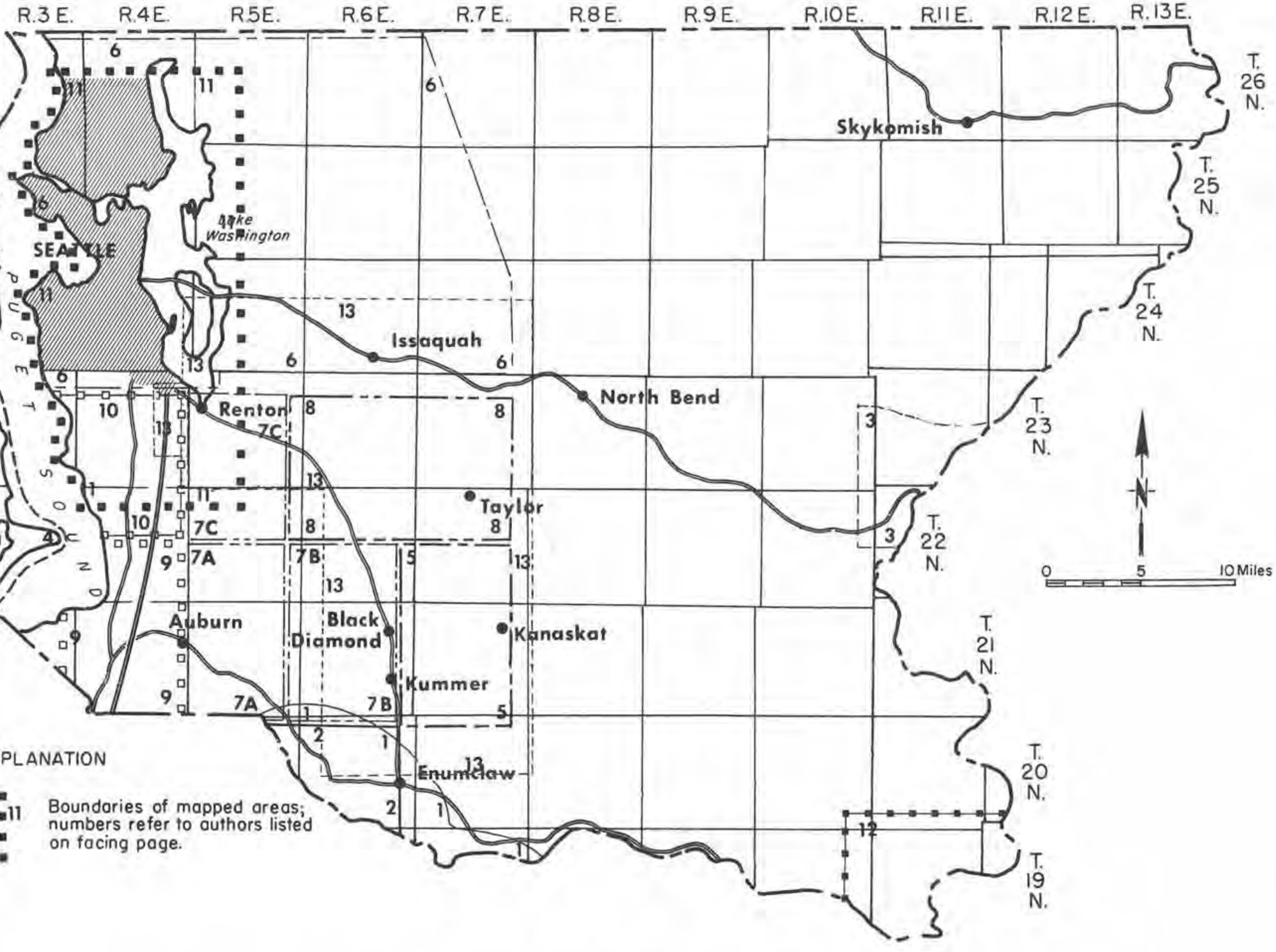


FIGURE 7.— Index to geologic mapping in King County, Washington, published after 1940.

AUTHORS OF GEOLOGIC MAPPING SHOWN ON FIGURE 7

1. Crandell, D. R.; Waldron, H. H., 1956, A Recent volcanic mudflow of exceptional dimensions from Mt. Rainier, Washington: Am. Jour. Sci., v. 254, p. 349-362. [Fig. 1.]

2. Crandell, D. R.; Gard, L. M., Jr., 1959, Geology of the Buckley quadrangle: U.S. Geol. Survey Geol. Quad. Map GQ-125.

Crandell, D. R., 1963, Surficial geology and geomorphology of the Lake Tapps quadrangle, Washington: U.S. Geol. Survey Prof. Paper 388-A, 84 p. [Pl. 1.]

3. Foster, R. J., 1960, Tertiary geology of a portion of the central Cascade Mountains, Washington: Geol. Soc. America Bull., v. 71, no. 2, p. 99-125. [Pl. 1.]

4. Garling, M. E.; Molenaar, Dee; and others, 1965, Water resources and geology of the Kitsap Peninsula and certain adjacent islands [including Vashon and Maury Islands in King County]: Washington Div. Water Resources Water Supply Bull. 18, 309 p. [Pl. 1.]

5. Gower, H. D.; Wanek, A. A., 1963, Preliminary geologic map of the Cumberland quadrangle, King County, Washington: Washington Div. Mines and Geology Geol. Map GM-2.

6. Liesch, B. A.; Price, C.E.;Walters, K. L., 1963, Geology and ground-water resources of northwestern King County, Washington: Washington Div. Water Resources Water Supply Bull. 20, 241 p. [Pl. 1.]

7A. Mullineaux, D. R., 1965a, Geologic map of the Auburn quadrangle, King and Pierce Counties, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-406.

7B. Mullineaux, D. R., 1965b, Geologic map of the Black Diamond quadrangle, King County, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-407.

7C. Mullineaux, D. R., 1965c, Geologic map of the Renton quadrangle, King County, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-405.

8. Vine, J. D., 1962a, Preliminary geologic map of the Hobart and Maple Valley quadrangles, King County, Washington: Washington Div. Mines and Geology Geol. Map GM-1.

9. Waldron, H. H., 1961b, Geology of the Poverty Bay quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-158.

10. Waldron, H. H., 1962, Geology of the Des Moines quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-159.

11. Waldron, H. H.; Liesch, B. A.; Mullineaux, D. R.; Crandell, D. R., 1962, Preliminary geologic map of Seattle and vicinity, Washington: U.S. Geol. Survey Misc. Geol. Inv. Map I-354.

12. Warren, W. C., 1941, Relation of the Yakima Basalt to the Keechelus andesitic series: Jour. Geology, v. 49, p. 795-814. [Fig. 2.]

13. Warren, W. C.; Norbisrath, Hans; Grivetti, R. M.; Brown, S. P., 1945, Preliminary geologic map and brief description of the coal fields of King County, Washington: U.S. Geol. Survey Prelim. Map.

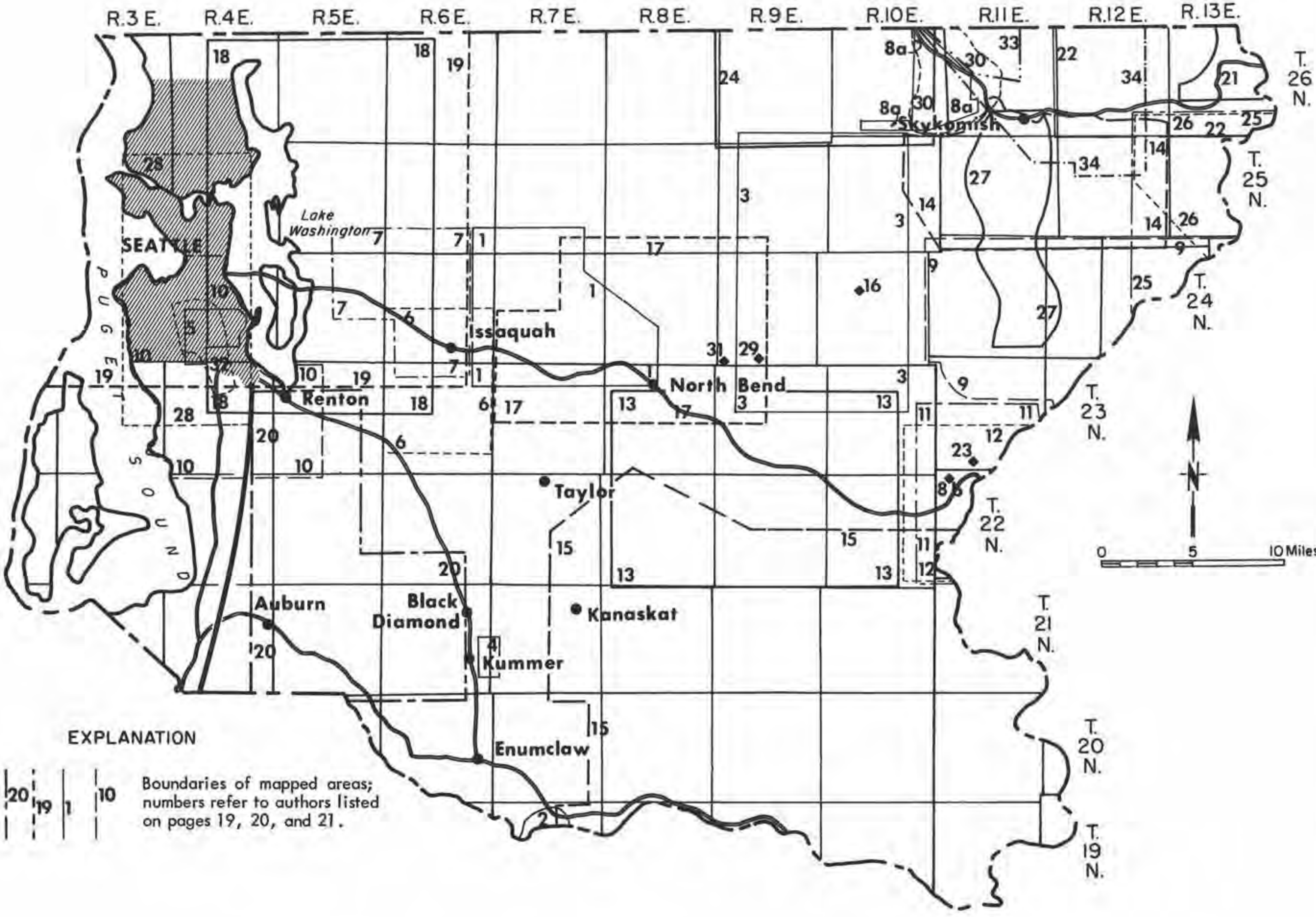


FIGURE 8.— Index to unpublished geologic mapping in King County, Washington.

AUTHORS OF GEOLOGIC MAPPING SHOWN ON FIGURE 8

1. Anderson, C. A., 1965, Surficial geology of the Fall City area, Washington: Univ. of Washington M.S. thesis, 70 p.

2. Anderson, N. R., 1954, Glacial geology of the Mud Mountain district, King County, Washington: Univ. of Washington M.S. thesis, 48 p.

3. Bethel, H. L., 1951, Geology of the southeastern part of the Sultan quadrangle, King County, Washington: Univ. of Washington Ph.D. thesis, 244 p.

4. Bond, J. G., 1959, Sedimentary analysis of the Kummer Formation within the Green River Canyon, King County, Washington: Univ. of Washington M.S. thesis, 113 p.

5. Bravinder, K. M., 1932, Stratigraphy and paleontology of the Oligocene in the eastern portion of the Puget Sound Basin: Univ. of Washington M.S. thesis, 38 p.

6. Carr, F. E.; Bagshaw, E. W., 1908, Geology of Squak Mountain: Univ. of Washington M.A. thesis, 34 p.

7. Curran, T. A., 1965, Surficial geology of the Issaquah area, Washington: Univ. of Washington M.S. thesis, 57 p.

8. Danner, W. R., 1957, A stratigraphic reconnaissance in the northwestern Cascade Mountains and San Juan Islands of Washington State: Univ. of Washington Ph.D. thesis, 562 p. [8A—Pl. 7; 8B—Pl. 8.]

9. Ellis, R. C., 1959, The geology of the Dutch Miller Gap area, Washington: Univ. of Washington Ph.D. thesis, 113 p.

10. Fettke, C. R., 1910, A study of the bedrock in the vicinity of Seattle, Port Orchard, and Renton, Washington: Univ. of Washington B.S. thesis, 21 p.

11. Foster, R. J., 1955, A study of the Guye Formation, Snoqualmie Pass, King and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 57 p.

12. Foster, R. J., 1957, The Tertiary geology of a portion of the central Cascade Mountains, Washington: Univ. of Washington Ph.D. thesis, 186 p.

13. Fuller, R. E., 1925, The geology of the northeastern part of the Cedar Lake quadrangle, with special reference to the deroofed Snoqualmie batholith: Univ. of Washington M.S. thesis, 96 p.

AUTHORS OF GEOLOGIC MAPPING SHOWN ON FIGURE 8—Continued

14. Galster, R. W., 1956, Geology of the Miller-Foss River area, King County, Washington: Univ. of Washington M.S. thesis, 96 p.

15. Hammond, P. E., 1963, Structure and stratigraphy of the Keechelus Volcanic Group and associated Tertiary rocks in the west-central Cascade Range, Washington: Univ. of Washington Ph.D. thesis, 264 p.

16. Kimball, A. L., 1961, A study of hydrothermal alteration at the Rainy mine, King County, Washington: Univ. of Washington B.S. thesis, 34 p.

17. Kremer, D. E., 1959, The geology of the Preston-Mount Si area: Univ. of Washington M.S. thesis, 103 p.

18. McKnight, E. F. T., 1923, The origin and history of Lake Washington: Univ. of Washington B.S. thesis, 61 p.

19. McKnight, E. T.; Ward, A. H., 1925, Geology of the Snohomish quadrangle: Univ. of Washington M.S. thesis, 92 p.

20. Mullineaux, D. R., 1961b, Geology of the Renton, Auburn, and Black Diamond quadrangles, Washington: U.S. Geol. Survey open-file rept., 202 p.

21. Oles, K. F., 1951, The petrology of the Stevens Pass-Nason Ridge area, Washington: Univ. of Washington M.S. thesis, 92 p.

22. Oles, K. F., 1956, The geology and petrology of the crystalline rocks of the Beckler River-Nason Ridge area, Washington: Univ. of Washington Ph.D. thesis, 192 p.

23. Pariseau, W. G.; Gooch, A. E., 1960, Geology of the Guye iron deposit, Mammoth group claims, King County, Washington: Univ. of Washington B.S. thesis, 32 p.

24. Plummer, C. C., 1964, The geology of the Mount Index area of Washington State: Univ. of Washington M.S. thesis, 62 p.

25. Pratt, R. M., 1954, Geology of the Deception Pass area, Chelan, King, and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 58 p.

AUTHORS OF GEOLOGIC MAPPING SHOWN ON FIGURE 8— Continued

26. Pratt, R. M., 1958, The geology of the Mount Stuart area, Washington: Univ. of Washington Ph.D. thesis, 228 p.

27. Smith, W. S.; Carr, D. E., 1912, Geology and economic resources of the Lake Dorothy region, Washington: Univ. of Washington B.S. thesis, 62 p.

28. Stark, W. J.; Mullineaux, D. R., 1950, The glacial geology of the City of Seattle: Univ. of Washington M.S. thesis, 89 p.

29. Stevens, D. L., 1961, A geological investigation of the iron-bearing deposits on Green Mountain, King County, Washington: Univ. of Washington B.S. thesis, 33 p.

30. Stockwell, C. E., 1961, A geological reconnaissance of the Baring magnetite deposit, King County, Washington: Univ. of Washington B.S. thesis, 32 p.

31. Todd, W. A., 1961, Geology of the Bald Hornet claims: Univ. of Washington B.S. thesis, 29 p.

32. Wimmler, Norman, 1908, Geology of the east side of the Duwamish Valley, King County, Washington: Univ. of Washington B.S. thesis, 14 p.

33. Yeats, R. S., Jr., 1956, Petrology and structure of the Mount Baring area, Northern Cascades, Washington: Univ. of Washington M.S. thesis, 78 p.

34. Yeats, R. S., 1958, Geology of the Skykomish area in the Cascade Mountains of Washington: Univ. of Washington Ph.D. thesis, 243 p.

and (1962b) worked out part of the Eocene stratigraphy of western King County. Waldron and others (1962) mapped the geology in and around Seattle and included a brief engineering geology and ground-water summary for each lithologic unit. Waldron (1962) mapped the Des Moines $7\frac{1}{2}$-minute quadrangle, which is a northward continuation of the Poverty Bay map he finished in 1961. Liesch and others (1963) mapped the surficial geology and made a ground-water study of northwest King County. Crandell (1963) mapped the surficial geology of the Lake Tapps 15-minute quadrangle, which includes the area of the Buckley $7\frac{1}{2}$-minute quadrangle. The Cumberland $7\frac{1}{2}$-minute quadrangle, which is just south of the Hobart and east of the Black Diamond, was mapped by Gower and Wanek (1963). Garling and others (1965) mapped the geology and made a ground-water report on Vashon and Maury Islands as part of a larger report that covered all of Kitsap County and a small part of King County. Mullineaux mapped the Auburn (1965a), Black Diamond (1965b), and Renton (1965c) $7\frac{1}{2}$-minute quadrangles. Hidaka and Garrett (1967) studied seepage problems of Chester Morse Lake and Masonry Pool on the Cedar River. Richardson and others (1968) summarized the county's water resources and discussed future problems.

Student theses projects have made a significant contribution to the geologic knowledge of King County, especially in the remote and rugged eastern part. Figure 8 is an index to student mapping in the county. Carr and Bagshaw (1908), Wimmler (1908), and Hance (1908) were apparently the first to do thesis work in the county. Carr and Bagshaw mapped the geology of Squak Mountain, and Wimmler worked along the Duwamish River's east valley wall, in what is now the south Seattle area. Hance did his work on the Newcastle coal area. In 1910 Fettke studied the bedrock in the vicinity of Seattle, Renton, and Port Orchard. Crary (1912) examined the Seattle Cascade mine and worked on methods of treating ore from the mine. Smith and Carr (1912) studied the geology and economic resources of the Lake Dorothy region, near Skykomish. Later, W. S. Smith extended this work for his master's degree (1913) and doctorate (1916a). Davis (1923) worked on the ore deposits and geology of the Mount Si area. McKnight (1923) studied the origin and history of Lake Washington. Young (1924) made a study of the workable clay deposits in Seattle. Aguinaldo (1924) did work on the concentration of arsenic ore from the Skykomish area.

McNaughton and Middleton (1925) made a petrographic study of some of the glacial sediments in the Puget Sound area. Also in 1925, McKnight and Ward mapped the geology of the Snohomish 30-minute quadrangle. Fuller (1925) mapped the geology of the northeastern part of the Cedar Lake quadrangle and made a special study of the Snoqualmie batholith in that area. Herdlick (1931) studied the mineralogy of the National Gold mine, on Miller River, and did experimental work on ore milling problems. In 1932 Coats made a study of the Apex gold mine, on Money Creek near Skykomish. Bravinder (1932) worked on the Oligocene stratigraphy and paleontology in the western part of the county. Gence (1934) studied the White River valley. Van Ornum (1937) mapped the geology of the Coney Basin mine, on the West Fork of the Miller River near Skykomish. In 1938 Knowles studied the contact relations between the Grotto area limestone beds and igneous dikes that cut them. V. B. Pratt (1939) mapped the geology and studied methods for concentrating ore from the Great Republic antimony mine, in the Miller River district. Biderbost (1939) studied the mineralogy of the Coney Basin mine and worked on methods of ore treatment. Luther (1941) worked on the beneficiation of glass sand from the Hammer Bluff Formation. Also in 1941, S. K. Smyth studied the mineralogy and method of treatment of gold ore from Lennox Creek, in the Buena Vista district. Mills (1949) mapped the Coney Basin mine.

In 1950 Stark and Mullineaux mapped the glacial geology of the Seattle area. Bethel (1951) reported on the geology of the southeastern part of the Sultan quadrangle. In 1951 Oles worked on the petrology of an area that covered part of Chelan County and the Stevens Pass area of King County. In 1956 he extended his King County work westward to the Beckler River. N. R. Anderson (1954) examined the glacial geology of the Mud Mountain area in King County. R. M. Pratt (1954) worked on the geology of the Deception Pass area, and expanded his work in 1958 for his doctorate. Foster (1955) made a study of the Guye Formation in the Snoqualmie Pass area, and in 1957 continued his work for a doctorate. Galster (1956) mapped the geology in the Miller River-Foss River area near Skykomish. In 1956 Yeats studied the petrology and structure of the rocks in the Mount Baring area, and in 1958 he expanded his work eastward for his doctor's degree. Danner (1957) added to the paleontological knowledge of the metamorphic belt near Grotto and did reconnaissance mapping near Snoqualmie Pass. Bond (1959) made a sedimentation study on the sedimentary rocks in the Green River Canyon. Ellis (1959) mapped the structure and lithology of the Dutch Miller Gap area. Kremer (1959) mapped the geology of the Preston-Mount Si area, covering both Tertiary and pre-Tertiary rocks.

Pariseau and Gooch (1960) worked on the Guye iron deposit, in the Snoqualmie Pass area. Todd (1961) reported on the geology of the Bald Hornet claims, in the Mount Teneriffe area near North Bend. Also in 1961, Stockwell made a geologic reconnaissance of the iron deposits near Baring. Stevens (1961) studied the geology of the iron deposits at the Bessemer mine, on Green Mountain near North Bend. Kimball (1961) made a study of hydrothermal alteration in the Rainy mine (also known as the Quartz Creek property). Mullineaux (1961a and 1961b) mapped the geology of the Renton, Auburn, and Black Diamond quadrangles. Hammond (1963) mapped the structure and worked out the stratigraphy of the Keechelus Volcanics and associated rocks in the southeastern part of the county. Plummer (1964) mapped the geology of the Mount Index area and proposed the origin of the sedimentary rocks that compose Red Mountain. In 1965 C. A. Anderson mapped the Pleistocene geology of the Fall City area. Curran (1965) mapped the surficial geology of the Issaquah area. A thesis that does not deal with geology but adds to the understanding of the economic conditions and history of the Green River coal area was done by Thorndale (1965). Knoll (1967) mapped the surficial geology of the Tolt River area.

GEOLOGY

PHYSIOGRAPHIC PROVINCES

King County lies within two physiographic provinces– the Puget Lowlands and the Cascade Mountains. The two provinces are separated along a fairly well defined line (Fig. 9).

Puget Lowlands

An east-west-trending mountain outlier, composed of Cougar, Squak, and Tiger Mountains, divides the lowlands province into two almost equal parts (Fig. 9). These parts have very similar physiography, each being made up of a gently rolling or hilly drift plain that is cut by wide, flat-bottomed, steep-sided valleys. The drift plain surfaces are covered with small ridges, rounded hills, and depressions, almost all of which were formed by the continental ice sheet that covered the area during the Pleistocene Epoch. The ridges and hills rise less than 200 feet above the drift plain and represent glacial features such as drumlins, kames, kame terraces, eskers, and rocdrumlins. Depressions or kettles are abundant and usually contain either lakes or peat bogs. The drift plain surface, though very irregular, has a westward regional slope away from the Cascade front.

The main river valleys are steep-walled, flat-bottomed, and mostly 200 to 500 feet deep. During the last ice retreat some of them, such as the Duwamish, Snoqualmie, and Sammamish Valleys, served as lake impoundments and outwash channels. The valley walls are serrated by numerous short V-shaped gullies that have steep gradients. Along the walls of the Duwamish Valley the gullies are very prominent. Streams that cross the lowlands usually do a considerable amount of meandering and are subject to periodic flooding. In only a very few places do they cut bedrock. One of the most conspicuous and interesting exposures of bedrock is in the gorge of the Green River, south and east of Black Diamond. Here the river established itself on the drift plain after the last glacial retreat, developing a meander pattern as it crossed the almost flat, ground-moraine-covered, glacially developed initial surface. As erosion continued, the meanders became entrenched, cutting first through the drift and then into bedrock.

The Duwamish Valley is reported (Mullineaux, 1961a, p. 185) to have been part of Puget Sound as recently as 4,800 years ago. Until the twentieth century, three main

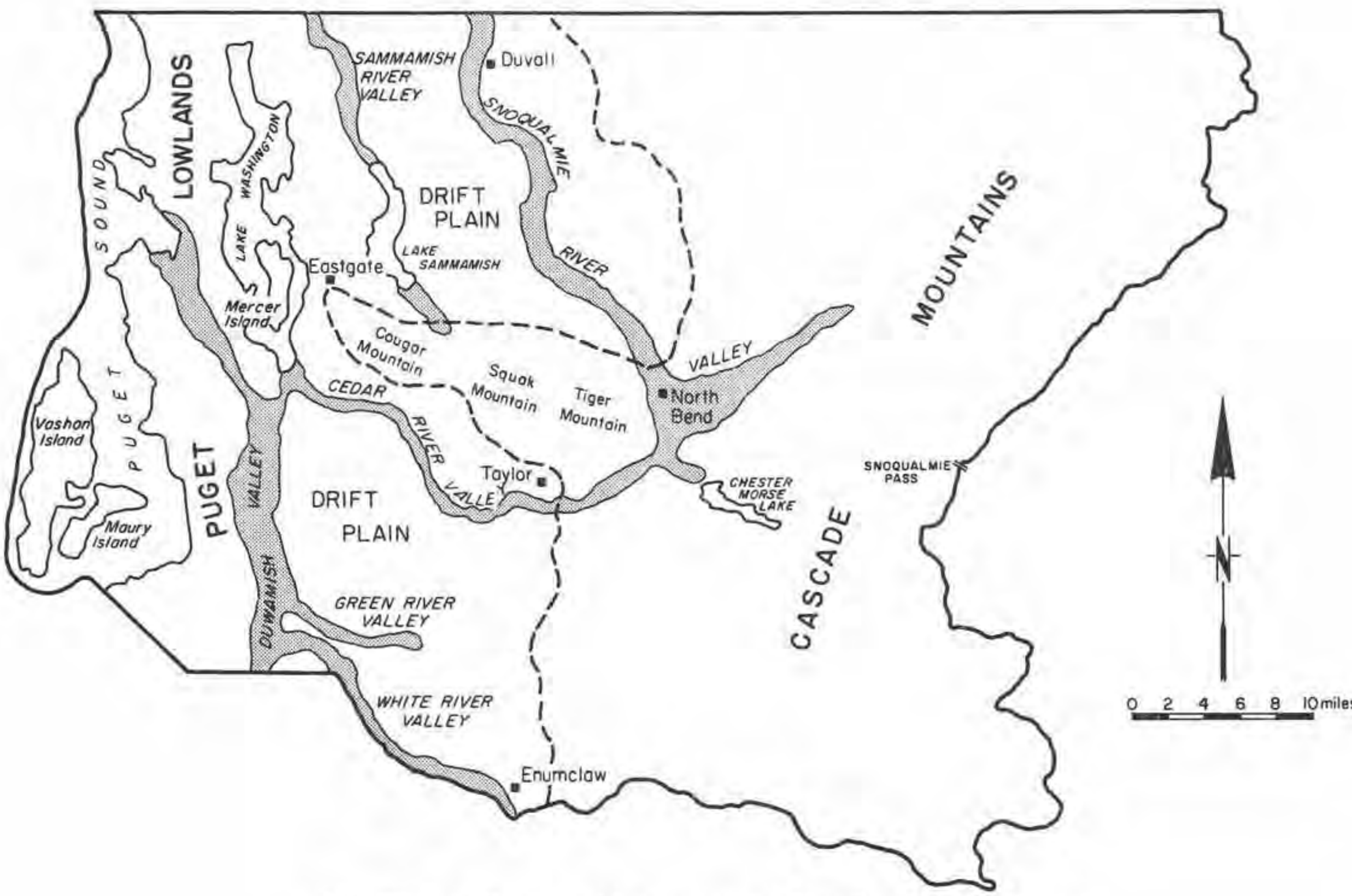


FIGURE 9.— Physiographic provinces of King County, Washington.

rivers flowed through the valley. The White River at one time bifurcated as it entered the Duwamish Valley southeast of Auburn— one channel joined the Green River and flowed northward, and the other channel turned southward to join the Puyallup River at Sumner. A flood in 1906 plugged the north channel with debris, causing the total discharge to flow southward; manmade modifications have since insured that the river will continue to flow southward. This short channel between Auburn and Sumner is called the Stuck River. The Green River enters the Duwamish Valley about 2 miles north of the White River, turns north, and flows into Elliot Bay at Seattle. At one time it combined with the Black River near Renton to form the Duwamish River. The Black River was a very short river, only about 2 to 3 miles long, that drained Lake Washington. In 1917 the surface level of Lake Washington was lowered; the Cedar River, which formerly emptied into the Black River, was diverted into the lake; and the Black River became a small swampy creek.

Glacial lineation in the Puget Lowlands is quite pronounced. Many outcrops of bedrock are grooved and striated, and drumlins are oriented parallel to the direction of ice movement. In the northern and southwestern parts of the lowlands the glacial lineation is in a general north-south direction; in the southeastern part of the lowlands, however, the lineation is strikingly southeast.

In the southeast part of the lowlands, around Enumclaw, many of the glacial features have been hidden by a very big mudflow that came down the White River valley (Crandell and Waldron, 1956) and spread out over the drift plain. Only the higher drumlins in the vicinity of Enumclaw were not covered by this large mudflow. Farther out from the mountain front on the drift plain, drumlins were veneered with debris, but their topographic expression is still obvious.

Cascade Mountains

In King County the Cascade Mountains can be considered in two parts. From Snoqualmie Pass southward they are composed predominantly of folded Tertiary volcanic rocks and lesser amounts of sedimentary and intrusive rocks. North of the pass the mountains consist primarily of granitic and metamorphic rocks.

Alpine glaciation has been an important agent in sculpturing the mountains. All major river valleys have been shaped or modified to some extent by glaciation, especially in their upper reaches. The valleys lose elevation rapidly; the rivers are almost a continuous series of cascades in their headwaters. Small tributary valleys are very steep, and many of them open into a main valley well above its floor. In the heart of the Cascade Range, cirques are common and many of them contain lakes. The ridges are sharp and serrated, and the peaks are steep rocky Matterhorn-like crags. The highest peak in the county is Mount Daniels, which rises to an elevation of 7,986 feet; it is 10 miles south and slightly west of Scenic.

The mountains north of Snoqualmie Pass are much more rugged than those south of the pass. This difference is due to the higher elevations and more intense glaciation in the northern part.

Most of the major rivers that flow out of the Cascades have a northwesterly trend. This, according to Mackin and Cary (1965, p. 13-14), is because the rivers originally established their courses during Oligocene time and were controlled by a series of northwest-trending ridges. As the Cascade Range was uplifted, the rivers were able to maintain their pre-established drainage courses, and only the pattern of the smaller tributaries is the result of the most recent mountain-building movements.

DESCRIPTION OF ROCKS

Rocks ranging in age from Paleozoic to Recent have been mapped in King County; however, Tertiary and Pleistocene rocks are by far the most abundant. The older rocks occur in the Cascade Mountains of the eastern part of the county, and the younger rocks are most abundant in the Puget Lowlands.

Pre-Tertiary Rocks

The migmatite that occurs as a klippen on Mount Baring is probably the oldest rock in King County. Yeats (1958, p. 83-99, 123-126) described the unit in detail and discovered that it is composed of amphibolite or amphibolite-derived rocks such as hornblende migmatite, hornblende gneiss, or gneissose hornblende quartz diorite. He described the petrography of the different rocks in detail and pointed out that the unit is poor in potash. This distinctive lack of potash minerals was used by Yeats (p. 123-126) to theorize an origin from basic volcanic rocks, and to correlate the formation with similar units discovered by other geologists who have worked in the Cascade Mountains north of King County. Yeats made no attempt to date the unit.

Pre-Tertiary phyllites, schists, gneisses, and migmatites crop out in the northeast part of the county. A band of metamorphic rocks consisting of gneisses and schists was mapped by Oles (1956) between Barrier Peak and Captain Point. Gneisses in this metamorphic zone are mostly migmatitic; coarser-grained varieties are present in subordinate amounts. The schist is predominantly a biotite quartz variety, and its chemical composition is thought to be essentially the same as that of the parent sediments. The schist grades continuously into the adjacent gneisses, and the gneisses grade continuously into directionless granitic rocks of the Mount Stuart Granodiorite. Schists and phyllites underlie most of the area from Beckler River eastward for about 4 miles, and also the area between Foss River and Sawyer Creek. Schists also crop out near Deception Pass (Pratt, R. M., 1954, 1958) and Dutch Miller Gap (Ellis, 1959). The metamorphic rocks of the eastern part of the county have not been dated, except that they are known to be older than the Swauk Formation. In some areas they have undergone such a complete change that they have been converted to directionless granitic rocks of the Mount Stuart batholith, which is considered to be Mesozoic in age. This would date the metamorphics as being pre-Mesozoic in age.

Paleozoic Rocks

A rock unit composed of ribbon chert, quartzite, greenstone, argillite, chert breccia, tuff, hornfels, phyllite, and marble crops out near Baring and Grotto and has been traced as far south as Snoqualmie Pass by Danner (1957, p. 249-255). In the Grotto area the rocks are reported by Danner (p. 233) to be mostly greenstone, ribbon chert, argillite, and quartzite; minor amounts of marble are also present. The marble is mostly along the east side of the belt and in most places is associated with the greenstone. In the Snoqualmie Pass area Danner (1957, p. 249-250) and Foster (1960, p. 111) found ribbon chert, chert breccia, fine-grained hornfels, and marble. The rocks in both areas have undergone mild static metamorphism. Where they are adjacent to intrusive rocks, they have undergone contact metamorphism.

The unit as a whole crops out on the northeast side of the Skykomish River between Grotto and Baring, extends along the east side of Palmer Mountain, crosses Lowe Creek, makes up the west part of Maloney Peak, and crops out along Kimball Creek. Farther south, near Snoqualmie Pass, rocks of similar lithology crop out on Denny Mountain, Chair Peak, and Guye Peak.

In the Snoqualmie Pass area Foster (1960, p. 111) proposed the name Denny Formation for the unit and designated Denny Mountain as the type locality.

W. S. Smith (1916a and 1916b) made the first attempt to date the marble-bearing formation of the Baring-Grotto area. He assigned an Ordovician age to the rocks on the basis of fossils. Later, Thompson and others (1950, p. 49) identified Permian fusulinids from the marble. After a thorough search of the area, Danner (1957, p. 50-51) reported that he was able to find only fusulinids and crinoid columnals. In light of the facts that Smith's fossils are not available for examination (Danner, 1957, p. 51) and that only Permian fossils have been found in the Grotto area marbles since Smith did his work, it seems reasonable to assume that most, if not all, of the unit is Permian in age.

Mesozoic Rocks

Mount Stuart Granodiorite.—About 40 to 50 square miles of the northeast corner of the county is underlain by rocks of the Mount Stuart Granodiorite. Several large (a few miles long) patches or bands of high-grade metamorphic rocks occur in the granodiorite and appear to have been part of the parent material from which the batholithic mass was formed. Where the contacts between the metamorphics and granitics are not faults, they are gradational from one lithology to another. Oles (1956, p. 150) reported that most of the rock of the Mount Stuart Granodiorite in the Beckler River-Nason Ridge area is quartz diorite; however, trondhjemite, granodiorite, and alaskite are also present. The Mount Stuart Granodiorite is considered to be of Mesozoic age.

Mesozoic-Early Cenozoic Sedimentary Rocks

A band of slightly metamorphosed sedimentary rocks extends from the North Bend area northward beyond the North Fork of the Snoqualmie River. The formation consists mainly of graywacke, breccia, shale, and argillite. The rocks strike in a general northerly direction, and steep dips are common. Graywacke is the most common rock type; its occurrence varies from thick massive beds to thin beds with intercalated argillite. Where they have been intruded by granodiorite the sedimentary rocks have been hornfelsed along the contact. Both Bethel (1951, p. 23-56) and Kremer (1959, p. 40-56) have studied this formation, and each assigned a different age to it. Bethel (p. 55), on the basis of lithologic similarities between the unit and the Swauk and on some admittedly weak fossil evidence, considered that the formation is Cretaceous-Paleocene in age. Kremer (p. 54-56) concluded that the unit correlates with similar-appearing rocks in Whatcom County that are known Late Jurassic to Late Cretaceous in age. Both workers indicated that the formation's age is open to question until more conclusive evidence is presented.

Plummer (1964) described a sedimentary unit that crops out in the vicinity of Red Mountain near the headwaters of Money Creek for which no lithologic equivalent has been found in the Cascade Mountains to date (1969). It is composed of statically metamorphosed conglomerate, argillaceous sandstone, and hornfelsed argillite. Conglomerate is the predominant lithology, and the hornfelsed argillite is minor. The clastic material that makes up the unit was apparently derived partly from Paleozoic rocks similar to those that crop out near Grotto and Baring (Plummer, p. 26, 60). No attempt to date the formation was made by Plummer (p. 60), other than to say it is younger than the Paleozoic rocks from which it is derived.

Mesozoic-Early Cenozoic Volcanic Rocks

As with the sedimentary rocks just described, there is no unanimous agreement as to the age of the volcanic rocks that are associated with them. Kremer (1949, p. 68-69) thought that the metavolcanics that compose Mount Si might be as young as late Eocene. Bethel (1951) considered the volcanics that crop out in the Lennox Creek-North Fork of the Snoqualmie River area to be intercalated with the graywacke-argillite formation, and to be more or less contemporaneous with the Swauk Formation, which he considered to be Late Cretaceous to Paleocene in age. Plummer (1964, p. 8) correlated them with volcanic rocks southeast of Skykomish that were mapped by Galster (1956, p. 66), who assigned a Paleocene-early Eocene age to them. At the present time (1969), the position held by the volcanic rocks in the stratigraphic column has not been firmly established. In the Mount Si area the volcanics have been metamorphosed and consist of greenstone and greenschist. To the northeast about 10 miles, in the Lennox Creek-North Fork of the Snoqualmie River area, the rocks are massive andesitic flows, coarse andesitic tuffs or breccias, fine tuffs, and tuffaceous sediments. The tuffs are intercalated with the shale and graywacke beds of the sedimentary formation described by Bethel (1951) and Kremer (1959). Just north of the area Bethel mapped, Plummer (1964) discovered that andesite flows predominate, but that dacite, basalt, and breccias are common in the formation.

Tertiary Rocks

Swauk Formation.— The name Swauk Formation was applied by Russell (1900, p. 118) to sandstone, conglomerate, and shale beds that crop out in the Swauk mining district in Kittitas County. In King County, rocks of the Swauk Formation crop out in a continuous belt from the mouth of the Beckler River southeastward to Deception Pass. In the vicinity of the Foss River and Sawyer Creek the outcrop of the unit is split into two prongs for about 4 miles by a narrow strip of south-trending pre-Tertiary schistose rocks. A small patch of Swauk also crops out near Dutch Miller Gap.

In King County the Swauk is composed of arkosic sandstone, conglomerate, and shale. In a few places near igneous contacts the rocks have been hornfelsed. Galster (1956, p. 36) reported that in some places the arkosic sandstone can easily be mistaken for granodiorite because of its composition, massive nature, and color. Pebbles in the conglomerate are granodiorite, quartzite, schist, and slate. The shale is lenticular in nature, and some beds may be as much as 100 feet thick. Galster (p. 36) estimated the thickness of the formation in the Foss River area to be more than 10,000 feet.

The Swauk Formation unconformably overlies the pre-Tertiary metamorphics and the Mount Stuart Granodiorite. In the area between the Foss and Miller Rivers the formation grades laterally into volcanic rocks (Galster, 1956, p. 43).

The age of the Swauk has been the subject of a considerable amount of conjecture. Various workers have dated it from Late Cretaceous to Eocene. Most geologists apparently believe that it is predominantly Paleocene in age, the lower part possibly being Cretaceous, and that it is equivalent to the Chuckanut Formation of the Bellingham basin.

Guye Formation.— The name Guye Formation was proposed by Smith and Calkins (1906, p. 7) for a heterogeneous group of sedimentary and volcanic rocks that crop out in the vicinity of Snoqualmie Pass. In 1960 Foster (p. 112) determined that the Guye Formation actually included four formations; he therefore restricted the name to a thick sequence of shale, sandstone, and conglomerate.

Foster (p. 113) estimated that the formation is at least 5,000 feet thick. The rock types are mixed in various proportions, and the beds range in thickness from thin to massive and are lenticular in nature.

Originally, Smith and Calkins assigned a Miocene age to the Guye. The later work by Foster (1960, p. 112-113) showed evidence for an older age. Basing his theory on leaf fossils identified by R. W. Brown (In Foster, 1960, p. 113), of the U.S. Geological Survey, Foster dated the unit as Paleocene to Eocene. The lower contact has not been observed, and the upper contact is unconformable with the Mt. Catherine Rhyolite.

Mt. Catherine Rhyolite.— Foster (1960, p. 114) named a group of rhyolite flows, tuffs, and breccias that crop out in the vicinity of Snoqualmie Pass the Mt. Catherine Rhyolite.

Most rocks from the formation are some tone of purple, but light-orange and light-blue rocks are common. Weathered rocks are usually light brown and are commonly stained by limonite. Clastic rocks appear to be the most abundant. They are composed of angular fragments of devitrified glass embedded in a matrix of similar composition.

No fossils have been found in the Mt. Catherine Rhyolite. However, it overlies the Guye Formation of Paleocene to Eocene age and in turn is concordantly overlain by the Naches Formation of probable Eocene age; thus it is probably Eocene in age.

Naches Formation.— The Naches Formation was named by Smith and Calkins (1906, p. 4-5); it comprises intercalated sandstones and basalts that occur extensively in the drainage basin of the Naches River. The formation is composed of about 5,000 feet of interbedded basalt, sedimentary rock, and rhyolite. Because the lithology varies from place to place, no general section has been described. Foster (1960, p. 116) noted that basalt is usually more prevalent in the lower part of the unit. The basalts of the formation that are exposed in roadcuts of the Snoqualmie Pass highway on the west side of the pass have been thermally metamorphosed by the Snoqualmie Granodiorite.

The only information available on fossils from the Naches Formation was written by F. K. Knowlton (In Smith and Calkins, 1906, p. 6), who stated that he did not recognize any of the leaf species collected; however, he thought their closest affinities were with leaves found in the Puget Group. This, coupled with the formation's stratigraphic position above the Guye Formation and the Mt. Catherine Rhyolite, strongly indicates an Eocene age.

Raging River Formation.— The name Raging River Formation (Fig. 10) was proposed by Vine (1962b, p. 7) for about 3,000 feet of marine rocks that crop out on the east side of Tiger Mountain, along the west valley wall of Raging River. This has been designated by Vine as the type locality for the formation.

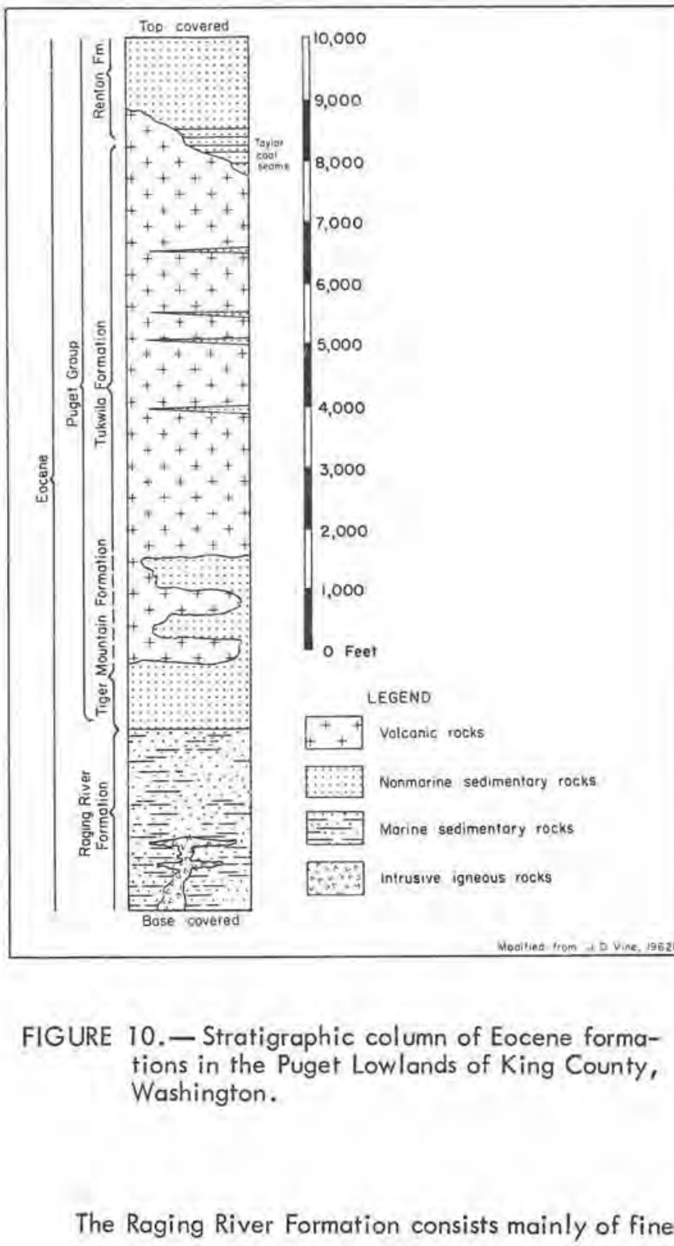


FIGURE 10.— Stratigraphic column of Eocene formations in the Puget Lowlands of King County, Washington.

The Raging River Formation consists mainly of fine-grained sediments— sandstone, siltstone, and claystone— that contain marine invertebrate fossils. These beds are generally dark-gray, thick-bedded, hard, ledge formers. Interbedded with the resistant beds are strata as much as 200 feet thick of softer, more friable rocks consisting of fine- to coarse-grained sandstone, siltstone, and chert pebble conglomerate. The sandstone beds are poorly sorted and consist of volcanic rock fragments.

The lower outcrops of the Raging River Formation show considerable complication by faulting and igneous intrusion. As the base of the unit is covered by glacial drift, the nature of the underlying rocks is unknown. The upper contact was placed by Vine (1962b, p. 8) at the top of a fossil-bearing, dark-gray claystone that is overlain by gray nonfossiliferous micaceous sandstone. Identified fossils from the Raging River Formation place the unit's age at middle to possibly early late Eocene (Vine, 1962b, p. 8).

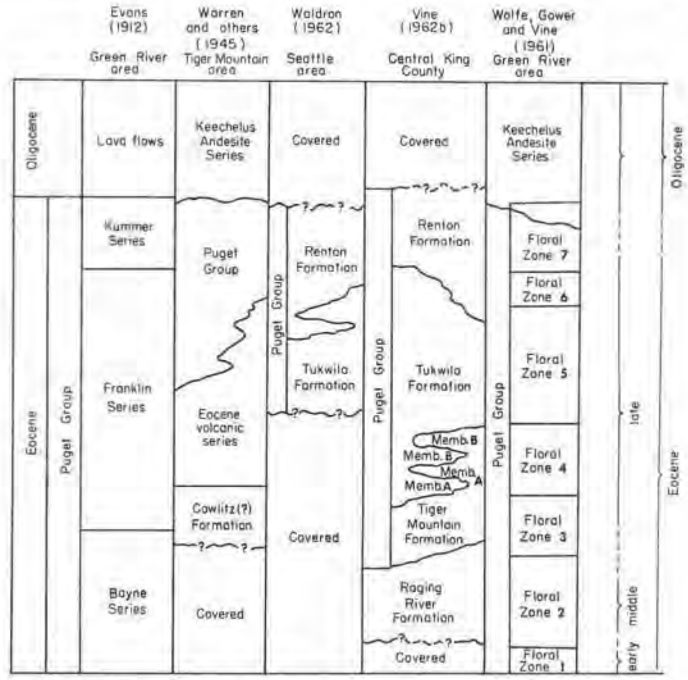


FIGURE 11.— Correlation chart showing the Puget Group and equivalent formations, also floral zones, in western King County, Washington. [Modified from Figure 2 of Vine, 1962b, p. 3.]

Puget Group

The name Puget Group was first used by White (1888, p. 446) for brackish-water sedimentary rocks that occur in the Puget Lowlands. Willis (1898a) divided the group into three formations in the Pierce County coal area— the Pittsburg, Wilkeson, and Carbonado, in descending order. In King County, Evans (1912) considered the Puget to be a formation and made a threefold subdivision of it into what he called series— in descending order— Kummer, Franklin, and Bayne. These three names have not been widely accepted and are rarely used. He measured 8,392 feet of Puget Group sedimentary rocks in the Green River gorge. The Puget Group is composed of arkosic sandstones, quartzose sandstones, shales, bony beds, and coal. The sandstones vary in color from light gray to almost white. Generally, they are softer and coarser grained at the top of the section than at the base. The shales range from sandy to carbonaceous, and the coal grades from bony to good bituminous.

In the west-central part of King County the Puget Group has been divided into three formations. In descending order, they are the Renton, Tukwila, and Tiger Mountain Formations (Figs. 10 and 11).

Tiger Mountain Formation.— Vine (1962b, p. 12) named the nonmarine sedimentary rocks that conformably overlie the Raging River Formation the Tiger Mountain Formation (Figs. 10 and 11). The type locality was designated as the south and east slopes of Tiger Mountain in secs. 9, 16, 17, 20, and 21, T. 23 N., R. 7 E. The formation consists of about 2,000 feet of nonmarine arkosic sandstone, claystone, and impure coal. The sandstone beds are commonly medium grained and crossbedded; they weather gray to brown. Matrix material, which may constitute as much as 10 percent of the rock, is chiefly clay.

Leaf fossils collected from the formation indicate that it is probably middle to late Eocene in age. The formation is conformable with the underlying Raging River Formation and is interfingered with the overlying Tukwila Formation.

Tukwila Formation.— The name Tukwila Formation (Figs. 10 and 11) was proposed by Waldron (1962) for about 2,500 feet of rocks that crop out near the town of Tukwila, in King County. Elsewhere in the county the formation is approximately 7,000 feet thick. At the type locality the formation is composed of a volcanic-derived lower sedimentary unit that constitutes most of the formation, a middle arkosic unit about 250 feet thick, and an upper volcanic sedimentary unit. Farther east, the formation is characterized by tuff breccia and fine- to coarse-grained epiclastic rocks.

The volcanic-derived sedimentary rocks of the formation are mostly volcanic sandstone, siltstone, and shale; however, some conglomerate, tuff, breccia, tuffaceous sandstone, and siltstone, and a few carbonaceous shale beds are also present. The rocks vary in color from dark brown to white, and most of them are poorly sorted and bedded.

The age of the Tukwila Formation has been established as late Eocene (Vine, 1962b, p. 16) from plant fossil remains. A checklist of leaves found in the formation (Vine, 1962b, p. 15) indicates that they belong to floral zones 4 and 5 of Wolfe and others (1961).

The Tukwila Formation interfingers with the underlying Tiger Mountain Formation. The upper contact, with the Renton Formation, is locally sharp; however, on a regional scale it probably transgresses time.

Renton Formation.— The name Renton Formation (Figs. 10 and 11) was proposed by Waldron (1962) for more than 4,000 feet of rocks that crop out in the vicinity of Renton. The formation consists mostly of fine- to medium-grained arkosic sandstone; lesser amounts of siltstone, shale, and coal are also present. Most of the sandstones are weakly cemented by calcite; however, locally clay and silt act as binder materials. The sandstone and siltstone commonly are well sorted and thin bedded. Locally the formation contains massive crossbedded sandstone beds.

The age of the Renton Formation is considered by Vine (1962b, p. 16) to be late Eocene to earliest Oligocene.

The lower contact of the Renton Formation is conformable with the Tukwila. The upper contact has not been studied, but it appears to be conformable with the overlying volcanic rocks.

Oligocene Sedimentary Rocks

A total of 2,140 feet of Oligocene rocks in south Seattle have been described by Weaver (1937, p. 153). The formation consists predominantly of massive sandstone and shale beds and includes lesser amounts of conglomerate. It crops out along the east wall of the Duwamish Valley from Edmonds Street southward to Graham Street. The formation also crops out eastward along several streets to Lake Washington. Other outcrops of Oligocene rocks can be seen at Alki Point at low tide, along U.S. Highway 10 about 8 miles east of Seattle, and along State Highway 203 near the King County-Snohomish County line.

Invertebrate fossils found at Alki Point by Weaver, and Foraminifera collected by the author from a bank along the Seattle Freeway near the north end of Boeing Field and identified by W. W. Rau, indicate an age similar to that of the Blakeley Formation in the Bremerton-Bainbridge Island area.

Hammer Bluff Formation

The Hammer Bluff Formation was named by Glover (1936c, p. 77); it comprises a few outcrops of clayey sandstone along the Green River about 2 miles below Flaming Geyser Park. The formation is fluvial and lacustrine in origin and includes clayey sandstone, gravel, silt, and clay, along with minor ash beds and seams of woody lignite. It also contains a considerable amount of kaolinitic clay and was probably derived by the reworking of Puget Group arkosic sandstone. The total thickness of the formation is probably not much more than 100 feet.

A fossil plant assemblage found in the formation was dated late Miocene by R. W. Brown of the U.S. Geological Survey (In Mullineaux, 1961a, p. 61, 62). The Hammer Bluff Formation unconformably overlies the Puget Group and is overlain by Vashon Drift of Pleistocene age.

Hammer Bluff, in the NE$\frac{1}{4}$ sec. 28, T. 21 N., R. 6 E., was designated the type locality of the formation.

Tertiary Volcanic Rocks Undivided

Almost all of southeastern King County and some areas in the northeastern part of the county are covered by volcanic rocks that at one time or another have been called the Keechelus Andesite Series by various workers, starting with Smith and Calkins (1906) in the Naches Pass area. Much confusion exists as to what the Keechelus is, and, as a result, it has become a catchall name for volcanic rocks that range in age from Eocene to Quaternary. In the area around Mount Rainier in Pierce County the Keechelus has been divided by Waters (1961) into three formations, which range in age from late Eocene to early Miocene. In King County a considerable amount of work has been done on the unit, mostly by students, but no formal subdivisions have been proposed to date (1969).

The gross lithology of the unit consists of andesitic tuffs, tuff breccias, flow breccias, lava flows, and arkosic sandstone beds. Tertiary volcanic rocks of this type have been mapped by W. S. Smith (1915), W. S. Smith (1916a), Fuller (1925), Warren and others (1945), Bethel (1951), Galster (1956), Danner (1957), Ellis (1959), Kremer (1959), Foster (1960), Vine (1962a), Gower and Wanek (1963), Hammond (1963), and Plummer (1964). The most complete study was done by Hammond (1963) as a doctoral thesis, but, as of 1969, none of his work has been published. The possibilities are good that at least two other similar formations described by Warren (1941, p. 800) and Waters (1961, p. 48) occur in King County also. The total thickness of the unit is unknown, but probably exceeds 20,000 feet.

Snoqualmie Granodiorite

The Snoqualmie Granodiorite was described by Smith and Calkins (1906, p. 9) as granodioritic rocks that occur in headwaters of the Snoqualmie River drainage. The term "granodiorite" is somewhat misleading, inasmuch as many other types of granitic rocks occur in the batholithic mass. Bethel (1951) and Plummer (1964), who have probably best described these rocks in King County, have reported granodiorite, quartz diorite, diorite, granite, aplite, intrusive breccia, dacite porphyry, tonalite, and gabbro.

In King County, rocks of the Snoqualmie batholith have an outcrop area of about 250 square miles. Mostly, they occur north of Snoqualmie Pass and east of a line between Chester Morse Lake and the Snohomish County town of Index. A definite relation exists between the metallic ore deposits of the county and the batholithic rocks; this is shown on Figure 12. The mineral deposits are associated with the Tertiary granitics but not with the older Mesozoic Mount Stuart Granodiorite.

The age of the Snoqualmie batholithic rocks is considered to be Miocene. Lipson and others (1961), using

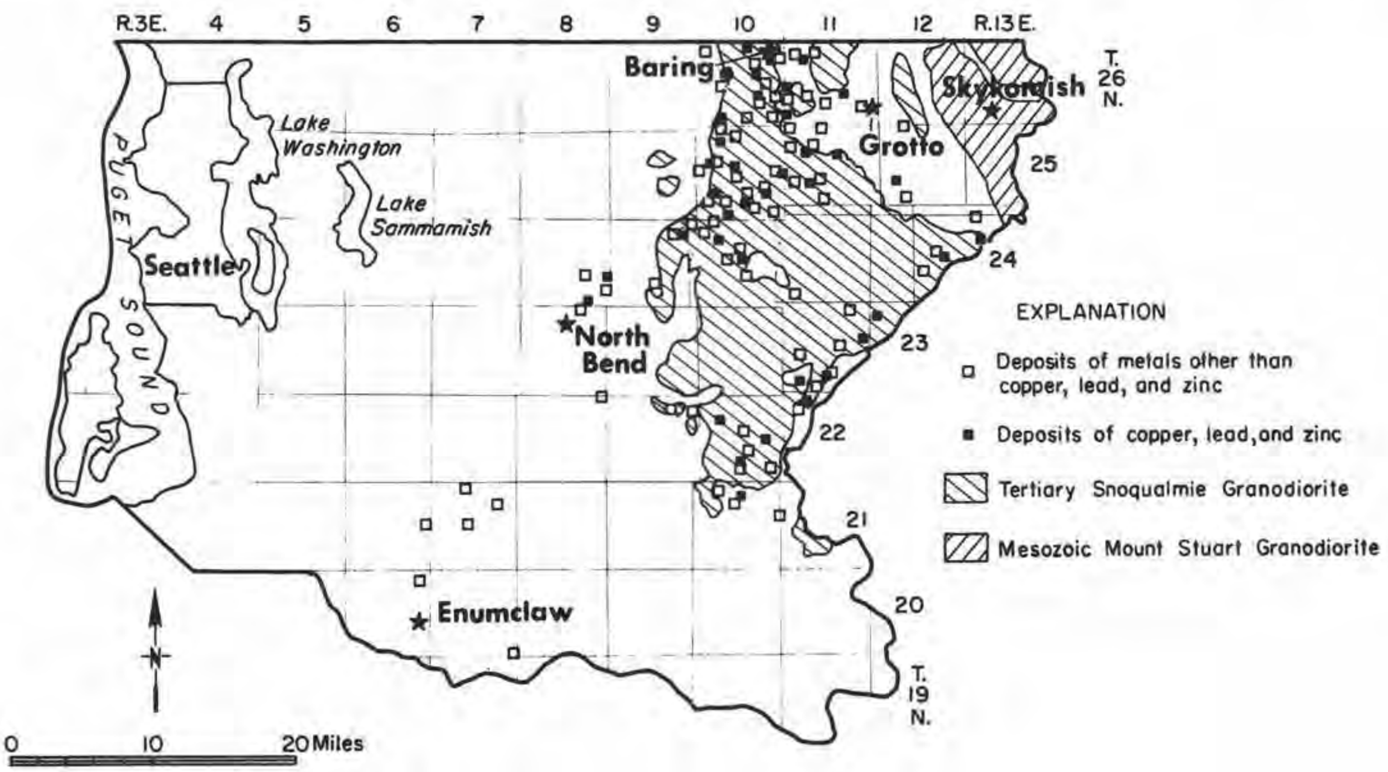


FIGURE 12.— Relation of metallic ore deposits to granitic rocks in King County, Washington. [Compiled by W. S. Moen.]

the potassium-argon method, dated the Snoqualmie rocks at 17 million years.

Tertiary Intrusive Rocks Undifferentiated

A variety of Tertiary intrusive rocks in King County range in age from Eocene to Miocene. The compositions vary from basalt to granite; generally speaking, the intrusions are less calcic from west to east. In the Allentown-Tukwila area the rocks are porphyritic basalt and andesite; in the foothills of the Cascades they are andesite porphyry; and in the Cascades they are dacite porphyry, rhyolite, diorite, andesite porphyry, and granodiorite. None of these intrusions is very large; the largest covers about 5 square miles. Most, however, are much smaller and are dikes and sills enclosed in older sedimentary and volcanic rocks. These hypabyssal rocks are widespread, cropping out almost everywhere bedrock is exposed.

Quaternary Deposits

All Quaternary deposits in King County are sedimentary, having been deposited by glaciers as till, by streams as outwash and alluvium, and in lakes as lacustrine deposits. These deposits are well exposed along most of the steep river-valley walls in the Puget Lowlands, and there are extensive outcrops along the shores of Puget Sound and at various places around Vashon and Maury Islands. Drift deposits from four glaciations have been found in King County; in ascending order they are the Orting Drift, Stuck Drift, Salmon Springs Drift, and Vashon Drift. The Kitsap Formation occurs on Vashon and Maury Islands, between the Vashon and Salmon Springs Drifts, and the Puyallup Formation occurs between the Salmon Springs and Stuck Drifts.

Orting Drift.— The oldest Quaternary deposit recognized in King County is the Orting Drift. It crops out in the valley walls of the Green River, where it lies on eroded Tertiary bedrock. The Orting Drift is composed mostly of oxidized sand and gravel, and at its type locality in Pierce County is 165 feet thick. Till sheets are interbedded with the sand and gravel at more than one horizon. Typically, the drift is dense and brown, and joint and pebble surfaces are coated with iron oxide.

Stuck Drift.— Unconformably overlying the Orting Drift in the southern part of King County is the Stuck Drift, named by Crandell and others (1958, p. 391) for the second period of glaciation in the Puget Sound area. The unit consists chiefly of an unoxidized to slightly oxidized till sheet, 5 to 20 feet thick, which is underlain and overlain by oxidized sand and gravel. In King County the Stuck Drift occurs only in the southern part of the Duwamish Valley, near the Pierce County line.

Puyallup Formation.— Originally, the Puyallup Formation was described as the Puyallup Sand by Willis (1898b, p. 111), but was redefined by Crandell and others (1958, p. 392-394). The formation has a maximum thickness of about 100 feet in King County and is exposed along the walls of the Duwamish Valley. It is composed chiefly of fine to medium, light-gray to brown sand, but includes volcanic debris, mudflows, silt, clay, peat, and volcanic ash that were deposited during a glacial interstage.

Salmon Springs Drift.— Overlying the Puyallup Formation in King County is the Salmon Springs Drift— so named by Crandell and others (1958, p. 394). The unit is best exposed along the walls of the Duwamish, Green, and White river valleys. It crops out also along the shores of Puget Sound and around Vashon and Maury Islands. The unit is composed of sand and gravel and thin beds of silt, clay, and peat. In the Duwamish Valley two till lenses are separated by interbedded outwash. Only one till lens occurs in the valleys of the Green and White Rivers. In King County the maximum thickness of the Salmon Springs Drift is about 200 feet.

Kitsap Formation.— In the Vashon-Maury Island area the Salmon Springs Drift is overlain by the Kitsap Formation. The formation was originally called the Kitsap Clay Member of the Orting Drift by Sceva (1957, p. 17-19). Garling and others (1965, p. 29) redefined the unit and designated as the type locality a beach bluff one-half mile north of Maplewood, on the west shore of Clovis Passage in Kitsap County. The formation consists mainly of clays and silts, including minor amounts of sand and gravel. A stratum of peat in the formation ranges from 1 to 4 feet in thickness.

Vashon Drift.— As first described by Willis (1898b), the Vashon Drift included material that was older than the Vashon. Later workers have restricted and redefined the unit. The Vashon Drift was deposited by the last glacial advance and includes till, outwash sand and gravel, and varved silt and clay. This drift covers much of western King County.

Stratified drift in the Vashon is probably the most economically important rock type in King County. It is from this material that most of the sand and gravel suitable for aggregate is produced.

Undifferentiated drift and alluvium.— In some areas of the county, particularly along the eastern part of the Puget Lowlands, the surficial geology has not been worked out. These areas are covered by deposits of till, outwash sand and gravel, lacustrine silts and clays, alluvium along streams, and mudflow debris.

Peat.— Peat bogs are scattered abundantly over the Vashon Drift plains of the Puget Lowlands. Many of the bogs occupy old kettle lakes, others have filled old stream channels or have formed on alluvial flats where streams empty into lakes. The various bogs contain sphagnum, fibrous, woody, and sedimentary peat, as well as minor beds of pumicite and diatomite.

Landslides.— Landslides are common along the steep valley walls of the drift plain. The slides consist predominantly of rotated, sheared, and deformed blocks of glacial drift material. Where clay beds are abundant, landslides are common.

Osceola mudflow.— Northwest of Enumclaw a formation of unsorted, subangular to subrounded pebble-, cobble-, and boulder-size fragments in a clayey to silty sand matrix mantles the drift plain. The formation was originally described by Willis (1898b, p. 143) as a sheet of till. However, work by Crandell and Waldron in 1956 revealed the true nature of the unit; they were able to show good evidence that it originated as a mudflow on the slopes of Mount Rainier.

Alluvium.— Alluvium in King County occurs along most of the major rivers and streams. Much of the material, especially in the Puget Lowlands, is reworked glacial debris. In the eastern part of the county most of the alluvium has been derived from the weathering of bedrock. It consists of clay, silt, sand, and gravel. As might be expected, fine-grained material predominates in the western part of the county and coarser material is most abundant in the eastern part. Alluvium is part of the material used as aggregate in the county.

STRUCTURE

The geologic structure of King County is very complex, especially in the eastern part of the county. Two prominent structural grains occur— one striking northwest and the other to the north. According to Mackin and Cary (1965, p. 13-16), the northwest trend was established during Oligocene time, when earth stresses folded the Oligocene and older rocks into what Mackin and Cary called the Calkins Range. This structural grain became so firmly established that present-day main river courses are influenced by it. At a later time, probably during the late Pliocene to early Pleistocene, the Cascade Range was arched along a north-south axis. Although there is no obvious structural axis along the Cascades, the mountains apparently represent a large arch with many superimposed minor folds that obliterate the axis of the main fold. The term "minor" implies only that they are smaller than the main north-south uplift. Many, if not most, of these smaller folds predate the uplift of the Cascade Range. The forces that produced the northwest trends were probably still active and thus they reinforced pre-existing structures when the Cascades were uplifted. Large, pronounced northwest-trending shear zones in the plutonic rocks indicate that this system may still be active.

Folding is not evident in the Snoqualmie Granodiorite; however, the batholithic mass in the vicinity of Snoqualmie Pass plunges from alpine highs in the northern part of the county southward beneath Tertiary volcanic rocks. Whether this was caused by a stronger uplift to the north or is simply a doming effect of the batholith is not known. The origin and emplacement of the Snoqualmie batholith was both by granitization of older rocks and by intrusion of a magmatic mass into older rocks.

Faults are common; however, few large ones have been mapped. In batholithic rocks they are particularly hard to recognize, and it is in those rocks that they are most important in the control of ore bodies. There are several large shear zones cutting the granodiorite in the Money Creek-Miller River-Lennox Creek area, but they have not been studied, so their relative movement and relation to ore deposits are not known. Breccia pipes are common in the northeastern part of the county and often serve as loci for ore mineralization.

Thick vegetation and glacial overburden form an effective mask over the Tertiary rocks of the Puget Lowlands area, making structural determinations very difficult. In only a few places are there enough outcrops of pre-Pleistocene rocks to make it possible to map bedrock with any degree of confidence. Dips in the Tertiary sedimentary rocks of the lowlands are moderate to steep, much the same as they are in older rocks of the Cascades. There are two general fold systems in the Tertiary rocks of the lowlands— northwest as exemplified by the folds in the Newcastle Hills-Renton area, and north-northeast as typified by the folds in the Green River area. Jointing occurs throughout the pre-Pleistocene rocks and is especially abundant in the granitic rocks. Usually there is more than one joint set in granitics at any given locality.

MINERAL RESOURCES

Apparently, coal was the first mineral to be mined in King County. The first mine is reported to have been opened in 1853, and for many years coal was the most important mineral of the county in value of production. Records in the King County Auditor's office in Seattle indicate that the first mineral claim was recorded April 12, 1871, by Job, Anthony, and Howard Carr.

Early reports on the mineral potential of the county predicted a great future for mining in the area. This prediction has been fulfilled, but not necessarily in the same sense that it was made. Early prospectors, mining engineers, and geologists, aside from their efforts on coal, spent most of their time and energy on the metallic mineral deposits, and almost every deposit, at one time or another, has been described in eloquent and glowing terms. Relatively little attention was given to the nonmetallic minerals during the early days; however, they have proven to be the most productive deposits thus far. Although the development of metallic mineral deposits has lagged far below the expected level of activity over the years, there is no question that valuable metallic deposits are present in the county and that many of them hold good promise for future development. Early workers failed to comprehend the many problems that would be encountered, and that have stifled almost every mining attempt. Even today, with the aid of geochemical and geophysical prospecting techniques, helicopter transportation, and modern drilling and mining equipment, developing a mine is a formidable job. All the most promising deposits are in the Cascade Mountains, where early and heavy snowfall, remoteness, rugged terrain, and heavy forest cover combine to make development difficult.

King County Mining Districts

The mining districts in King County were established several decades ago; however, their bounds were never fully described. The first district to be formed was the Snoqualmie (Bethune, 1891, p. 91). In 1897 Hodges mentioned the Miller River (p. 36), Money Creek (p. 39), Cedar River (p. 47), and Buena Vista (p. 43) districts and described their locations in part. The present report uses the boundaries established by Hodges, except for a few minor changes and additions that serve only to tie the boundaries together (Fig. 13).

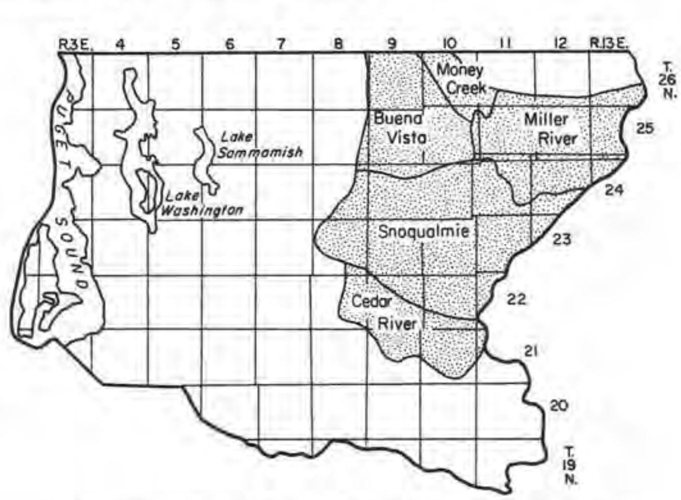


FIGURE 13.— Mining districts in King County, Washington.

The Money Creek district is bounded by a line that trends west from Baring along the King County-Snohomish County line to Mount Index. From there it extends southeast to Lennox Mountain and Coney Lake along the drainage divide that separates Money Creek from the Tolt and North Fork of the Snoqualmie Rivers. From there it trends northeast along the drainage divide between Money Creek and the Miller River to a point where the Miller River empties into the Skykomish River. From the confluence of these two rivers the line follows the Skykomish River to Baring.

The Buena Vista district is bounded by a line that trends west along the King County-Snohomish County line from Mount Index to the northeast corner of T. 26 N., R. 9 E., where it turns and extends southward to the vicinity of Fuller Mountain. From Fuller Mountain it trends eastward along the drainage divide between Hancock Creek and Calligan Creek, and between the Taylor River and Lennox Creek to a point about 1 mile west of Dream Lake. From there it extends north along the drainage divide between Lennox Creek and the West Fork of the Miller River to Lennox Mountain. It then trends northwest to Mount Index.

The Miller River district is considered to be encompassed by a line that follows the highway from Stevens Pass to the confluence of the Miller and Skykomish Rivers. It then trends southwestward along the west border of the basin drained by the Miller and the West Fork of the Miller River to about a mile west of Dream Lake. From there it follows eastward along the drainage divide between the Snoqualmie River and the streams that drain into the Tye and Skykomish Rivers to the crest of the Cascade Mountains at Mount Hinman. From Mount Hinman the line follows the Cascade crest northwest to Stevens Pass.

The Snoqualmie district is bounded on the north by the drainage divide that extends from Mount Hinman to Fuller Mountain, and on the east by the Cascade crest between Mount Hinman and Tinkham Peak. From Tinkham Peak the boundary follows the drainage divide between the Snoqualmie and Cedar Rivers to the west end of Rattlesnake Mountain, where it bends around and extends north to Fuller Mountain.

The Cedar River district is bounded on the east by the Cascade crest between Meadow Mountain and Tinkham Peak, and on the north by the drainage divide separating the Cedar and Snoqualmie Rivers between Tinkham Peak and Cedar Butte. The boundary on the south follows the drainage divide between Meadow Mountain on the Cascade crest and Cedar Butte to the west.

The use of mining districts in the description of properties, in the location of mines, or to delimit an area encompassing deposits of similar mineralization has been more or less restricted to metallic minerals in King County. Coal deposits have been described as being in coalfields or areas, and only occasionally has coal been referred to as coming from a district. So far as other nonmetallic minerals are concerned, they are usually referred to as having come from a certain area— such as the Enumclaw area, Green River gorge area, etc., using a geographic name to identify the area.

NONMETALLIC MINERAL DEPOSITS

Alunite

The alunite deposits are on the slopes of the White River valley in both King and Pierce Counties, mainly in Tps. 19 and 20 N., R. 8 E. They are approached from Enumclaw by 5 miles of paved highway (U.S. 410) and several miles of dirt road belonging to the Weyerhaeuser Company.

Most of the land in the alunite area is owned by the Weyerhaeuser Company, but some deposits are on State-owned land. Alunite has been found in secs. 4, 5, 6, 7, 9, and 10, T. 19 N., R. 8 E.; secs. 31, 32, and 33, T. 20 N., R. 8 E.; sec. 36, T. 20 N., R. 7 E.; and secs. 1 and 12, T. 19 N., R. 7 E.

Alunite was first encountered by the White River Logging Company in 1928, while constructing their main rail line through the NE$\frac{1}{4}$ sec. 7, T. 19 N., R. 8 E. It was thought to be an ordinary clay and went unidentified until 1934. In 1939 the Kalunite Company of Salt Lake

City, Utah, became interested in the deposits and did a considerable amount of exploration work. The U.S. Geological Survey and the State of Washington Division of Mines and Mining did much work also. This exploration activity resulted in 4,400 feet of diamond drilling and 3,600 feet of trenching. Kelly and others (1956, p. 32) report the reserves as follows: "In the SE$\frac{1}{4}$ sec. 4 some 600,000 tons of 30-percent alunite is found, 1$\frac{1}{4}$ miles southeast an estimated 240,000 tons of 21.4 percent alunite is found, and in the NE$\frac{1}{4}$ sec. 7 and in secs. 5 and 6 there is some 300,000 tons, making a total of 1,140,000 tons of alunite-bearing rock." This covers a few of the 12 sections reported to contain alunite. No doubt the reserves are larger, but the grade is low and much of the area in King County is complicated by landslides.

Figure 14 is an index map of the prospect trenches in the alunite deposits in sec. 7, T. 19 N., R. 8 E., and Figures 15 to 30, inclusive, are maps showing the geology of these trenches, each followed by sample descriptions written by Harold Kirkemo, who was the Field Supervisor of an (unpublished) alunite survey made by the State of Washington Division of Mines and Mining.

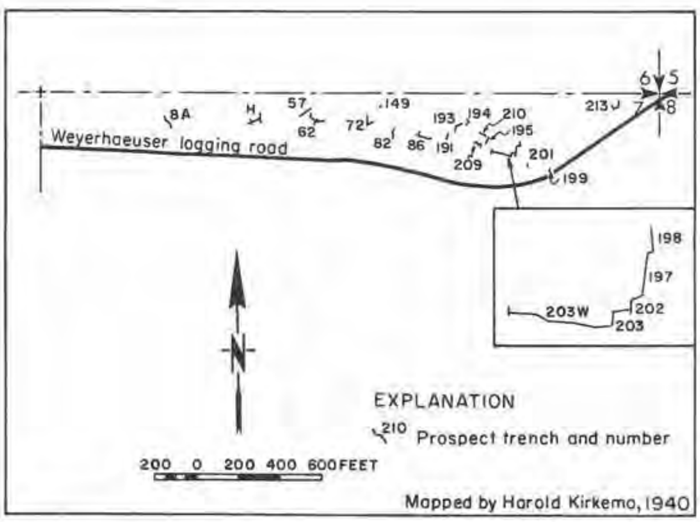


FIGURE 14.— Index of alunite prospect trenches in sec. 7, T. 19 N., R. 8 E., in King County, Washington.

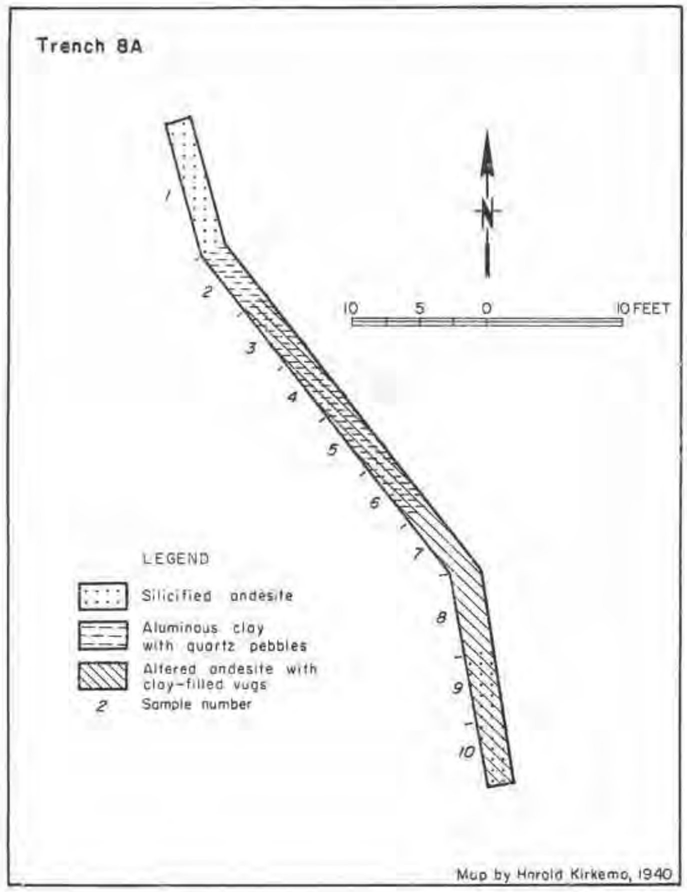


FIGURE 15.— Detailed geology of alunite prospect trench 8A, in King County, Washington.

Sample no.	Sample Description
	Trench 8A — Sec. 7, T. 19 N., R. 8 E.
1	10-foot sample beginning 2 feet north of station 2 traverse 7-8-1 and continuing N. 15° W. for 10 feet.
	Light-colored silicified andesite, in places completely silicified. Where rock is not completely silicified, white phenocrysts can be seen in the andesite filling the feldspar vugs. The material in the phenocrysts is soft, light-colored (gray), and claylike. There is doubt whether any alunite is in sample.

2 5-foot sample beginning at station 2 traverse 7-8-1 and bearing S. 38° E.

Soft, gray- to buff-colored clay and a considerable amount of silica in small pebbles.

3 5-foot sample beginning at south end of sample 2 and bearing S. 38° E.

Zone of much alteration; not much quartz. Soft, decomposed andesite and a considerable amount of clay that may be alunite. Clay is buff colored and iron stained.

4 5-foot sample continued S. 38° E. from south end of sample 3.

Soft altered andesite having alunite present as replacement in former feldspar cavities.

5 5-foot sample continued S. 38° E. from sample 4.

Very good sample— seems to be richest part of trench. Soft-gray to white alunite and some altered andesite.

6 5-foot sample continued from sample 5, same bearing.

Good showing of alunite, although more andesite is present than in sample 5. Much limonitic stain.

7 5-foot sample continued S. 38° E. from sample 6.

Andesite becoming more prominent— alunite decreasing in quantity. Andesite is dark green in color, soft; there is much limonitic weathering.

8 6-foot sample continued S. 9° E. from sample 7.

Andesite, dark green in color, containing phenocrysts of white, soft, clayey material. Not much alunite in sample.

9 5-foot sample continued S. 9° E. from sample 8.

Andesite— a little harder than in sample 8.

10 5-foot sample continued S. 9° E. from sample 9.

Andesite, quite siliceous— very little, if any, alunite.

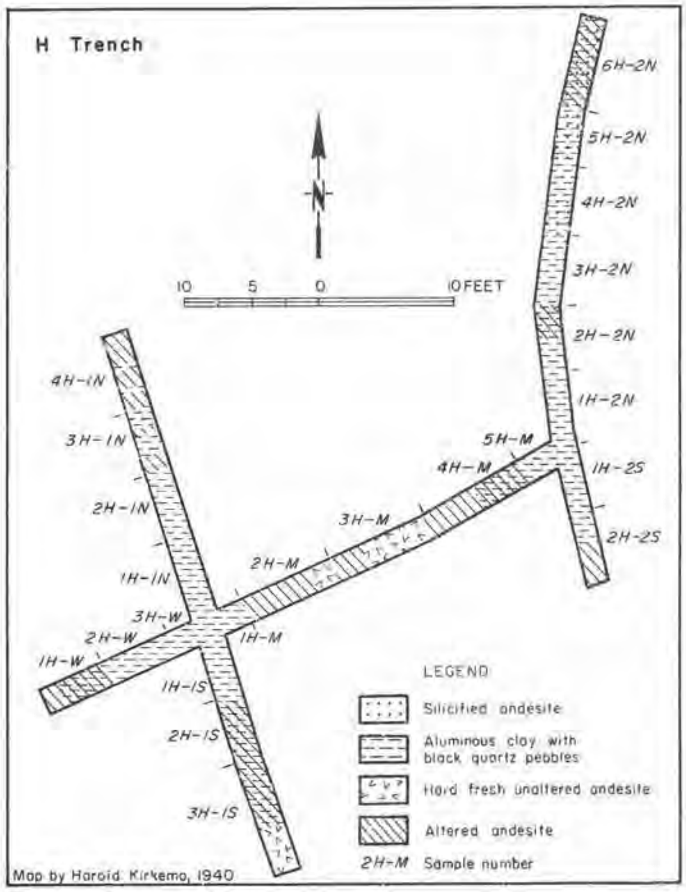


FIGURE 16.— Detailed geology of alunite prospect trench H, in King County, Washington.

Sample no.	Sample Description

Trench H — Sec. 7, T. 19 N., R. 8 E.

1H-W 5-foot sample starting in west end of western extension and trending N. 68° E. Sample taken in steep part of trench, so horizontal length is 4 feet.

West face of trench is a green, equigranular, fairly soft andesite that is iron stained along joints and shows a tendency to break along joint planes. In bottom of trench, andesite becomes softer, plagioclases are replaced by soft clayey material, and rock is a buff color.

Alunite zone seems to turn down under the relatively unaltered andesite in the face or grade into it. Trench is about 7 feet deep. Alunite zone is stronger on south side of trench.

Alunite-bearing clay is soft, white to buff-colored material without structure. Very little, if any, silica present; dark siliceous masses have been found in the white clay. Iron crusts, present in the clay, are harder than the clay. This clay seems to lack the definitely soapy feel of good alunite.

2H-W 5-foot-4-inch sample continued N. 68° E. from sample 1H-W. White and gray soft moist clay containing rounded black 1/16-inch to 1/8-siliceous pebbles. Andesite completely altered. The clay should carry alunite.

3H-W 5-foot sample continued N. 68° E. from sample 2H-W, the eastern 3 feet being vertical into bottom of the western end of trench section H-M.

Soft, white to gray clay with pieces of black, subangular quartz. In the vertical drop into trench section H-M the clay is firmer and the black quartz fragments are larger. No structure.

1H-M 4-foot sample beginning on west edge of trench section H-1 and bearing N. 68° E.

Brecciated, black angular quartz cemented with white to gray-colored clay that has alunite. Pieces of andesite hardened by an iron crust are present in the clay.

2H-M 7-foot sample continued N. 68° E. from sample 1H-M.

Log— going eastward:

1 foot of green soft altered andesite; feldspars prominent; no alunite.

4-foot sample of soft, dark-green to blue, very altered andesite containing pockets or small masses of white alunitic(?) clay.

2 feet of hard, dark blue-green fresh andesite with prominent feldspar phenocrysts.

3H-M 8-foot sample continued N. 68° E. from sample 2H-M.

Log— going eastward:

2½ feet of buff, soft, highly altered andesite; may carry alunite in white material in the vugs.

3 feet of hard, dark-green or blue andesite; little altered; prominent feldspar phenocrysts.

2½-foot zone of black, hard, broken andesite(?) — probably a dike.

4H-M 8-foot sample continued N. 62° E. from sample 3 H-M. 2½ feet in vertical face.

Soft buff altered andesite similar to that seen in first 2½ feet of sample 3H-M. As a rise is made in the trench the amount of clay increases, as does the number of silica pebbles.

5H-M 6½-foot sample continued N. 62° E. from sample 4H-M.

Soft, clayey material; gray, buff, and black in color, without structure. Black material resembles black quartz pebbles noted for sample 2H-W but it can be broken in the fingers. May be weathered rotten silica, for this sample is only 4 feet below the surface of the ground, whereas sample 2H-W was at least 6 feet deep. Sample ends in middle of trench section H-2.

1H-2N 5-foot sample bearing N. 4° W., starting at east end of sample 5H-M.

Gray and buff alunitic clay including dark, soft material that resembles dark quartz except for hardness.

2H-2N 5-foot sample continued from sample 1 H-2N, bearing N. 4° W.

South half of sample from same material as sample 1 H-2N. North half of sample from buff, altered, soft andesite carrying some alunite, but not as good as the south half.

3H-2N 5-foot sample continued N. 10° E. from sample 2H-2N.

Buff to gray alunitic clay containing dark masses or spots. No structure.

4H-2N 5-foot sample continued N. 10° E. from sample 3H-2N.

Altered andesite, siliceous in southern half. Some alunitic clay in northern half.

5H-2N 5-foot sample continued N. 10° E. from sample 4H-2N. Altered, siliceous andesite and some alunite. Silica is black or dark, and in places forms about 75 percent of the rock.

6H-2N 7-foot sample continued N. 16° E. from sample 5H-2N.

Siliceous, altered, gray and buff andesite; considerable amount of alunite present. Silica is dark. Alunite seems to get deeper at north end of trench.

1H-2S 5-foot sample starting at east end of trench section H-M and bearing S. 11° E.

Siliceous breccia cemented with alunitic gray clay. Silica is dark and dense. Southern end of sample from clay without much silica.

2H-2S 5-foot sample S. 11° E. from sample 1H-2S.

Same material as in sample 1H-2S, but visible alunite decreases in quantity in southern end, where zone of alteration extends under black sand or silt.

1H-1N 7-foot sample beginning at east end of trench section H-W, bearing N. 15° W.

Dark, siliceous breccia cemented with alunitic clay— the best clay in the H system of trenches. Fairly uniform in grade. No structure.

2H-1N 5-foot sample continued N. 15° W. from sample 1H-1N. Dark, siliceous breccia in southern 3 feet. Northern 2 feet in very good clay that should show best assay of all sampling to date. Clay is gray, has very minute dark quartz fragments. Northern edge of sample in a pale-green clay.

3H-1N 5-foot sample continued N. 15° W. from sample 2.

Log— going north:

$1\frac{1}{2}$ feet of green altered andesite including a little alunite in southern end.

$1\frac{1}{2}$ feet of gray, gritty clay; may have alunite.

9 inches of green, altered andesite with a definite soapy feel; contains no silica. Remainder of sample is siliceous breccia cemented with clay.

4H-1N 6-foot sample N. 15° W. from sample 3 to end of trench.

Chiefly altered blue and green andesite; some silica and clay. Some clay seams 6 to 8 inches wide containing alunite.

1H-1S 5-foot sample bearing S. 14° E. from east end of trench section H-W.

Gray and buff clay containing dark, siliceous pebbles. No structure. Should show alunite.

2H-1S 5-foot sample bearing S. 14° E. from sample 1H-1S.

6 inches alunitic clay in north end. Remainder is buff, highly altered, soft andesite containing white clay mineral phenocrysts.

3H-1S 9-foot sample continued S. 17° E. from sample 2H-1S.

Northern 5 feet in buff soft altered andesite including a white clay mineral that may be alunite. Southern 4 feet in dark green, hard, altered andesite that still retains the original rock texture.

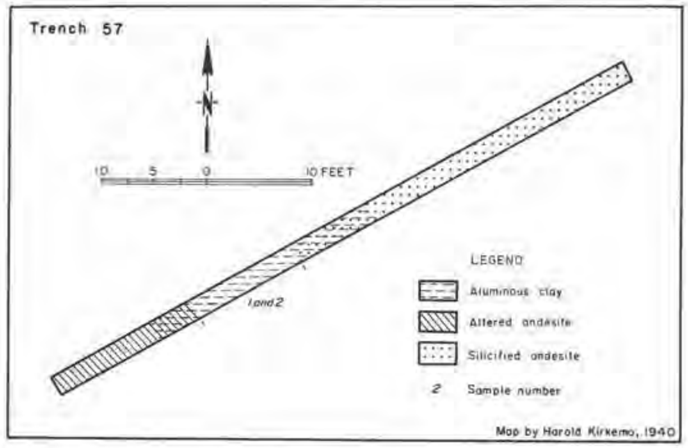


FIGURE 17. — Detailed geology of alunite prospect trench 57, in King County, Washington.

Sample no.	Sample Description

Trench 57 — Sec. 7, T. 19 N., R. 8 E.

Trench 57 is 62 feet long and has quartz in the northeast end, altered andesite including clay in the middle, and altered andesite in the southwest end.

1 11-foot sample beginning 15 feet from the southwest end of the trench and bearing N. 62° E.

Buff, weathered, badly decomposed rock that originally was andesite, now a siliceous pebbly clay. The clay is soft, moist, and gray— very similar to the H trench clay but contains far more silica and andesitic pebbles.

2 11-foot sample taken parallel to and 2 feet above sample 1 on north wall of trench. Zone of alteration containing soft white and gray clay; siliceous pebbles; and small boulders of completely silicified andesite.

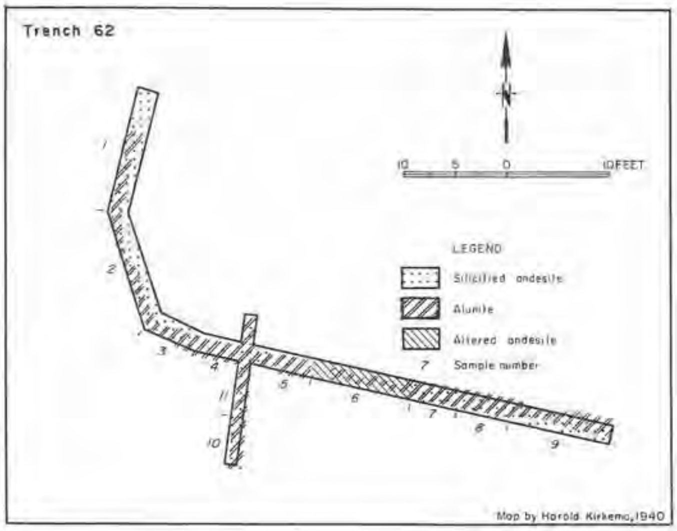


FIGURE 18.—Detailed geology of alunite prospect trench 62, in King County, Washington.

Sample no.	Sample Description

Trench 62 — Sec. 7, T. 19 N., R. 8 E.

1 12½-foot sample beginning at north end of trench 62, bearing S. 13° W. down a 25° slope.

Northern 3 feet of sample is a gray, dense hard quartz containing a few feldspar laths. Not very promising for alunite.

Remaining 9½ feet is gray quartz that has an increasing amount of alunite completely replacing the feldspar. Quartz becomes darker in color. Breccia zones about 6 inches wide at 6 feet and 11 feet. White powder covers the outcrop at 12 feet; may be finely powdered alunite. Quartz quite hard; no definite structure.

2 12-foot sample continued S. 18° E. from sample 1.

Mostly hard, gray quartz; a little alunite. Stained with limonite in some places, slightly porous where oxidized. No structure evident.

3 5-foot sample bearing S. 66° E. from south end of sample 2.

Gray quartz and some alunite from west end of sample grading into soft white alunite(?) in east end. Buff limonitic stain on outcrop forms very hard crust.

4 5-foot sample bearing S. 78° E. from sample 3. Sample taken from face of a vertical joint plane that trends S. 78° E.

Mainly a white, soft clay containing dark quartz fragments. White powder on rock is soapy, probably alunite.

5 6½-foot sample continued from sample 4, bearing S. 78° E.

West 2 feet of sample in hard dense quartz with alunite. Rest of sample carries more alunite and less quartz.

6 10-foot sample continued from sample 5, bearing S. 78° E.

Poor sample—mostly siliceous, porous, iron-stained, altered andesite with only a little alunite. Not much andesitic texture remaining.

7 5-foot sample continued S. 78° E. from sample 6.

Dark quartz, dense, and has a considerable amount of alunite. Is iron stained; no structure.

8 5-foot sample continued S. 78° E. from sample 7.

Dense, dark quartz including a considerable amount of alunite. Structureless.

9 10-foot sample continued S. 78° E. from sample 8.

Dense, dark quartz containing much alunite, which increases in quantity eastward. This 10-foot section is considerably broken up, so that most of the rock is loose yet still in place.

10 5-foot sample bearing N. 7° E. taken from floor of trench that crosses between samples 4 and 5.

Best sample in this trench. Pink alunite in a gray, dense quartz.

11 9½- foot sample continued N. 7° E. from sample 10.

South 3 feet from floor of pit. Very good alunite. Soft zone between 2 feet and 3 feet—iron stained, contains much alunite.

Past the 3-foot mark is dark brecciated quartz containing much alunite; crosses the west end of sample 5 at the 5-foot mark of this sample.

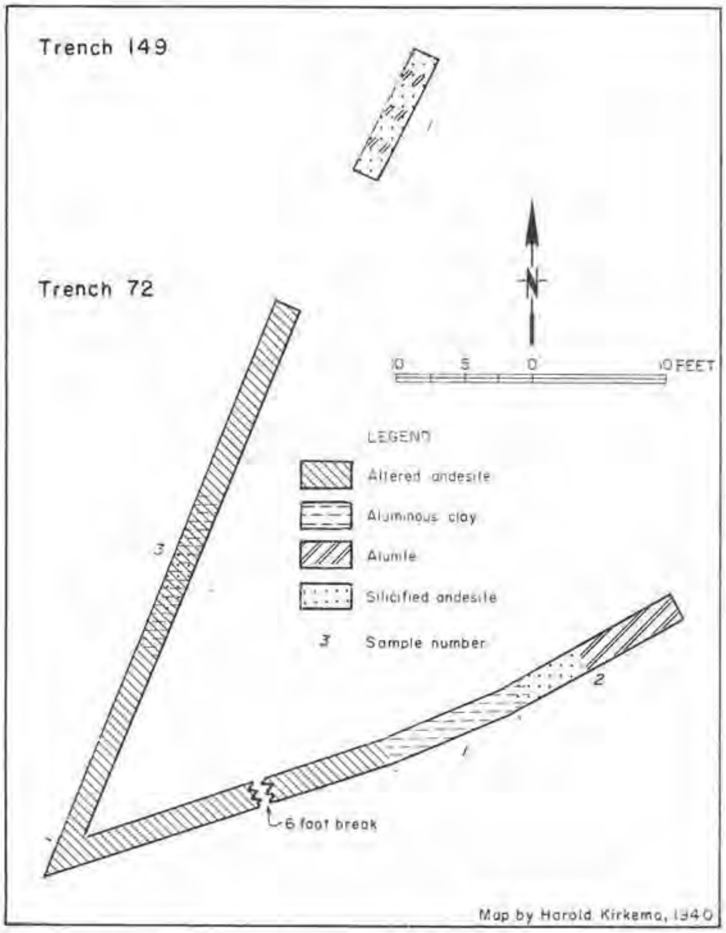


FIGURE 19.— Detailed geology of alunite prospect trenches 149 and 72, in King County, Washington.

Sample no.	Sample Description
	Trench 149 — Sec. 7, T. 19 N., R. 8 E.
1	10-foot sample bearing N. 27° E.
	Hard, dense gray quartz including some soft material along joint cracks— probably gouge, but sampled anyway for alunite. Quartz spotted with minute clay particles.
	Trench 72 — Sec. 7, T. 19 N., R. 8 E.
1	10-foot sample beginning 29 feet N. 72° E. from west end of trench and bearing N. 67° E.
	The sample is in light-gray clay very similar to the H trench type.
2	14-foot sample continued, bearing N. 60° E., from sample 1 to end of trench.
	First 3 feet becoming more siliceous and brecciated. Quartz becomes darker in color until it is black at 5 feet from west end of sample.
	In east 5 feet of sample, crystalline pink alunite in brecciated black quartz is very abundant. In appearance the alunite and the quartz resemble that found in trenches 210 and 203.
	Suggestion of vertical jointing N. 10° E. in the quartz. Gray, porous quartz also occurs with the alunite in this zone.
3	42-foot sample bearing N. 22° E. from south end of west branch of trench 72.
	Largely altered andesite— less altered in first 15 feet of trench— highly altered in rest of trench. Chloritized in extreme north end. Very little silicification, some in center of sample. Some gray clay like that in trench 57 just sampled.

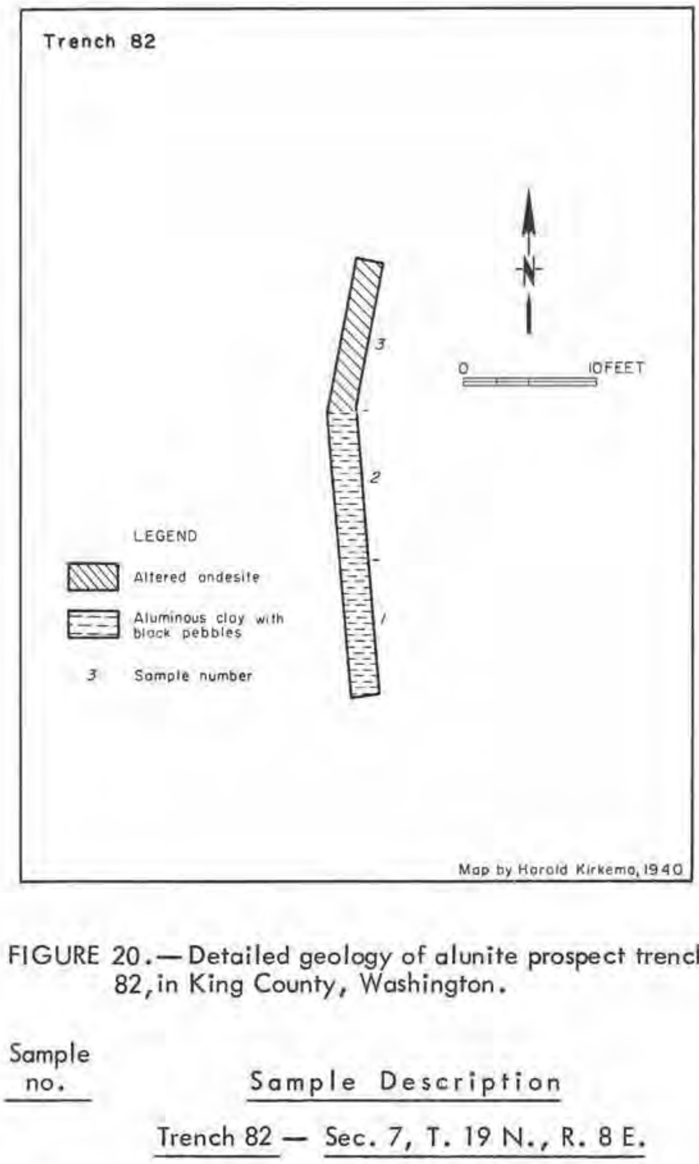


FIGURE 20.— Detailed geology of alunite prospect trench 82, in King County, Washington.

Sample no.	Sample Description
	Trench 82 — Sec. 7, T. 19 N., R. 8 E.
1	10-foot sample beginning in south end of trench and bearing N. 5° W.
	Sample entirely from a gray clay, slippery when

wet. Contains a few black siliceous pebbles. Limonitic stain along cracks and joints. Very similar to clay found in H trench and in trench 8A. Does not seem heavy enough for alunite.

2 11-foot sample continued N. 5° W. from sample 1.

Same clay throughout sample, but more altered rock is present than in sample 1. Rock is gray, dense, and relatively soft but harder than the clay.

3 11-foot sample continued from sample 2, bearing N. 10° E.

Largely altered, soft green andesite. Feldspar vugs filled with gray clay.

Rock becomes predominantly harder in north end of trench.

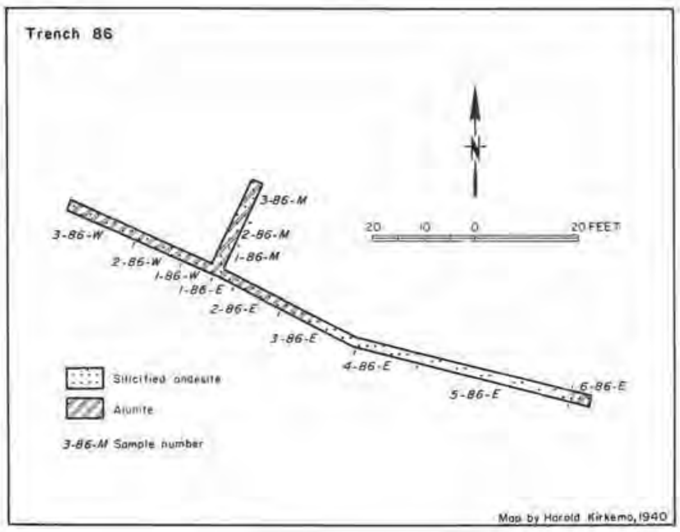


FIGURE 21.— Detailed geology of alunite prospect trench 86, in King County, Washington.

Sample no.	Sample Description

Trench 86 — Sec. 7, T. 19 N., R. 8 E.

1-86-M 5-foot sample starting in middle of the long east-west trench and bearing N. 25° E.

Highly silicified, brecciated andesite including much alunite in irregular masses throughout. The former andesite has been completely silicified. Alunite is both pink and white in color.

2-86-M 5-foot sample continued N. 25° E. from sample 1-86-M.

Hard, siliceous rock, formerly andesite, including alunite. Alunite decreases in quantity northward in the trench, so that it finally occurs only as a replacement of the feldspar(?).

3-86-M 8-foot sample continued N. 25° E. from sample 2-86-M.

Hard quartz and some alunite. One-foot section across some gray quartz shows very distinct phenocrysts. Quartz is porous in some places.

1-86-E 5-foot sample beginning at south end of sample 1-86-M and continuing S. 63° E.

Hard quartz and some alunite. Some of the quartz is brecciated and dark in color.

2-86-E 10-foot sample continued from sample 1-86-E and bearing S. 63° E.

Hard, dark-gray quartz and some alunite. Some parts of the quartz contain more alunite than do other parts. Plagioclase vugs are filled with alteration material that may be alunite. Andesite completely replaced, but outlines of the former feldspars are yet distinct.

Well-defined fault 2 feet east of the west end of this sample; strike N. 54° E., dip 63° W. Fault zone is 4 inches wide, filled with siliceous gouge, is iron-stained, and contains one or two small 1/8-inch-wide veinlets of a soft, white, soapy mineral that resembles alunite but may be dickite.

Alunite zone is stronger in the quartz west of the fault than in that east of it.

3-86-E 16-foot sample continued S. 63° E. from sample 2-86-E.

First 6 feet in a fair showing of alunite. Some of it is pink in color, as is that noted for trench 210. Brecciated dark quartz in the first 6 feet.

Rest of sample in hard, dense, gray quartz including little, if any, alunite.

4-86-E 12-foot sample continued S. 76° E. from sample 3-86-E.

Silicified andesite, in places retaining original andesitic texture, in others completely lacking in texture. Quartz is dense and is light gray in color. Some alunite.

Sulfur, 3.67 percent; alumina, 13.46 percent; silica, 45.60 percent.

An 8-foot zone of loose rock between this sample and sample 5-86-E was not sampled.

5-86-E 30-foot sample continued S. 76° E. from sample 4-86-E.

Broken andesite; very little of it is in place.

6-86-E — 4½-foot sample continued S. 76° E. from sample 5-86-E.

Hard dark quartz and a considerable amount of alunite(?) of a variety not seen before. The mineral is bladed, curved, pink in color, and has a lustrous sheen as if moistened. The quartz is dark in color, very hard, and has no relict andesitic texture— even the feldspar outlines are gone.

Sulfur, 15.29 percent; alumina, 13.49 percent; silica, 36.61 percent.

1-86-W — 6-foot sample beginning at south end of sample 1-86-M and bearing N. 66° W.

Brecciated, dark-gray hard quartz including a considerable amount of alunite.

Sulfur, 3.81 percent.

2-86-W — 10-foot sample continued N. 66° W. from sample 1-86-W.

Hard dark quartz, brecciated and containing some alunite. Part of sample was taken in loose rock.

3-86-W — 15-foot sample continued N. 66° W. from sample 2-86-W.

Completely silicified andesite including some clay, either alunite or dickite.

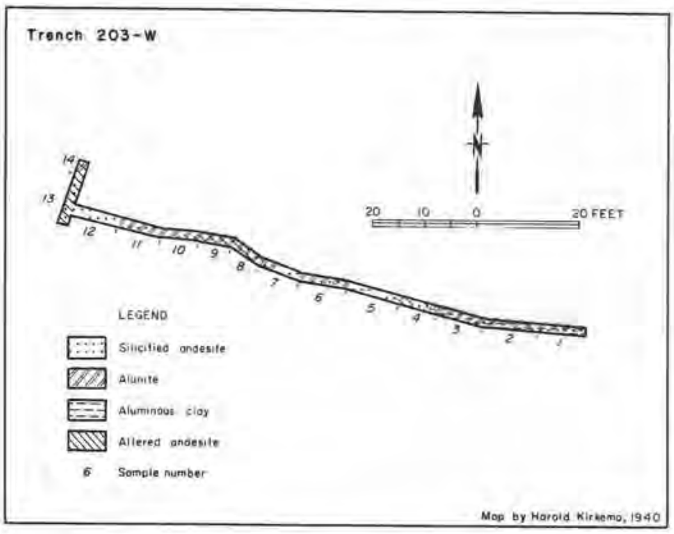


FIGURE 22.— Detailed geology of alunite prospect trench 203-W, in King County, Washington.

Sample no. — Sample Description

Trench 203-W — Sec. 7, T. 19 N., R. 8 E.

1 — 8-foot sample beginning at south end of trench 203 and bearing N. 85° W.

Crystalline pink alunite in a dense, light-gray quartz; some dickite present also. Some of the alunite contains brecciated black quartz. On weathered surfaces the alunite is a dull buff color, but on a fresh fracture it is very pink.

2 — 8-foot sample continued N. 85° W. from sample 1.

Pink alunite including a little more dickite than in sample 1. Black brecciated quartz more abundant than in sample 1. West end of sample ends at 2-foot zone of soft, loose rock.

Sulfur, 18.34 percent; silica, 26.40 percent.

3 — 9-foot sample bearing N. 75° W. from west end of zone noted in sample 2 description.

Crystalline pink alunite cementing brecciated black quartz and some dickite. Amount of brecciated quartz greater than in previous two samples.

Light-gray quartz almost absent.

Sulfur, 13.43 percent.

4 — 8-foot sample continued N. 75° W. from sample 3.

Black to gray, hard quartz, including crystalline pink alunite in eastern 4 feet of sample. Rest of sample is partially silicified gray andesite containing green phenocrysts of a chloritic mineral. Western half of sample in loose rock, which is largely in place.

Sulfur, 7.70 percent; alumina, 18.19 percent; silica, 40.17 percent.

5 — 11-foot sample continued from sample 4, bearing N. 73° W.

Gray, slightly porous quartz; no alunite.

6 — 9-foot sample continued from sample 5, bearing N. 80° W.

Gray quartz and some alunite, the pink variety. Also some brecciated black quartz containing alunite.

Sulfur, 10.28 percent; alumina, 13.84 percent; silica, 37.24 percent.

7 $8\frac{1}{2}$-foot sample continued from sample 6, bearing N. 70° W.

Eastern $3\frac{1}{2}$ to 4 feet in hard gray barren quartz.

Western half of sample is in gray quartz including quite a bit of alunite.

Sulfur, 9.08 percent; alumina, 18.01 percent; silica, 35.09 percent.

8 6-foot sample continued from sample 7, bearing N. 55° W.

Altered and partly silicified andesite and gray quartz. Contains a considerable amount of white and gray, soft material that resembles alunite.

9 $6\frac{1}{2}$-foot sample continued from sample 8, bearing N. 80° W.

Eastern $2\frac{1}{2}$ feet in siliceous andesite, dark gray in color; no alunite.

Rest of sample is in soft, altered rock, including much white soft clay that is probably alunite. Groundmass is quartz.

Sulfur, 5.35 percent; alumina, 13.45 percent; silica, 42.27 percent.

10 7-foot sample continued from sample 9, bearing N. 85° W.

White soft clay (alunite) in a gray quartz groundmass. Some brecciated black quartz included in the alunite. About half of the rock is clay.

11 $8\frac{1}{2}$-foot sample continued from sample 10, bearing N. 77° W.

Eastern 2 feet in material like that described for sample 10.

At 2 feet is a 10-inch zone, striking N. 5° E., that is either a vertical fault zone or closely spaced vertical joints.

West of this zone is the brecciated black quartz in a buff soft material that may be alunite but is weathered and stained. It resembles the pink alunite seen in trench 210, up the hill from this trench, except in color.

12 10-foot sample continued N. 77° W. from sample 11.

Hard, dense dark quartz, including very little, if any, alunite.

Sulfur, 1.72 percent; alumina, 13.68 percent; silica, 54.95 percent.

13 10-foot sample beginning 2 feet south of west end of sample 12 and bearing N. 17° E.

Very siliceous andesite and a small amount of alteration material.

Sulfur, 10.62 percent; silica, 39.41 percent.

14 3-foot sample continued N. 17° E. from sample 13.

Much pink, white, and gray alteration material, some of which is alunite.

Some dark brecciated quartz.

Sulfur, 19.36 percent.

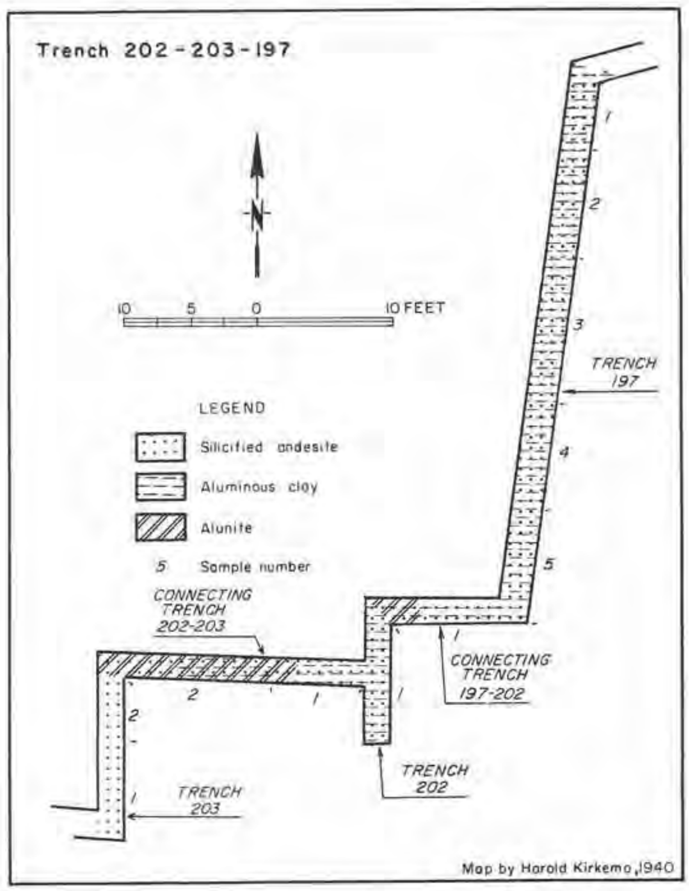


FIGURE 23.— Detailed geology of alunite prospect trench 202, connecting trench 202-203, trench 203, connecting trench 197-202, and trench 197, in King County, Washington.

Sample no. — Sample Description

Trench 202 — Sec. 7, T. 19 N., R. 8 E.

1 10-foot sample bearing due north up a 43° slope.

Black dense quartz and a mineral that appears to be dickite rather than alunite; quartz and dickite occur in nearly equal amounts.

The dickite is gray white in color, dense, massive, shows no crystal faces, hardness about 2.5 to 3, same weight as alunite, has conchoidal fracture. No variation in color; has no cryptocrystalline faces such as alunite displays.

Sulfur, 4.50 percent; alumina, 17.48 percent; silica, 44.41. percent.

Connecting Trench 202-203 — Sec. 7, T. 19 N., R. 8 E.

1 8-foot sample beginning in trench 202, 5 feet north of south end of sample 1 of trench 202. Connecting trench 202-203 bears N. 88° W.

Eastern 5½ feet of sample is in black dense quartz and an equal amount of what appears to be dickite.

Western 2½ feet of sample was taken in black or dark quartz including pink alunite. Alunite becomes more pink in color near west end of sample. Contact between dickite and alunite parts of sample marked by a broken zone— perhaps a fault? Rock bearing the alunite seems to be harder than that containing the dickite and has a smoother outcrop.

2 12-foot sample continuing N. 88° W. from sample 1 to middle line of trench 203.

Eastern 7 feet of sample is in brecciated quartz including alunite. Some zones containing siliceous sand may be fault zones. Quite a bit of white mineral included with the pink alunite.

Western 5 feet of sample is in black quartz and crystalline pink alunite. Quartz has been brecciated— individual quartz fragments are crisscrossed with tiny veinlets of pink alunite.

Trench 203 — Sec. 7, T. 19 N., R. 8 E.

1 7-foot sample beginning at south end of trench and bearing due north.

Black quartz including abundant pink alunite and quite a bit of dickite.

2 5-foot sample continued from sample 1, bearing due north, and connecting to west end of sample 2 of connecting trench 202-203.

Pink alunite and dickite in black quartz.

Connecting trench 197-202 — Sec. 7, T. 19 N., R. 8 E.

1 10-foot sample bearing due west from south end of trench 197 to north end of trench 202.

Gray to black quartz including a considerable amount of dickite. Alunite found only in small area near trench 202.

Trench 197 — Sec. 7, T. 19 N., R. 8 E.

1 6-foot sample beginning in north end of trench and bearing S. 7° W.

Gray siliceous rock; original phenocrysts now filled with dickite. Dickite very abundant, gray and white in color, massive in character. Brecciated and included in the dickite is dark to black quartz.

Surrounding the dickite masses is a film of reddish brown material— may be weathering stain or may be another mineral. This border is also seen around the included black quartz pieces. The quartz is crisscrossed with dickite veinlets.

Sulfur, 2.58 percent.

2 8-foot sample continued S. 7° W. from sample 1.

Gray siliceous rock containing much dickite— same as in sample 1.

Red or brownish material noted in sample 1 is also in this sample, and in addition seems to have colored the brecciated quartz.

3 10½-foot sample continued S. 7° W. from sample 2. Same description holds true for this sample as for samples 1 and 2.

About 2 feet of the northern end is in harder, more barren quartz than rest of sample.

4 8-foot sample continued S. 7° W. from sample 3.

Same dense gray quartz as in sample 3. Much dickite.

5 8-foot sample continued S. 7° W. from sample 4 and ending at east end of sample 1 of connecting trench 197-202.

Gray quartz, brecciated, and much dickite. Southern 2 feet does not contain as much dickite as does the rest of the sample.

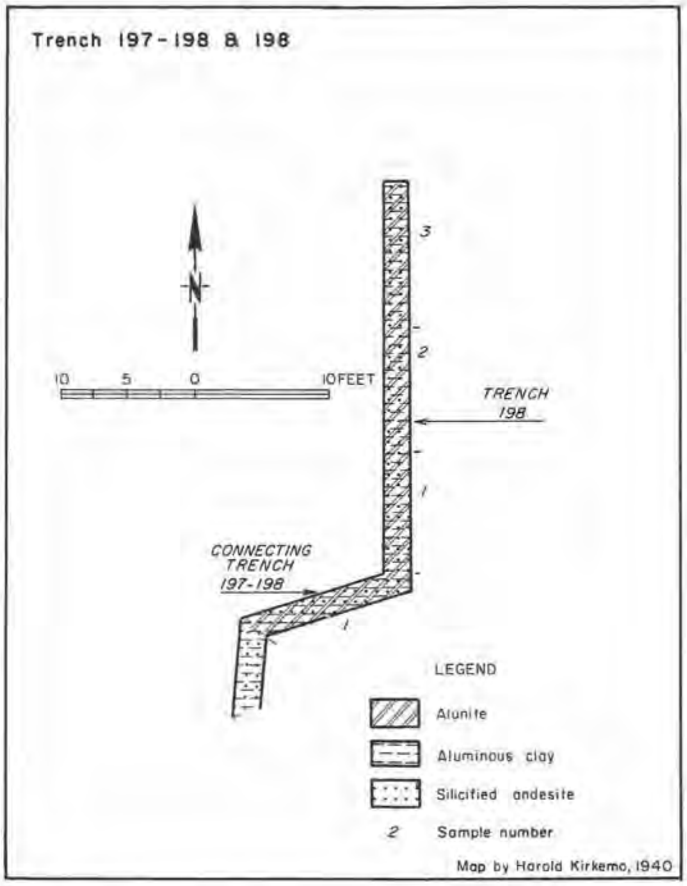


FIGURE 24.—Detailed geology of alunite prospect connecting trench 197-198 and trench 198, in King County, Washington.

Sample no. — Sample Description

Connecting Trench 197-198 — Sec. 7, T. 19 N., R. 8 E.

1 11-foot sample beginning at north end of sample 1 (which is on the north end of trench 197) and bearing N. 73° E. to south end of trench 198.

Brecciated dark quartz cemented with white and gray dickite and some alunite. Pink, amorphous material resembling quartz is present, but is too soft to be quartz— it may be alunite.

Trench 198 — Sec. 7, T. 19 N., R. 8 E.

1 9-foot sample beginning at east end of sample 1 of connecting trench 197-198, at south end of trench 198, bearing due north.

Very good sample of alunite and dickite in brecciated black and gray quartz.

Sulfur, 14.39 percent; alumina, 16.39 percent; silica, 29.85 percent.

2 9-foot sample continued due north from sample 1.

White dickite, pink alunite, and a soft, buff material that is probably weathered alunite in brecciated dark quartz groundmass.

Sulfur, 6.19 percent; alumina, 17.28 percent; silica, 40.16 percent.

3 11-foot sample continued due north from sample 2.

Pink, amorphous alunite and some dickite in brecciated, dark quartz groundmass.

Sulfur, 8.19 percent; silica, 39.82 percent.

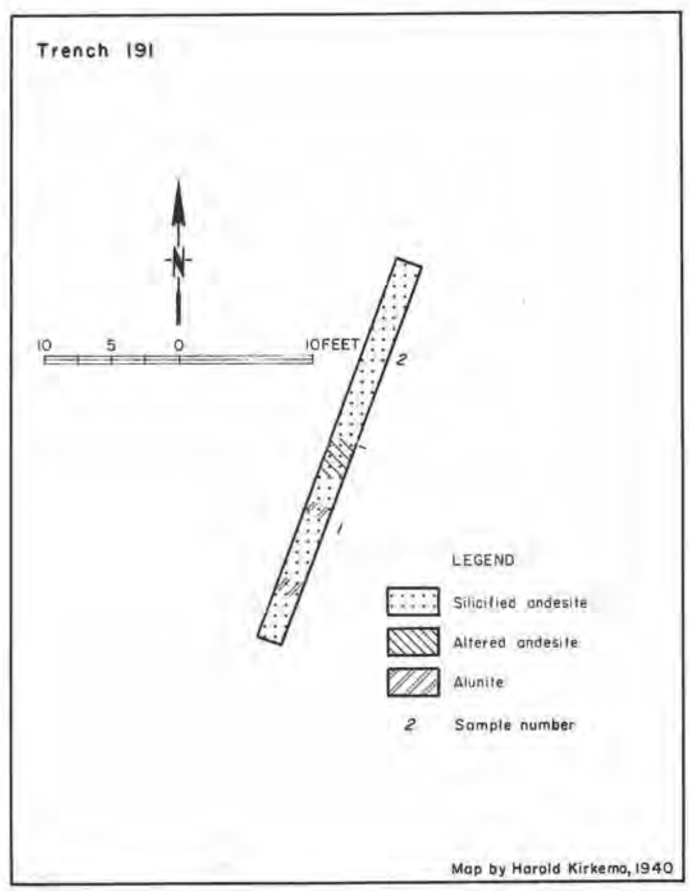


FIGURE 25.—Detailed geology of alunite prospect trench 191, in King County, Washington.

Sample no.	Sample Description
	Trench 191 — Sec. 7, T. 19 N., R. 8 E.
1	16-foot sample beginning in south end of trench and bearing N. 20° E.
	Hard gray and dark quartz and very little alunite. Some of the dark quartz in the north end of the sample contains rounded masses that look like altered andesite.
2	14-foot sample continued N. 20° E. from sample 1.
	Hard gray quartz and very little, if any, alunite.
	Sulfur, 13.12 percent.

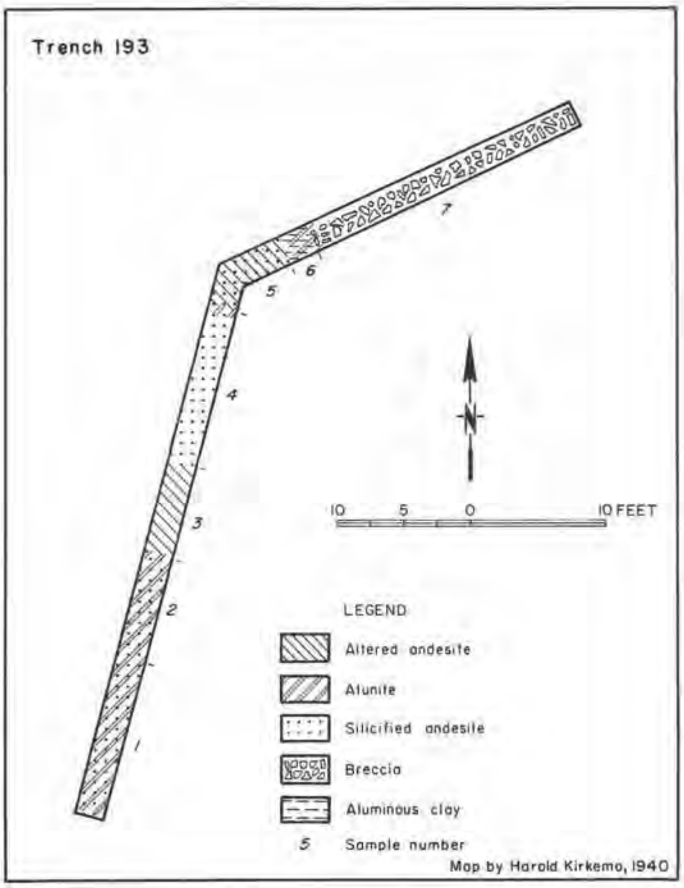


FIGURE 26.— Detailed geology of alunite prospect trench 193, in King County, Washington.

Sample no.	Sample Description
	Trench 193 — Sec. 7, T. 19 N., R. 8 E.
1	12-foot sample beginning at south end of trench and bearing N. 15° E.
	Partially silicified andesite carrying some white powdered material, probably alunite, in the southern 3 or 4 feet of sample.
	Rest of sample has much more of the white alunite, and the rock is light-gray quartz without any relict andesitic texture.
2	8-foot sample continued N. 15° E. from sample 1.
	Partially silicified andesite, in places almost completely silicified, in other places merely altered to a soft material; feldspar vugs filled with a soft white mineral similar to that in sample 1.
	In sample 2 the white clay occurs also in rounded concretionary bodies 2 to 3 inches in diameter.
	2 feet from south end of sample 2 is a suggestion of a vertical fault striking N. 31° W. Zone is about 4 inches wide; it contains dark hard quartz and much of the white mineral that is probably dickite.
	Sulfur, 1.87 percent; alumina, 19.67 percent; silica, 56.24 percent.
3	7-foot sample continued N. 15° E. from sample 2.
	Altered buff andesite and very little quartz. Quite a bit of white alunite present— massive and slightly pink in north end of sample.
	Sulfur, 1.74 percent.
4	12-foot sample continued N. 15° E. from sample 3.
	Most of sample is hard gray quartz; no alunite. Northern 1 foot of sample is in quartz with a little alunite.
5	8-foot sample continued N. 15° E. from sample 4 for 3 feet, then N. 65° E. for 5 feet.
	Altered andesite and quartz including very little alunite.
	Andesite between the 4- and 6-foot marks is dark green and silicified; former feldspar vugs now filled with white clay.
	Sulfur, 1.01 percent; alumina, 10.74 percent; silica, 65.63 percent.
6	2-foot sample continued N. 65° E. from sample 5.
	Soft buff clay, probably alunite. Very similar to that in eastern 4 feet of sample 3 of trench 194.
7	22-foot sample continued N. 65° E. from sample 6.
	Very poor sample. Doubt if any of the rock is in place. Large quartz boulders mixed with

smaller pebbles and rocks. Some of the boulders are 2 to 3 feet in diameter and of hard gray quartz having some alunite in thin films along cracks and joints.

Judging from trench 194 to the east, this part of trench 193 is not deep enough to reach the soft alunite, or the alunite has been leached and washed away, leaving a loose quartz rubble.

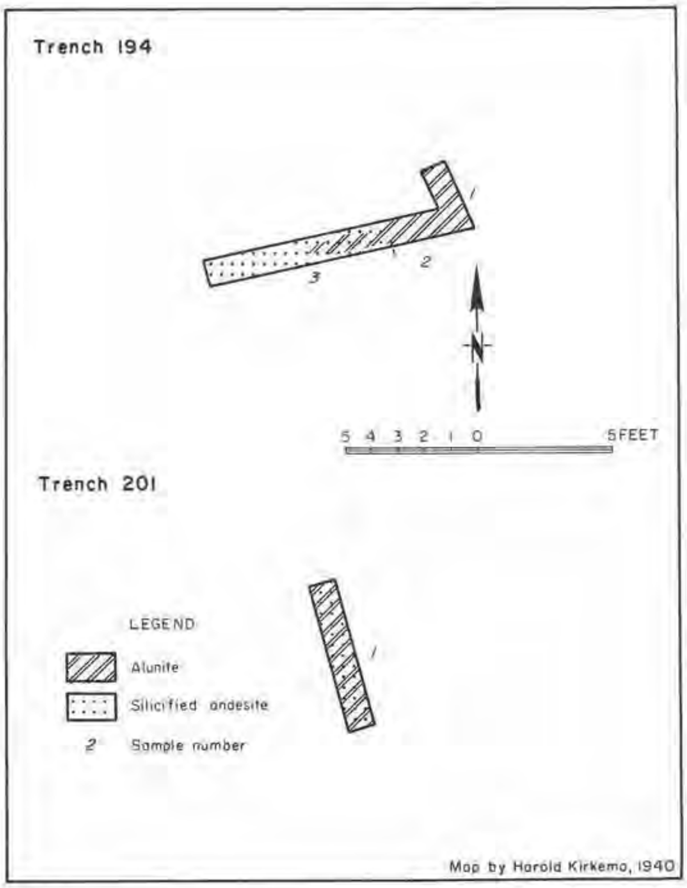


FIGURE 27.— Detailed geology of alunite prospect trenches 194 and 201, in King County, Washington.

Sample no.	Sample Description

Trench 194 — Sec. 7, T. 19 N., R. 8 E.

1 2-foot sample bearing N. 25° W. in best part of trench, eastern end.

Very soft, clayey material, resembling the alunite exposed in the diamond drill settings below the railroad track.

2 2-foot sample beginning in east end of trench and bearing S. 77° W.

Soft, white and pink alunite in a solid mass; no rock present. Alunite looks exactly like that below the railroad track where diamond drill holes are located.

3 7-foot sample continued S. 77° W. from sample 2.

Eastern 4 feet in buff, light-weight clay containing rounded gray quartz nodules and nodules of white, soft clay like that seen in sample 2.

Western 3 feet in a hard, dense gray quartz boulder apparently imbedded in the clay.

The northern wall of this trench is a groundmass of buff, soft clay in which are imbedded quartz boulders and pebbles. These vary in size from that of peas to boulders 6 feet in diameter. These quartz inclusions are usually rounded or subangular, light gray in color, and extremely hard.

Trench 201 — Sec. 7, T. 19 N., R. 8 E.

1 5½-foot sample bearing N. 15° W. Only sample in trench.

Light-gray siliceous rock and both dickite and alunite, probably more dickite than alunite. No structure.

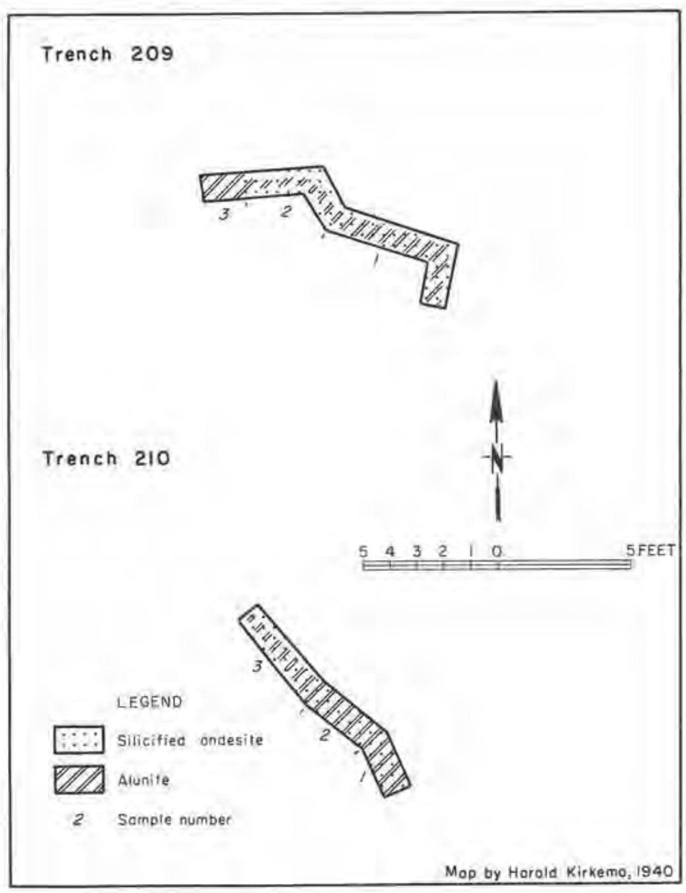


FIGURE 28.— Detailed geology of alunite prospect trenches 209 and 210, in King County, Washington.

Sample no.	Sample Description
	Trench 209 — Sec. 7, T. 19 N., R. 8 E.
1	10-foot sample beginning in east end of trench and bearing N. 10° E. for 3 feet and N. 72° W. for 8 feet.
	Hard, dark-gray quartz including alunite. From 3 feet to 8 feet, sample is not in bedrock but in a gritty, sandy gray clay that has nodules of what appears to be alunite. Nodules may be 1 inch in diameter. Sand grains are larger near bedrock; probably derived from the bedrock.
	Sulfur, 1.18 percent; silica, 55.07 percent.
2	$7\frac{1}{2}$-foot sample bearing N. 32° W. for 3 feet and S. 85° W. for $4\frac{1}{2}$ feet from sample 1.
	Hard, dense gray quartz and a little alunite. Soft gouge zones contain a clay resembling alunite, but it doesn't seem heavy enough.
3	3-foot sample taken in western side of face of trench. West of sample 2.
	Deposit of clay resembling alunite, but not as heavy, lies on top of the quartz bedrock. Clay body is lenticular.
	Trench 210 — Sec. 7, T. 19 N., R. 8 E.
1	4-foot sample beginning in east end of trench and bearing N. 24° W.
	Crystalline pink alunite in dark, hard quartz. No structure. Andesite has been completely silicified.
2	5-foot sample continued from west end of sample 1, bearing N. 53° W.
	Black quartz, much pink alunite, and some dickite. West end of sample is in loose rock, which seems to be in place.
3	8-foot sample continued N. 38° W. from sample 2.
	Rock becoming more brecciated and decomposed. In west end of trench, rock is reduced to a siliceous breccia cemented with alunite or dickite. Veinlet of alunite, dickite, or perhaps calcite at 4 feet from west end of trench. Veinlet is about 1/8 inch wide, in broken rock, irregular in trend but roughly vertical.

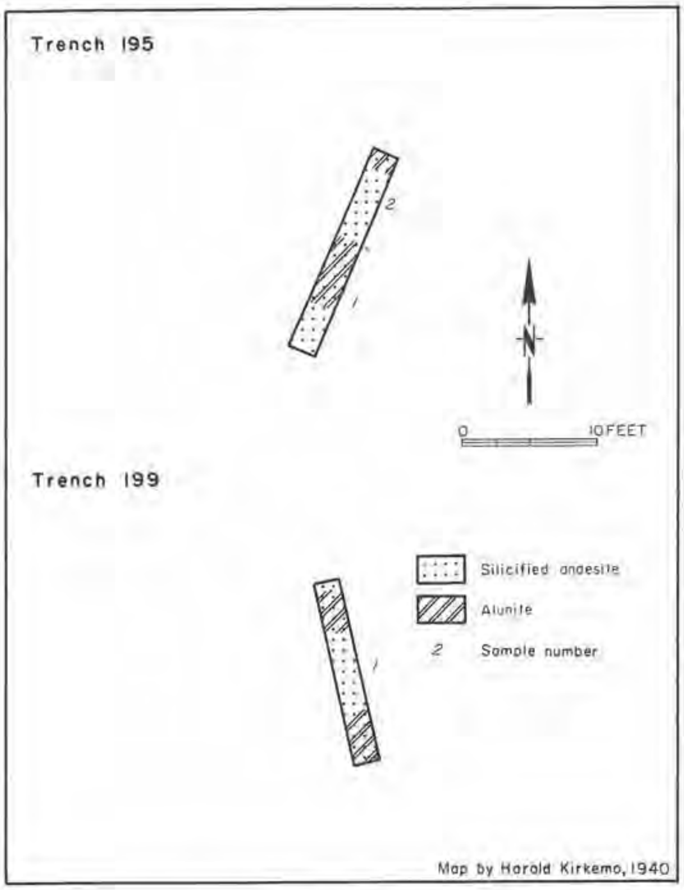


FIGURE 29.— Detailed geology of alunite prospect trenches 195 and 199, in King County, Washington.

Sample no.	Sample Description
	Trench 195 — Sec. 7, T. 19 N., R. 8 E.
1	9-foot sample bearing N. 23° E. from south end of trench.
	Southern 2 feet of sample is in buff siliceous rock containing white phenocrysts. Very similar to altered siliceous andesite. White material may be alunite.
	Rest of sample is dark to black quartz, including some pink alunite in little veinlets and also in round phenocrysts. Not much alunite in proportion to the quartz.
2	7-foot sample continued N. 23° E. from sample 1.
	Black massive quartz replacement of the andesite.

Northern 1½ feet of sample has pink crystalline alunite like that found in trench 210.

Trench 199 — Sec. 7, T. 19 N., R. 8 E.

1 14-foot sample bearing N. 12° W.

Replaced andesite and some alunite. Gray, dense quartz, brecciated and cemented with alunite. Alunite is gray and white, not crystalline. Rock in middle 4 feet of trench more broken than that at either end of trench.

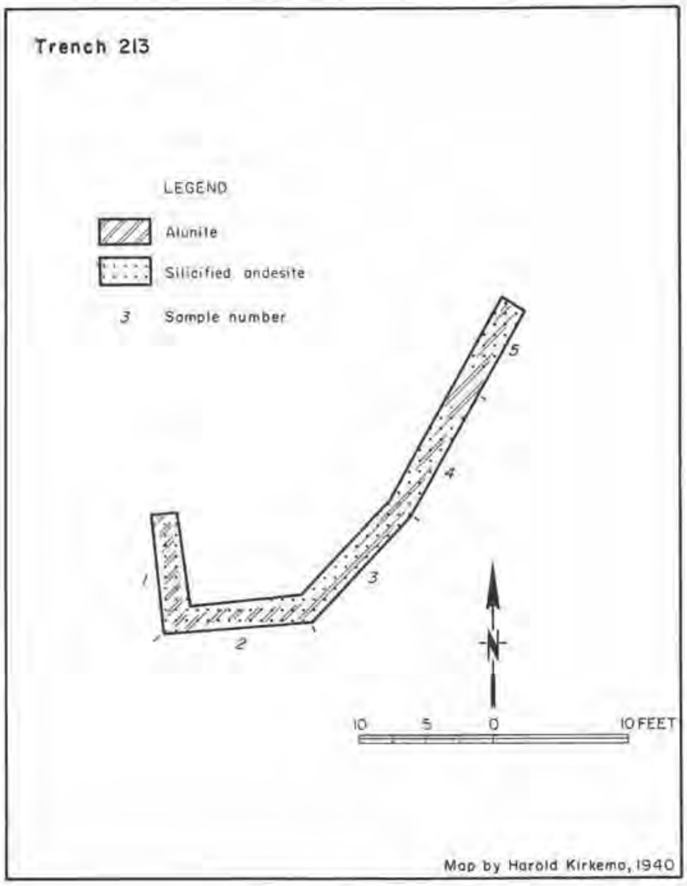


FIGURE 30.— Detailed geology of alunite prospect trench 213, in King County, Washington.

Sample no.	Sample Description

Trench 213 — Sec. 7, T. 19 N., R. 8 E.

1 7-foot sample beginning at south end of the N-S trench bearing N. 7° W.

Gray, relatively soft siliceous rock containing a considerable amount of alunite and dickite.

The rock has been brecciated; there are dark quartz fragments in the country rock.

2 8-foot sample beginning at south end of sample 1 and bearing N. 85° E.

Light-gray quartz and much pink alunite, especially in the middle of the sample. Brecciated black and gray quartz included with the alunite.

3 10-foot sample bearing N. 43° E. from east end of sample 2.

Gray dense quartz containing brecciated black and gray quartz and much pink alunite, especially at east end of sample.

4 10-foot sample beginning at east end of sample 3 and bearing N. 29° E.

Gray quartz, brecciated black quartz, and a great amount of pink alunite; wholly alunite at eastern part of sample.

5 7-foot sample bearing N. 30° E. from east end of sample 4.

Pink alunite in west end; quartz becoming more abundant in eastern part of sample. Brecciated black and gray quartz in the alunite where the alunite is not pure. Quartz has a porphyritic appearance near the pure alunite—phenocrysts of alunite. Farther from the alunite masses the quartz is dense and alunite occurs in irregular clots, not as vug fillings.

Trench 213 seems to be on the strike of the alunite outcrop on the north side of the railroad track, 128 feet west of the east section line, sec. 7, T. 19 N., R. 8 E., along the railroad track. It is in this outcrop that the silicified andesite and the gray quartz was found completely surrounded by pink alunite. Characteristics seen on a large scale in this outcrop are seen on a minute scale in trench 213.

The alunite occurs in andesitic rocks of the Ohanapecosh(?) Formation. The unit is composed of flows, flow breccias, and water-laid pyroclastic breccias. Hammond (1963) mapped part of the area in which the alunite occurs, and he shows intrusive rocks on the ridge immediately north of the deposits. Ohanapecosh(?) rocks have been severely altered in the area; they vary from hard, completely bleached and silicified material to a soft pyritic clay. The silicified rock is porous, containing many quartz crystal-lined cavities varying in size from microscopic to almost a foot in diameter. Many of these cavities are filled with clay. The softer altered rock is chiefly a mixture of clay, quartz, alunite, and pyrite.

The alunite is regarded as having replaced the original rock by some filling in of open spaces along faults in the silicified rocks. Both core and trench samples show angular fragments of silicified rocks cemented by alunite. Because of their close spatial relation, it is thought that possibly the silicification and alunitization are part of the same alteration phase, although the alunite, at least in part, may be later. The highest grade alunite occurs in small bodies that formed in places most favorable for maximum replacement. This, of course, depended on the location of channels for ascending solutions, conditions of deposition, and a continuous supply of replacing minerals. Outside of these small high-grade areas, alunite is disseminated in varying amounts through the altered rocks. Most of the alunite thus far discovered has been beneath a cap of silicified rock, so areas where silicification occurs must be considered as favorable for prospecting.

Clay

Clay has been mined in King County since at least 1892, when the first brick plant started production at Taylor, using shales from the Puget Group as the raw material. The Seattle fire of 1889 was probably the greatest single factor in stimulating the use of clay products, as people looked to noncombustible material for rebuilding of the city. Extensive use of paving brick in Seattle also helped to establish the industry. Records show that by 1901 more than 29 million red bricks were produced annually. Available records indicate that more than 2 million tons of clay was used between 1920 and 1969.

Refractory and common clays are the principal clays presently being mined in King County. Other clays, with either a bloating potential or a high alumina content, occur in the county but were not being produced in 1969.

Most of the clay mined in the county comes from shale and claystone beds of the Puget Group of Eocene age, and is used in making refractory and heavy clay products. Glacial clay mined from Pleistocene drift is used to make flower pots and is mixed with limestone in the manufacture of cement.

Shales and claystones of the Puget Group.— There is sufficient similarity in the physical properties of the Puget shales and claystones so that they can be considered as a single group. In many instances properties of samples taken from different beds in a deposit show a wide variation, but when mixed together this wide range in properties disappears.

The shales generally have a low lime content but are moderately high in iron. Some are soft and friable and readily respond to treatment; others are hard and tough and difficult to work. A combination of jaw crusher and dry-pan is all that is required to work most kinds. Good plasticity can usually be developed in a wet-pan.

Certain beds in the Puget Group contain very refractory shale, having cone fusions as high as 34; however, most of the shale in the Puget fuses at a much lower cone. Fired shrinkage is low. The fired color is brown or red except for the refractory types, which fire buff. When fired to steel hardness, the clayware is dense, tough, and has a low porosity. Carbonaceous material is common in the shales because they are usually associated with coal seams; in firing, it may cause bloating or black-coring.

Hammer Bluff clay.— Clays of the Hammer Bluff Formation occur in a small area about 10 miles east of Auburn, toward Black Diamond. They are mostly sandy, but show considerable variation in texture. Generally, they are all free-working clays of good plasticity and moderate shrinkage. The firing range varies between cone 3 and cone 15, and complete fusion generally occurs at about cone 23. Some samples have been fired to cone 28, however. The clays fire to grays and buffs, and when properly treated are suitable for terra cotta, some kinds of stoneware, and yellow earthenware.

Table 5 includes descriptions of three samples of Hammer Bluff clay (Glover, 1941) that give a general idea of the characteristics of the clays in that formation. Following is a list of definitions for abbreviations used in the tables:

L.S.% d.l.— Linear shrinkage in percent of dry length.

T.L.S.% d.l.— Total linear shrinkage (drying and firing) in percent of dry length.

V.S.% d.v.— Volume shrinkage in percent of dry volume.

Abs.— Absorption.

A. Por.— Apparent porosity.

*— Indicates that the sample was fired to the given temperature in a commercial kiln.

S.H., Lt., Dk.,— Steel hard, light, dark.

TABLE 5.— Properties of Hammer Bluff clay in King County, Washington

[Modified from Glover, 1941, p. 145, 146]

Hammer Bluff sample 158 (Glover, 1941, p. 145) is of a 12-foot bed of clayey sand taken from Hammer Bluff in the NE$\frac{1}{4}$ sec. 28, T. 21 N., R. 6 E. The material is nearly white in color and has a uniformly coarse texture. It is composed of quartz sand, kaolin, muscovite, and some few grains of basalt. When dry the clay is so friable it is easily pulverized between the fingers.

Plastic and dry properties

Plasticity	Weak
Shrinkage water	3.6%
Pore water	13.9%
Water of plasticity	17.5%
Volume shrinkage	6.7% dry volume
Linear shrinkage	2.3% dry length
Dry condition	Weak

Fired properties

Cone	Color	Condition	L.S.% d.l.	T.L.S.% d.l.	V.S.% d.v.	Abs.	A. Por.
04	Light gray, near white	Granular, weak, soft	0.7	3.0	2.2		
01	Light gray, near white	Granular, weak, soft				19.0	33.7
3-4	Light gray, near white	Granular, soft	0.8	3.1	2.6	18.5	32.5
6-7*	Spotted light gray	Granular, soft				15.6	28.1
12*	Spotted light gray	Granular, hard	1.7	4.0	5.0	12.9	22.6

Remarks: Best firing range: 8-15. Cone fusion: 28-29. Weak plastic and dry strength. Does not develop strength until late. Needs mixing with more plastic clay.

Class of ware: No. 2 siliceous refractory.

TABLE 5.— Properties of Hammer Bluff clay in King County, Washington— Continued

Hammer Bluff sample 159 (Glover, 1941, p. 146) is from 4 feet of tough gray clay that overlies the clayey sand of sample 158 and is separated from it by $1\frac{1}{2}$ feet of woody lignite. It is nearly white in color and is rather fine-grained, especially so when compared with the foregoing sample. In fact, the chief difference between the two is in fineness of grain and in the greater amount of clay substance of sample 159, which makes it more compact.

Plastic and dry properties

Plasticity.................................Fair
Shrinkage water.........................5.8%
Pore water............................15.1%
Water of plasticity.....................20.9%

Volume shrinkage...........10.9% dry volume
Linear shrinkage.............3.8% dry length
Dry condition...........Moderate dry strength

Fired Properties

Cone	Color	Condition	L.S.% d.l.	T.L.S.% d.l.	V.S.% d.v.	Abs.	A. Por.
04	Light cream	Weak, soft	0.9	4.7	2.7		
03	Light cream	Weak, soft				18.8	33.1
1	Light cream	Weak, soft				16.4	32.6
3-4*	Light buff	Good, hard	2.2	6.0	6.5	14.7	28.9
6-7*	Light spotted buff	Good, S.H.	2.8	6.6	8.2	12.7	23.4
12*	Gray-buff	Good, S.H.	5.4	9.2	15.2	8.2	17.4

Remarks: Best firing range: 3-15. Cone fusion: 27.
Class of ware: Buff-firing structural wares; terra cotta. Buff-colored pottery, siliceous type.

Hammer Bluff sample 160 (Glover, 1941, p. 146) is similar to sample 159 but is of more weathered material from a little farther east in the same exposure. It is somewhat stained in part with iron oxide.

Plastic and dry properties

Plasticity..............................Good
Shrinkage water........................11.6%
Pore water............................16.2%
Water of plasticity.....................27.8%

Volume shrinkage........20.9% dry volume
Linear shrinkage...........7.5% dry length
Dry condition.....................Good

Fired properties

Cone	Color	Condition	L.S.% d.l.	T.L.S.% d.l.	V.S.% d.v.	Abs.	A. Por.
012	Light gray, near white	Weak, soft				22.3	36.7
01	Light buff	Good, hard				20.4	33.6
3-4*	Light buff	Good, S.H.	5.3	12.8	15.0	14.2	26.6
6	Light buff	Good, S.H.	6.1	13.6	17.3	10.9	22.0
15	Spotted gray	Good, S.H.				1.4	

Remarks: Best firing range: 01-8. Cone fusion: 27.
Class of ware: Buff-colored structural wares; terra cotta.

TABLE 6.— Properties of glacial clays in King County, Washington

[Modified from Glover, 1941, p. 153, 154]

Glacial clay sample 386 (Glover, 1941, p. 153) is a mixture of sand and bluish-gray glacial clay from a deposit at 5000 West Marginal Way, Seattle.

Plastic and dry properties

Plasticity.............................Good
Shrinkage water.......................9.5%
Pore water...........................14.5%
Water of plasticity..................24.0%

Volume shrinkage.........18.7% dry volume
Linear shrinkage...........6.7% dry length

Fired properties

Cone	Color	Condition	L.S.% d.l.	T.L.S.% d.l.	V.S.% d.v.	Abs.	A. Por.
010	Buff-brown	Weak, soft	0.0	6.7	0.0	16.2	30.1
06	Buff-red	Good, hard, light scum	2.5	9.2	7.4	14.9	30.3
02	Red-brown	Good, S.H.	5.7	12.4	16.2	6.0	13.6

Remarks: Best firing range: 07-02. Cone fusion: 2.
Class of ware: Now used for common structural wares.

Glacial clay sample 391 (Glover, 1941, p. 154) is a mixture of sand and bluish-gray glacial clay from a deposit at 4200 West Marginal Way, Seattle.

Plastic and dry properties

Plasticity.............................Good
Shrinkage water.......................9.8%
Pore water...........................18.9%
Water of plasticity..................28.7%

Volume shrinkage.........17.3% dry volume
Linear shrinkage...........6.1% dry length

Fired properties

Cone	Color	Condition	L.S.% d.l.	T.L.S.% d.l.	V.S.% d.v.	Abs.	A. Por.
010	Buff-brown	Weak, soft			1.3	20.5	35.5
06	Buff-red	Light, scum, good, soft	0.9	7.0	2.7	19.4	34.5
02	Dk. red-brown	Vitreous, good, S.H.	9.5	15.6	26.0	1.6	4.1
2	Dk. red-brown	Glazed, badly stuck, S.H.	4.5	10.6	12.9	0.0	0.0

Remarks: Best firing range: 05-02. Cone fusion: 3-4
Class of ware: Now used for red-brown structural wares.

Glacial clays.— In King County, glacial clays are abundant and were once used on a large scale for making brick and tile. These clays are light to dark blue on unweathered surfaces, and weather to various tones of light brown to buff. They are usually sandy or silty and contain pebbles of quartzite and igneous rock. Lateral variation is marked, which makes it difficult to turn out a product of consistent firing characteristics. The clay beds may be as much as 40 feet thick in places.

The working characteristics of the clay are generally good; however, the addition of sand may be needed to open the body up and prevent dragging as the clay goes through the die. Shrinkage is moderate, but the vitrification range is short, which makes proper firing difficult. Fusion begins at about cone 02, and complete fusion occurs between cones 2 and 6. Because of the firing problem, bricks made from glacial clay were not fired to steel hardness and the color was not uniform. At higher temperatures the color is red brown and may become purple or black.

The results shown in Table 6 (from Glover, 1941) are typical of the glacial clays.

Description of Deposits

Various clay deposits in the county have been discussed by Shedd (1910, p. 237-271), Wilson (1923, p. 96, 97, 106-108, 117-118, 122, 131-133, 143, 144, 145, 156, 158, 159, 187, 188, 196, 197), Glover (1941, p. 108-160), and Chew and Boyd (1960, p. 123-143).

Expanding clays have been reported on by Riley (1952), Shapiro (1952), and Riley, Mueller, and Shapiro (1953).

High-alumina clays were examined by Popoff (1945), and Nichols (1946).

Only deposits that were in production in 1969 or were of especial interest because of bloating properties or high-alumina content are described below.

Blum deposit.— The Blum deposit, just east of the abandoned Blue Blaze coal mine, in the NW¼ sec. 31, T. 21 N., R. 7 E., is owned by International Pipe and Ceramics Corp. (Interpace), in Renton. The Blum clay, which is a continuation of the Kummer clay (Chew and Boyd, 1960, p. 136), occurs on the nose and both flanks of the Green River anticline.

The Blum "A" clay seam lies immediately below the Kummer "O" coal seam. The thickness of the clay ranges from 8 feet on the nose of the anticline to 20 feet on the limbs. The clay varies in color from tan to blue and is commonly iron stained. It contains siderite and pyrite, is carbonaceous in part, and breaks with a conchoidal fracture. A chemical analysis of the clay is shown in Table 7.

TABLE 7.— Chemical analysis of the Blum "A" flint clay

[From Chew and Boyd, 1960, p. 138]

	Percent
SiO_2	47.64
Al_2O_3	40.56
Fe_2O_3	7.09
TiO_2	2.38
CaO	2.29
MgO	0.23
Na_2O and K_2O	0.31
Total	100.50

Use of the Blum "A" clay is limited to refractory products that are not affected by the clay's high iron content. The clay has fair plasticity, burns gray to buff at cone 13, and has a fusion temperature of cone 29.

Below the Blum "A" clay is the Blum "B" clay, which represents a transition zone from the flint clay to a thick sandstone unit. Chew and Boyd (1960, p. 138) report that the Blum "B" bed is a 6- to 12-foot sandy clay composed of buff to gray fine-grained sandstone including varying amounts of gray clay as lenticular partings and matrix. It is quite dense, but tends to spall when exposed to weathering. The Blum "B" clay is used for structural and low-duty refractory ware. The clay has poor plasticity, burns white at cone 13, and has a fusion temperature of cone 19.

The Blum clay is one of the deposits studied by Popoff (1945, p. 11) and Nichols (1946) as a possible source of alumina. Popoff (Table 1, p. 13) estimated measured and indicated reserves at 1,047,000 dry tons of clay having 33.0 percent available Al_2O_3 and 8.9 percent Fe_2O_3; Kelly and others (1956, p. 32) report that kaolinite is the principal clay mineral and that boehmite and gibbsite are also present.

FIGURE 32.— Mined-out section of the Blum clay deposit, in King County, Washington, that is being developed as a recreation site.

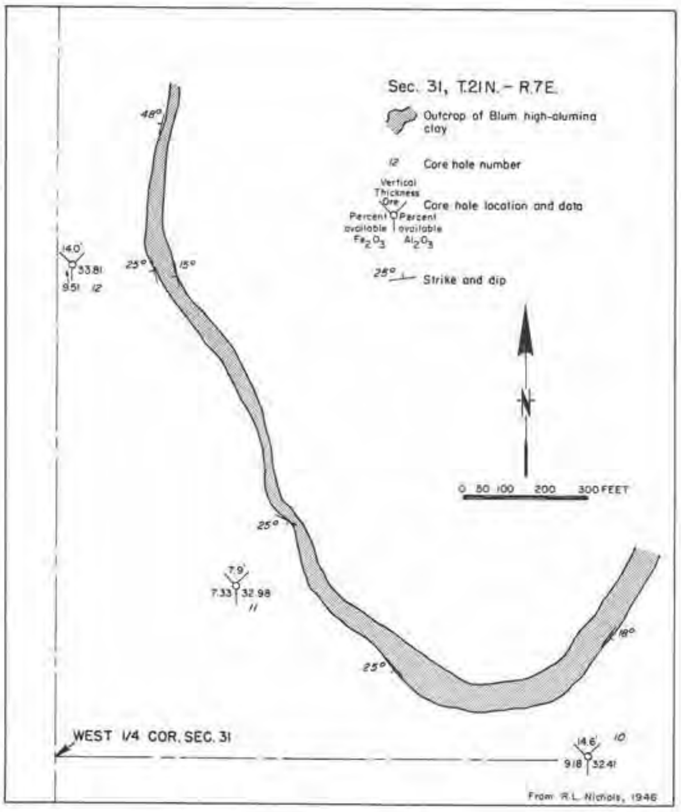


FIGURE 31.— Blum high-alumina clay deposit, in King County, Washington.

For about 10 years Interpace has mined this deposit, using stripping methods. About 2 to 20 feet of glacial overburden must be removed to get to bedrock. The amount of bedrock overburden that must be removed is dependent on the dip of the beds, which varies from about 15° to 48° (Fig. 31). Mining is done at 2-year intervals, at which time the clay is taken out of the pit and put into stockpiles on the property. By mining ahead in this manner, the company is able to maintain a uniform product by blending different clays as necessary.

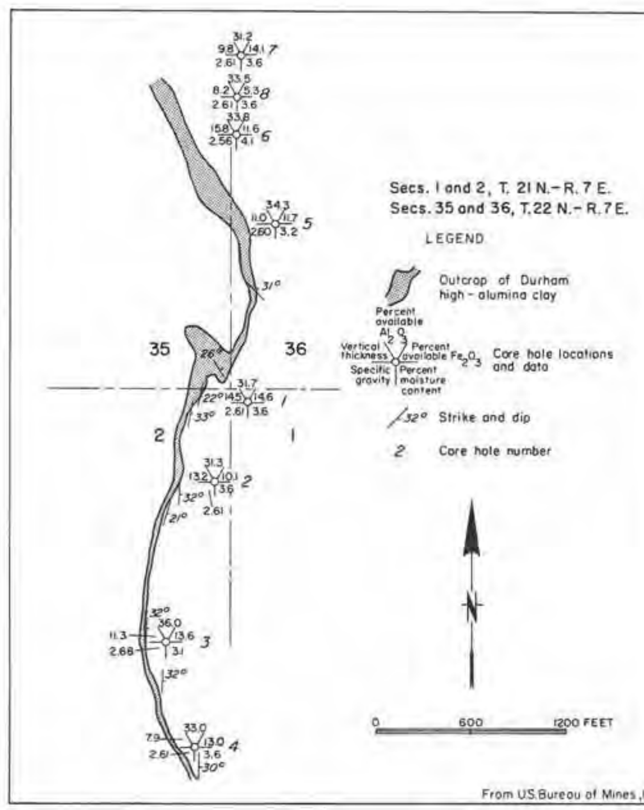


FIGURE 33.— Durham high-alumina clay deposit, in King County, Washington. [Figure 3 from U.S. Bureau of Mines War Minerals Report 18, project 1202.]

Durham high-alumina clay deposit.— This deposit was examined by Popoff (1945, p. 9) and Nichols (1946, p. 12). It is in secs. 35 and 36, T. 22 N., R. 7 E., and secs. 1 and 2, T. 21 N., R. 7 E., and crops out along the west face of the mountain front.

The clay, which ranges in thickness from 7 to 15 feet, is interbedded with sandstone, shale, and siltstone. The strike of the clay bed is about N. 15° W. in the southern part of the outcrop area (Fig. 33), swings around to N. 15° E. in the center, and then swings back to about N. 30° W. at the north end. Dips are from about 20° to 30° E.

Popoff (1945, Table 1) estimated that the measured and indicated reserves were 2,384,000 tons of clay, having 33.1 percent available Al_2O_3 and 12.1 percent Fe_2O_3. Because of the dip and strike of the clay bed and its location on the hillside, it would have to be mined by underground methods.

Elk deposit.— The Elk clay deposit is on the east side of Sugarloaf Mountain, about 1.25 miles north of Kanaskat, in the SW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 34, T. 22 N., R. 7 E. The property is owned by Mutual Materials Co., Seattle. The clay is mined with a ripper and a front-end loader and is transported by truck to Mutual's brick plant at Newcastle.

The pit is in a shale sequence of the Puget Group and is floored on an altered volcanic sill. The shale weathers out in small chips or flakes, and weathered material crumbles very easily. The clay beds strike N. 5° W. and dip about 5° NE. The complete section exposed in the pit, starting at the bottom, consists of 12 feet of black coaly shale, a 9-foot white, partially silicified volcanic rock, 20 feet of dark carbonaceous shale, and 15 feet of gray to tan clayey siltstone.

Only the clay material on top of the sill is mined by the owner. The clay is used to make structural ware. Table 8 gives the firing characteristics of the different units in the pit.

Harris deposit.— The Harris clay pit has been described by Glover (1941, p. 120), Hodge (1938c, p. 761), and Chew and Boyd (1960, p. 130). It is along the Issaquah-Renton highway about 3 miles from Issaquah in the SW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 32, T. 24 N., R. 6 E. The property is owned by International Pipe and Ceramic Corp., Renton.

The clay is interbedded with sandstones and conglomerates of the Puget Group and lies below the Jones coal seam (Chew and Boyd, p. 130). The beds strike about N. 70° W. and dip northeast into the valley wall at approximately 30°. The total clay section appears to be about 75 feet thick. The clay that is mined is about 20 feet thick and is in the upper part of the clay section. It is dark gray and massive when fresh, but a shaly structure develops upon weathering. It is compact and has a high organic content. At one time the clay was mined by underground methods, but now it is taken from an open pit by using a ripper and a front-end loader, then hauled by truck to Renton (Fig. 34).

FIGURE 34.— Stripping overburden off the clay seam at the Harris deposit, in King County, Washington. Front-end loader is on minable clay.

Hodge (1938, p. 762) reported the following results of an analysis of a sample from the Harris clay:

	Percent
SiO_2	53.36
Al_2O_3	29.14
Fe_2O_3	3.66
CaO	1.34
MgO	0.19
Loss on ignition	14.56
Total	101.25

The clay has good plasticity, is buff firing, and has a fusion temperature of approximately cone 31. When fired at cone 13, it has a total shrinkage of 4.9 percent, absorption of 14.3 percent, and porosity of 27.2 percent. It is used to make refractory ware.

TABLE 8.—Results of thermal gradient tests on samples from the Elk clay deposit, King County, Washington

Elk No. 1, dark carbonaceous silty shale (bottom of section)

Percent water of plasticity... 10.5
Percent dry shrinkage 3.1

Firing temperature (°F)...	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage...	4	3	3	....	3	....	....	1
Percent absorption.......	19	20	18	....	24	....	....	26
Color..................	White							White

Elk No. 2, dark-gray carbonaceous claystone

Percent water of plasticity... 9.9
Percent dry shrinkage 1.3

Firing temperature (°F) ..	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage ..	3	2	....	2	....	1	....	1
Percent absorption	24	22	....	25	....	25	....	28
Color	White							White

Elk No. 3, dark carbonaceous, almost coaly shale

Percent water of plasticity... 12.3
Percent dry shrinkage 1.5

Firing temperature (°F) ..	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage ..	7	7	....	5	....	0	....	0
Percent absorption	20	20	....	26	....	28	....	34
Color	White							White

Elk No. 4, light-gray sandy siltstone

Percent water of plasticity... 10.6
Percent dry shrinkage 3.1

Firing temperature (°F) ..	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage ..	6	4	....	2	....	1	1	....
Percent absorption	20	22	....	23	....	24	24	....
Color	White							White

Elk No. 5, dark-gray carbonaceous shale

Percent water of plasticity... 11.6
Percent dry shrinkage 1.3

Firing temperature (°F)...	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage...	5	5	4	....	2	....	1	....
Percent absorption.......	15	17	18	....	21	....	27	....
Color	White							White

Elk No. 6, light-gray claystone having abundant iron staining (top of section)

Percent water of plasticity... 11.0
Percent dry shrinkage 1.0

Firing temperature (°F)..	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage..	5	2	....	2	....	2	2	1
Percent absorption	23	20	....	21	....	22	22	24
Color.................	White							White

Elk No. 7, sample from surge pile on property

Percent water of plasticity... 11.8
Percent dry shrinkage 2.0

Firing temperature (°F) ..	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage ..	4	2	2	....	2	....	1	....
Percent absorption	10	14	15	....	17	....	22	....
Color	White							White

Kanaskat high-alumina clay deposit.— The Kanaskat deposit is in sec. 12, T. 21 N., R. 7 E. It crops out along the southwest face of the same mountain on which the Durham clay is located.

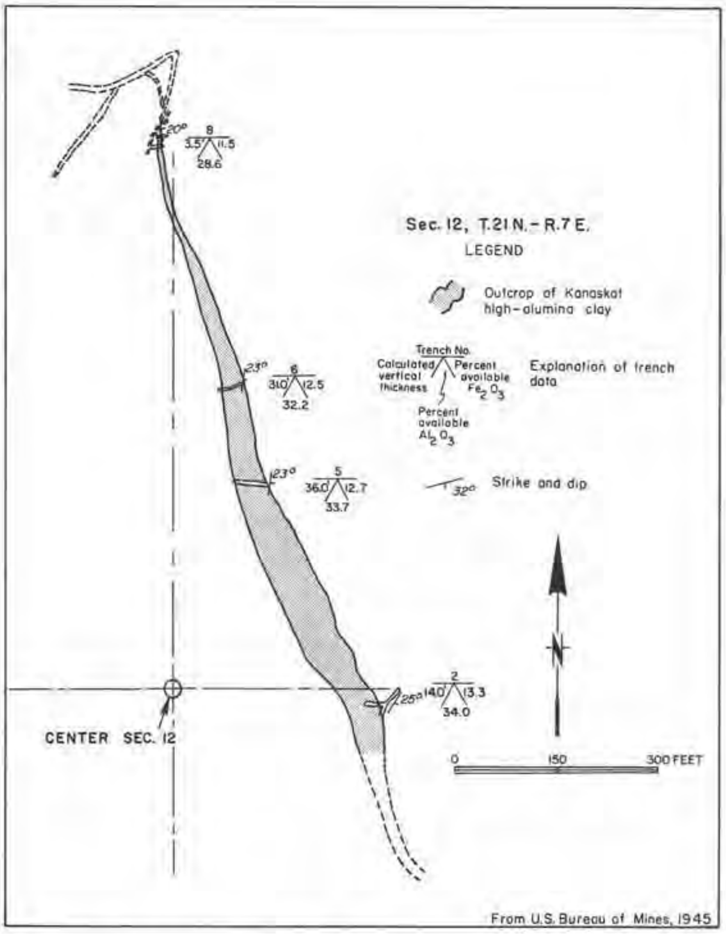


FIGURE 35.— Kanaskat high-alumina clay deposit, in King County, Washington. [Figure 5 from U.S. Bureau of Mines War Minerals Report 18, project 1202.]

The clay bed is overlain by a coal seam and is underlain by sandstone and siltstone beds of the Puget Group. The contact of the Puget Group and the Keechelus Andesite is only about 350 feet stratigraphically above the clay. The clay strikes north and dips between 20° and 25° E. It ranges in thickness from 3.5 feet to 30 feet and averages 18 feet. It is thickest in the northern part of the deposit (Fig. 35). Popoff (1945, Table 1) estimates 312,000 tons of indicated reserves containing 32.9 percent Al_2O_3 and 12.7 percent Fe_2O_3. The clay is predominantly kaolinite, including a small amount of boehmite. Impurities are siderite, quartz, feldspar, mica, and carbonaceous material (Kelly and others, 1956, p. 32).

Like the Durham deposit, the Kanaskat clay would have to be mined by underground methods, because it dips into the hillside.

Kangley high-alumina clay deposit.— The Kangley clay is in the SE¼ sec. 26, T. 22 N., R. 7 E., about 900 feet east of the town of Kangley. Two beds, about 30 feet apart, that strike N. 10° to 15° W. and dip about 35° to 40° E., are exposed along Alta Creek. Popoff (1945, p. 10) reports that the lower bed is 5.5 feet thick where exposed and that the upper bed is almost 9 feet thick. Analyses show that the lower bed contains 32.1 percent Al_2O_3 and 7.2 percent Fe_2O_3. The upper bed has 27.1 percent Al_2O_3 and 4.9 percent Fe_2O_3. Popoff made no estimate of reserves. Kelly and others (1956, p. 32) report that the clay is primarily kaolinite, including minor amounts of boehmite. Impurities are quartz, mica, and carbonaceous material.

Palmer clay deposit.— The Palmer clay deposit is on Northern Pacific Railway property in the NE¼ sec. 14, T. 21 N., R. 7 E., and is operated by the International Pipe and Ceramic Corp., Renton. The pit is in a hard, slightly silty shale of the Puget Group. The beds strike north and dip about 30° E. The clay is mined by using a ripper and a front-end loader, then is hauled by truck to Renton. The shale has good plasticity, is buff to brown firing, and has a fusion temperature of cone 17. When fired to cone 13, it has a total shrinkage of 10 percent, linear shrinkage of 9 percent, absorption of 6.4 percent, and porosity of 12.9 percent. It is used for low-duty refractories and building brick.

Section 31 clay and sand deposit.— This deposit is on Northern Pacific Railway property in the NE¼NW¼ sec. 31, T. 24 N., R. 6 E., on top of Cougar Mountain. It is operated by the Mutual Materials Co., Seattle. The pit is in shale, siltstone, and sandstone of the Puget Group, and the sequence being mined lies on top of the Primrose coal seam. The beds strike N. 75° W. and dip 50° NE. On fresh surfaces the shale is dark gray, but it weathers light gray to tan. Near the center of the pit a white, fairly massive sandstone unit crops out. Bedding in the shale varies from very thin laminations to beds 3 feet thick.

TABLE 9.—Results of thermal gradient tests on samples from the Sec. 31 clay and sand deposit, King County, Washington

Sec. 31 No. 2 (sand deposit)

Percent water of plasticity... 14.2
Percent dry shrinkage 1.6

Firing temperature (°F)	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage	....	5	....	3	....	1	....	1
Percent absorption	....	20	....	20	....	22	....	20
Color		Buff						Buff

Sec. 31 No. 4 (sand deposit)

Percent water of plasticity ... 17.3
Percent dry shrinkage........ 1.6

Firing temperature (°F)	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage	5	3	....	3	....	1	1	....
Percent absorption	22	26	....	27	....	28	30	....
Color	Dark brown	Brown		Dark buff			Buff	

Sec. 31 No. 5 (clay deposit)

Percent water of plasticity.... 10.4
Percent dry shrinkage........ 0.8

Firing temperature (°F)	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage	8	5	....	5	....	2	2	2
Percent absorption	9	13	....	16	....	23	24	29
Color	Dark brown			Medium brown		Light brown		

Sec. 31 No. 6 (clay deposit)

Percent water of plasticity.... 11.3
Percent dry shrinkage........ 2.3

Firing temperature (°F)	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage	10	7	....	3	....	3	3	....
Percent absorption	16	13	....	18	....	23	24	....
Color	Dark brown			Medium brown		Light brown		

Sec. 31 No. 7 (clay deposit)

Percent water of plasticity.... 16.0
Percent dry shrinkage 2.3

Firing temperature (°F)	2,080	2,050	2,000	1,950	1,800	1,750	1,540	1,500
Percent fired shrinkage	8	6	....	6	....	4	3	....
Percent absorption	5	5	....	8	....	11	19	....
Color	Red brown			Dark red		Red	Salmon pink	

The clay is mined from three areas in the pit and blended to produce the desired firing qualities. The firing qualities of the clay are shown in Table 9. The overall fusion temperature is about cone 01. Building brick is the basic product manufactured from the material in this pit. Mutual Materials Co. has opened a sand pit just off the southeast corner of the clay pit, but stratigraphically below the Primrose coal seam. This material is mixed with the shales to achieve optimum firing characteristics. Table 9 also shows the firing qualities of the material from the sand pit.

"55" sand deposit.— The "55" sand deposit is in the W½ sec. 25, T. 23 N., R. 5 E., on land owned by the Northern Pacific Railway. The pit is operated by the International Pipe and Ceramic Corp., Renton, and is in a massive light-gray- to buff-weathering sandstone that is used as an additive to give desired physical properties to structural materials produced by the company. So far as physical properties are concerned, the sand has poor plasticity, burns orange at cone 3 and gray at cone 13, and has a fusion temperature of cone 15. The pit has been used for several years, but soon will be covered by urban development that is advancing from the west. The pit is being mined with the idea that when it is closed, the land will be better suited for real estate development than for mining purposes.

Miscellaneous clay analyses.— Table 10 gives the results of analyses made on samples collected by geologists of the U.S. Geological Survey in 1959.

The Preston expanding shale (No. 4 on Plate 2) is a medium- to dark-gray, thin-bedded carbonaceous shale that occurs in sec. 29, T. 23 N., R. 7 E. The overall shale section is about 330 feet thick, and includes minor sandstone interbeds. It is overlain by a thick massive sandstone unit, and is thought to be near the top of the Raging River Formation of Eocene age. Figures 36 and 37 show shrinkage and absorption curves on thermal gradient tests run on this shale.

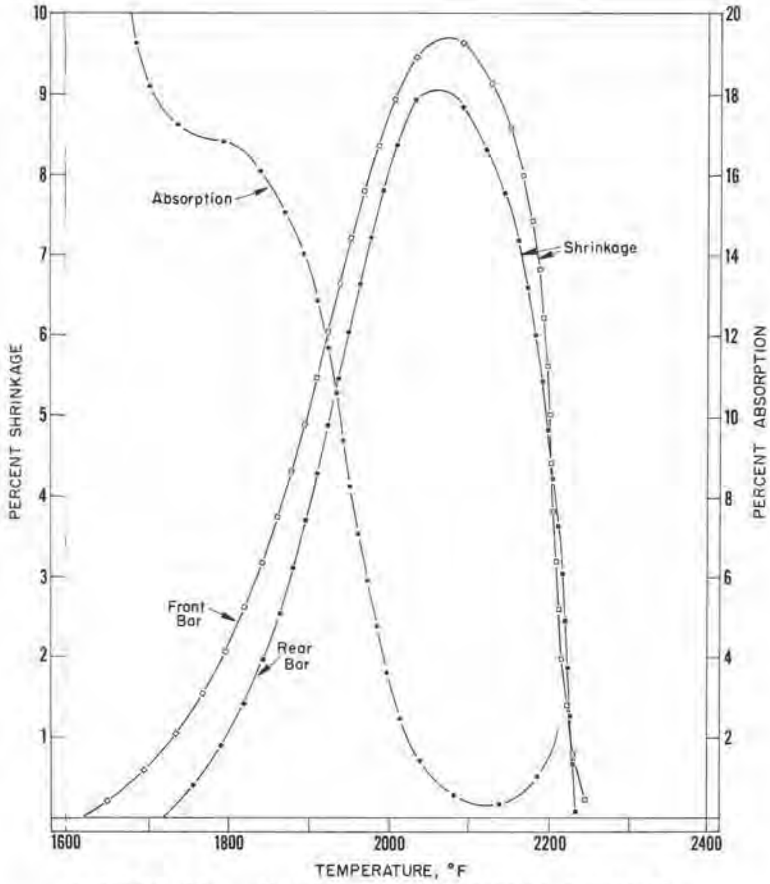


FIGURE 36.— Shrinkage and absorption curves of Preston expanding shale. [Courtesy International Pipe and Ceramics Co.]

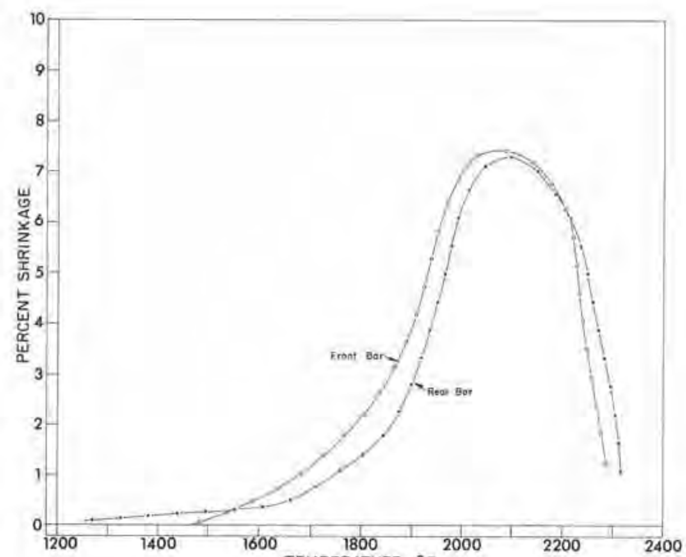


FIGURE 37.— Shrinkage curves of Preston expanding shale. [Courtesy International Pipe and Ceramics Co.]

TABLE 10.— Results of tests on clay samples collected by geologists of the U.S. Geological Survey in King County, Washington, during 1959 1/

Sample no. 2/	PCE	Color cone	Type of bloating	Refractory classification	Mineral content by DTA
W-1	12+	Red-brown.......	Medium.......	Non	Low kaolinite.
W-2	<12	Purple-black.....	High.........	Non	Low kaolinite and organic content.
W-3	12	Red-brown.......	None	Non.........	Low kaolinite and silica.
W-4	19+	Gray-brown......	None	Low.........	Medium kaolinite and high organic content.
W-5	<12	Dark-purple	High.........	Non	Low kaolinite, high organic content, and trace carbonate.
W-6	12-19	Gray-black......	None	Non	Low kaolinite, silica, and carbonate.
W-7	12	Dark-brown......	None	Non	Low kaolinite and silica.
W-8	<12	Brown	High..........	Non	Low kaolinite and medium organic content.
W-9	<12	Dark-brown......	Medium.......	Non........	Low kaolinite, medium organic content, and trace carbonate.
W-10	12	Dark-brown......	None	Non	Low kaolinite, medium organic content, and trace carbonate.
V-6	12+	Dark-gray.......	None	Non	Low kaolinite, silica, and carbonate.
V-20	26	Purple-black.....	None	Low	High kaolinite and medium gibbsite.
V-22	34-	Buff-tan.........	None.........	Super........	Very high kaolinite and low organic content.
V-22A	17	Light-cream......	Medium.......	Non	Low kaolinite.
V-23A	11	Dark-tan	Medium.......	Non	Not tested.
V-23B (brown)	23	Brown-black	None	Low	High kaolinite, montmorillonite intergrowth.
V-23C (gray)	23	Brown-black	None.........	Low	High kaolinite, montmorillonite intergrowth, gibbsite?
PP-1	11	Red-brown.......	None	Non	Not tested.
PP-2	11-19	Light-brown......	Low..........	Non	Not tested.
PP-3	11-19 est. 12	Purple-brown.....	Very high	Non	Not tested.
PP-4	11-19 est. 13	Purple-brown.....	High..........	Non	Not tested.
PP-5	<11	Dark-brown......	Very high	Non	Not tested.
PP-6	11-19 est. 17	Tan	Low..........	Non	Medium kaolinite and high organic content.
PP-7	19	Dark-buff	None.........	Low	Medium kaolinite and high organic content.
PP-8	11+	Light-brown......	None	Non	Not tested.
PP-10	11-19 est. 12	Red-brown.......	Low..........	Non	Not tested.
PP-11	11-19 est. 12	Green-brown.....	Low..........	Non	Not tested.
PP-12	11-19 est. 15	Light-brown	Low..........	Non	Not tested.
PP-13	19+	Dark-buff	None	Low	Medium kaolinite and medium organic content.
AW-1	23-26	Tan	None	Low	Medium kaolinite or halloysite.
AW-2	33+	Black	None	Super	High kaolinite and medium boehmite.

1/ Analyses by U.S. Bureau of Mines.

2/ Sample numbers correspond to sample locations shown on Plate 2.

The Cedar Mountain expanding shale (E-1 on Plate 2), in the NW¼ sec. 29, T. 23 N., R. 6 E., has the following physical properties:

Before Firing

Bulk density (lb/ft^3)...........73
Moisture content................3.5 percent
Loss on ignition................5.8 percent

After Firing

Processing temp. (°C)..........1,195-1,210
Bulk density (lb/ft^3)...............50-58.8
Compaction strength (psi).......1,970
Absorption......................9.8 percent

The Franklin coal mine expanding shale (E-2 on Plate 2), in the NE¼ sec. 19, T. 21 N., R. 7 E., has the following physical properties:

Before Firing

Bulk density (lb/ft^3)...........80
Moisture content................0.9 percent
Loss on ignition................10.1 percent

After Firing

Processing temp. (°C)..........1,150-1,160
Bulk density (lb/ft^3)..............46.0-61.0
Compaction strength (psi).......1,720
Absorption.....................10.5 percent

The Newcastle strip mine expanding shale (E-3 on Plate 2), in the SW¼ sec. 27, T. 24 N., R. 5 E., has the following physical properties:

Before Firing

Bulk density (lb/ft^3)...........78
Moisture content................2.2 percent
Loss on ignition................5.4 percent

After Firing

Processing temp. (°C)..........1,125-1,130
Bulk density (lb/ft^3)..............52.2-61.8
Compaction strength (psi).......2,250
Absorption.....................10.7 percent

Coal

Coalfields occur in the central and south-central parts of King County (Plate 2). The central part of the county has six primary coal areas: the Newcastle-Grand Ridge, Renton, Cedar Mountain, Tiger Mountain and Niblock, and Taylor fields. All deposits in the south-central part are in the Green River district, which is the largest area and has produced the most coal. The coalfields of the county have been described in detail by Evans (1912), Warren and others (1945), and Beikman and others (1961).

All coal seams in King County occur within the Puget Group. Those in the central area are in the Renton Formation. Gower and Wanek (1963), who mapped many of the coal beds near Cumberland, in the Green River district, did not subdivide the Puget Group in that area.

Coal is reported to have been discovered in King County first during 1853, along the Black River near Renton. A mine was opened on the seams, and coal was produced until 1855, when hostilities between whites and Indians forced closing of the mine. In 1863, coal was discovered near Issaquah, and also on Coal Creek near Newcastle. At first, the Newcastle coal was transported to Lake Washington by wagon and then barged across Lake Washington to Seattle. Later, it was barged down the Black River to the Duwamish River, thence down the Duwamish to Elliot Bay and the Seattle waterfront. In 1870, a tram was built from the mine to Lake Washington. The coal was trammed to the lake, where it was loaded on barges and shipped across the lake. There it was loaded on a second tram that moved it to Lake Union for distribution. King County coal mining grew from this beginning to an industry that produced 1.5 million tons in 1907, the year of greatest production. Annual production hovered around a million tons until 1920, when it began a slow decline that has not stopped— only about 58,000 tons was produced in 1969. Coal production from the county has totaled about 47 million tons, more than half of which came from the Green River fields (Table 11, in pocket).

Remaining coal reserves in King County are estimated by Beikman and others (1961, p. 34) to be about 828 million tons, of which 394 million is bituminous and 435 million tons is subbituminous coal.

TABLE 12.—Averages of analyses (as-received basis) of coal samples from the Renton, Cedar Mountain, Tiger Mountain, Taylor, Niblock, and Newcastle-Grand Ridge areas, King County, Washington

[Tables 9 and 10 from Beikman and others, 1961, p. 34 and 38]

(M—moisture; VM—volatile matter; FC—fixed carbon; Btu—British thermal units. Sources of analyses are Fieldner and others, 1931; Cooper and Abernethy, 1941; and Daniels and others, 1958.)

Area	Coal bed	Proximate (percent)				Sulfur (percent)	Btu	Number of analyses used in obtaining average
		M	VM	FC	Ash			
Renton	No. 1...........	16.6	32.2	39.9	11.2	0.5	9,546	3
	No. 2...........	15.0	32.6	38.6	13.8	.6	9,470	2
	No. 3...........	15.4	34.6	41.5	8.4	.5	10,277	8
	Springbrook	14.1	33.5	46.9	5.6	.4	11,060	1
	Sunbeam..........	14.9	36.0	42.3	6.8	1.0	10,823	3
	Newenham	13.2	37.4	43.1	6.3	1.6	11,130	1
Cedar Mountain...	Discovery	10.1	34.4	37.1	18.3	.5	9,755	2
	Jones............	10.7	36.1	42.2	10.9	.4	10,700	13
	Cavanaugh No. 2..	9.7	40.1	43.7	6.5	.9	11,800	1
Tiger Mountain....	No. 1...........	19.2	32.5	35.9	12.4	.2	8,810	1
Taylor...........	No. 2...........	6.4	36.7	41.4	15.5	1.3	11,140	1
	No. 3...........	4.9	36.1	34.1	24.9	1.9	10,000	1
	No. 4...........	4.8	36.5	48.6	10.1	.8	12,410	1
	No. 5...........	4.3	35.6	45.2	14.9	.7	11,870	1
	No. 6...........	5.6	36.0	44.0	14.4	.9	11,550	1
	Unnamed.........	6.0	34.2	42.9	16.9	.4	11,000	1
Niblock	No. 5...........	4.9	27.3	43.5	24.3	1.5	10,580	1
	No. 4...........	6.1	22.7	58.8	12.4	.9	10,710	1
	No. 3...........	8.2	27.2	53.9	10.7	.5	12,440	1
Newcastle-Grand Ridge	No. 4...........	16.1	30.5	42.2	9.0	.5	9,920	5
	No. 3...........	16.1	31.9	40.6	11.3	.8	9,665	4
	No. 2[a].........	13.8	32.5	36.0	17.7	.5	9,140	1
	Bagley...........	12.7	35.1	40.2	11.9	.4	10,227	10
	May Creek	15.0	34.3	40.2	10.3	.6	10,047	4
	Muldoon.........	14.4	33.0	38.1	14.3	.7	9,537	7
	Dolly Varden	14.2	32.3	40.4	13.0	.7	9,986	6
	Jones	13.8	35.2	36.2	14.8	.6	9,890	1

[a] Present only in Grand Ridge area.

TABLE 13.—Estimated remaining reserves of coal in the Newcastle-Grand Ridge area, King County, Washington, as of January 1, 1960, by township and bed

[Table 11, Beikman and others, 1961, p. 48]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown											
		Measured and indicated				Inferred				All categories			
		2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total
						T. 24 N., R. 5 E.							
No. 4	0-1,000	3.59	-----	-----	3.59	0.60	-----	-----	0.60	4.19	-----	-----	4.19
	1,000-2,000	4.03	-----	-----	4.03	.40	-----	-----	.40	4.43	-----	-----	4.43
	2,000-3,000	-----	-----	-----	-----	4.31	-----	-----	4.31	4.31	-----	-----	4.31
Bed total		7.62	-----	-----	7.62	5.31	-----	-----	5.31	12.93	-----	-----	12.93
Muldoon	0-1,000	-----	1.49	-----	1.49	-----	0.80	-----	0.80	-----	2.29	-----	2.29
	1,000-2,000	-----	4.37	-----	4.37	-----	.82	-----	.82	-----	5.19	-----	5.19
	2,000-3,000	-----	3.77	-----	3.77	-----	1.12	-----	1.12	-----	4.89	-----	4.89
Bed total		-----	9.63	-----	9.63	-----	2.74	-----	2.74	-----	12.37	-----	12.37
No. 3	0-1,000	1.17	2.31	-----	3.48	-----	0.77	-----	0.77	1.17	3.08	-----	4.25
	1,000-2,000	2.32	2.54	-----	4.86	-----	.60	-----	.60	2.32	3.14	-----	5.46
	2,000-3,000	2.24	1.40	-----	3.64	-----	.70	-----	.70	2.24	2.10	-----	4.34
Bed total		5.73	6.25	-----	11.98	-----	2.07	-----	2.07	5.73	8.32	-----	14.05
Bagley	0-1,000	-----	4.52	-----	4.52	-----	1.32	-----	1.32	-----	5.84	-----	5.84
	1,000-2,000	-----	6.04	-----	6.04	-----	1.72	-----	1.72	-----	7.76	-----	7.76
	2,000-3,000	-----	4.84	-----	4.84	-----	1.25	-----	1.25	-----	6.09	-----	6.09
Bed total		-----	15.40	-----	15.40	-----	4.29	-----	4.29	-----	19.69	-----	19.69
Maycreek	0-1,000	3.76	-----	-----	3.76	1.59	-----	-----	1.59	5.35	-----	-----	5.35
	1,000-2,000	2.61	-----	-----	2.61	1.61	-----	-----	1.61	4.22	-----	-----	4.22
	2,000-3,000	.19	-----	-----	.19	3.28	-----	-----	3.28	3.47	-----	-----	3.47
Bed total		6.56	-----	-----	6.56	6.48	-----	-----	6.48	13.04	-----	-----	13.04
Shoo Fly	0-1,000	-----	-----	-----	-----	1.19	-----	-----	1.19	1.19	-----	-----	1.19
	1,000-2,000	-----	-----	-----	-----	.77	-----	-----	.77	.77	-----	-----	.77
Bed total		-----	-----	-----	-----	1.96	-----	-----	1.96	1.96	-----	-----	1.96
Dolly Varden	0-1,000	0.32	-----	-----	0.32	0.38	-----	-----	0.38	0.70	-----	-----	0.70
	1,000-2,000	.28	-----	-----	.28	.47	-----	-----	.47	.75	-----	-----	.75
	2,000-3,000	.10	-----	-----	.10	.50	-----	-----	.50	.60	-----	-----	.60
Bed total		0.70	-----	-----	0.70	1.35	-----	-----	1.35	2.05	-----	-----	2.05
Jones	0-1,000	-----	-----	-----	-----	4.40	-----	-----	4.40	4.40	-----	-----	4.40
	1,000-2,000	-----	-----	-----	-----	4.02	-----	-----	4.02	4.02	-----	-----	4.02
Bed total		-----	-----	-----	-----	8.42	-----	-----	8.42	8.42	-----	-----	8.42
Township total		20.61	31.28	-----	51.89	23.52	9.10	-----	32.62	44.13	40.38	-----	84.51
						T. 24 N., R. 6 E.							
No. 4	0-1,000	3.13	-----	-----	3.13	3.21	-----	-----	3.21	6.34	-----	-----	6.34
	1,000-2,000	6.14	-----	-----	6.14	3.09	-----	-----	3.09	9.23	-----	-----	9.23
	2,000-3,000	-----	-----	-----	-----	5.41	-----	-----	5.41	5.41	-----	-----	5.41
Bed total		9.27	-----	-----	9.27	11.71	-----	-----	11.71	20.98	-----	-----	20.98
No. 3	0-1,000	2.06	8.19	-----	10.25	2.20	1.92	-----	4.12	4.26	10.11	-----	14.37
	1,000-2,000	2.12	3.98	-----	6.10	3.85	5.73	-----	9.58	5.97	9.71	-----	15.68
	2,000-3,000	.37	-----	-----	.37	3.86	8.38	-----	12.24	4.23	8.38	-----	12.61
Bed total		4.55	12.17	-----	16.72	9.91	16.03	-----	25.94	14.46	28.20	-----	42.66
Bagley	0-1,000	-----	4.83	-----	4.83	-----	6.47	-----	6.47	-----	11.30	-----	11.30
	1,000-2,000	-----	2.74	-----	2.74	-----	17.56	-----	17.56	-----	20.30	-----	20.30
	2,000-3,000	-----	1.49	-----	1.49	-----	7.99	-----	7.99	-----	9.48	-----	9.48
Bed total		-----	9.06	-----	9.06	-----	32.02	-----	32.02	-----	41.08	-----	41.08
No. 2	0-1,000	1.61	-----	-----	1.61	1.89	-----	-----	1.89	3.50	-----	-----	3.50
	1,000-2,000	-----	-----	-----	-----	3.09	-----	-----	3.09	3.09	-----	-----	3.09
	2,000-3,000	-----	-----	-----	-----	.34	-----	-----	.34	.34	-----	-----	.34
Bed total		1.61	-----	-----	1.61	5.32	-----	-----	5.32	6.93	-----	-----	6.93
May Creek	0-1,000	5.48	-----	-----	5.48	2.63	-----	-----	2.63	8.11	-----	-----	8.11
	1,000-2,000	3.38	-----	-----	3.38	6.27	-----	-----	6.27	9.65	-----	-----	9.65
	2,000-3,000	.09	-----	-----	.09	5.98	-----	-----	5.98	6.07	-----	-----	6.07
Bed total		8.95	-----	-----	8.95	14.88	-----	-----	14.88	23.83	-----	-----	23.83
Muldoon	0-1,000	1.32	1.18	-----	2.50	2.19	4.20	-----	6.39	3.51	5.38	-----	8.89
	1,000-2,000	.14	1.84	-----	1.98	4.66	4.27	-----	8.93	4.80	6.11	-----	10.91
	2,000-3,000	-----	1.17	-----	1.17	2.11	3.94	-----	6.05	2.11	5.11	-----	7.22
Bed total		1.46	4.19	-----	5.65	8.96	12.41	-----	21.37	10.42	16.60	-----	27.02

TABLE 13.— Estimated remaining reserves of coal in the Newcastle-Grand Ridge area, King County, Washington, as of January 1, 1960, by township and bed— Continued

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown: Measured and indicated				Inferred				All categories			
		2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total
						T. 24 N., R. 6 E.							
Dolly Varden	0-1,000	5.67	4.00	-----	9.67	-----	0.60	-----	0.60	5.67	4.60	-----	10.27
	1,000-2,000	5.23	5.43	-----	10.66	1.80	.64	-----	2.44	7.03	6.07	-----	13.10
	2,000-3,000	3.50	-----	-----	3.50	3.91	5.11	-----	9.02	7.41	5.11	-----	12.52
Bed total		14.40	9.43	-----	23.83	5.71	6.35	-----	12.06	20.11	15.78	-----	35.89
Jones	0-1,000	-----	0.92	-----	0.92	-----	12.99	-----	12.99	-----	13.91	-----	13.91
	1,000-2,000	-----	-----	-----	-----	-----	12.79	-----	12.79	-----	12.79	-----	12.79
Bed total		-----	0.92	-----	0.92	-----	25.78	-----	25.78	-----	26.70	-----	26.70
Township total		40.24	35.77	-----	76.01	56.49	92.59	-----	149.08	96.73	128.36	-----	225.09
Grand total		60.85	67.05	-----	127.90	80.01	101.69	-----	181.70	140.86	168.74	-----	309.60

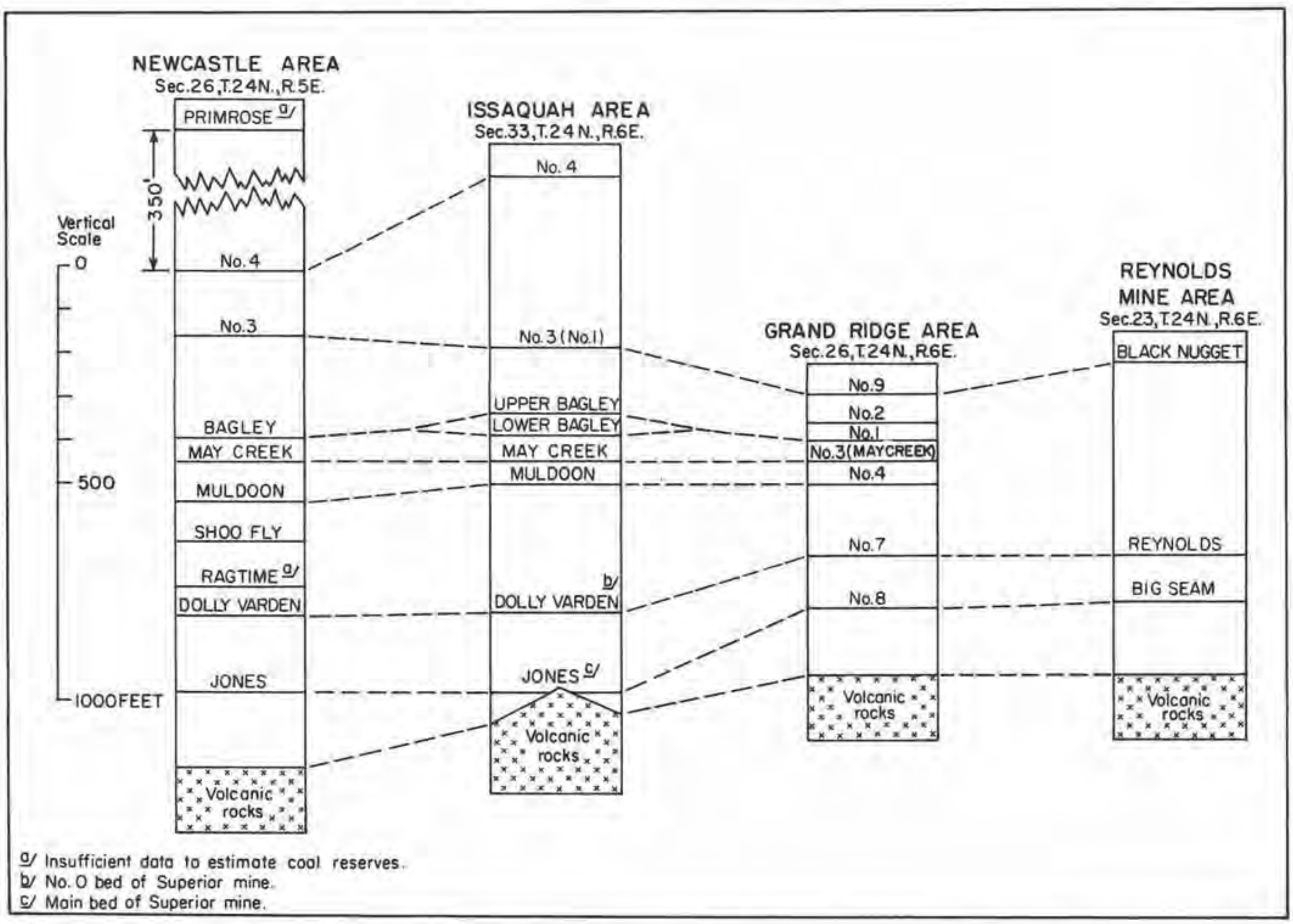


FIGURE 38.— Generalized columnar sections in the Newcastle-Grand Ridge area, King County, Washington, showing coalbeds and correlations used in estimating coal reserves. [Figure 18, Beikman and others, 1961, p. 35.]

Newcastle-Grand Ridge area.— The northernmost coal area known in King County is the Newcastle-Grand Ridge area (Plate 2). The structure is fairly simple; the coal seams strike east and dip 30° to 40° northward. At Issaquah the strike swings to the northeast toward Grand Ridge, and at Grand Ridge the strike is nearly north. In this area the dip increases to about 70° to 75° W.

Coal from this area is mostly subbituminous A; however, some coals are of slightly higher grade. There is no current production from the area; past production totaled about 13 million tons. Average coal analyses for the area are shown in Table 12, and reserve figures are shown in Table 13.

Renton area.— The coal-bearing rocks in the Renton area are considered by Warren and others (1945) to be the same age as those in the Newcastle-Grand Ridge area. Generally, the rocks in the Renton area have been gently folded and have low dips. In the southern part of the area, deformation apparently was more intense; dips as steep as 65° are present. Faults have cut the rocks in several places. At two places, the coal seams were not found on the south side of what apparently are major faults.

The Renton coals are generally considered to be subbituminous in rank; however, some can be classified as subbituminous A, or high-volatile C bituminous. Currently (1969), coal is not being produced; total past production from the Renton area is estimated at nearly 4 million tons.

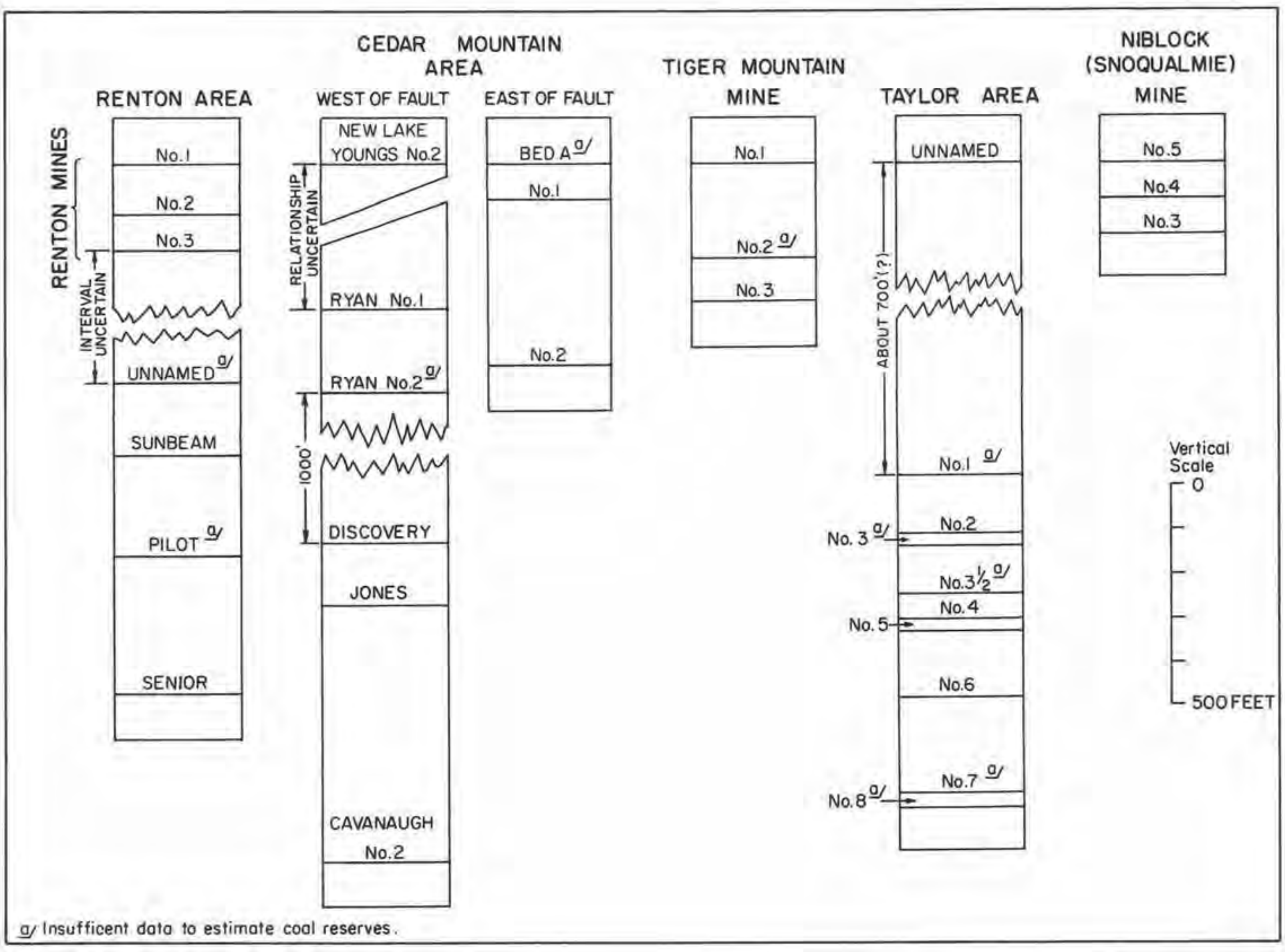


FIGURE 39.— Generalized columnar sections of the Renton, Cedar Mountain, Tiger Mountain, Taylor, and Niblock areas, King County, Washington. [Figure 19, Beikman and others, 1961, p. 39.]

TABLE 14.— Estimated remaining reserves of coal in the Renton area, King County, Washington, as of January 1, 1960, by township and bed

[Table 12, Beikman and others, 1961, p. 49]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown: Measured and indicated: 2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	Inferred: 2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	All categories: 2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total
						T. 23 N., R. 4 E.							
Newenham	0-1,000	-----	-----	-----	-----	0.57	-----	-----	0.57	0.57	-----	-----	0.57
						T. 23 N., R. 5 E.							
No. 1	0-1,000	-----	1.74	-----	1.74	-----	5.49	-----	5.49	-----	7.23	-----	7.23
	1,000-2,000	-----	-----	-----	-----	-----	1.74	-----	1.74	-----	1.74	-----	1.74
	2,000-3,000	-----	-----	-----	-----	-----	.53	-----	.53	-----	.53	-----	.53
Bed total		-----	1.74	-----	1.74	-----	7.76	-----	7.76	-----	9.50	-----	9.50
No. 2	0-1,000	2.69	-----	-----	2.69	4.54	-----	-----	4.54	7.23	-----	-----	7.23
	1,000-2,000	-----	-----	-----	-----	1.73	-----	-----	1.73	1.73	-----	-----	1.73
	2,000-3,000	-----	-----	-----	-----	.58	-----	-----	.58	.58	-----	-----	.58
Bed total		2.69	-----	-----	2.69	6.85	-----	-----	6.85	9.54	-----	-----	9.54
No. 3	0-1,000	-----	2.74	-----	2.74	-----	3.02	-----	3.02	-----	5.76	-----	5.76
	1,000-2,000	-----	-----	-----	-----	-----	2.58	-----	2.58	-----	2.58	-----	2.58
	2,000-3,000	-----	-----	-----	-----	-----	.95	-----	.95	-----	.95	-----	.95
Bed total		-----	2.74	-----	2.74	-----	6.55	-----	6.55	-----	9.29	-----	9.29
Springbrook	0-1,000	0.08	1.99	-----	2.07	-----	0.54	-----	0.54	0.08	2.53	-----	2.61
	1,000-2,000	-----	-----	-----	-----	-----	1.71	-----	1.71	-----	1.71	-----	1.71
	2,000-3,000	-----	-----	-----	-----	-----	.48	-----	.48	-----	.48	-----	.48
Bed total		0.08	1.99	-----	2.07	-----	2.73	-----	2.73	0.08	4.72	-----	4.80
Sunbeam	0-1,000	0.81	-----	-----	0.81	6.76	-----	-----	6.76	7.57	-----	-----	7.57
Senior	0-1,000	-----	-----	-----	-----	-----	1.74	-----	1.74	-----	1.74	-----	1.74
	1,000-2,000	-----	-----	-----	-----	-----	7.34	-----	7.34	-----	7.34	-----	7.34
Bed total		-----	-----	-----	-----	-----	9.08	-----	9.08	-----	9.08	-----	9.08
Township total		3.58	6.47	-----	10.05	13.61	26.12	-----	39.73	17.19	32.59	-----	49.78
						All townships							
Grand total		3.58	6.47	-----	10.05	14.18	26.12	-----	40.30	17.76	32.59	-----	50.35

Average coal analyses are shown in Table 12, and reserve figures are shown in Table 14.

Cedar Mountain area.— The coal seams of the Cedar Mountain area occur in the Renton Formation, as do those of the Renton and Newcastle-Grand Ridge areas. However, the coal seams of the Cedar Mountain area have not been correlated with seams of the Renton and Newcastle-Grand Ridge areas. The beds dip moderately to the southeast and northeast as they curl around the nose of the Cedar Moun-

TABLE 15.— Estimated remaining reserves of coal in the Cedar Mountain area, King County, Washington, as of January 1, 1960, by township and bed

[Table 14, Beikman and others, 1961, p. 50]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown: Measured and indicated: 2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	Inferred: 2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	All categories: 2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total
						T. 23 N., R. 5 E.							
Cavanaugh No. 2	0-1,000	0.42	-----	-----	0.42	1.43	-----	-----	1.43	1.85	-----	-----	1.85
	1,000-2,000	-----	-----	-----	-----	2.10	-----	-----	2.10	2.10	-----	-----	2.10
	2,000-3,000	-----	-----	-----	-----	1.28	-----	-----	1.28	1.28	-----	-----	1.28
Bed total		0.42	-----	-----	0.42	4.81	-----	-----	4.81	5.23	-----	-----	5.23

TABLE 15.— Estimated remaining reserves of coal in the Cedar Mountain area, King County, Washington, as of January 1, 1960, by township and bed— Continued

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown											
		Measured and indicated				Inferred				All categories			
		2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total
T. 23 N., R. 5 E.													
Jones	0-1,000	0.65	-----	-----	0.65	1.71	-----	-----	1.71	2.36	-----	-----	2.36
	1,000-2,000	1.13	-----	-----	1.13	1.26	-----	-----	1.26	2.39	-----	-----	2.39
	2,000-3,000	.28	-----	-----	.28	1.63	-----	-----	1.63	1.91	-----	-----	1.91
Bed total		2.06	-----	-----	2.06	4.60	-----	-----	4.60	6.66	-----	-----	6.66
Discovery	0-1,000	1.70	-----	-----	1.70	2.38	-----	-----	2.38	4.08	-----	-----	4.08
	1,000-2,000	.92	-----	-----	.92	2.24	-----	-----	2.24	3.16	-----	-----	3.16
	2,000-3,000	-----	-----	-----	-----	1.95	-----	-----	1.95	1.95	-----	-----	1.95
Bed total		2.62	-----	-----	2.62	6.57	-----	-----	6.57	9.19	-----	-----	9.19
Ryan No. 1	0-1,000	-----	1.65	-----	1.65	-----	2.53	-----	2.53	-----	4.18	-----	4.18
	1,000-2,000	-----	-----	-----	-----	-----	2.52	-----	2.52	-----	2.52	-----	2.52
	2,000-3,000	-----	-----	-----	-----	-----	2.01	-----	2.01	-----	2.01	-----	2.01
Bed total		-----	1.65	-----	1.65	-----	7.06	-----	7.06	-----	8.71	-----	8.71
New Lake Youngs No. 2*	0-1,000	-----	-----	0.47	0.47	-----	-----	0.97	0.97	-----	-----	1.44	1.44
	1,000-2,000	-----	-----	-----	-----	-----	-----	1.05	1.05	-----	-----	1.05	1.05
Bed total		-----	-----	0.47	0.47	-----	-----	2.02	2.02	-----	-----	2.49	2.49
Township total		5.10	1.65	0.47	7.22	15.98	7.06	2.02	25.06	21.08	8.71	2.49	32.28
T. 23 N., R. 6 E.													
Cedar Mtn. No. 2	0-1,000	0.80	-----	-----	0.80	2.01	-----	-----	2.01	2.81	-----	-----	2.81
	1,000-2,000	-----	-----	-----	-----	2.78	-----	-----	2.78	2.78	-----	-----	2.78
	2,000-3,000	-----	-----	-----	-----	1.89	-----	-----	1.89	1.89	-----	-----	1.89
Bed total		0.80	-----	-----	0.80	6.68	-----	-----	6.68	7.48	-----	-----	7.48
Jones	0-1,000	0.48	-----	-----	0.48	-----	-----	-----	-----	0.48	-----	-----	0.48
	1,000-2,000	.55	-----	-----	.55	0.22	-----	-----	0.22	.77	-----	-----	.77
	2,000-3,000	.30	-----	-----	.30	.74	-----	-----	.74	1.04	-----	-----	1.04
Bed total		1.33	-----	-----	1.33	0.96	-----	-----	0.96	2.29	-----	-----	2.29
Cedar Mtn. No. 1	0-1,000	-----	-----	-----	-----	-----	2.72	-----	2.72	-----	2.72	-----	2.72
	1,000-2,000	-----	-----	-----	-----	-----	6.20	-----	6.20	-----	6.20	-----	6.20
	2,000-3,000	-----	-----	-----	-----	-----	4.49	-----	4.49	-----	4.49	-----	4.49
Bed total		-----	-----	-----	-----	-----	13.41	-----	13.41	-----	13.41	-----	13.41
Discovery	0-1,000	0.55	-----	-----	0.55	-----	-----	-----	-----	0.55	-----	-----	0.55
	1,000-2,000	1.12	-----	-----	1.12	-----	-----	-----	-----	1.12	-----	-----	1.12
	2,000-3,000	.63	-----	-----	.63	0.51	-----	-----	0.51	1.14	-----	-----	1.14
Bed total		2.30	-----	-----	2.30	0.51	-----	-----	0.51	2.81	-----	-----	2.81
Ryan No. 1	0-1,000	-----	1.08	-----	1.08	-----	0.92	-----	0.92	-----	2.00	-----	2.00
	1,000-2,000	-----	1.70	-----	1.70	-----	.63	-----	.63	-----	2.33	-----	2.33
	2,000-3,000	-----	-----	-----	-----	-----	3.77	-----	3.77	-----	3.77	-----	3.77
Bed total		-----	2.78	-----	2.78	-----	5.32	-----	5.32	-----	8.10	-----	8.10
New Lake Youngs No. 2*	1,000-2,000	-----	-----	-----	-----	-----	-----	0.39	0.39	-----	-----	0.39	0.39
Township total		4.43	2.78	-----	7.21	8.15	18.73	0.39	27.27	12.58	21.51	0.39	34.48
Grand total		9.53	4.43	0.47	14.43	24.13	25.79	2.41	52.33	33.66	30.22	2.88	66.76

*Bituminous coal. Coal 42 or more inches thick is shown in the 10 or more feet thickness category.

tain anticline, and are complicated somewhat by faulting.

The Cedar Mountain coals vary in rank from subbituminous A to high-volatile C bituminous. Coal of the Cedar Mountain area was first mined about 1880. Until 1944, when the last mine closed, total production of the area was about 4 million tons. Average analyses and remaining reserves are shown in Table 12 (on p. 64) and Table 15, respectively.

Tiger Mountain and Niblock areas.— These two areas are presented together because little is known about them and they have not been important coal producers in the past. The coal in both areas occurs in the Puget Group, but the stratigraphic positions of the coal seams are unknown. The strata dip about 45° NE. at Tiger Mountain and steeply to the southwest in the Niblock area.

The coals from the Tiger Mountain area are subbituminous B rank, and those at Niblock are of high-volatile A bituminous rank. About 50,000 tons of coal has been produced from the Tiger Mountain area, and about 25,000 tons from the Niblock area. Average coal analyses from the two areas are shown in Table 12, on page 64, and reserves are shown in Tables 16 and 17.

TABLE 16.— Estimated remaining reserves of coal in the Tiger Mountain area, King County, Washington, as of January 1, 1960, by township and bed

[Table 13, Beikman and others, 1961, p. 49]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown: Measured and indicated				Inferred				All categories			
		2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total	2.5 to 5.0 feet	5.0 to 10.0 feet	10.0 or more feet	Total
						T. 23 N., R. 6 E.							
No. 1	0-1,000	0.60	------	------	0.60	1.01	------	------	1.01	1.61	------	------	1.61
	1,000-2,000	.21	------	------	.21	1.20	------	------	1.20	1.41	------	------	1.41
	2,000-3,000	------	------	------	------	.26	------	------	.26	.26	------	------	.26
Bed total		0.81	------	------	0.81	2.47	------	------	2.47	3.28	------	------	3.28
No. 3	0-1,000	------	------	------	------	------	2.91	------	2.91	------	2.91	------	2.91
	1,000-2,000	------	------	------	------	------	2.38	------	2.38	------	2.38	------	2.38
	2,000-3,000	------	------	------	------	------	.44	------	.44	------	.44	------	.44
Bed total		------	------	------	------	------	5.73	------	5.73	------	5.73	------	5.73
Township total		0.81	------	------	0.81	2.47	5.73	------	8.20	3.28	5.73	------	9.01

TABLE 17.— Estimated remaining reserves of coal in the Niblock area, King County, Washington, as of January 1, 1960, by township and bed

[Table 15, Beikman and others, 1961, p. 51]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown: Measured and indicated				Inferred				All categories			
		14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total
						T. 23 N., R. 7 E.							
No. 5	0-1,000	------	------	1.03	1.03	------	------	0.71	0.71	------	------	1.74	1.74
	1,000-2,000	------	------	.98	.98	------	------	.83	.83	------	------	1.81	1.81
	2,000-3,000	------	------	.34	.34	------	------	1.37	1.37	------	------	1.71	1.71
Bed total		------	------	2.35	2.35	------	------	2.91	2.91	------	------	5.26	5.26
No. 4	0-1,000	------	0.50	------	0.50	------	0.45	------	0.45	------	0.95	------	0.95
	1,000-2,000	------	.41	------	.41	------	.50	------	.50	------	.91	------	.91
	2,000-3,000	------	------	------	------	------	.83	------	.83	------	.83	------	.83
Bed total		------	0.91	------	0.91	------	1.78	------	1.78	------	2.69	------	2.69
No. 3	0-1,000	------	------	1.37	1.37	------	------	0.55	0.55	------	------	1.92	1.92
	1,000-2,000	------	------	1.50	1.50	------	------	.71	.71	------	------	2.21	2.21
	2,000-3,000	------	------	.53	.53	------	------	1.57	1.57	------	------	2.10	2.10
Bed total		------	------	3.40	3.40	------	------	2.83	2.83	------	------	6.23	6.23
Township total		------	0.91	5.75	6.66	------	1.78	5.74	7.52	------	2.69	11.49	14.18

Taylor area.— The coal beds in the Taylor area occur in the Puget Group, but their stratigraphic position with respect to other beds in the county is not known. The seams dip steeply to the southeast.

At least 10 seams that rank from high-volatile B bituminous to high-volatile A bituminous occur in the area. Mines in the area were first opened in 1891, and the last mine was closed in 1940. Production is estimated at slightly more than 640,000 tons. Coal analyses are shown in Table 12, on page 64, and reserves are shown in Table 18.

TABLE 18.— Estimated remaining reserves of coal in the Taylor area, King County, Washington, as of January 1, 1960, by township and bed

[Table 16, Beikman and others, 1961, p. 51]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown											
		Measured and indicated				Inferred				All categories			
		14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total
T. 22 N., R. 7 E.													
Unnamed	0-1,000	------	------	0.27	0.27	------	------	1.22	1.22	------	------	1.49	1.49
No. 2	0-1,000	------	------	0.62	0.62	------	------	1.49	1.49	------	------	2.11	2.11
	1,000-2,000	------	------	------	------	------	------	1.20	1.20	------	------	1.20	1.20
Bed total		------	------	0.62	0.62	------	------	2.69	2.69	------	------	3.31	3.31
No. 4	0-1,000	------	0.45	------	0.45	------	0.94	------	0.94	------	1.39	------	1.39
	1,000-2,000	------	------	------	------	------	1.35	------	1.35	------	1.35	------	1.35
Bed total		------	0.45	------	0.45	------	2.29	------	2.29	------	2.74	------	2.74
No. 5	0-1,000	------	------	0.43	0.43	------	------	1.42	1.42	------	------	1.85	1.85
	1,000-2,000	------	------	------	------	------	------	2.45	2.45	------	------	2.45	2.45
Bed total		------	------	0.43	0.43	------	------	3.87	3.87	------	------	4.30	4.30
No. 6	0-1,000	------	------	0.88	0.88	------	------	1.64	1.64	------	------	2.52	2.52
	1,000-2,000	------	------	------	------	------	------	2.76	2.76	------	------	2.76	2.76
Bed total		------	------	0.88	0.88	------	------	4.40	4.40	------	------	5.28	5.28
Township total		------	0.45	2.20	2.65	------	2.29	12.18	14.47	------	2.74	14.38	17.12
T. 23 N., R. 7 E.													
No. 2	0-1,000	------	------	------	------	------	------	0.27	0.27	------	------	0.27	0.27
No. 4	0-1,000	------	------	------	------	------	0.30	------	0.30	------	0.30	------	0.30
No. 5	0-1,000	------	------	------	------	------	------	0.40	0.40	------	------	0.40	0.40
No. 6	0-1,000	------	------	------	------	------	------	0.70	0.70	------	------	0.70	0.70
Township total		------	------	------	------	------	0.30	1.37	1.67	------	0.30	1.37	1.67
Grand total		------	0.45	2.20	2.65	------	2.59	13.55	16.14	------	3.04	15.75	18.79

Green River district.— The coal-bearing beds in the Green River district occur in the Puget Group. The strata have been contorted into several tight folds that have been considerably complicated by faulting. Dips are steep, fold trends are mostly north-south, and fault trends are mostly west to northwest. The complexity of the geology of the district is well illustrated by Gower and Wanek (1963). The steep dips and abundant faults have contributed to difficult mining problems and high production costs.

The coal in the Green River district is mostly of high-volatile B bituminous rank, but it varies from high-volatile A bituminous to subbituminous B. Beikman and others (1961, p. 53) report that generally the higher the coal seam is in the stratigraphic section, the lower it is in rank. Coal has been mined continuously from the Green River area since about 1883. Total production from the field has been about 25 million tons. The principal coal beds are shown in Figure 40. Average coal analyses for the district are shown in Table 19, and reserves are shown in Table 20. The economic history of the Green River district is discussed in considerable detail by Thorndale (1965).

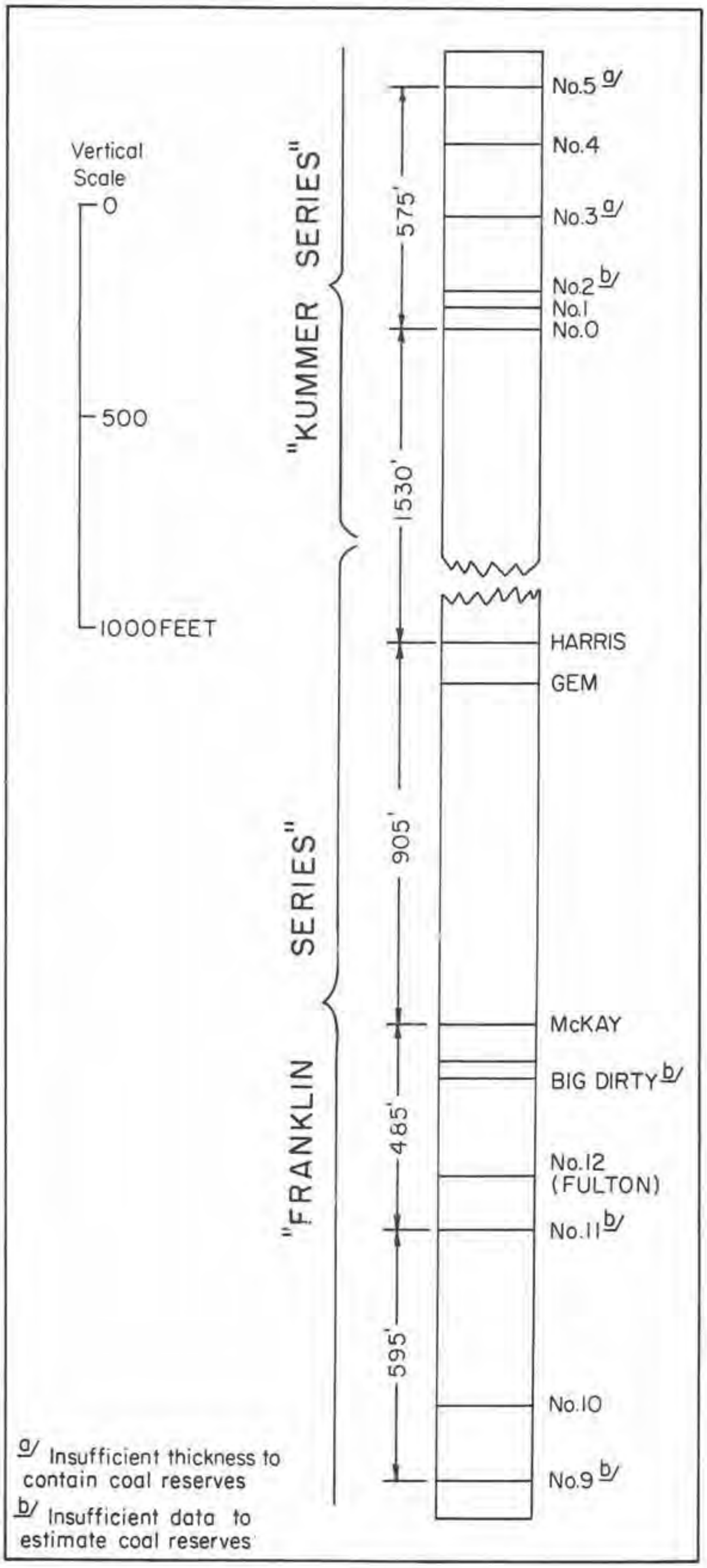


FIGURE 40.— Generalized section of principal coalbeds in the Green River district, King County, Washington. [Figure 28, Beikman and others, 1961, p. 52.]

TABLE 19.—Averages of analyses (as-received basis) of coal samples from the Green River district, King County, Washington

[Table 17, Beikman and others, 1961, p. 54]

(M—moisture; VM—volatile matter; FC—fixed carbon; Btu—British thermal units. Sources of analyses are Fieldner and others, 1931; Cooper and Abernethy, 1941; and Daniels and others, 1958.)

Mine or prospect	Coal bed	Proximate (percent)				Sulfur (percent)	Btu	Number of analyses used in obtaining average
		M	VM	FC	Ash			
Danville ----------	Frazier-----------	15.6	32.5	43.0	8.8	0.5	10,860	3
	Eight-Foot---------	8.9	38.1	40.3	7.6	.9	12,555	2
	Landsburg No. 1 ---	11.1	47.5	41.3	10.0	.3	12,140	2
	Six-Foot ----------	9.0	39.9	41.2	9.9	.5	12,610	1
Ravensdale --------	Ravensdale No. 9 --	7.3	40.3	46.6	5.8	.6	12,370	1
	Ravensdale No. 5 --	9.1	36.5	41.3	13.0	.6	10,856	5
	Ravensdale No. 4 --	7.4	37.4	44.0	11.2	.5	11,500	1
	Ravensdale No. 3 --	9.4	36.3	45.0	9.2	.6	11,455	2
Dale-McKay-------	Dale No. 4 -------	16.0	32.6	41.8	9.4	.5	9,855	6
	Dale No. 7--------	14.9	32.8	42.9	9.3	.6	10,116	3
	Gem--------------	11.6	34.7	40.8	12.7	.5	11,438	5
	McKay------------	9.7	38.8	46.0	5.2	.5	12,134	33
	Franklin No. 10 ---	6.1	37.0	40.6	16.2	.6	13,567	4
Kummer -----------	Kummer No. 4-----	18.7	32.7	32.9	15.7	.6	10,360	1
	Kummer No. 1-----	13.7	32.4	41.6	12.0	.4	10,545	3
Sunset ------------	No. 1 ------------	12.7	31.1	43.7	12.5	.9	9,890	1
	No. 2 ------------	5.0	34.2	42.3	18.4	1.6	11,205	2
	No. 7 ------------	4.9	26.4	30.2	38.5	.4	7,990	1
Navy -------------	No. 6 ------------	5.1	33.9	44.6	16.4	.5	11,488	1
	No. 4 ------------	4.8	33.0	45.1	17.1	.6	11,445	2
Eureka ------------	Unnamed ----------	5.9	31.3	43.9	18.9	.5	10,940	1
Occidental --------	No. 1 ------------	5.2	34.6	47.4	12.6	.7	12,075	1
	No. 2 ------------	5.4	33.0	47.1	14.5	.7	11,590	1
	No. 3 ------------	4.4	35.8	47.8	11.8	.9	12,268	6
	No. 6 ------------	5.3	33.0	45.9	20.7	.5	10,660	2
	No. 14 -----------	4.1	34.9	51.6	11.9	.5	------	2
Carbon-Bayne------	Carbon------------	4.6	32.7	49.5	13.1	.8	12,280	3
	No. 3 and No. 5 --	7.5	33.8	44.0	14.5	.6	11,050	4
	No. 2 and No. 3 --	4.4	33.3	44.0	18.2	.6	11,362	5
	No. 1 ------------	5.5	32.0	48.9	13.1	.4	11,475	3
	Pocahontas No. 6 --	4.6	31.0	52.2	12.2	.7	12,730	1
Durham -----------	No. 2 ------------	3.4	31.4	47.8	17.4	.9	14,300	1
Elk ---------------	Dutch-------------	5.8	31.8	32.9	29.5	.6	13,620	2
	Victory -----------	7.2	34.4	38.4	19.9	.8	13,305	2
	No. 1 ------------	7.6	33.2	43.7	15.3	.4	12,130	2
	Big Elk -----------	5.7	35.9	42.6	15.6	.6	11,550	1
	No. 2 ------------	5.6	33.7	45.0	15.6	.6	11,285	2
Kangley-Alta ------	Big Seam ----------	4.7	38.0	45.2	12.1	.9	12,420	1
McIntyre ----------	Unnamed ----------	10.5	35.2	42.4	11.9	.4	10,700	1

TABLE 20.—Estimated remaining reserves of coal in the Green River district, King County, Washington, as of January 1, 1960, by township and bed

[Table 18, Beikman and others, 1961, p. 60]

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown: Measured and indicated: 14 to 28 inches	28 to 42 inches	42 or more inches	Total	Inferred: 14 to 28 inches	28 to 42 inches	42 or more inches	Total	All categories: 14 to 28 inches	28 to 42 inches	42 or more inches	Total
T. 20 N., R. 6 E.													
Kummer No. 4*	0-1,000	-----	0.41	-----	0.41	-----	0.41	-----	0.41	-----	0.82	-----	0.82
	1,000-2,000	-----	-----	-----	-----	-----	.28	-----	.28	-----	.28	-----	.28
Township total		-----	0.41	-----	0.41	-----	0.69	-----	0.69	-----	1.10	-----	1.10
T. 21 N., R. 6 E.													
Dale No. 4*	0-1,000	-----	1.59	-----	1.59	-----	-----	-----	-----	-----	1.59	-----	1.59
	1,000-2,000	-----	-----	-----	-----	-----	2.68	-----	2.68	-----	2.68	-----	2.68
	2,000-3,000	-----	-----	-----	-----	-----	3.12	-----	3.12	-----	3.12	-----	3.12
Bed total		-----	1.59	-----	1.59	-----	5.80	-----	5.80	-----	7.39	-----	7.39
Harris	0-1,000	-----	-----	-----	-----	-----	3.67	-----	3.67	-----	3.67	-----	3.67
	1,000-2,000	-----	-----	-----	-----	-----	3.40	-----	3.40	-----	3.40	-----	3.40
	2,000-3,000	-----	-----	-----	-----	-----	3.26	-----	3.26	-----	3.26	-----	3.26
Bed total		-----	-----	-----	-----	-----	10.33	-----	10.33	-----	10.33	-----	10.33
Kummer No. 4*	0-1,000	-----	4.60	-----	4.60	-----	2.80	-----	2.80	-----	7.40	-----	7.40
	1,000-2,000	-----	-----	-----	-----	-----	.27	-----	.27	-----	.27	-----	.27
Bed total		-----	4.60	-----	4.60	-----	3.07	-----	3.07	-----	7.67	-----	7.67
Dale No. 7*	0-1,000	0.90	-----	-----	0.90	-----	-----	-----	-----	0.90	-----	-----	0.90
	1,000-2,000	-----	-----	-----	-----	1.27	-----	-----	1.27	1.27	-----	-----	1.27
	2,000-3,000	-----	-----	-----	-----	1.56	-----	-----	1.56	1.56	-----	-----	1.56
Bed total		0.90	-----	-----	0.90	2.83	-----	-----	2.83	3.73	-----	-----	3.73
Gem	0-1,000	-----	1.12	1.00	2.12	-----	3.29	2.07	5.36	-----	4.41	3.07	7.48
	1,000-2,000	-----	.71	-----	.71	-----	2.94	.19	3.13	-----	3.65	.19	3.84
	2,000-3,000	-----	.93	-----	.93	-----	.69	-----	.69	-----	1.62	-----	1.62
Bed total		-----	2.76	1.00	3.76	-----	6.92	2.26	9.18	-----	9.68	3.26	12.94
Kummer No. 1*	0-1,000	0.98	-----	-----	0.98	1.91	-----	-----	1.91	2.89	-----	-----	2.89
	1,000-2,000	4.00	-----	-----	4.00	2.22	-----	-----	2.22	6.22	-----	-----	6.22
Bed total		4.98	-----	-----	4.98	4.13	-----	-----	4.13	9.11	-----	-----	9.11
McKay	0-1,000	-----	-----	3.24	3.24	-----	-----	4.11	4.11	-----	-----	7.35	7.35
	1,000-2,000	-----	-----	6.94	6.94	-----	-----	2.50	2.50	-----	-----	9.44	9.44
	2,000-3,000	-----	-----	5.43	5.43	-----	-----	12.51	12.51	-----	-----	17.94	17.94
Bed total		-----	-----	15.61	15.61	-----	-----	19.12	19.12	-----	-----	34.73	34.73
Kummer No. 0*	0-1,000	0.78	-----	-----	0.78	1.39	-----	-----	1.39	2.17	-----	-----	2.17
	1,000-2,000	1.42	-----	-----	1.42	2.96	-----	-----	2.96	4.38	-----	-----	4.38
Bed total		2.20	-----	-----	2.20	4.35	-----	-----	4.35	6.55	-----	-----	6.55
Fulton (No. 12)	0-1,000	-----	-----	-----	-----	-----	-----	16.42	16.42	-----	-----	16.42	16.42
	1,000-2,000	-----	-----	-----	-----	-----	-----	12.82	12.82	-----	-----	12.82	12.82
	2,000-3,000	-----	-----	-----	-----	-----	-----	10.23	10.23	-----	-----	10.23	10.23
Bed total		-----	-----	-----	-----	-----	-----	39.47	39.47	-----	-----	39.47	39.47
Franklin No. 10	0-1,000	-----	-----	-----	-----	-----	-----	7.74	7.74	-----	-----	7.74	7.74
	1,000-2,000	-----	-----	-----	-----	-----	-----	14.72	14.72	-----	-----	14.72	14.72
	2,000-3,000	-----	-----	-----	-----	-----	-----	2.90	2.90	-----	-----	2.90	2.90
Bed total		-----	-----	-----	-----	-----	-----	25.36	25.36	-----	-----	25.36	25.36
Township total		8.08	8.95	16.61	33.64	11.31	26.12	86.21	123.64	19.39	35.07	102.82	157.28
T. 21 N., R. 7 E.													
Harris	0-1,000	-----	-----	-----	-----	-----	1.54	-----	1.54	-----	1.54	-----	1.54
	1,000-2,000	-----	-----	-----	-----	-----	.94	-----	.94	-----	.94	-----	.94
	2,000-3,000	-----	-----	-----	-----	-----	1.04	-----	1.04	-----	1.04	-----	1.04
Bed total		-----	-----	-----	-----	-----	3.52	-----	3.52	-----	3.52	-----	3.52
Occidental No. 1	0-1,000	-----	-----	-----	-----	-----	-----	0.40	0.40	-----	-----	0.40	0.40
Carbon	0-1,000	-----	-----	-----	-----	-----	0.95	-----	0.95	-----	0.95	-----	0.95
Eureka-unnamed	0-1,000	-----	-----	-----	-----	-----	-----	0.87	0.87	-----	-----	0.87	0.87
Navy No. 6	0-1,000	-----	-----	-----	-----	-----	-----	1.40	1.40	-----	-----	1.40	1.40
Sunset No. 1*	0-1,000	1.54	-----	-----	1.54	2.36	-----	-----	2.36	3.90	-----	-----	3.90
	1,000-2,000	-----	-----	-----	-----	2.66	-----	-----	2.66	2.66	-----	-----	2.66
Bed total		1.54	-----	-----	1.54	5.02	-----	-----	5.02	6.56	-----	-----	6.56

*Subbituminous coal. Coal 2.5 to 5.0 feet and 5.0 to 10.0 feet thick is shown in the 14 to 28 inches and 28 to 42 inches thickness categories.

TABLE 20.— Estimated remaining reserves of coal in the Green River district, King County, Washington, as of January 1, 1960, by township and bed— Continued

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown											
		Measured and indicated				Inferred				All categories			
		14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total
T. 21 N., R. 7 E.													
Gem	0-1,000	-----	1.66	-----	1.66	-----	-----	-----	-----	-----	1.66	-----	1.66
	1,000-2,000	-----	2.92	-----	2.92	-----	-----	-----	-----	-----	2.92	-----	2.92
	2,000-3,000	-----	.12	-----	.12	-----	0.24	-----	0.24	-----	.36	-----	.36
Bed total		-----	4.70	-----	4.70	-----	0.24	-----	0.24	-----	4.94	-----	4.94
Occidental No. 2	0-1,000	-----	0.22	-----	0.22	-----	0.21	-----	0.21	-----	0.43	-----	0.43
Carbon-Bayne No. 3	0-1,000	-----	-----	0.72	0.72	-----	-----	2.71	2.71	-----	-----	3.43	3.43
Navy No. 4	0-1,000	-----	-----	-----	-----	-----	-----	1.21	1.21	-----	-----	1.21	1.21
Sunset No. 2	0-1,000	1.44	-----	-----	1.44	0.41	-----	-----	0.41	1.85	-----	-----	1.85
	1,000-2,000	-----	-----	-----	-----	1.45	-----	-----	1.45	1.45	-----	-----	1.45
Bed total		1.44	-----	-----	1.44	1.86	-----	-----	1.86	3.30	-----	-----	3.30
Durham No. 2	0-1,000	-----	-----	0.46	0.46	-----	-----	0.08	0.08	-----	-----	0.54	0.54
McKay	0-1,000	-----	-----	3.00	3.00	-----	-----	3.37	3.37	-----	-----	6.37	6.37
	1,000-2,000	-----	-----	4.62	4.62	-----	-----	4.00	4.00	-----	-----	8.62	8.62
	2,000-3,000	-----	-----	2.79	2.79	-----	-----	5.08	5.08	-----	-----	7.87	7.87
Bed total		-----	-----	10.41	10.41	-----	-----	12.45	12.45	-----	-----	22.86	22.86
Occidental No. 3	0-1,000	-----	-----	0.47	0.47	-----	-----	0.89	0.89	-----	-----	1.36	1.36
Carbon-Bayne No. 2	0-1,000	-----	-----	0.69	0.69	-----	-----	1.88	1.88	-----	-----	2.57	2.57
Sunset No. 7	0-1,000	-----	-----	-----	-----	-----	1.38	-----	1.38	-----	1.38	-----	1.38
Fulton (No. 12)	0-1,000	-----	-----	-----	-----	-----	-----	10.82	10.82	-----	-----	10.82	10.82
	1,000-2,000	-----	-----	-----	-----	-----	-----	9.83	9.83	-----	-----	9.83	9.83
	2,000-3,000	-----	-----	-----	-----	-----	-----	9.28	9.28	-----	-----	9.28	9.28
Bed total		-----	-----	-----	-----	-----	-----	29.93	29.93	-----	-----	29.93	29.93
Occidental No. 6	0-1,000	-----	0.44	-----	0.44	-----	0.44	-----	0.44	-----	0.88	-----	0.88
Carbon-Bayne No. 1	0-1,000	-----	-----	2.68	2.68	-----	-----	1.65	1.65	-----	-----	4.33	4.33
Franklin No. 10	0-1,000	-----	-----	5.17	5.17	-----	-----	4.54	4.54	-----	-----	9.71	9.71
	1,000-2,000	-----	-----	6.76	6.76	-----	-----	4.87	4.87	-----	-----	11.63	11.63
	2,000-3,000	-----	-----	5.66	5.66	-----	-----	3.28	3.28	-----	-----	8.94	8.94
Bed total		-----	-----	17.59	17.59	-----	-----	12.69	12.69	-----	-----	30.28	30.28
Occidental No. 14	0-1,000	-----	0.44	-----	0.44	-----	0.29	-----	0.29	-----	0.73	-----	0.73
	1,000-2,000	-----	.49	-----	.49	-----	.38	-----	.38	-----	.87	-----	.87
Bed total		-----	0.93	-----	0.93	-----	0.67	-----	0.67	-----	1.60	-----	1.60
Pocahontas (?)	0-1,000	-----	-----	-----	-----	-----	0.75	-----	0.75	-----	0.75	-----	0.75
Township total		2.98	6.29	33.02	42.29	6.88	8.16	66.16	81.20	9.86	14.45	99.18	123.49
T. 22 N., R. 6 E.													
Frazier	0-1,000	-----	-----	-----	-----	-----	-----	1.68	1.68	-----	-----	1.68	1.68
	1,000-2,000	-----	-----	-----	-----	-----	-----	2.01	2.01	-----	-----	2.01	2.01
	2,000-3,000	-----	-----	-----	-----	-----	-----	2.02	2.02	-----	-----	2.02	2.02
Bed total		-----	-----	-----	-----	-----	-----	5.71	5.71	-----	-----	5.71	5.71
Ravensdale No. 9	0-1,000	-----	0.89	-----	0.89	-----	-----	-----	-----	-----	0.89	-----	0.89
	1,000-2,000	-----	-----	-----	-----	-----	0.71	-----	0.71	-----	0.71	-----	0.71
	2,000-3,000	-----	-----	-----	-----	-----	.52	-----	.52	-----	.52	-----	.52
Bed total		-----	0.89	-----	0.89	-----	1.23	-----	1.23	-----	2.12	-----	2.12
Dale No. 4*	0-1,000	-----	0.04	-----	0.04	-----	-----	-----	-----	-----	0.04	-----	0.04
	1,000-2,000	-----	-----	-----	-----	-----	0.10	-----	0.10	-----	.10	-----	.10
	2,000-3,000	-----	-----	-----	-----	-----	.12	-----	.12	-----	.12	-----	.12
Bed total		-----	0.04	-----	0.04	-----	0.22	-----	0.22	-----	0.26	-----	0.26
Eight-Foot	0-1,000	-----	-----	-----	-----	-----	-----	1.27	1.27	-----	-----	1.27	1.27
	1,000-2,000	-----	-----	-----	-----	-----	-----	1.58	1.58	-----	-----	1.58	1.58
	2,000-3,000	-----	-----	-----	-----	-----	-----	2.67	2.67	-----	-----	2.67	2.67
Bed total		-----	-----	-----	-----	-----	-----	5.52	5.52	-----	-----	5.52	5.52
Ravensdale No. 5	0-1,000	-----	-----	0.56	0.56	-----	-----	-----	-----	-----	-----	0.56	0.56
	1,000-2,000	-----	-----	2.21	2.21	-----	-----	-----	-----	-----	-----	2.21	2.21
	2,000-3,000	-----	-----	-----	-----	-----	-----	1.63	1.63	-----	-----	1.63	1.63
Bed total		-----	-----	2.77	2.77	-----	-----	1.63	1.63	-----	-----	4.40	4.40

*Subbituminous coal. Coal 2.5 to 5.0 feet and 5.0 to 10.0 feet thick is shown in the 14 to 28 inches and 28 to 42 inches thickness categories.

TABLE 20.—Estimated remaining reserves of coal in the Green River district, King County, Washington, as of January 1, 1960, by township and bed—Continued

Coal bed	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown											
		Measured and indicated				Inferred				All categories			
		14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total	14 to 28 inches	28 to 42 inches	42 or more inches	Total
T. 22 N., R. 6 E.—continued													
Dale No. 7*	0-1,000	0.05	-----	-----	0.05	-----	-----	-----	-----	0.05	-----	-----	0.05
	1,000-2,000	-----	-----	-----	-----	0.08	-----	-----	0.08	.08	-----	-----	.08
	2,000-3,000	-----	-----	-----	-----	.18	-----	-----	.18	.18	-----	-----	.18
Bed total		0.05	-----	-----	0.05	0.26	-----	-----	0.26	0.31	-----	-----	0.31
Landsburg No. 1	0-1,000	-----	-----	1.58	1.58	-----	-----	2.70	2.70	-----	-----	4.28	4.28
	1,000-2,000	-----	-----	-----	-----	-----	-----	5.12	5.12	-----	-----	5.12	5.12
	2,000-3,000	-----	-----	-----	-----	-----	-----	5.39	5.39	-----	-----	5.39	5.39
Bed total		-----	-----	1.58	1.58	-----	-----	13.21	13.21	-----	-----	14.79	14.79
Ravensdale No. 4	0-1,000	-----	-----	1.17	1.17	-----	-----	-----	-----	-----	-----	1.17	1.17
	1,000-2,000	-----	-----	1.84	1.84	-----	-----	-----	-----	-----	-----	1.84	1.84
	2,000-3,000	-----	-----	-----	-----	-----	-----	1.42	1.42	-----	-----	1.42	1.42
Bed total		-----	-----	3.01	3.01	-----	-----	1.42	1.42	-----	-----	4.43	4.43
McKay	0-1,000	-----	-----	0.73	0.73	-----	-----	-----	-----	-----	-----	0.73	0.73
	1,000-2,000	-----	-----	.43	.43	-----	-----	-----	-----	-----	-----	.43	.43
	2,000-3,000	-----	-----	-----	-----	-----	-----	0.14	0.14	-----	-----	.14	.14
Bed total		-----	-----	1.16	1.16	-----	-----	0.14	0.14	-----	-----	1.30	1.30
Six-foot	0-1,000	-----	-----	-----	-----	-----	-----	1.08	1.08	-----	-----	1.08	1.08
	1,000-2,000	-----	-----	-----	-----	-----	-----	1.39	1.39	-----	-----	1.39	1.39
	2,000-3,000	-----	-----	-----	-----	-----	-----	1.51	1.51	-----	-----	1.51	1.51
Bed total		-----	-----	-----	-----	-----	-----	3.98	3.98	-----	-----	3.98	3.98
Ravensdale No. 3	0-1,000	-----	-----	1.43	1.43	-----	-----	-----	-----	-----	-----	1.43	1.43
	1,000-2,000	-----	-----	.71	.71	-----	-----	0.91	0.91	-----	-----	1.62	1.62
	2,000-3,000	-----	-----	-----	-----	-----	-----	1.23	1.23	-----	-----	1.23	1.23
Bed total		-----	-----	2.14	2.14	-----	-----	2.14	2.14	-----	-----	4.28	4.28
Township total		0.05	0.93	10.66	11.64	0.26	1.45	33.75	35.46	0.31	2.38	44.41	47.10
T. 22 N., R. 7 E.													
Ravensdale No. 9	0-1,000	-----	0.04	-----	0.04	-----	-----	-----	-----	-----	0.04	-----	0.04
Dutch	0-1,000	-----	-----	-----	-----	-----	1.63	-----	1.63	-----	1.63	-----	1.63
	1,000-2,000	-----	-----	-----	-----	-----	.66	-----	.66	-----	.66	-----	.66
Bed total		-----	-----	-----	-----	-----	2.29	-----	2.29	-----	2.29	-----	2.29
Big	0-1,000	-----	-----	1.06	1.06	-----	-----	-----	-----	-----	-----	1.06	1.06
	1,000-2,000	-----	-----	-----	-----	-----	-----	0.92	0.92	-----	-----	.92	.92
Bed total		-----	-----	1.06	1.06	-----	-----	0.92	0.92	-----	-----	1.98	1.98
Victory	0-1,000	-----	-----	2.68	2.68	-----	-----	2.02	2.02	-----	-----	4.70	4.70
	1,000-2,000	-----	-----	-----	-----	-----	-----	2.53	2.53	-----	-----	2.53	2.53
Bed total		-----	-----	2.68	2.68	-----	-----	4.55	4.55	-----	-----	7.23	7.23
Unnamed	0-1,000	-----	-----	-----	-----	-----	-----	0.32	0.32	-----	-----	0.32	0.32
Ravensdale No. 4	0-1,000	-----	-----	0.23	0.23	-----	-----	-----	-----	-----	-----	0.23	0.23
Elk No. 1	0-1,000	-----	-----	1.57	1.57	-----	-----	0.46	0.46	-----	-----	2.03	2.03
	1,000-2,000	-----	-----	-----	-----	-----	-----	1.83	1.83	-----	-----	1.83	1.83
Bed total		-----	-----	1.57	1.57	-----	-----	2.29	2.29	-----	-----	3.86	3.86
Durham No. 2	0-1,000	-----	-----	1.36	1.36	-----	-----	0.32	0.32	-----	-----	1.68	1.68
Ravensdale No. 3	0-1,000	-----	-----	0.21	0.21	-----	-----	-----	-----	-----	-----	0.21	0.21
Big Elk	0-1,000	-----	-----	3.50	3.50	-----	-----	2.28	2.28	-----	-----	5.78	5.78
	1,000-2,000	-----	-----	-----	-----	-----	-----	4.06	4.06	-----	-----	4.06	4.06
Bed total		-----	-----	3.50	3.50	-----	-----	6.34	6.34	-----	-----	9.84	9.84
Elk No. 2	0-1,000	-----	-----	-----	-----	0.66	-----	-----	0.66	0.66	-----	-----	0.66
Township total		-----	0.04	10.61	10.65	0.66	2.29	14.74	17.69	0.66	2.33	25.35	28.34
Grand total		11.11	16.62	70.90	98.63	19.11	38.71	200.86	258.68	30.22	55.33	271.76	357.31

*Subbituminous coal. Coal 2.5 to 5.0 feet and 5.0 to 10.0 feet thick is shown in the 14 to 28 inches and 28 to 42 inches thickness categories.

Limestone

Limestone occurs in two areas in King County— near Grotto, in the northern part of the county and near Snoqualmie Pass, in the east central part. The deposits in both areas are described in detail by Danner (1966, p. 359-386), and data on the deposits are summarized in Table 21, on the p. 82, of the present report.

The limestone has undergone considerable recrystallization and occurs in lenses that vary in size from less than 1 ton to more than 1 million tons. Four of the largest deposits in the Grotto area were quarried to furnish raw material for the cement plant at Grotto. These quarries were worked to the extent that they were either depleted or it was no longer economically feasible to operate them; they are now abandoned. The remaining limestone deposits in the county, because of one reason or another— inaccessibility, small size, or lack of uniform composition— can be considered as being outside the range of economic importance at the present time (1969). This situation could change in the future if a road made the deposits accessible; however, Danner (1966, p. 368) indicates that at the time of his study none of the deposits had the tonnage or composition to justify building a road or tramline to it.

Limestone may have been first discovered in King County by John Maloney, an early prospector in the Grotto area. First quarrying of limestone in the county began some time between 1926, when Northwestern Portland Cement Co. acquired the deposits near Grotto, and 1928, when the plant began producing cement. The quarries produced continuously until 1953, at which time they were abandoned.

Deposits in the Baring-Grotto Area

The limestone in the Grotto area (Fig. 41) consists of lenticular masses of recrystallized limestone intercalated with argillite, quartzite, ribbon chert, and altered volcanic rocks that Danner (1966, p. 360) calls the Trafton sequence. The belt of rocks that contains the limestone is fairly narrow, probably not more than 3 miles wide, and is approximately 8 miles long. The unit strikes north parallel to the long dimension of its outcrop area. The rocks of the Trafton sequence are complexly folded and faulted, and are cut by dikes of hypabyssal and plutonic rocks. Both to the west and to the east, the Trafton is in contact with rocks of the Snoqualmie batholith. Where limestone pods have been intruded, they are altered, recrystallized, and have skarn zones along the contact.

The limestone-bearing sequence was first described by W. S. Smith (1915, 1916a, and 1916b), who assigned it to the Ordovician on the basis of fossils found near Lowe Creek. Danner (1957, p. 230; 1966, p. 363) was unable to find Ordovician fossils, but did find fusulinids that are characteristic of the Permian. As a result, he tentatively assigned the Trafton rocks to the Permian.

Limestone was produced from four deposits in the Grotto area— Marble No. 1, Marble No. 2, Maloney No. 6, and the Calcite Placer claim (also called Roche Harbor deposit).

Marble No. 1 quarry.— The first limestone to be quarried in King County came from the Marble No. 1 deposit, which is about 2 miles west of Grotto on Palmer Mountain at an elevation of 2,520 feet; the deposit is about 600 feet above Lowe Creek (Fig. 41). The quarry has been abandoned for many years, and a lake about 20 feet deep occupies most of the quarry floor. The limestone body was about 450 feet long and 150 feet wide, and originally must have appeared to be plastered on the side of the valley wall. It has been intruded on the east by diorite, and the contact contains a skarn zone about 1 foot thick. The contact dips about 70° W. and strikes slightly east of north. An altered, fine-grained, basic volcanic rock is on the west side of the limestone. The deposit is cut by two basalt dikes that strike more or less east. The limestone is bluish gray to almost white, depending upon the intensity of recrystallization— the coarser crystalline material is lighter in color. Where recrystallization had not been too severe, Danner (1966, p. 363) found faint outlines of large crinoid stems in the rock.

The limestone from this quarry has been almost totally removed, having been transported by tramline to the cement plant at Grotto. Only small remnants are left at each end of the quarry, and this material has been covered by talus.

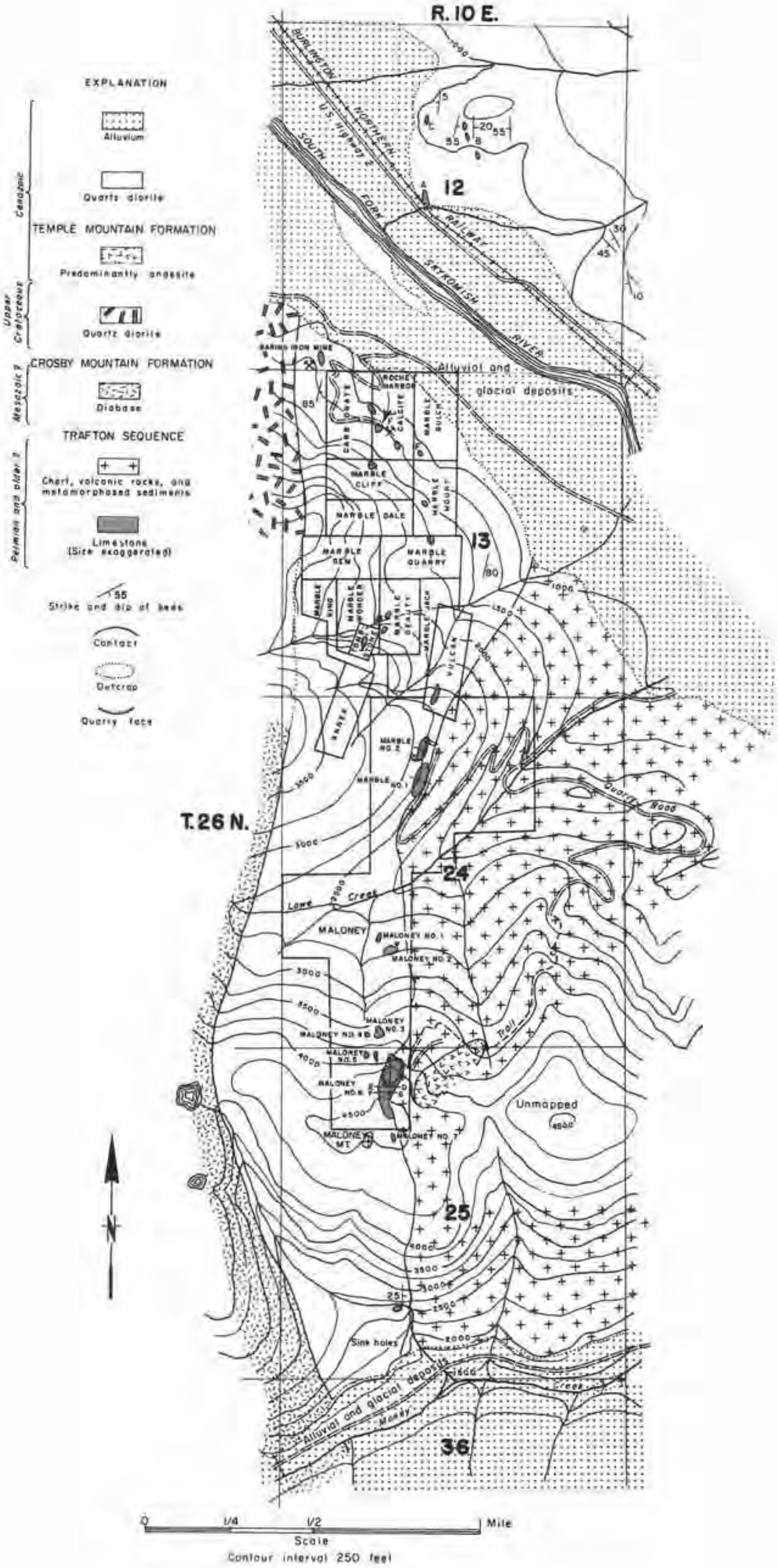


FIGURE 41.—Geologic map of limestone deposits of the Baring-Grotto area, King County, Washington. [Figure 180, Danner, 1966, p. 360.]

Marble No. 2 quarry.— The Marble No. 2 limestone deposit is about 200 feet northwest of the Marble No. 1 and at an elevation of 2,600 feet. The limestone beds stand nearly vertical— dipping at a high angle to the west at the top, and steeply to the east at the bottom. Quarrying of the deposit produced a deep narrow trench about 300 feet long and 60 feet wide across the quarry floor. The slightly wider top of the quarry may be the result of spalling or slumping of the quarry walls. Core holes drilled by the cement company indicate that the limestone tends to widen eastward below the quarry floor (Danner, 1966, p. 364). By 1951 the quantity of rock left in the quarry was small, and taking it out would have been so hazardous that the cement company decided to abandon the deposit.

The limestone is fine to medium grained and medium gray to white in color. It is cut by two small, dark-colored, south-dipping dikes of volcanic rock. The wall rock on the west side of the deposit is a dark, altered volcanic rock, and to the east the limestone is in contact with impure quartzite.

Calcite placer claim (also called Roche Harbor deposit).— The Calcite deposit is on a northwestern ridge spur on the northeast side of Palmer Mountain. The limestone strikes about N. 15° W. and dips steeply to the northeast. It is finely crystalline and varies from black through dark gray to white. Danner (1966, p. 369) found small nondiagnostic, poorly preserved crinoid columnals in the limestone. The deposit is a lenticular mass underlain and overlain by metavolcanic rocks, chert, and cherty argillite.

During 1953, the deposit was quarried for a short time to supply limestone for the cement plant at Grotto. After about 40,000 tons had been removed, using trucks for transportation, the quarry was abandoned.

Maloney No. 6 deposit.— The Maloney No. 6 deposit is on the north face and almost at the top of Maloney Mountain. The deposit is about 600 feet long and 150 to 200 feet wide. Early surveys (Danner, 1966, p. 366) reported a substantial tonnage of limestone in the deposit, but drilling data obtained in 1952 by the Northwestern Portland Cement Company indicated less than 1 million tons of limestone. A little more than 500,000 tons was quarried between 1948 and 1952. The material was moved by tramline from the mountain to the cement plant.

Drilling of the limestone body showed that it had been intruded by quartz diorite, and that part of it had been faulted down. Danner (1966, p. 366, Fig. 187) shows how the intrusive and fault relations at the deposit gave it a superficial appearance of being much larger than it really is. The limestone is in contact with quartz diorite on the east and an impure quartzite on the west. A skarn zone occurs along the east contact. The limestone is light gray to bluish gray, and is generally fine grained except along the intrusive contact, where it is coarsely crystalline.

Vulcan deposit.— The Vulcan deposit crops out about 400 feet northeast of the Marble No. 2 quarry. The deposit is composed of a narrow body of banded, bluish-gray, finely crystalline, vertical-standing limestone that is bordered on each side by impure quartzite. The limestone is exposed for about 300 feet from north to south and has a maximum width of 40 feet. The deposit is on a steep slope in virgin timber and would be difficult to quarry.

Tombstone deposit.— The Tombstone deposit consists of a small pod of white crystalline limestone about 8 feet wide and 100 feet long.

Maloney No. 1 deposit.— The Maloney No. 1 deposit is a small limestone lens that crops out on a steep hillside below the Maloney No. 2 and south of the Marble quarries. The deposit is described (Danner, 1966, p. 364) as being 150 feet long, about 50 feet wide, and lying at an altitude between 2,740 and 2,820 feet above sea level.

Maloney No. 2 deposit.— The Maloney No. 2 deposit is above the Maloney No. 1 deposit on the north slope of Maloney Mountain at an elevation between 2,830 and 2,920 feet. Its long dimension trends northeast. It is about 160 feet long and 70 feet wide. The limestone is cut by at least one volcanic dike, and it contains chert and garnet as impurities. Danner (1966, p. 364) estimates that the deposit contains about 20,000 tons of limestone.

Maloney No. 3 deposit.— The Maloney No. 3 deposit is a small limestone pod exposed on a cliff face at about 3,700 feet in elevation on the north slope of Maloney Mountain. Danner (1966, p. 366) estimates that the deposit contains about 50,000 tons.

Maloney No. 4 deposit.— The Maloney No. 4 deposit is about 150 feet west of the Maloney No. 3 on Maloney Mountain. The outcrop of limestone is about 75 feet long and 50 feet wide.

Maloney No. 5 deposit.— The Maloney No. 5 deposit is at an elevation between 3,790 and 3,900 feet on the north face of Maloney Mountain. The limestone lens is about 200 feet long and 125 feet wide.

Maloney No. 7 deposit.— The Maloney No. 7 deposit is on the south side of Maloney Mountain at an elevation of about 4,500 feet. The limestone is about 40 feet long and 10 feet wide. It is in contact with volcanic rocks to the west, and probably to the east also. The west contacts dips 60° W.

Baring Iron Mine deposit.— The Baring Iron Mine deposit consists of a limestone lens about 10 feet wide, exposed for about 100 feet along a vertical cliff face. North and south of the outcrop the limestone is covered by talus. The outcrop is near a contact between intrusive quartz diorite and the limestone-bearing Trafton rocks. The limestone is white and has a coarsely crystalline texture. Small veins of magnetite occur within the limestone near its western contact.

Carbonate placer deposit.— Danner (1966, p. 369) reports that the deposit consists of many limestone pods, the largest of which is exposed for 50 feet vertically and 35 feet horizontally on a cliff face. Drilling in 1954 showed that the deposit is less than 20 feet thick. The limestone is badly fractured, and the deposit is estimated to contain between 2,000 and 3,000 tons.

Marble Beauty deposit.— The Marble Beauty deposit consists of four small limestone pods that crop out in a steep-sided gully. Danner (1966, p. 369) estimates the reserves to be less than 500 tons.

Marble Cliff deposit.— Limestone of this deposit crops out on the face of a vertical cliff. The limestone outcrop is estimated to be 100 feet wide and not more than 200 feet high. Its depth into the hillside is unknown. The deposit is cut by two large volcanic dikes and is overlain by cherty argillite and volcanic rock.

Marble Gulch deposit.— Two small outcrops of limestone compose the Marble Gulch deposit. Neither outcrop covers more than 100 square feet. Danner (1966, p. 370) found Permian fusulinids in limestone float boulders in a gully below the deposits.

Marble Mount deposit.— Danner (1966, p. 370) reports that several small limestone lenses are exposed in a cliff.

Marble Quarry deposit.— The Marble Quarry deposit consists of a small limestone lens that crops out on a cliff face near the top of a northeast spur on Palmer Mountain. Danner (1966, p. 371) reports that it is poorly exposed and covers less than 100 square feet.

Money Creek deposits.— Galster (1956, p. 20) reports several small limestone lenses in the pre-Jurassic rocks south of Money Creek. Danner (1966, p. 372) found two small pods of limestone exposed in a stream bottom that he estimated to be a little east of the center of the SW$\frac{1}{4}$ sec. 25, T. 26 N., R. 10 E. The limestone is interbedded with volcanic rocks and dips about 25° E. One bed is 6 inches thick, and the other has a maximum thickness of 3 feet. Both beds pinch out along the strike.

Baring deposits.— The Baring limestone beds crop out beside the Great Northern Railway tracks and along the Bonneville-Grand Coulee-Chief Joseph powerline in the N$\frac{1}{2}$ and the central part of sec. 12, T. 26 N., R. 10 E., about 2 miles northwest of Grotto. The deposits consist of small limestone beds that Danner (1966, p. 373) designated Deposits A and B. Deposit A is about 50 feet thick and at least 75 feet long; an estimated minimum of 4,500 tons of limestone is exposed (Danner, 1966, p. 373). Deposit B is 10 feet thick and crops out for 300 feet. The deposits are small lenticular beds of crystalline limestone interbedded with ribbon chert, cherty argillite, and metamorphosed volcanic rock.

Deposits in the Snoqualmie Pass Area

Limestone occurs on Denny Mountain, Guye Peak, and Chair Peak in the Snoqualmie Pass area (Fig. 42). No production has been reported from any of the deposits; however, a considerable amount of exploration work was done on the Denny Mountain deposit. The limestone deposits in this area are thought to correlate with those to the north near Grotto. Foster (1960, p. 111) proposed the name Denny Formation for the unit in which they occur

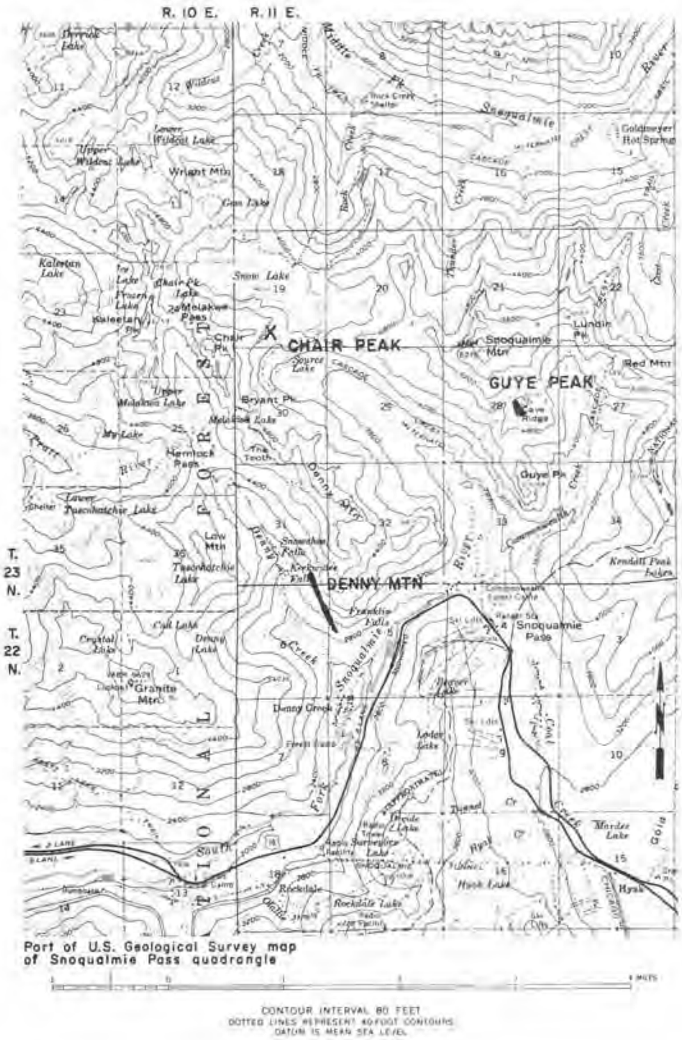


FIGURE 42.— Index map of limestone deposits near Snoqualmie Pass, King County, Washington. [Figure 193, Danner, 1966, p. 375.]

and suggested a pre-Tertiary age for them. Danner (1957, p. 249) proposed a tentative Permian age for them.

Denny Mountain deposit.— The Denny Mountain limestone deposit crops out on the west side of Denny Mountain in the SE$\frac{1}{4}$ sec. 31, T. 23 N., R. 11 E., and the NE$\frac{1}{4}$ sec. 6 and NW$\frac{1}{4}$ sec. 5, T. 22 N., R. 11 E., at an altitude between 2,800 and 4,000 feet. The deposit is a large lenticular body of medium to coarsely crystalline, white to dark-gray limestone that, according to Danner's (1966, p. 375) estimate, contains 6 million tons of reserves. The limestone deposit is about 2,500 feet long and as much as 500 feet wide. The limestone appears to dip steeply to the west at some places and steeply east at others. Above the limestone is a greenish-black altered spilitic basalt and relatively unaltered basalt. Below it are similar basalts that have been intruded by granodiorite. The granodiorite has also intruded the limestone at several places, and large skarn zones have developed. The limestone has also been intruded by dikes of andesitic or basaltic composition. Danner (1966, p. 377) reports that at two places the limestone contains large masses of basaltic rock.

Guye Peak (Cave Ridge) deposit.— The Guye Peak limestone deposit occurs on Cave Ridge about three-quarters of a mile north of Guye Peak and 1.5 miles north of Snoqualmie Pass. The deposit lies on the west side of and near the top of Cave Ridge at an elevation between 4,300 and 5,200 feet. It consists of a few thin recrystallized limestone beds intercalated with schist. The deposit has been intruded by granodiorite, and a contact skarn zone has been developed. The limestone is reported to be of good quality, but its location and size are such that under present (1969) economic conditions it could not be worked.

Chair Peak deposit.— Danner (1966, p. 386) reports limestone float at about 4,400 to 4,800 feet in elevation south of Snow Lake on the east side of Chair Peak, in the south part of sec. 19, T. 23 N., R. 11 E. Danner was unable to find the outcrop from which the limestone came, but he believes that it is associated with a sequence of ribbon chert that occurs in the area.

Summary of Limestone Data

King County contains two main limestone areas— one near Grotto and the other near Snoqualmie Pass. The limestone occurs in formations that probably are correlative. Some of the deposits in the Grotto area are depleted, and some are so situated that they could not be worked economically. Many are too small to be of value. All told, there are probably less than 300,000 tons of known reserves in the area. Production from the Grotto area was continuous from 1928 to 1953; it is estimated that slightly less than 2,000,000 tons of limestone was quarried. Practically all of the limestone produced was used by the Northwestern

TABLE 21.— Summary of King County, Washington, limestone deposits—reserves and potential uses

[Extracted from Table 12, Danner, 1966, p. 59]

Deposit	Development	Use	Reserves (tons)	Potential uses			
				Cement	Pulp	Agri-culture	Chemi-cal
KING COUNTY							
Grotto area							
Marble No. 1	Exhausted	Cement rock	...	...	...	...	...
Marble No. 2	Exhausted	Cement rock	...	...	...	...	...
Vulcan	Undeveloped	...	±100,000	X	?	X	?
Tombstone	Undeveloped	...	-100	...	...	...	...
Maloney No. 1	Undeveloped	...	±50,000	X	?	X	?
Maloney No. 2	Undeveloped	...	±20,000	X	?	X	?
Maloney No. 3	Undeveloped	...	±50,000	X	?	X	?
Maloney No. 4	Undeveloped	...	±3,000	X	?	X	?
Maloney No. 5	Undeveloped	...	±8,000	X	?	X	?
Maloney No. 6	Exhausted	Cement rock	...	...	...	...	...
Maloney No. 7	Undeveloped	...	±300	...	?	X	?
Baring Iron Mine	Undeveloped	...	-1,000	X	...	...	...
Calcite Placer	Exhausted	Cement rock	...	...	...	...	...
Carbonate Placer	Undeveloped	...	±3,000	...	...	...	...
Marble Beauty	Undeveloped	...	-500	...	?	X	?
Marble Cliff	Undeveloped	...	±20,000	X	...	...	...
Marble Gulch	Undeveloped	...	-100	...	...	...	...
Marble Mount	Undeveloped	...	-100	...	...	...	...
Marble Quarry	Undeveloped	...	-100	...	?	X	X
Baring (Skyko Camp)	Undeveloped	...	±5,000	X	...	...	...
Snoqualmie Pass area							
Denny Mountain	Undeveloped	...	6,000,000	...	?	X	...
Guye Peak	Undeveloped	...	Unknown	Unknown			
Chair Peak	Undeveloped	...	Trace	...	...	...	...
	King County total		±6,261,200				

Portland Cement Company (later the Ideal Cement Company) to make cement at its Grotto plant. An estimated 20,000,000 barrels of cement was produced during the life of the Grotto quarries.

No production has been recorded from the limestone deposits near Snoqualmie Pass. Although there are probably more than 6,000,000 tons of limestone reserves in the area, the rock is so poorly situated geographically and has such a variable composition that it can be considered only as a possible future source of low-grade lime rock.

Molding Sand

Molding sand has been mined in King County since 1930, when Fred B. Cavanaugh began producing material for foundry moldings from a pit in the NE¼ sec. 30, T. 23 N., R. 6 E. (Fig. 43).

A plastic mixture of clayey sandstone, siltstone, shale, and claystone is produced from the pit, which is in the Renton Formation. The strata from which the material comes appears to be just above the Cedar Mountain coal seam.

Wilson and others (1942, p. 29) report that a sample taken from the pit showed 76.8 percent silica and 2.2 percent ferric oxide. Removal of the minus 200-mesh fraction by washing increased the silica to 78.7 percent, but had no effect on the amount of ferric oxide present. The pyrometric cone equivalent gave a medium-gray fusion at cone 18. The 65- to 100-mesh fraction gave a light-gray fusion at cone 14. Petrographic examination of the washed sand

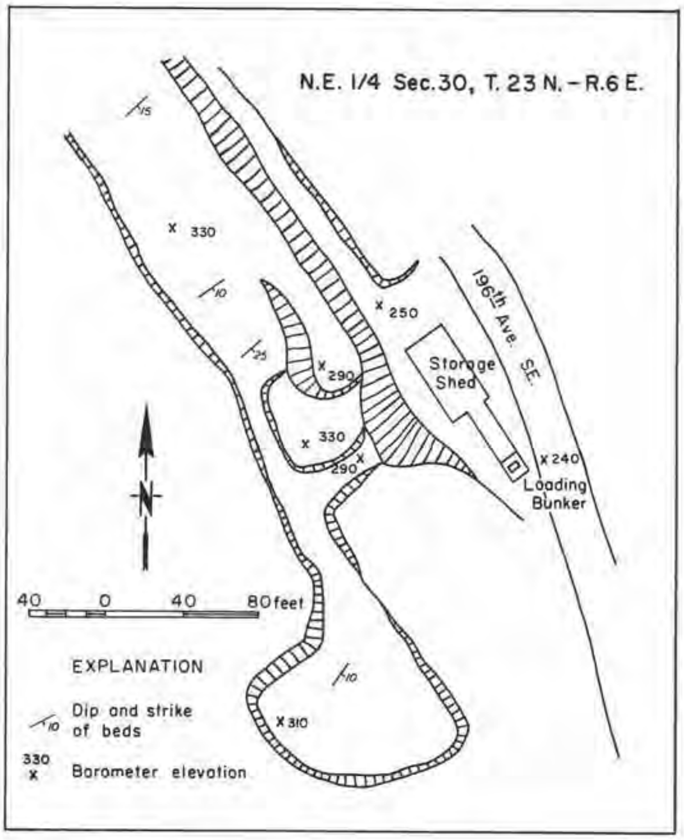


FIGURE 43.— Cavanaugh molding sand pit, in King County, Washington.

showed 65 percent quartz, 11 percent fresh feldspar, 19 percent turbid feldspar, 2 percent muscovite, 2 percent glass, 1 percent blacks, and traces of other minerals. Washing and screening of the untreated material through a 20-mesh screen removed 47 percent of the sample. When the screened and washed sand was beneficiated by magnetic means, the ferric oxide content was lowered from 2.2 percent to 0.55 percent.

Oil and Gas

Oil and gas exploration in King County is reported to have started prior to 1902, with the drilling of the Des Moines test well. The well was unsuccessful and no details are available on it. Since that time 24 dry holes have been drilled, mostly on the Kummer anticline, in the Black Diamond-Enumclaw area. The only other structure that has been seriously tested is the Tukwila anticline, near Kent. Table 22 is a summary of oil and gas exploration in the county, Figure 44 shows the location of wells drilled in the county, and Figure 45 shows the different anticlines that have been mapped in the western part of the county.

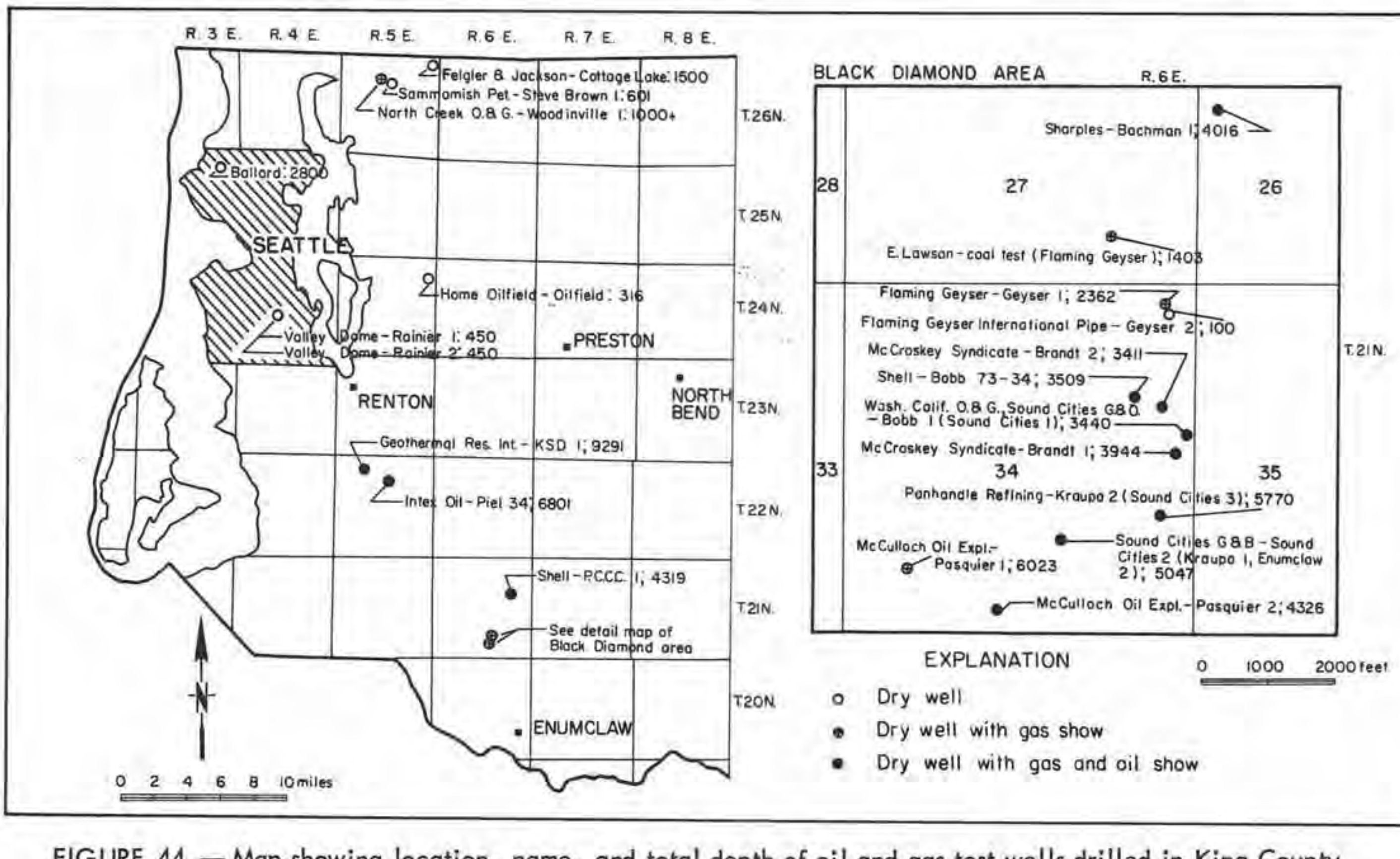


FIGURE 44.— Map showing location, name, and total depth of oil and gas test wells drilled in King County, Washington.

TABLE 22.— Summary of oil and gas test wells drilled in King County, Washington, between 1900 and 1969

[Modified from Livingston, 1958, p. 28-29]

Company	Well name	Location and elevation	Spud date / Abandon date	Total depth	Remarks and records available from State Oil and Gas Supervisor's office
Pacific Oil Wells Co.	Des Moines	Near Des Moines	Prior to 1902	(?)	Details unknown.
Seattle & King County Oil Co.	(?)	Near South Park, on W. side of Duwamish River	1902 / ?	700+	Cable tools. Details unknown.
Eugene Lawson	coal test (Flaming Geyser)	Black Diamond area. Near center S½SE¼ sec. 27, (21-6E). Elev. 275 ft. topo	1911 / ?	1,403	Cable tools. Gas showings 900 to 1,000 ft. Encountered several carbonaceous shales and coal beds. Salt water below 1,000 ft. Driller's log, well cuttings, gas analysis.
(?)	Ballard	In Ballard	1913 / ?	2,800(?)	Cable tools. Results unknown.
Home Oil Co. of Seattle	Oilfield	Seattle area. Sec. 12, (24-5E)	1914 / ?	316	Cable tools. Results unknown.
Flaming Geyser Co.	Geyser No. 1 (Petchnick)	Black Diamond area. 420 ft. S., 300 ft. W. of NE. cor. sec. 34, (21-6E). Elev. 590 ft. topo	1928 / ?	2,362	Cable tools. Bottom of glacial drift at 286 ft. Good gas showing. Driller's log.
Valley Dome Oil Co.	Rainier No. 1	Rainier Valley at 6932 - 28th Ave. S., Seattle	1930(?) / ?	450	Cable tools. Gas and oil reported. Abandoned because of mechanical trouble.
Valley Dome Oil Co.	Rainier No. 2	A few feet from Rainier No. 1	1930 / ?	450	Cable tools. Gas and oil reported. No casing run.
Flaming Geyser Gas Co. & International Pipe Lines Co., Ltd.	Geyser No. 2	250 ft. S. of Geyser No. 1	1931 / ?	100+	Cable tools. Results unknown.
North Creek Oil & Gas Co.	Woodinville No. 1	Bothell area. Sec. 9, (26-5E)	1935 / ?	1,000+	Cable tools. Gas, 78.5% methane, reported at 978 ft.
Washington-California Oil & Gas Co.; Sound Cities Gas & Oil Co., Inc.	Bobb No. 1 (Sound Cities No. 1)	Black Diamond area. 350 ft. N., 100 ft. W. of E. ¼ cor. sec. 34, (21-6E). Elev. 535 ft. topo	1936 / 1941	3,440	Base of glacial drift at 294 ft. Good oil and gas showings. Thoroughly tested. Driller's log, well cuttings, gas analysis, E log.
Sound Cities Gas & Oil Co., Inc.	Sound Cities No. 2 (Kraupa No. 1, Enumclaw No. 2)	Black Diamond area. 60 ft. N. of SW. cor. SE¼NW¼SE¼ sec. 34, (21-6E), about 2,500 ft. SW. of Bobb No. 1	9-19-37 / 1941	5,047	Cable tools. Slight gas and oil showings. Driller's log, E log.
Felger & Jackson	Cottage Lake	Bothell area. Near center sec. 1, (26-5E)	1939 / 1939	1,500(?)	Cable tools. Results unknown.
Panhandle Refining Co.	Kraupa No. 2 (Sound Cities No. 3, Panhandle)	Black Diamond area. Approx. 3,520 ft. S., 500 ft. W. of NE. cor. sec. 34, (21-6E) Elev. 675 ft. Gr.	7-12-42 / ?	5,770	Some traces of oil and gas. Driller's log, core analysis, E log, core desc.
The Sharples Corp.	Bachmann No. 1	Black Diamond area. 380 ft. E. of W. ¼ cor. sec. 26, (21-6E). Elev. 665 ft. R. T.	1943 / ?	4,016	Traces of oil and gas. Driller's log, core desc., core analysis, well cuttings, E log.
Shell Oil Co.	Pacific Coast Coal Co. No. 1	Black Diamond area. 320 ft. S., 1,498 ft. W. of NE. cor. sec. 14, (21-6E). Elev. 755 ft. D.F.	10-1-47 / 12-2-47	4,319	Several small gas showings, one small oil showing at 3,210 ft. Core desc., well history, s.w. core desc., ditch sample desc., E. log. Realgar at 3,274-3,284 ft., s.w. core analysis.
Shell Oil Co.	Bobb 73-34	Black Diamond area. 3,624 ft. N., 990 ft. W. of SE. cor. sec. 34, (21-6E). Elev. 618 ft. D.F.	9-22-48 / 12-1-48	3,509	Bottom of glacial drift at 660 ft. Core from 900 ft. has oil odor. Core desc., well history, s.w. core desc., E log, ditch sample desc.

TABLE 22.— Summary of oil and gas test wells drilled in King County, Washington, between 1900 and 1969— Continued

Company	Well name	Location and elevation	Spud date / Abandon date	Total depth	Remarks and records available from State Oil and Gas Supervisor's office
McCulloch Oil Exploration Co. of California, Inc.	Pasquier No. 1	Enumclaw area. 990 ft. N., 990 ft. E. of SW. cor. sec. 34, (21-6E). Elev. 565 ft. topo	4-30-57 / 6-6-57	6,023	Several gas showings. Driller's log, micro log, baroid log, E log, dipmeter survey.
McCulloch Oil Exploration Co. of California, Inc.	Pasquier No. 2	Enumclaw area. 330 ft. N., 330 ft. W. of S. ¼ cor. sec. 34, (21-6E). Elev. 575 ft. topo	6-12-57 / 7-6-57	4,326	Gas and oil showings. Driller's log, microlog, baroid log, E log, core desc., core analysis.
McCulloch Oil Exploration Co. of California, Inc.	Krainick No. 1	Enumclaw area. 493 ft. S., 642 ft. E. of NW. cor. sec. 10, T. 20 N., R. 6 E. Elev. 589 ft. D.F.	8-12-58 / 9-7-58	5,069	Dry hole. E log, microlog, dipmeter, mud log, formation tests.
A. E. McCroskey Syndicate	Brandt No. 1	Enumclaw area. 417 ft. N., 312 ft. W. of E. ¼ cor. sec. 34, T. 21 N., R. 6 E. Elev. 657 ft. Gr.	1-6-61 / 1-30-61	3,944	Dry hole. E log, sonic log, mud log, s.w. core desc., ditch samples.
A. E. McCroskey Syndicate	Brandt No. 2	Enumclaw area. 791 ft. N., 450 ft. W. of E. ¼ cor. sec. 34, T. 21 N., R. 6 E. Elev. 629 ft. Gr.	5-10-61 / 6-10-61	3,411	Dry hole. Fluorescence in core. E log, sonic log, dipmeter, ditch descr., core descr.
Intex Oil Company	Piel - 34	Kent area, 536 ft. W., 172 ft. N. of center sec. 10, T. 22 N., R. 5 E. Elev. 495 ft. topo	11-17-66 / 1-11-67	6,801	Dry hole. Show of high-gravity oil at 5,914 to 5,945 ft. E log, dipmeter, mud log, ditch samples.
Sammamish Petroleum, Inc.	Steve Brown No. 1	340 ft. N., 980 ft. W. of E. ¼ cor. sec. 9, T. 26 N., R. 5 E. Elev. 26 ft. topo	7-13-67 / 9-6-67	601	Dry hole. Driller's log.
Geothermal Resources International, Inc.	KSD No. 1	Kent area. 330 ft. N., 1,220 ft. W. of SE. cor. sec. 4, T. 22 N., R. 5 E. Elev. 440 ft. topo	9-16-67 / 12-11-67	9,291	Dry hole. Several oil shows. Could not be tested because of mechanical problems. E log, sonic log, dipmeter, mud log, ditch samples, s.w. core descr.

Most of the drilling in the county has been directed toward testing the nonmarine Eocene section of the Puget Group. J. Q. Anderson (1959, p. 111-113, 117) has summarized the exploration activity prior to 1959 and evaluated the oil and gas producing potential of the Puget Group. In 1966, the first attempt to test the marine section (Raging River Formation) below the Puget was made when the Intex Oil Company, of Bakersfield, California, drilled its Piel No. 34 well in sec. 10, T. 22 N., R. 5 E. The well bottomed in the Tiger Mountain Formation, the oldest Formation of the Puget Group, at 6,801 feet without reaching the Raging River Formation. On the basis of information gathered from the Intex-Piel well, Geothermal Resources International, Inc., of Bakersfield, during the fall of 1967 drilled the KSD No. 1 well in sec. 4, T. 22 N., R. 5 E., in another attempt to test the marine section below the Puget Group. Because of mechanical difficulties, this well was abandoned at 9,292 feet without having reached the marine section. Both wells had encouraging oil shows.

Gas was first discovered in King County in 1911, when a hole drilled to check coal reserves in sec. 27, T. 21 N., R. 6 E., encountered gas between 900 and 1,000 feet. The well proved to be noncommercial and was eventually abandoned. The first confirmed oil shows came in 1936, from the Washington-California Oil and Gas Co. and Sound Cities Gas and Oil Co., Inc. - Bobb No. 1 well, drilled in sec. 34, T. 21 N., R. 6 E. Many of the wells drilled since have had confirmed oil and gas shows that give encouragement regarding the possibility that oil in commercial quantities may yet be discovered.

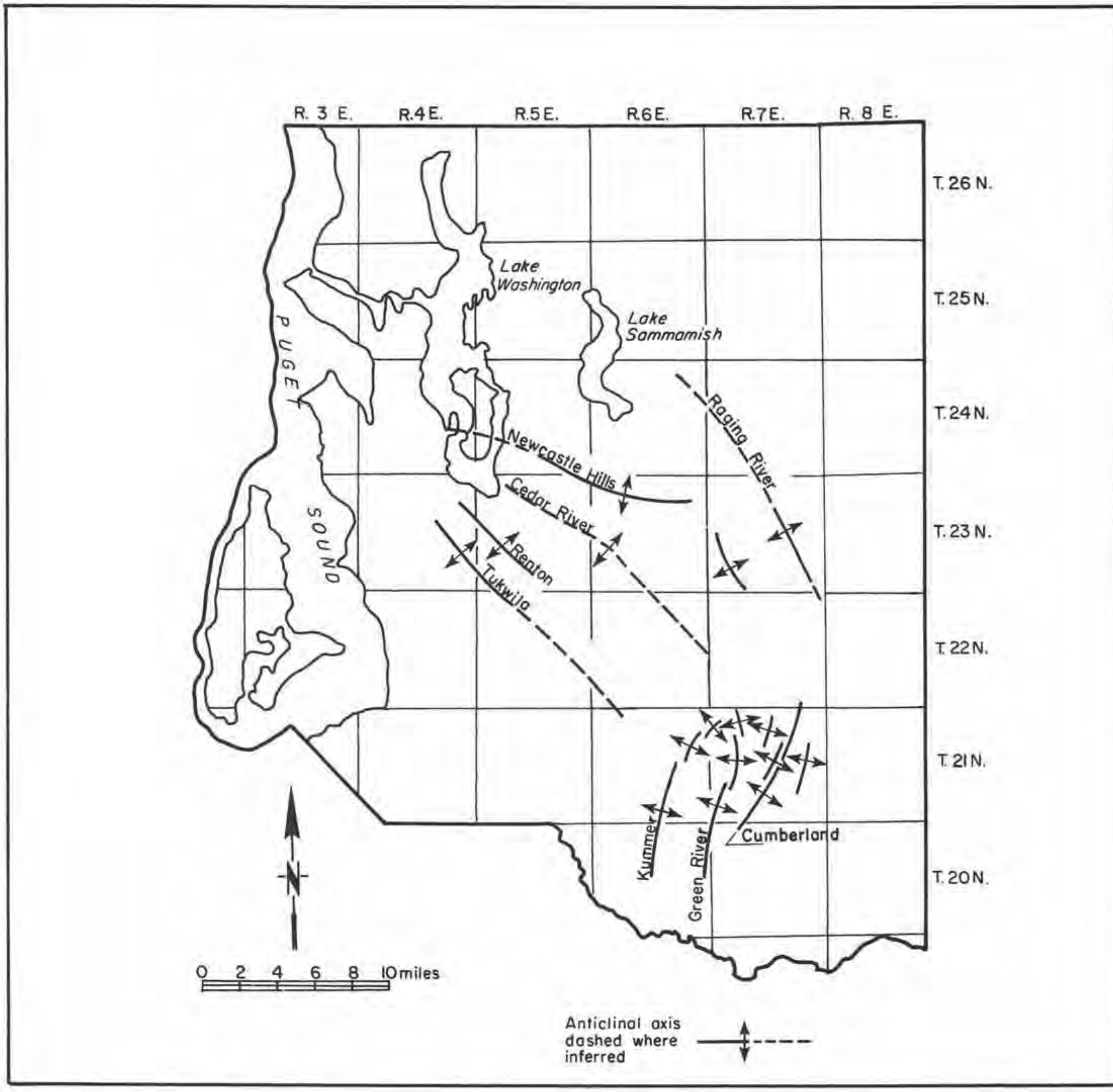


FIGURE 45.—Map showing location of anticlines in the Puget Lowlands part of King County, Washington.

Peat

Peat has been produced in King County for many years, but no complete record of production is available. During the past 10 years, production has generally been around 17,000 tons per year. Glover (1936b, p. 79) reports that 3 bogs in the Seattle area were in operation prior to 1936. Several bogs in that area were in production before 1950, and in the whole county there were 7 bogs in production during 1969 (Plate 2).

In King County, peat bogs are essentially restricted to the Puget Lowlands. Most of the bogs formed in depressions left on the land surface when the last continental ice sheet receded. The total area covered by peat is more than 12,540 acres (Table 23), of which approximately 900 acres is sphagnum. More than 380 bogs (Plate 2) occur in the county, 44 of which are described in detail by Rigg (1958, p. 69-95).

Poulson and others (1952, p. 22) report four types of organic soils in King County— Greenwood peat, Rifle peat, Mukilteo peat, and Carbondale muck.

Greenwood peat occurs in deep kettle lakes and potholes having poorly defined, sluggish outlets. It is composed chiefly of sphagnum moss, containing minor amounts of woody particles and fibers from other types of vegetation. The upper few feet of a typical bog is generally a spongy, fibrous, yellow-brown mat composed chiefly of sphagnum, including minor amounts of other mosses. As depth increases the color darkens through reddish brown to dark brown, and the vegetal material becomes more thoroughly decayed.

Rifle peat is usually found in swampy areas of stream bottoms, and, less commonly, marginal to large lakes. Approximately the top 16 inches of a typical Rifle bog is composed of granular decomposed dark reddish-brown woody peat. Below this the peat becomes increasingly decomposed with depth, consisting of matted fibrous woody fragments and some remnants of sedge, reed, and roots imbedded in colloidal organic material.

The largest Mukilteo peat bogs occur on deltas and adjacent to lakes, but they have also formed in shallow depressions on the drift plains. Mukilteo bogs are usually more swampy and open than Rifle peat bogs, and commonly are inundated during the winter months. In a representative bog the top 8 inches is a mixture of dark-brown spongy, finely fibrous peat and finely decomposed colloidal material, bound together by the roots of coarse marsh grasses and sedges. Below, the matted fibrous material decreases gradually downward and the colloidal material increases.

Carbondale muck is widely distributed in wet basins and stream bottoms, and in many places is associated with Rifle peat. The Carbondale is a reddish dark-brown, greasy organic material mixed with varying amounts of silty mineral soil. Generally, the organic material increases downward, and it contains sedge and woody fibers and fragments. Poulson and others (1952, p. 35) report that the muck rarely exceeds depths of 6 feet.

Rigg (1958, p. 5-10) describes the different bogs according to the type of peat they contain as well as the soil type. He describes sphagnum, fibrous, woody, and sedimentary peat, and muck, and gives the thickness of each type found in the bogs he studied.

The correlation between peat types Rigg describes and soil types that are described by Poulson and others (1952, p. 22) is as follows: Greenwood is sphagnum peat, Rifle is woody peat, Mukilteo is fibrous peat, and Carbondale is muck. The sedimentary peat that is described by Rigg (p. 7) receives only brief mention by Poulson and others (p. 102), because it does not occur as a bog surface deposit. It is composed of organic material that was deposited in water and is very fine grained, usually showing colloidal properties.

In Table 23 of this report the soil survey peat names given by Poulson and others (1952) have been used for all bogs. Where more detailed information from Rigg (1958) is available, the bog name and thickness of the peat types are also given.

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
1	Rifle	NE¼ sec. 4, (19-7E)		29			
2	Mukilteo	NW¼ sec. 12, (19-7E)		35			
3	Mukilteo	NE¼ sec. 12, (19-7E)		18			
4	Mukilteo and Greenwood	SW¼ sec. 6 and NW¼ sec. 7, (19-8E)	51	20			
5	Rifle	SE¼ sec. 1, (20-6E)		18			
6	Rifle	W½ sec. 1, (20-6E)		17			
7	Rifle	NW¼ sec. 1 and NE¼ sec. 2, (20-6-E); SE¼ sec. 35 and SW¼ sec. 36, (21-6E)		68			
8	Rifle	SE¼ sec. 14 and NW¼ sec. 13, (20-6E)		97			
9	Rifle	NW¼ sec. 14 and NE¼ sec. 15, (20-6E)		200			
10	Rifle	NW¼ sec. 15, (20-6E)		10			
11	Rifle	W½ sec. 36, (20-6E)		35			
12	Rifle	S½ sec. 5, (20-7E)		22			
13	Rifle	N½ sec. 7, (20-7E)		9			
14	Carbondale and Rifle	E½ secs. 13, 24, and 25, (20-6E); W½ secs. 18, 19, and 30, (20-7E)		397			
15	Greenwood	NE¼ sec. 19, (20-7E)	9				
16	Carbondale	SW¼ sec. 20, (20-7E)		9			
17	Carbondale	SW¼ sec. 20, (20-7E)		18			
18	Rifle	SW¼ sec. 21, (20-7E)		10			
19	Greenwood	NW¼ sec. 21, (20-7E)	10				
20	Rifle	SW¼ sec. 21, (20-7E)		9			
21	Mukilteo	SE¼ sec. 26, (20-7E)		20			
22	Rifle and Carbondale	SW¼ sec. 26, E½ sec. 34, and NW¼ sec. 35, (20-7E)		166			
23	Rifle	SE¼ sec. 31, (20-7E)		6			
24	Rifle	E½E½ sec. 31, (20-7E)		6			
25	Greenwood	NW¼ sec. 2, (21-4E)	9				
26	Greenwood	SW¼ sec. 2, (21-4E)	4				
27	Greenwood (Steel Lake)	NE¼ sec. 4, (21-4E)		44		16	Rigg (1958, p. 80-81)
28	Greenwood	NW¼ sec. 4, (21-4E)	32				
29	Mukilteo (Lakota)	SE¼ sec. 12, (21-3E); SW¼ sec. 7, (21-4E)		27			Rigg (1958, p. 84)
30	Mukilteo	SE¼ sec. 7, (21-4E)		7			
31	Mukilteo	SE¼ sec. 7 and NE¼ sec. 18, (21-4E)		9			
32	Mukilteo (Federal Way)	NE¼ sec. 8, (21-4E)		14		10	Rigg (1958, p. 90)
33	Mukilteo	SE¼ sec. 9, NE¼ sec. 16, and SW¼ sec. 10, (21-4E)		26			
34	Mukilteo (Dolloff Lake)	NW¼ sec. 10, (21-4E)		52		9	Rigg (1958, p. 79)
35	Carbondale	E½ sec. 11, (21-4E)		4			
36	Carbondale	S½S½ sec. 11, (21-4E)		5			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
37	Mukilteo (Misner Farm)	W½ sec. 14, (21-4E)		3½		5	Rigg (1958, p. 94)
38	Greenwood (North Lake)	NW¼ sec. 15, (21-4E)		13		13	Rigg (1958, p. 90-91)
39	Mukilteo	NE¼ sec. 18, (21-4E)		6			
40	Mukilteo	NW¼ sec. 18, (21-4E)		6			
41	Mukilteo	SW¼ sec. 18, (21-4E)		13			
42	Mukilteo	SW¼ sec. 18, (21-4E)		5			
43	Rifle and Mukilteo	SW¼ sec. 20 and NW¼ sec. 29, (21-4E)		100			
44	Mukilteo	NW¼SE¼ sec. 20, (21-4E)		9			
45	Rifle	SW¼ sec. 23, (21-4E)		16			
46	Carbondale and Rifle (Algona No. 1) (Algona No. 2)	SE¼ sec. 14, E½ sec. 23, SW¼ sec. 24, E½ sec. 26, W½ sec. 25, E½ sec. 35, and NW¼ sec. 36, (21-4E)		462		7	Rigg (1958, p. 70)
47	Mukilteo	W½ sec. 27, (21-4E)		32			
48	Carbondale	W½SE¼ sec. 29 and NE¼ sec. 32, (21-4E)		45			
49	Carbondale	SW¼ sec. 4, (21-5E)		35			
50	Rifle	SE¼ sec. 10 and SW¼ sec. 11, (21-5E)		45			
51	Rifle	SW¼ sec. 1 and N½ sec. 12, (21-5E)		32			
52	Carbondale	SE¼ sec. 13, (21-5E)		9			
53	Rifle	SW¼ sec. 13 and NW¼ sec. 24, (21-5E)		26			
54	Mukilteo	SE¼ sec. 14, (21-5E)		21			
55	Mukilteo	NE¼ sec. 23 and SW¼ sec. 24, (21-5E)		32			
56	Rifle	SW¼ sec. 13 and NW¼ sec. 24, (21-5E)		32			
57	Mukilteo	SW¼ sec. 24, (21-5E)		12			
58	Carbondale	SW¼ sec. 31, (21-5E)		9			
59	Carbondale	SW¼ sec. 31, (21-5E)		4			
60	Greenwood	NW¼SE¼ sec. 33, (21-5E)	7				
61	Rifle	SW¼ sec. 1, (21-6E)		53			
62	Rifle	NW¼ sec. 2, (21-6E)		9			
63	Rifle (Black Diamond)	NW¼ sec. 2, (21-6E)		18	2	16	Rigg (1958, p. 88)
64	Greenwood	NE¼SE¼ sec. 3 and NW¼SW¼ sec. 2, (21-6E)	29			8	
65	Rifle	NE¼ sec. 6, (21-6E)		5			
66	Rifle	NE¼ sec. 6, (21-6E)		10			
67	Rifle	SW¼ sec. 6 and NW¼ sec. 7, (21-6E)		100			
68	Greenwood	SW¼ sec. 9, (21-6E)	16				
69	Rifle	E½ sec. 9, (21-6E)		8			
70	Mukilteo	N½ sec. 10, (21-6E)		19			
71	Rifle	SE¼ sec. 10, NE¼ sec. 15, and NW¼ sec. 14, (21-6E)		13			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
72	Rifle	NE¼ sec. 11, (21-6E)		19			
73	Rifle	SE¼ sec. 14 and SW¼ sec. 13, (21-6E)		19			
74	Rifle	SE¼ sec. 15 and S½ sec. 14, (21-6E)		180			
75	Rifle	N½ sec. 16, (21-6E)		18			
76	Rifle	E½ sec. 22, (21-6E)		16			
77	Rifle	SW¼ sec. 24, (21-6E)		7			
78	Mukilteo	S½ sec. 32, (21-6E)		42			
79	Rifle	S½ sec. 34, (21-6E)		26			
80	Mukilteo	S½ sec. 4, (21-7E)		16			
81	Rifle	NE¼ sec. 5, (21-7E)		15			
82	Rifle	SW¼ sec. 5, (21-7E)		8			
83	Rifle (Lake Twelve)	N½ sec. 7, (21-7E)		48	5	13	Rigg (1958, p. 82-83)
84	Rifle (Lake Twelve)	NW¼ sec. 8, (21-7E)		22			
85	Rifle	SE¼ sec. 30 and NE¼ sec. 31, (21-7E)		33			
86	Carbondale	SW¼ sec. 8, (22-3E)		8			
87	Carbondale	NW¼ sec. 4, (22-4E)		27			
88	Carbondale	NW¼ sec. 10, NE¼ sec. 9, and SW¼ sec. 3, (22-4E)		8			
89	Carbondale and Greenwood (Bingaman Lake)	SE¼ sec. 34, (22-4E)	7		1	6	Rigg (1958, p. 93)
90	Carbondale	Center sec. 35, (22-4E)		141			
91	Mukilteo	NE¼ sec. 4, (22-5E)		6			
92	Rifle	NE¼ sec. 4 and SW¼ sec. 3, (22-5E)		102			
93	Rifle and Carbondale (Panther Lake)	NE¼ sec. 5, SW¼ sec. 4, and NW¼ sec. 9, (22-5E)		32		8	Rigg (1958, p. 84)
94	Rifle	NE¼ sec. 8, (22-5E)		16			
95	Carbondale	NW¼ sec. 10, (22-5E)		21			
96	Rifle and Carbondale	S½ sec. 10, (22-5E)		51			
97	Carbondale	NE¼ sec. 13, (22-5E)		27			
98	Rifle	NW¼ sec. 13, (22-5E)		5			
99	Carbondale	SE¼ sec. 14 and NE¼ sec. 23, (22-5E)		23			
100	Carbondale	SW¼ sec. 15, (22-5E)		5			
101	Greenwood	N½ sec. 16, (22-5E)	5				
102	Mukilteo	NE¼ sec. 21, (22-5E)		7			
103	Mukilteo	NW¼ sec. 23 and SE¼ sec. 15, (22-5E)		26			
104	Rifle	SW¼ sec. 23, (22-5E)		16			
105	Mukilteo	NW¼ sec. 24, (22-5E)		9			
106	Carbondale	S½ sec. 27, (22-5E)		8			
107	Carbondale	S½ sec. 28, (22-5E)		29			
108	Carbondale	NE¼ sec. 34 and SE¼ sec. 27, (22-5E)		13			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness — Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
109	Rifle	NE¼ sec. 36, (22-5E)		64			
110	Rifle	E½ sec. 1 and W½ sec. 2, (22-6E)		26			
111	Rifle	SE¼ sec. 2, (22-6E)		11			
112	Mukilteo	NW¼ sec. 2, (22-6E)		6			
113	Mukilteo	SE¼ sec. 3, (22-6E)		7			
114	Carbondale	SW¼ sec. 5 and SE¼ sec. 6, (22-6E)		37			
115	Rifle and Carbondale	SW¼ sec. 6, (22-6E); SE¼ sec. 1, (22-5E)		38			
116	Rifle	E½ sec. 7, (22-6E)		12			
117	Greenwood and Rifle (Shadow Lake)	S½ sec. 7 and NE¼ sec. 18, (22-6E)	40	17	5	12	Rigg (1958, p. 77-78)
118	Rifle	E½ sec. 11 and W½ sec. 12, (22-6E)		7			
119	Rifle	W½ sec. 12, (22-6E)		4			
120	Rifle	E½ sec. 12, (22-6E)		3			
121	Rifle	NW¼ sec. 13, (22-6E)		6			
122	Greenwood and Rifle	Center sec. 14, (22-6E)	11	10			
123	Rifle	N½ sec. 18 and S½ sec. 9, (22-6E)		8			
124	Rifle	NE¼ sec. 17, (22-6E)		16			
125	Rifle	SE¼ sec. 18, (22-6E)		14			
126	Rifle	SE¼ sec. 19, (22-6E)		23			
127	Rifle and Mukilteo	S½ sec. 20 and SE¼ sec. 19, (22-6E)		62			
128	Rifle	W½ sec. 21, (22-6E)		5			
129	Rifle	SE¼ sec. 21, (22-6E)		19			
130	Rifle	NE¼ sec. 24, (22-6E)		6			
131	Rifle	NE¼ sec. 28 and NW¼ sec. 27, (22-6E)		7			
132	Rifle	E½ sec. 28, (22-6E)		14			
133	Greenwood	NE¼ sec. 30, (22-6E)	19				
134	Rifle and Greenwood (Covington)	NW¼ sec. 32, (22-6E)	18	40	6	20	Rigg (1958, p. 77)
135	Rifle	NE¼ sec. 33, (22-6E)		25			
136	Rifle	NW¼ sec. 35, (22-6E)		7		20	
137	Carbondale	NW¼ sec. 36, (22-6E)		6			
138	Rifle	SE¼ sec. 7, SW¼ sec. 8, and NE¼ sec. 18, (22-7E)		30			
139	Greenwood	SW¼ sec. 9, (22-7E)	5				
140	Rifle and Greenwood	SE¼ sec. 9, SW¼ sec. 10, NE¼ sec. 16, and NW¼ sec. 15, (22-7E)	70	212			
141	Rifle	NE¼ sec. 15, (22-7E)		8			
142	Rifle	SW¼ sec. 15, (22-7E)		7			
143	Rifle	NE¼ sec. 18, (22-7E)		7			
144	Rifle	NW¼ sec. 18, (22-7E)		7			
145	Rifle	NW¼ sec. 29, (22-7E)		13			
146	Rifle	Center of sec. 30, (22-7E)		19			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
147	Greenwood	SE¼ sec. 25, (23-2E)	12				
148	Greenwood (Seola)	W½ sec. 1, (23-3E)	12		2	6	Rigg (1958, p. 91)
149	Carbondale	NE¼ sec. 5, (23-4E); SE¼ sec. 32, (24-4E)		40			
150	Greenwood	W½ sec. 5, (23-4E)	56				
151	Greenwood	SW¼ sec. 8, (23-4E)	6				
152	Mukilteo	SW¼ sec. 10, (23-4E)		33			
153	Greenwood (Sunnydale)	SW¼ sec. 16, (23-4E)	26		13	17	Rigg (1958, p. 84-86)
154	Carbondale	S½ sec. 7 and N½ sec. 18, (23-4E)		9			
155	Mukilteo	SE¼ sec. 19, (23-4E)		9			
156	Rifle and Carbondale (Miller Creek)	E½ sec. 20 and W½ sec. 21, (23-4E)		56		10	Rigg (1958, p. 78)
157	Rifle	SE¼ sec. 21, (23-4E)		14			
158	Carbondale	NW¼ sec. 23, (23-4E)		7			
159	Rifle	Center sec. 23, (23-4E)		64			
160	Rifle	SW¼ sec. 29, (23-4E)		5			
161	Mukilteo	SW¼ sec. 29, (23-4E)		9			
162	Rifle (Bow Lake)	E½ sec. 33, (23-4E)		36		19	Rigg (1958, p. 81-82)
163	Rifle	SW¼ sec. 3, (23-5E)		11			
164	Rifle	W½ sec. 8, (23-5E)		58			
165	Carbondale and Rifle	NE¼ sec. 11 and N½ sec. 12, (23-5E); NW¼ sec. 7, (23-6E)		110			
166	Mukilteo	SW¼ sec. 12 and NW¼ sec. 13, (23-5E)		14			
167	Rifle (Renton)	E½SW¼ and W½SE¼ sec. 19, and E½NW¼, W½NE¼, and SW¼ sec. 30, (23-5E)		180		1	Rigg (1958, p. 74)
168	Carbondale	NE¼ sec. 31, (23-5E)		18			
169	Rifle	SE¼ sec. 28 and NE¼ sec. 33, (23-5E)		35			
170	Carbondale	SW¼ sec. 34, (23-5E)		12			
171	Mukilteo	SE¼ sec. 16, (23-5E)		19			
172	Mukilteo	NE¼ sec. 35, (23-5E)		5			
173	Mukilteo	SW¼ sec. 25 and NW¼ sec. 36, (23-5E)		8			
174	Carbondale and Rifle	SE¼ sec. 7 and NW¼ sec. 17, (23-6E)		77			
175	Rifle	Center of sec. 18, (23-6E)		77			
176	Carbondale	NW¼ sec. 19, (23-6E)		11			
177	Rifle	NE¼ sec. 19, (23-6E)		14			
178	Carbondale	SW¼ sec. 17 and NW¼ sec. 20, (23-6E)		8			
179	Rifle	SW¼ sec. 25, (23-6E)		11			
180	Rifle	S½ sec. 28, (23-6E)		6			
181	Greenwood (Cedar Mountain)	SW¼ sec. 30, (23-6E)	33		1	7	Rigg (1958, p. 83-84)
182	Rifle and Greenwood (Otter Lake)	NE¼ sec. 6, (22-6E); S½ sec. 31, (23-6E)	15	54	7	13	Rigg (1958, p. 76-77)

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
183	Rifle	N½ sec. 33, (23-6E)		18			
184	Rifle	SW¼ sec. 34, (23-6E)		21			
185	Rifle (Webster Lake)	N½ sec. 34, (23-6E)		8			Rigg (1958, p. 93)
186	Rifle	SW¼ sec. 2, (23-7E)		21			
187	Rifle	SW¼ sec. 32, (23-7E)		9			
188	Rifle	SW¼ sec. 32, (23-7E)		2			
189	Rifle	S½ sec. 32, (23-7E)		15			
190	Carbondale	N½ sec. 4, (23-7E); S½ sec. 33, (24-7E)		41			
191	Mukilteo	NE¼ sec. 5, (23-7E)		41			
192	Mukilteo	N½ sec. 5, (23-7E)		7			
193	Mukilteo	NW¼ sec. 5, (23-7E); SE¼ sec. 31, (24-7E)		18			
194	Rifle and Carbondale	W½ sec. 5 and NW¼ sec. 8, (23-7E)		100			
195	Rifle	SE¼ sec. 22, (23-7E)		8			
196	Rifle	SE¼ sec. 22, (23-7E)		5			
197	Rifle	NW¼ sec. 23, (23-7E)		18			
198	Rifle	SE¼ sec. 34, (23-7E)		4			
199	Rifle	E½ sec. 1, (24-5E)		11			
200	Rifle	NW¼ sec. 1 and NE¼ sec. 2, (24-5E); SE¼ sec. 35, (25-5E)		26			
201	Rifle	N½ sec. 2, (24-5E); S½ sec. 35, (25-5E)		12			
202	Rifle	NE¼ sec. 4, (24-5E)		16			
203	Carbondale, Rifle, and Mukilteo (Mercer Slough)	W½ sec. 4, E½ sec. 5, NE¼ sec. 8, W½ sec. 9, NE¼ sec. 17, and NW¼ sec. 16, (24-5E); SE¼ sec. 30, (25-5E)		535		50	Rigg (1958, p. 69-70)
204	Rifle	SE¼ sec. 9, (24-5E)		7			
205	Rifle	E½ sec. 9, (24-5E)		18			
206	Rifle	S½ sec. 29, (24-5E)		38			
207	Greenwood	NW¼ sec. 1, (24-6E)	10				
208	Mukilteo	NW¼ sec. 1, (24-6E)		4			
209	Rifle	NE¼ sec. 2, (24-6E)		6			
210	Mukilteo (Beaver Lake)	S½ sec. 3 and N½ sec. 10, (24-6E)		48	6	6	Rigg (1958, p. 79-80)
211	Mukilteo	NW¼ sec. 4, (24-6E)		38			
212	Carbondale	NW¼ sec. 4, (24-6E)		5			
213	Mukilteo	NE¼ sec. 8 and NW¼ sec. 9, (24-6E)		48			
214	Rifle	SE¼ sec. 9, (24-6E)		7			
215	Rifle	SE¼ sec. 9, (24-6E)		3			
216	Rifle	S½ sec. 10 and N½ sec. 15, (24-6E)		48			
217	Mukilteo	SE¼ sec. 10 and SW¼ sec. 11, (24-6E)		19			
218	Greenwood	NW¼ sec. 12, (24-6E)	8				
219	Rifle	NE¼ sec. 13, (24-6E)		7			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
220	Rifle	NW¼ sec. 13, (24-6E)		7			
221	Rifle	S½ sec. 14 and N½ sec. 23, (24-6E)		64			
222	Rifle	SE¼ sec. 15 and NE¼ sec. 22, (24-6E)		32			
223	Rifle	SW¼ sec. 16, (24-6E)		8			
224	Rifle	E½ sec. 2, (24-7E)		13			
225	Mukilteo	SE¼ sec. 13, (24-7E)		6			
226	Greenwood	NE¼ sec. 26, (24-7E)	5				
227	Rifle	SE¼ sec. 27, NE¼ sec. 34, and NW¼ sec. 35, (24-7E)		38			
228	Rifle	S½ sec. 30 and SW¼ sec. 29, (24-7E)		58			
229	Rifle	NW¼ sec. 34, (24-7E)		4			
230	Rifle	NE¼ sec. 3, (23-7E); SE¼ sec. 34, (24-7E)		19			
231	Rifle and Greenwood	W½ sec. 3 and NW¼ sec. 10, (24-8E); SW¼ sec. 34, (25-8E)	25	65			
232	Mukilteo	SE¼ sec. 30, (24-8E)		10			
233	Mukilteo	SW¼ sec. 30, (24-8E)		10			
234	Mukilteo	E½ sec. 31 and W½ sec. 32, (24-8E)		45			
235	Mukilteo	SE¼ sec. 32, (24-8E)		19			
236	Rifle (Ravenna)	NE¼ sec. 4, (25-4E)		45		19	Rigg (1958, p. 80)
237	Rifle (Malmo)	SW¼ sec. 9, (25-4E)		24		6	Rigg (1958, p. 87)
238	Mukilteo	SE¼ sec. 24, (25-4E)		14			
239	Rifle	SE¼ sec. 25, (25-4E)		14			
240	Rifle	NW¼ sec. 4, (25-5E)		24			
241	Mukilteo and Rifle (Sammamish Lake)	SE¼ sec. 12 and NE¼ sec. 13, (25-5E); NW¼ sec. 18, (25-6E)		282		10	Rigg (1958, p. 71-72)
242	Rifle	SE¼ sec. 13, (25-5E)		34			
243	Mukilteo	SW¼ sec. 19, (25-5E)		18			
244	Rifle and Carbondale	SE¼ sec. 18, SW¼ sec. 17, NE¼ sec. 19, and NW¼ sec. 20, (25-5E)		75			
245	Carbondale	NE¼NW¼ sec. 27, (25-5E)		14			
246	Rifle and Mukilteo	NW¼ sec. 28, (25-5E)		64			
247	Carbondale	SW¼ sec. 28, (25-5E)		38			
248	Rifle	SW¼ sec. 32, (25-5E)		6			
249	Rifle (Phantom Lake)	NE¼ sec. 2, (24-5E); SE¼ sec. 2, SW¼ sec. 26, SE¼ sec. 34, and W½ sec. 35, (25-5E)		260		17	Rigg (1958, p. 72-73)
250	Rifle (Ames Lake and Ames Lake Creek)	SE¼ sec. 36, (26-6E); NW¼ sec. 1, SE¼ sec. 1, and NE¼ sec. 12, (25-6E); NW¼ sec. 1, NE¼ sec. 12, SW¼ sec. 6, and NW¼ sec.7, (25-7E)		367	14	45	Rigg (1958, p. 70-71 and 91-92)
251	Rifle	SE¼ sec. 3 and SW¼ sec. 2, (25-6E)		35			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. [1]	Type of peat or bog name [2]	Location [3]	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
252	Rifle	SW¼ sec. 3, (25-6E)		22			
253	Rifle	NW¼ sec. 3, (25-6E); SW¼ sec. 34, (26-6E)		11			
254	Mukilteo	SE¼ sec. 4, (25-6E)		22			
255	Rifle	SW¼ sec. 4, SE¼ sec. 5, and NW¼ sec. 9, (25-6E)		22			
256	Rifle	NE¼ sec. 5, (25-6E)		6			
257	Rifle (Redmond)	NW¼ sec. 7, (25-6E)		21		20	Rigg (1958, p. 88)
258	Rifle	SE¼ sec. 7 and NE¼ sec. 18, (25-6E)		58			
259	Rifle	W½ sec. 8, (25-6E)		78			
260	Rifle	SE¼ sec. 8 and SW¼ sec. 9, (25-6E)		10			
261	Rifle	SW¼ sec. 9, (25-6E)		4			
262	Rifle	SW¼ sec. 9, (25-6E)		9			
263	Rifle	SE¼ sec. 9 and SW¼ sec. 10, (25-6E)		14			
264	Rifle	NW¼ sec. 11, (25-6E)		14			
265	Rifle	NE¼ sec. 14 and NW¼ sec. 13, (25-6E)		25			
266	Greenwood (Carlson)	NE¼ sec. 16, (25-6E)	7		1	8	Rigg (1958, p. 93)
267	Rifle (Happy Valley and Evans Creek)	NE¼ sec. 17 and W½ sec. 16, (25-6E)		100			
268	Rifle (Happy Valley and Evans Creek)	NE¼ sec. 21 and N½ sec. 22, (25-6E)		130	1	16	Rigg (1958, p. 73-74)
269	Rifle	NE¼ sec. 26 and NW¼ sec. 25, (25-6E)		18			
270	Greenwood	SE¼ sec. 26, (25-6E)	6				
271	Rifle	SW¼ sec. 26, (25-6E)		14			
272	Rifle	NW¼ sec. 27, (25-6E)		12			
273	Rifle	NE¼ sec. 28, (25-6E)		6			
274	Rifle and Mukilteo	NE¼ sec. 34 and NW¼ sec. 35, (25-6E)		100			
275	Rifle	SW¼ sec. 3, (25-7E)		27			
276	Rifle	E½ sec. 4, (25-7E)		32			
277	Rifle	NE¼ sec. 5 and NW¼ sec. 4, (25-7E)		25			
278	Rifle	W½ sec. 10, (25-7E)		18			
279	Greenwood	NE¼ sec. 13, (25-7E)	30				
280	Rifle	NE¼ sec. 17, (25-7E)		5			
281	Greenwood	NW¼ sec. 19, (25-7E)	21				
282	Rifle	SE¼ sec. 20 and NE¼ sec. 29, (25-7E)		58			
283	Rifle	SE¼ sec. 21 and NE¼ sec. 28, (25-7E)		20			
284	Rifle	SW¼ sec. 22, (25-7E)		26			
285	Rifle	SE¼ sec. 22, (25-7E)		8			
286	Rifle	NW¼ sec. 24, (25-7E)		8			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
287	Rifle	NW¼ sec. 24, (25-7E)		18			
288	Rifle	NE¼ sec. 27, (25-7E)		10			
289	Rifle	NW¼ sec. 27, (25-7E)		8			
290	Rifle	SW¼ sec. 27, (25-7E)		5			
291	Rifle	SE¼ sec. 28 and SW¼ sec. 27, (25-7E)		16			
292	Rifle and Mukilteo	Sec. 25, (25-6E); secs. 30 and 31, (25-7E); sec. 6,(24-7E)		390			
293	Carbondale	S½ sec. 28 and N½ sec. 33, (25-7E)		77			
294	Rifle	NE¼ sec. 4, (24-7E); E½ sec. 33 and NW¼ sec. 34, (25-7E)		64			
295	Mukilteo	NW¼ sec. 2, (25-8E); SW¼ sec. 35, (26-8E)		9			
296	Mukilteo	SW¼ sec. 2, (25-8E)		7			
297	Greenwood	SW¼ sec. 18 and NW¼ sec. 19, (25-8E)	90				
298	Rifle	NE¼ sec. 27, (25-8E)		6			
299	Rifle	SW¼ sec. 27, (25-8E)		11			
300	Rifle	E½ sec. 31,(25-8E)		7			
301	Rifle	SW¼ sec. 1, (26-4E)		10			
302	Rifle	SE¼ sec. 4, (26-4E)		5			
303	Rifle	SE¼ sec. 4, (26-4E)		4			
304	Rifle	NW¼ sec. 4, (26-4E)		5			
305	Rifle and Carbondale	NE¼ sec. 5 and NW¼ sec. 4, (26-4E)		19			
306	Greenwood (Echo Lake)	SE¼ sec. 6, (26-4E)	5		2	7	Rigg (1958, p. 94)
307	Greenwood (Ronald)	SW¼ sec. 8, (26-4E)	25		4	13	Rigg (1958, p. 86)
308	Rifle and Greenwood (Meridian)	SW¼ sec. 8 and NW¼ sec. 17, (26-4E)	3½		6	5½	Rigg (1958, p. 94-95)
309	Rifle	SE¼ sec. 9, (26-4E)		9			
310	Rifle	SW¼ sec. 17, (26-4E)		37			
311	Mukilteo	NE¼ sec. 18, (26-4E)		5			
312	Greenwood	NE¼ sec. 18, (26-4E)	5				
313	Rifle	NE¼ sec. 20 and NW¼ sec. 21, (26-4E)		16			
314	Rifle	SW¼ sec. 21, (26-4E)		5			
315	Rifle	SE¼ sec. 24, (26-4E); SW¼ sec. 19, (26-5E)		19			
316	Carbondale	SW¼ sec. 27, (26-4E)		14			
317	Carbondale	SE¼ sec. 28 and NE¼ sec. 33, (26-4E)		8			
318	Rifle	NE¼ sec. 29, (26-4E)		11			
319	Rifle	S½ sec. 29, (26-4E)		26			
320	Rifle	NW¼ sec. 32, (26-4E)		22			
321	Carbondale	NW¼ sec. 32, (26-4E)		13			
322	Rifle	SW¼ sec. 3, (26-5E)		8			
323	Rifle	W½ sec. 4, (26-5E)		64			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
324	Rifle and Carbondale	NE¼ sec. 15, (26-5E)		105			
325	Rifle and Carbondale	W½ sec. 23, (26-5E)		64			
326	Rifle	SW¼ sec. 33, (26-5E)		4			
327	Rifle (Aries Farm)	SE¼ sec. 34, (26-5E)		54		3	Rigg (1958, p. 78-79)
328	Mukilteo	NW¼ sec. 36, (26-5E)		9			
329	Rifle	SW¼ sec. 1, (26-6E)		32			
330	Rifle	NE¼ sec. 2, (26-6E)		8			
331	Rifle	NE¼ sec. 2, (26-6E)		4			
332	Rifle	E½ sec. 2 and NE¼ sec. 11, (26-6E)		115			
333	Rifle	W½ sec. 5, (26-6E)		21			
334	Rifle	SE¼ sec. 5, (26-6E)		7			
335	Mukilteo and Rifle (Paradise Lake No. 1)	NW¼ sec. 5, (26-6E)		23	7	14	Rigg (1958, p. 87)
336	Rifle	NW¼ sec. 7, (26-6E)		20			
337	Rifle and Mukilteo (Cottage Lake No. 1)	SE¼ sec. 12, (26-5E); SW¼ sec. 7 and NW¼ sec. 18, (26-6E)		85	5	15	Rigg (1958, p. 74-75)
338	Rifle	SE¼ sec. 7, (26-6E)		5			
339	Rifle	SE¼ sec. 7, (26-6E)		8			
340	Mukilteo and Rifle	E½ sec. 8 and W½ sec. 9, (26-6E)		14			
341	Rifle	S½ sec. 11 and N½ sec. 14, (26-6E)		51			
342	Rifle	SE¼ sec. 15 and W½ sec. 14, (26-6E)		104			
343	Rifle	W½ sec. 15, (26-6E)		16			
344	Greenwood (Cottage Lake No. 2)	E½ sec. 18 and W½ sec. 17, (26-6E)	34		5	3	Rigg (1958, p. 75-76)
345	Rifle	SW¼ sec. 18 and NW¼ sec. 19, (26-6E)		23			
346	Mukilteo and Rifle	SW¼ sec. 20, (26-6E)		26			
347	Rifle	SW¼ sec. 22, (26-6E)		20			
348	Rifle	SW¼ sec. 27, (26-6E)		11			
349	Rifle	SE¼ sec. 28, (26-6E)		15			
350	Rifle	SW¼ sec. 30, (26-6E)		9			
351	Rifle	NW¼ sec. 34, (26-6E)		17			
352	Greenwood	SE¼ sec. 34, (26-6E)	14				
353	Greenwood	N½ sec. 3, (26-7E)	8				
354	Mukilteo	NE¼ sec. 4, (26-7E)		6			
355	Rifle	S½ sec. 5, (26-7E)		4			
356	Rifle	NE¼ sec. 6, (26-7E)		22			
357	Rifle	NE¼ sec. 8, (26-7E)		167			
358	Rifle	SE¼ sec. 8, (26-7E)		6			
359	Rifle	SE¼ sec. 8, (26-7E)		5			
360	Mukilteo	S½ sec. 1 and N½ sec. 12, (26-7E)		25			
361	Rifle	S½ sec. 14, (26-7E)		19			

(See footnotes at end of table, p. 98.)

TABLE 23.— Summary of peat bogs in King County, Washington, showing type of peat, location of bog, number of acres covered by the bog, and maximum thickness— Continued

Bog no. 1/	Type of peat or bog name 2/	Location 3/	Approximate acreage		Maximum thickness (feet)		References
			Sphagnum	Fibrous	Sphagnum	Fibrous	
362	Mukilteo	SW¼ sec. 14 and NW¼ sec. 23, (26-7E)		11			
363	Greenwood	N½ sec. 15, (26-7E)	5				
364	Greenwood	NE¼ sec. 18, (26-7E)	6				
365	Rifle	SE¼ sec. 16, SW¼ sec. 15, and W½ sec. 22, (26-7E)		64			
366	Mukilteo	NE¼ sec. 22, (26-7E)		6			
367	Greenwood	NE¼ sec. 23, (26-7E)	6				
368	Greenwood	SE¼ sec. 23 and NE¼ sec. 26, (26-7E)	11				
369	Greenwood	SW¼ sec. 24, (26-7E)	9				
370	Rifle	NE¼ sec. 25, (26-7E)		5			
371	Rifle	SW¼ sec. 25 and NW¼ sec. 36, (26-7E)		13			
372	Greenwood	W½ sec. 25, (26-7E)	8				
373	Greenwood	NE¼ sec. 26, (26-7E)	6				
374	Rifle (Lake Joy)	S½ sec. 26, (26-7E)		6	1	16	Rigg (1958, p. 93-94)
375	Greenwood	NE¼ sec. 27, (26-7E)	9				
376	Greenwood	E½ sec. 27, (26-7E)	6				
377	Rifle	SW¼ sec. 29, (26-7E)		5			
378	Rifle	SE¼ sec. 33, (26-7E)		9			
379	Rifle	NW¼ sec. 35, (26-7E)		9			
380	Greenwood (Moss Lake)	NE¼ sec. 36, (26-7E)	42		8	3	Rigg (1958, p. 81)
381	Rifle	S½ sec. 28 and N½ sec. 33, (26-8E)		33			
		Total	906	11,544			
		Total peat moss acreage	12,450				

1/ Bog numbers correspond to map numbers on Plate 2.

2/ Greenwood, Rifle, Mukilteo, and Carbondale are types of peat described by Poulson and others (1952, p. 22) and also discussed on page 87 of this report. Names enclosed in parentheses are those used for the bogs by Rigg (1958); he described these bogs on pages 69-95 of his report. All peat deposits listed are shown on the Soil Map of King County (Poulson and others, 1952).

3/ Locations by legal land descriptions are abbreviated; for example, NE¼ sec. 15, (23-5E), which written in full would be northeast quarter of section 15, township 23 north, range 5 east, Willamette meridian, and base.

Sand and Gravel

Sand and gravel is presently (1969) the largest mineral industry in King County. Between 1919 and 1969, production of sand and gravel in the county was 80,209,000 tons, valued at $64,411,000; of this total, 82 percent had been produced since 1945 (the end of World War II). Production has increased, except for minor setbacks, since 1934, when only 106,863 tons, valued at $80,579, was produced. Peak production was in 1965, when 5,937,000 tons, valued at $6,000,000, was produced. Figure 46 graphically compares King County's population with the county's production and value of sand and gravel from 1919 to 1969.

Most of the sand and gravel is mined from Vashon outwash gravels of Pleistocene age; however, some material is taken from gravel bars along streams. All pits that have been developed in outwash gravels are in the Puget Lowlands part of the county. Gravel from stream bars is removed on a seasonal basis, and from time to time the operators move to new gravel bars. This type of operation is limited mostly to the eastern part of the Puget Lowlands and to the foothills of the Cascade Mountains.

Areas shown as Qo on Plate 1 are composed primarily of sorted and stratified material deposited by outwash streams flowing out of the Vashon ice sheet during advance and retreat. The outwash sands and gravels contain a predominance of rocks that came from the north (North Cascades and Canada), although local Cascade Mountain material is commonly associated with it in the major river valleys.

The advance outwash is discontinuously scattered over the western part of the county and usually is overlain by a till sheet. The outwash consists mostly of sand and

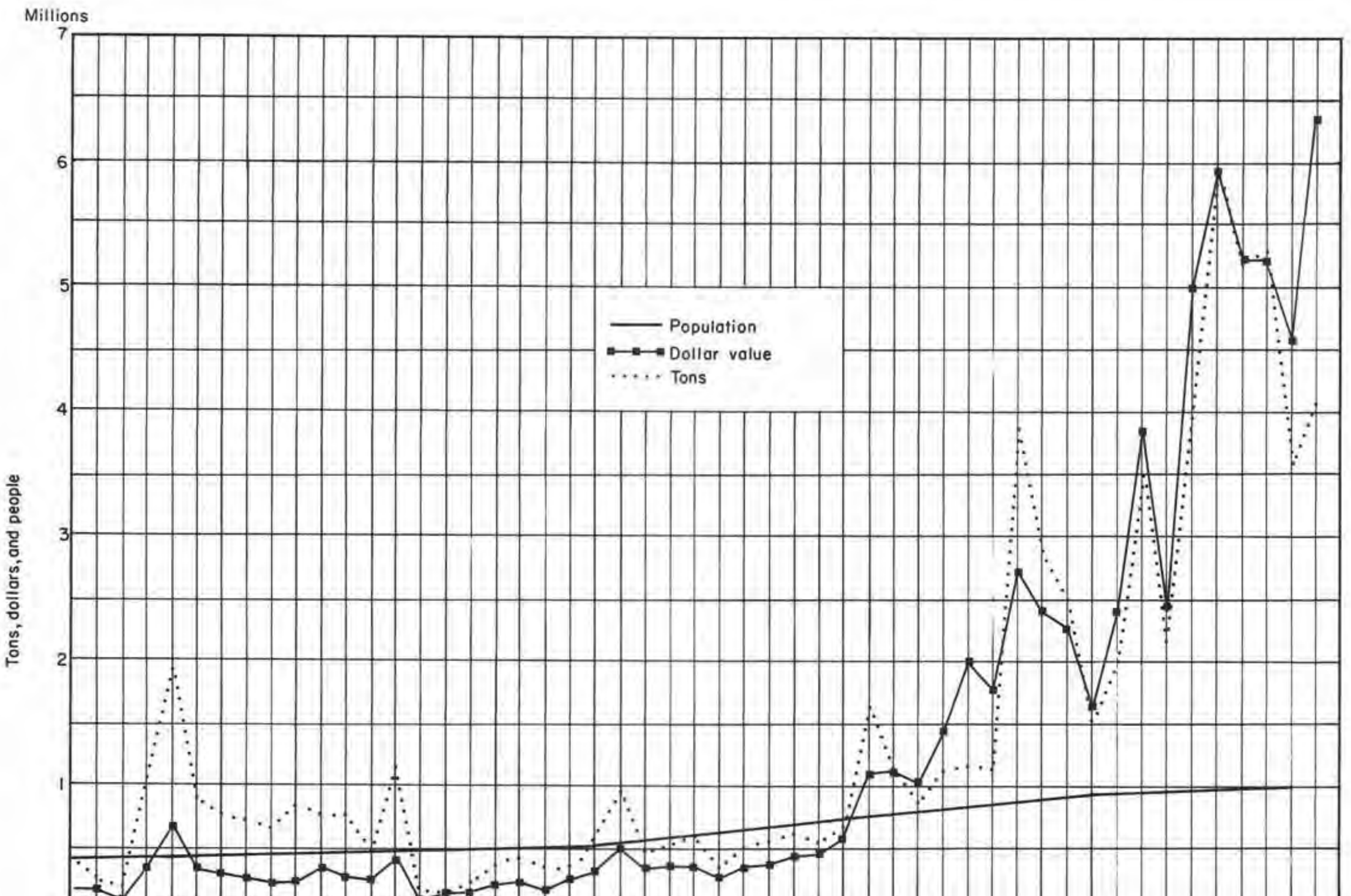


FIGURE 46.— Sand and gravel production and value compared with population in King County, Washington, from 1919 to 1969.

gravel, but includes some silt and clay lenses. Mullineaux (1961a, p. 109) reports that in the Renton-Auburn-Black Diamond area the thickness is highly variable, but is generally less than 50 feet and probably averages no more than 20 to 30 feet. The advance outwash is an unoxidized pebble-cobble gravel and pebbly sand. It is usually harder and more compact than the recessional outwash, and not as well stratified.

The recessional outwash occurs both as broad extensive deposits and as small, scattered, isolated ones. The recessional outwash gravels are fairly well sorted and usually are distinctly stratified. They are unweathered and only loosely compacted. They were deposited in kames, kame terraces, valley trains, deltas, and outwash plains.

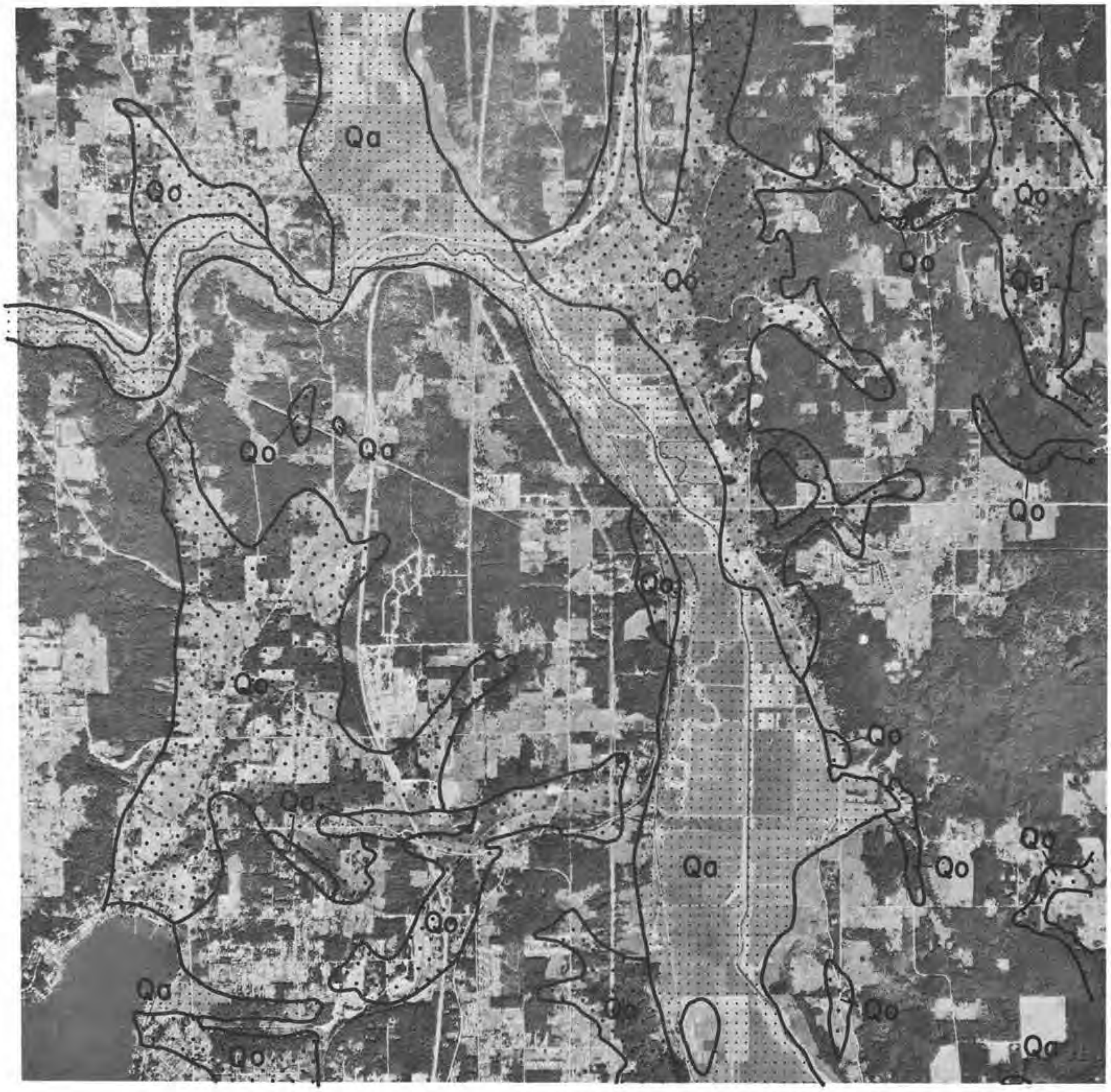
Areas shown as Qa on Plate 1 are composed mostly of unconsolidated alluvial silt, sand, and gravels, including some clay, and are associated with streams. This type of deposit is usually not very large, but the gravels are usually fresh and unoxidized.

Mining and beneficiation of sand and gravel in King County is not an elaborate operation. The sand and gravel is excavated by using power shovels and front-end loaders, and is moved to washing plants on conveyer belts and dump trucks. At most deposits the unwashed material is hauled only a short distance to the washer, but from a few deposits it is hauled several miles. Processing plants generally consist of a washing plant, primary jaw crusher and secondary roll or cone crushers, multiple deck vibratory screens, and spiral classifiers.

Individual sand and gravel pits are not discussed herein, but the producing pits are shown on Plate 2. The areas shown as Qo and Qa on the geologic map (Plate 1) have a potential for including deposits from which sand and gravel could be produced, provided the areas have not been covered by urban development or restricted by zoning. Figures 47 to 64, inclusive, show the distribution of Qo and Qa by township for parts of the county where urbanization has not completely precluded the possibility of developing a new property.

Detailed information about surficial deposits in which sand and gravel may occur is contained in reports by the following authors, who are listed in the bibliography:

Author	Area covered by report
Anderson, C. A. (1965)	Fall City area
Bretz (1913)	Puget Lowlands
Crandell and Gard (1959)	Buckley quadrangle
Crandell (1963)	Lake Tapps quadrangle
Curran (1965)	Issaquah area
Garling, Molenaar, and others (1965)	Vashon and Maury Islands
Gence (1934)	Western King County
Gower and Wanek (1963)	Cumberland quadrangle
Knoll (1967)	Tolt River area
Liesch and others (1963)	Northwestern King County
Luzier (1969)	Southwestern King County
Mullineaux (1965a, 1965b, 1965c)	Auburn, Black Diamond, and Renton quadrangles
Stark and Mullineaux (1950)	City of Seattle
Vine (1962a)	Maple Valley and Hobart quadrangles
Waldron (1961b, 1962, 1967)	Poverty Bay, Des Moines, and Duwamish Head quadrangles
Waldron and others (1962)	Seattle vicinity
Warren and others (1945)	Newcastle-Green River area



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

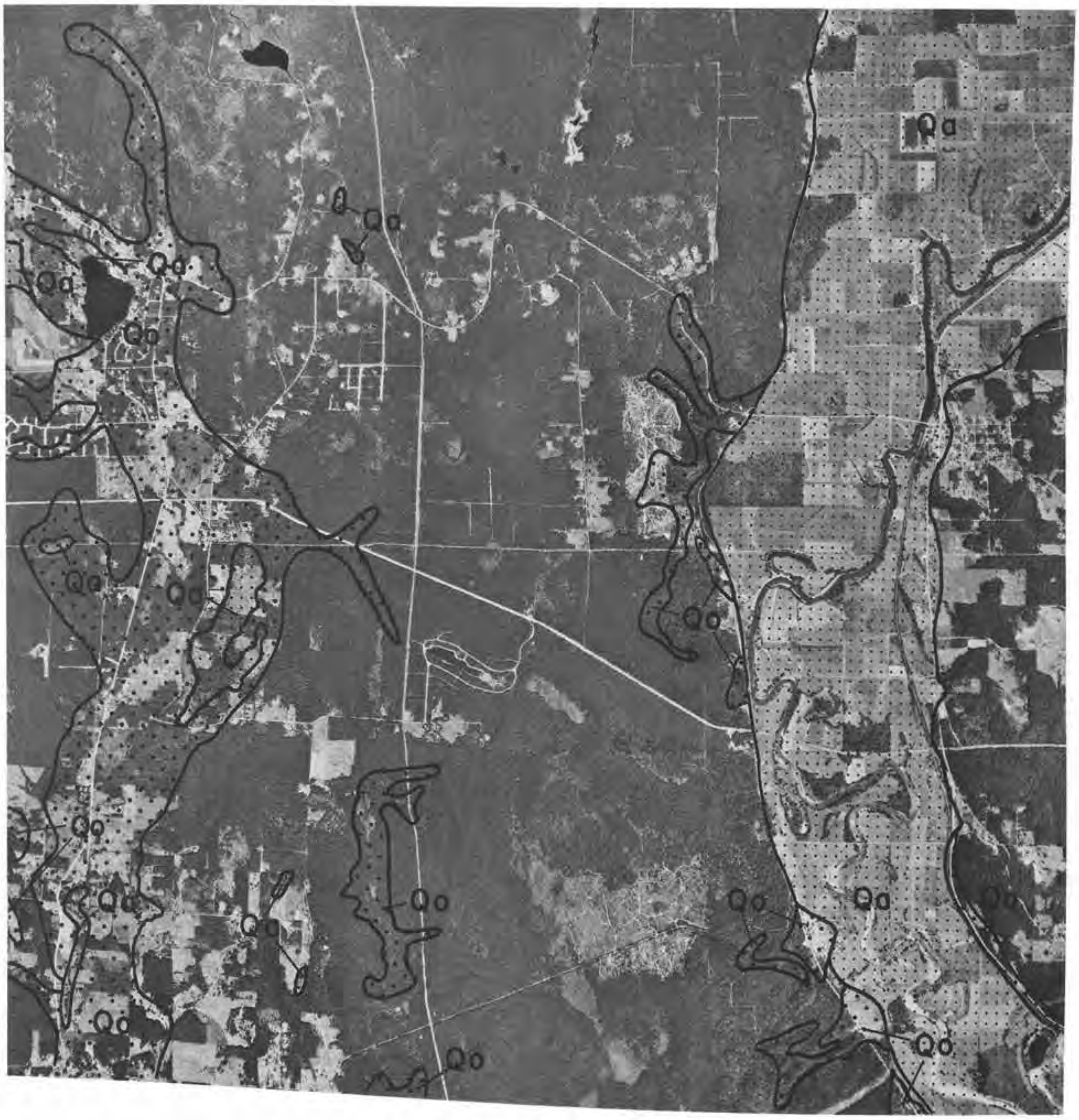
Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 26 N., R. 5 E.

N

Geology from Liesch and others, 1963

FIGURE 47.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 26 N., R. 5 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 26 N., R. 6 E.

Geology from Liesch and others, 1963

N

FIGURE 48.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 26 N., R. 6 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 25 N., R. 6 E.

Geology from Liesch and others, 1963

N

FIGURE 49.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 25 N., R. 6 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa	Unconsolidated silt, sand, and gravel valley fill
Qo	Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 25 N., R. 7 E.

N

Geology from Liesch and others, 1963

FIGURE 50.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 25 N., R. 7 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

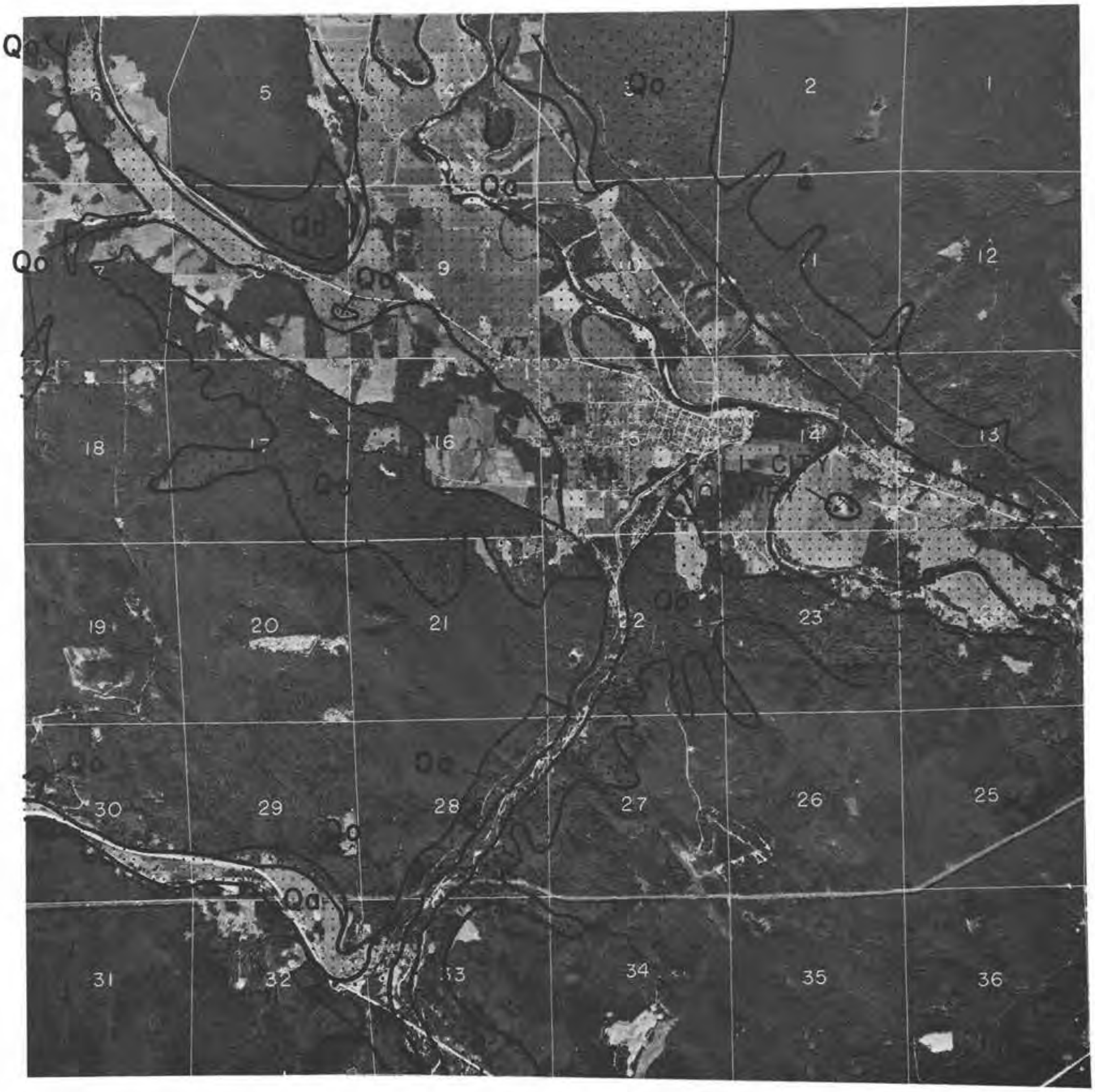
Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 24 N., R. 6 E.

Geology from Liesch and others, 1963

N

FIGURE 51.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 24 N., R. 6 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

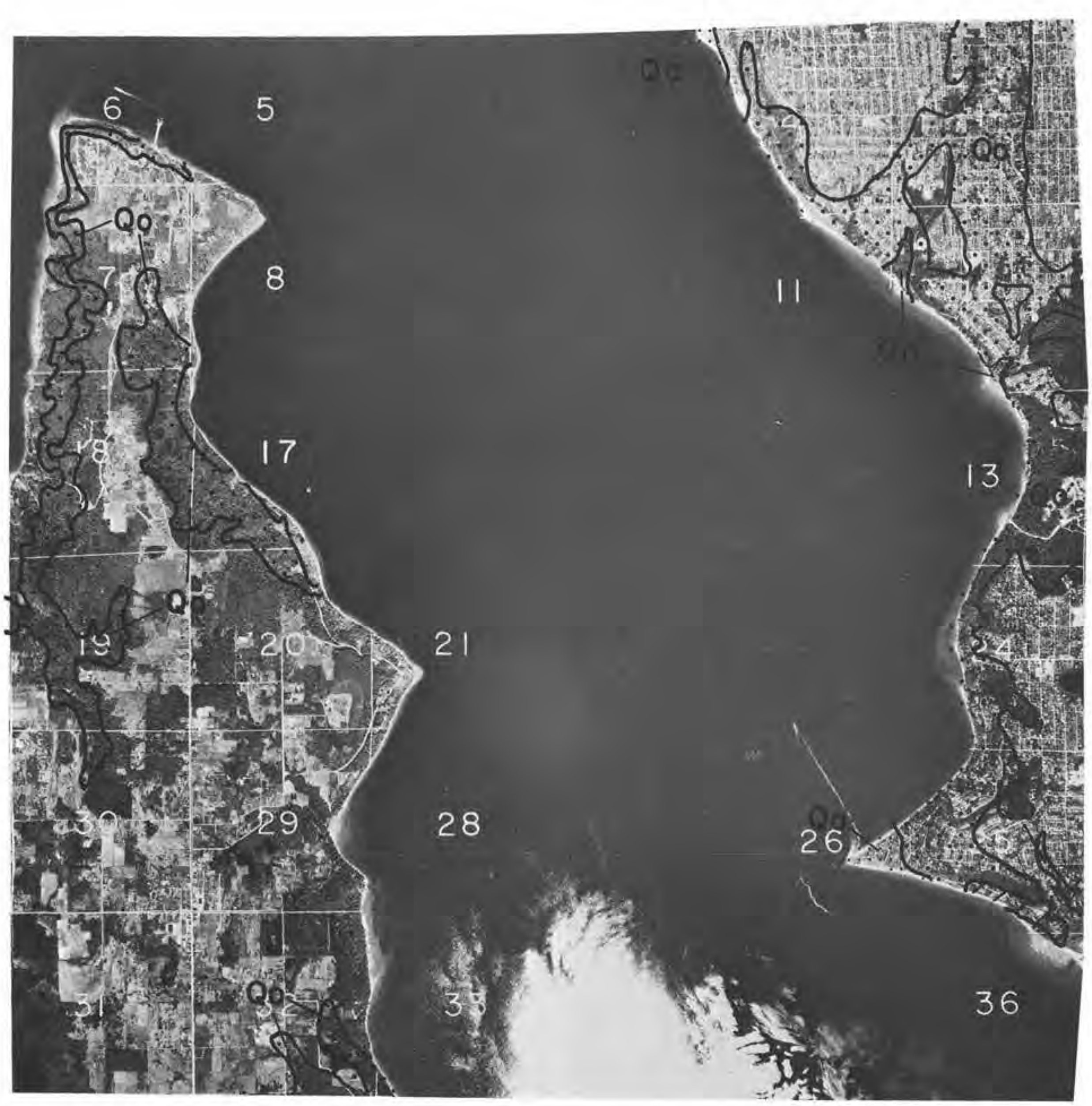
Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 24 N., R. 7 E.

Geology from Liesch and others, 1963

N

FIGURE 52.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 24 N., R. 7 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qa — Advance and recessional outwash, made up primarily of silt, sand, and gravel

Debris of mass flowage and block slides

T. 23 N., R. 3 E.

N

Vashon Island geology from Garling and others, 1965
Mainland geology from Luzier, 1969

FIGURE 53.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 23 N., R. 3 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

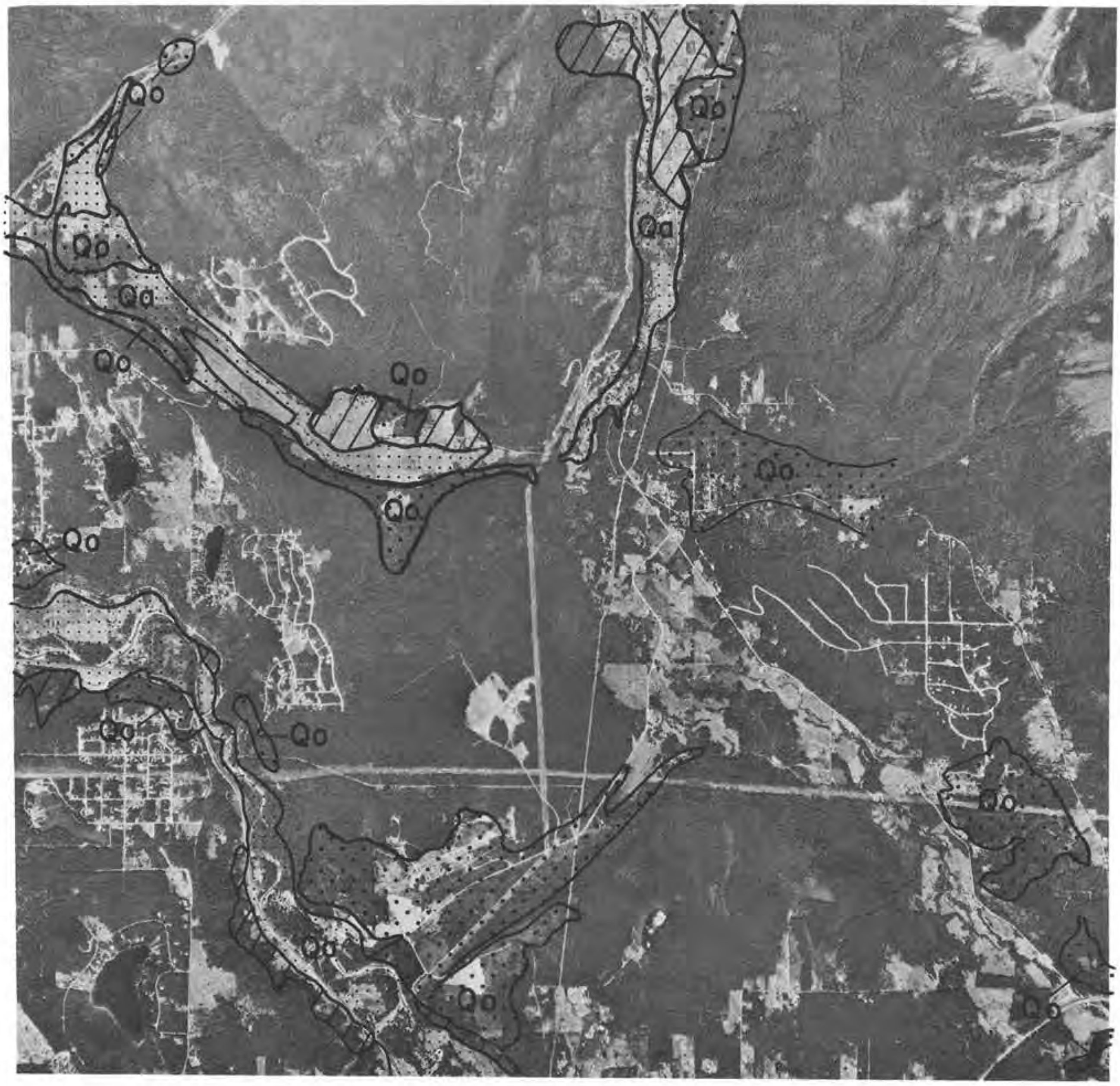
Debris of mass flowage and block slides

T. 23 N., R. 5 E.

N

Geology from Luzier, 1969

FIGURE 54.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 23 N., R. 5 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

Debris of mass flowage and block slides

T. 23 N., R. 6 E.

N

Geology from Luzier, 1969

FIGURE 55.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 23 N., R. 6 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 22 N., R. 3 E.

Geology from Garling and others, 1965

FIGURE 56.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 22 N., R. 3 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

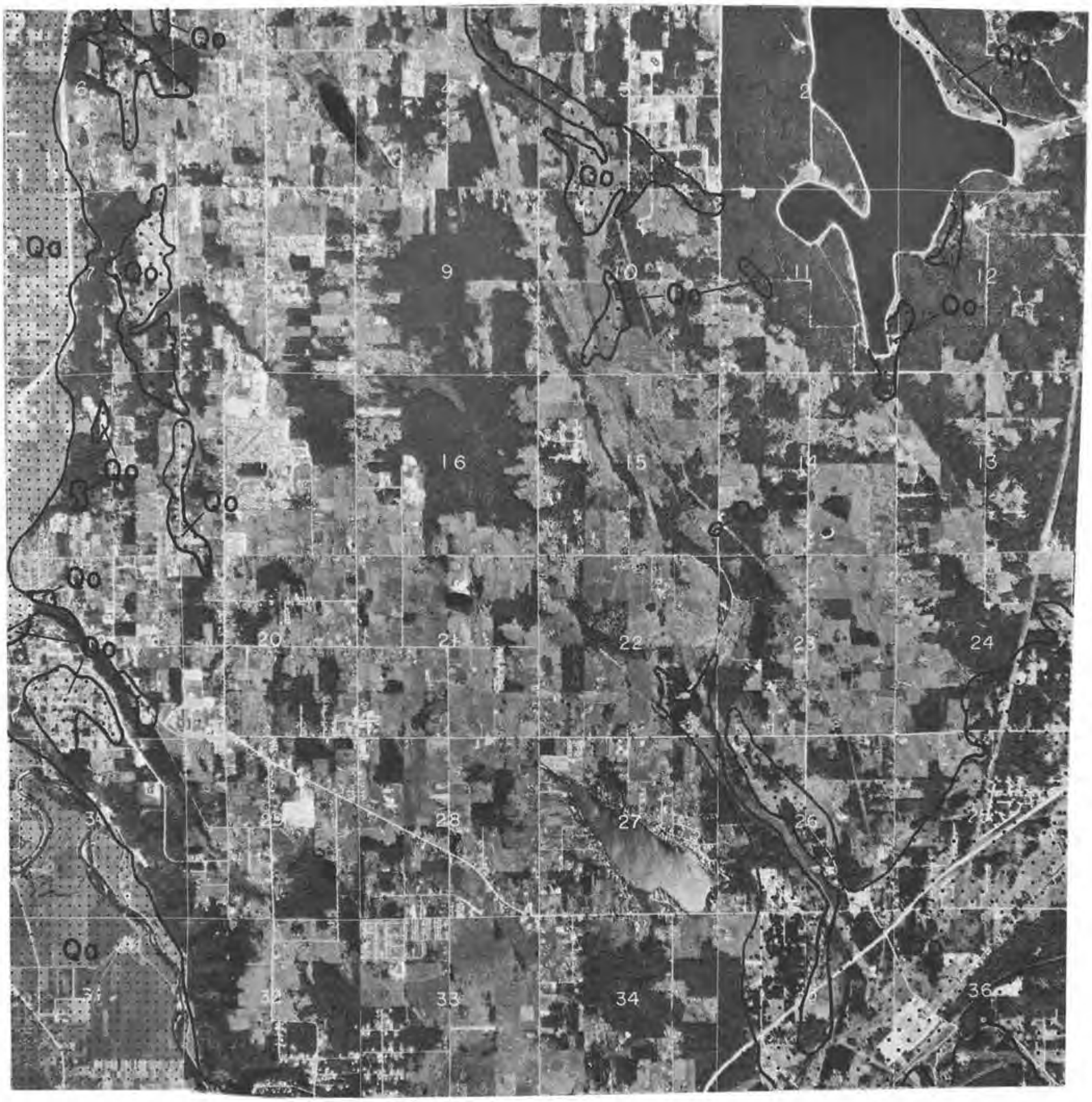
Qa	Unconsolidated silt, sand, and gravel valley fill
Qo	Advance and recessional outwash, made up primarily of silt, sand, and gravel
	Debris of mass flowage and block slides

T. 22 N., R. 4 E.

N

Geology from Luzier, 1969

FIGURE 57.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 22 N., R. 4 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

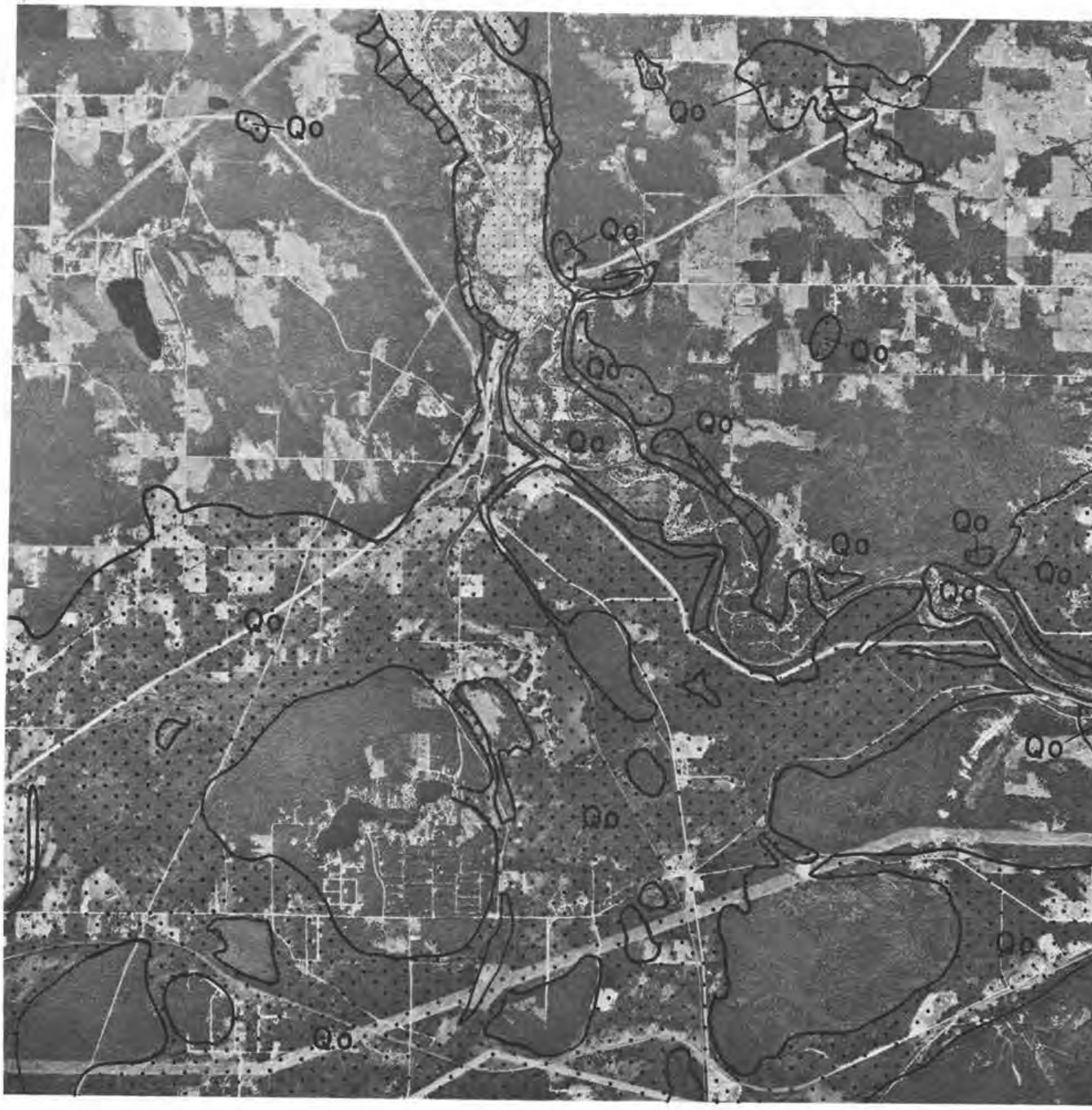
Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 22 N., R. 5 E.

N

Geology from Luzier, 1969

FIGURE 58.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 22 N., R. 5 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

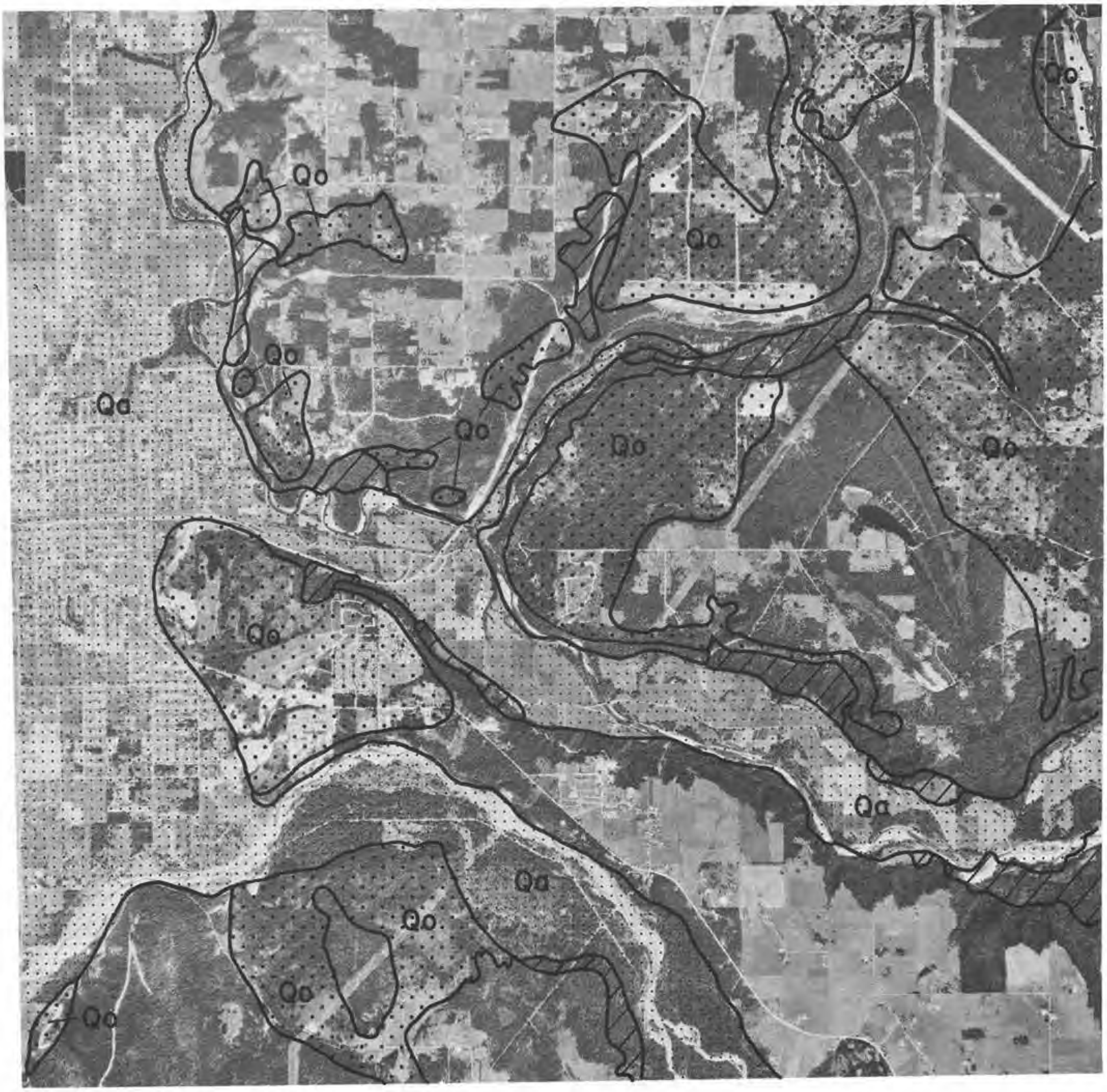
- Qa — Unconsolidated silt, sand, and gravel valley fill
- Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel
- Debris of mass flowage and block slides

T. 22 N., R. 6 E.

N

Geology from Luzier, 1969

FIGURE 59.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 22 N., R. 6 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

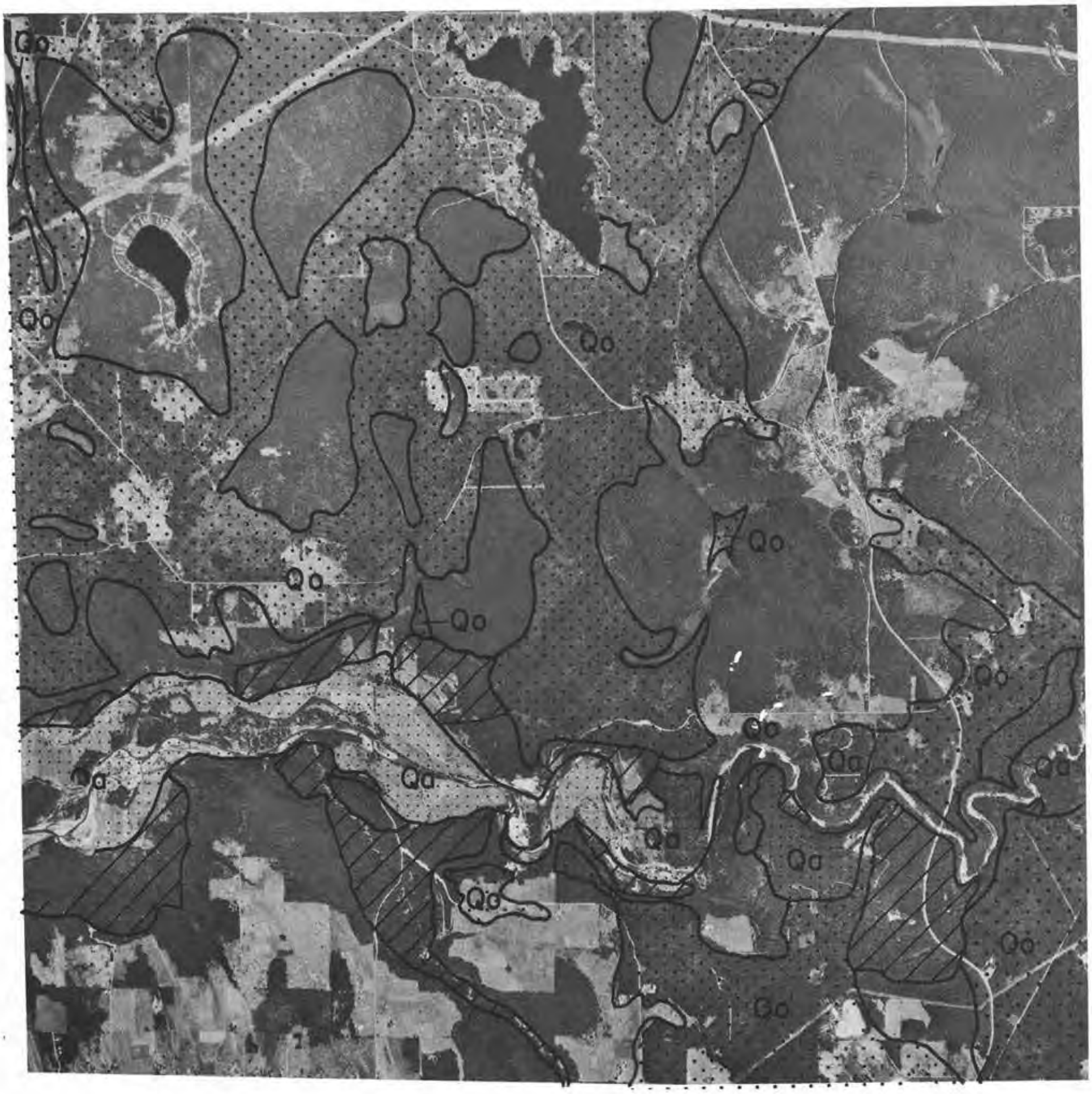
Debris of mass flowage and block slides

T. 21 N., R. 5 E.

N

Geology from Luzier, 1969

FIGURE 60.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 21 N., R. 5 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

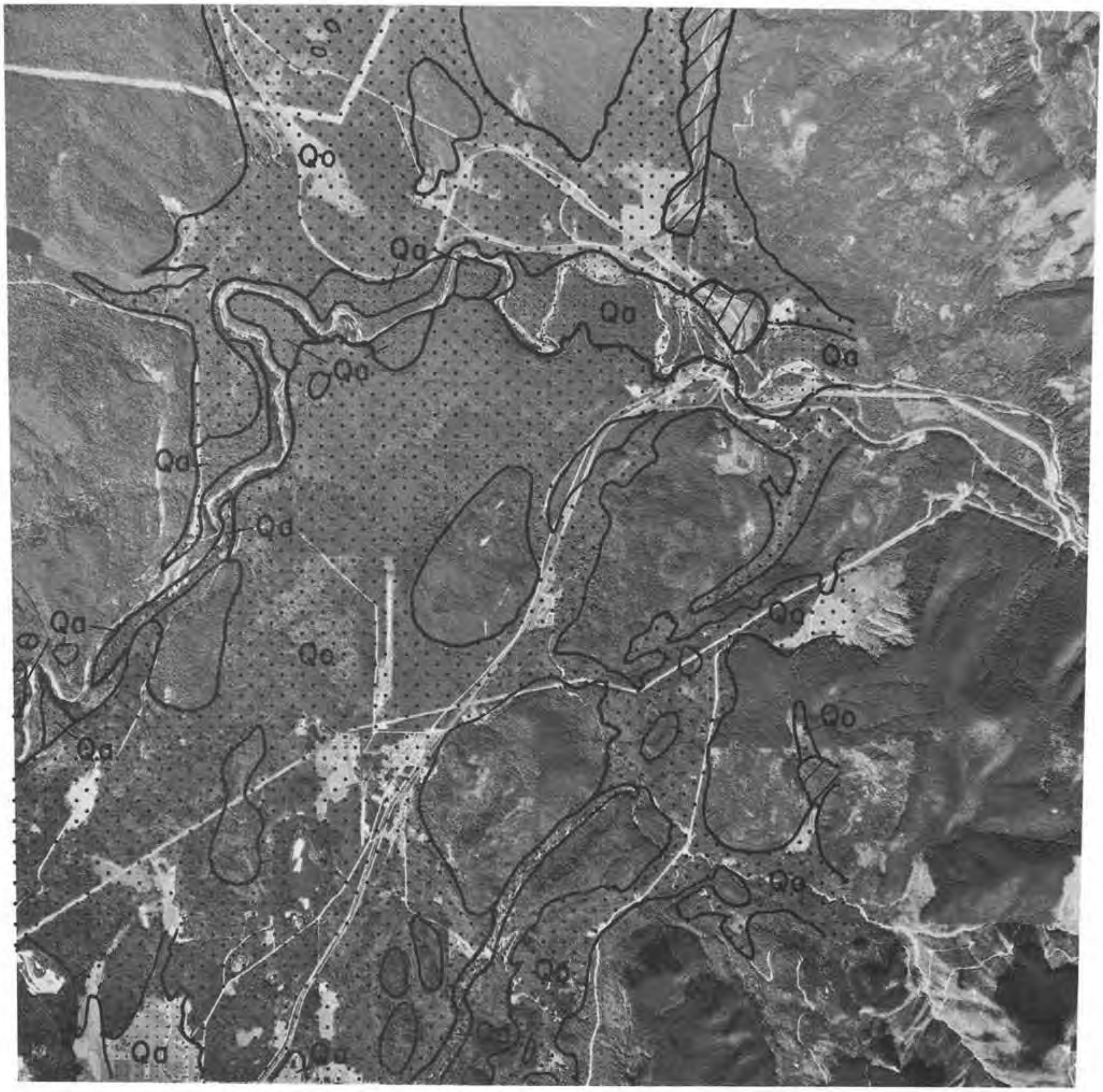
Debris of mass flowage and block slides

T. 21 N., R. 6 E.

N

Geology from Luzier, 1969

FIGURE 61.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 21 N., R. 6 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

Debris of mass flowage and block slides

T. 21 N., R. 7 E.

N

Geology from Luzier, 1969

FIGURE 62.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 21 N., R. 7 E., King County, Washington.

SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

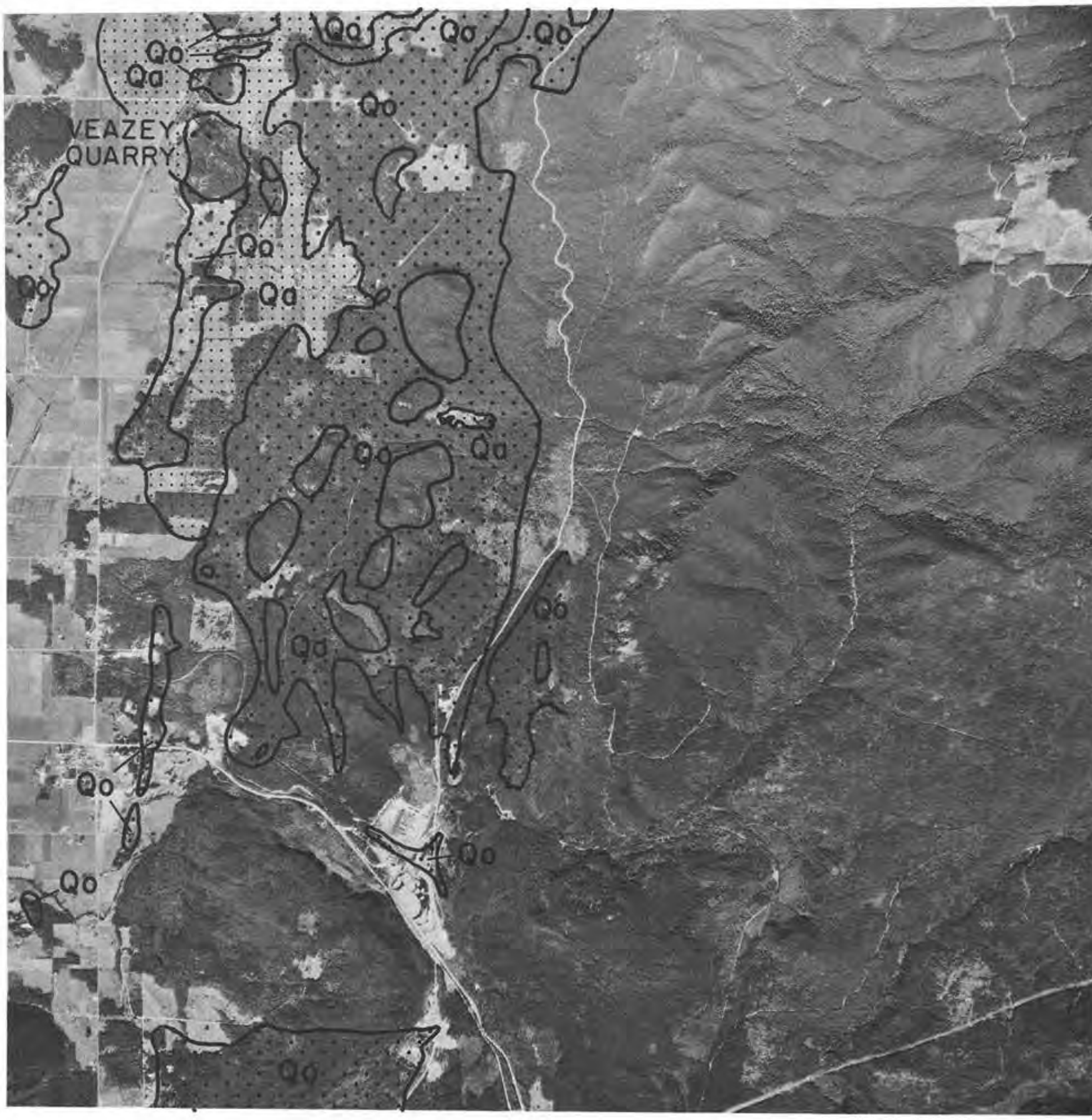
Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 20 N., R. 6 E.

Geology from Luzier, 1969

N

FIGURE 63.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 20 N., R. 6 E., King County, Washington.



SCALE APPROXIMATELY 1:60,000

EXPLANATION

Qa — Unconsolidated silt, sand, and gravel valley fill

Qo — Advance and recessional outwash, made up primarily of silt, sand, and gravel

T. 20 N., R. 7 E.

N

Geology from Luzier, 1969

FIGURE 64.— Photo-map showing distribution of units that may contain commercial quantities of sand and gravel in T. 20 N., R. 7 E., King County, Washington.

Silica

Many silica deposits occur in King County; however, most of them are either of low grade or are too small to warrant much attention.

Wilson and others (1942, p. 28-37), report on 35 samples taken from rock they consider likely sources of silica. The results of their work are summarized in Table 24. The only deposits that are described in this report are those that were operating in 1969.

Silica Sand

Smith Bros. Silica Sand Co., Inc., Auburn, is the only producer of silica sand in King County. When the company started in 1940, sand was taken from an exposure of the Hammer Bluff Formation, along the Green River about 10 miles east of Auburn. The processing plant was at that site until 1969, then was relocated near Ravensdale.

FIGURE 65.— Smith Bros. Silica Sand Co., Inc. processing plant at Ravensdale, King County, Washington. Plant scrubs and dries sand.

The Hammer Bluff deposit was depleted in 1960, and a new source of raw material was found in a deeply weathered sand unit of the Puget Group. This deposit, in the SE¼NW¼ sec. 30, T. 21 N., R. 7 E., near the old town of Franklin, was worked out in 1969. Analyses of the sand by the U.S. Geological Survey showed 89 percent sand, 11 percent silt, and 2 percent clay. The clay mineral appeared to be chiefly kaolinite. The sand fraction contained about 68 percent quartz, 30 percent feldspar, and 2 percent rock fragments. The operator reports the following analysis of the sand after washing:

	Percent
SiO_2	89 to 91
Al_2O_3	4 to 6
Fe_2O_3 and FeO	0.06 to 3.0
K_2O and Na_2O	2 to 4
CaO	0
MgO	0
Loss on ignition	0.5 to 0.8

Surprisingly, the sand from this pit that is the whitest usually contains too much iron to be used in making glass; the iron is present in the form of siderite. In examining the pit, it was discovered that the high-siderite material is distributed as uneven-shaped, randomly located gobs throughout the pit. The reason for the siderite accumulation or deposition is not apparent.

A new sand pit has been opened by Smith Bros. Silica Sand Co. near Ravensdale, in the NW¼ sec. 1, T. 21 N., R. 6 E. The sand is suitable for producing amber glass, to which use it is currently being put by the Northwestern Glass Company, in Seattle. A petrographic analysis of a washed sand sample from the Ravensdale pit showed:

	Percent
Quartz	68.8
Orthoclase	14.8
Albite	11.5
Muscovite	2.3
Kaolinite	2.4
Goethite	0.3

The deposit is in a deeply weathered sandstone bed in the Puget Group, and is between the Dale No. 4 coalbed and an unnamed seam above the Dale.

TABLE 24.—Chemical analyses, percentage of clay, pyrometric cone equivalents, and mineral constituents of sand samples from King County, Washington

[Modified from Table 7, Wilson, Skinner, and Couch, 1942]

Sample no.	Location (Section, Township, and Range)	Chemical analysis, percent*				Clay percent	P.C.E., cone*	Mineral constituents, percent*							
		SiO_2	Fe_2O_3	Al_2O_3	Ign. loss			Quartz	Feldspar		Chlorite	Horn-blende + augite	Mica	Iron min-erals	Other
									Fresh	Turbid					
King 1	16, (23-5E)	71.9	4.1	14.2	......	13	12	56	1	23	8	....	4	1	10
King 2	29, (23-6E)	78.7	2.2	....	......	13	18	65	11	19	2	....	2	1	....
King 3	29, (23-6E)	....	....	....	......	63	16-	48	18	8	10	6	4	3	3
King 4	29, (23-6E)	74.1	1.8	....	......	....	15	....	......	....	....	....	....	....	....
King 5	29, (23-6E)	77.1	2.1	10.8	......	13	16	56	7	27	1	1	2	4	2
King 6	7, 18, (21-7E)	....	1.34	....	......	17	18½	....	......	....	....	....	....	....	....
King 7, top	28, (21-6E)	93.3	.1	4.5	......	6	18	82	4	11	....	....	2	1	....
King 7, bottom	28, (21-6E)	90.7	....	....	......	29	18	....	......	....	....	....	....	....	....
King 8	28, (21-6E)	97.2	.1	....	......	54	30	....	......	....	....	....	....	....	....
King 9	28, (21-6E)	87.6	.9	....	......	49	23	....	......	....	....	....	....	....	....
King 10	28, (21-6E)	79.1	.8	....	......	38	20-23	....	......	....	....	....	....	....	....
King 11	28, (21-6E)	....	....	....	......	....	12	....	......	....	....	....	....	....	....
King 12	28, (21-6E)	65.8	8.9	....	......	36	6	34	6	14	21	10	....	4	17
King 13	27, (21-6E)	81.2	.17	10.1	1.4	19	19	....	......	....	....	....	....	....	....
King 14	27, (21-6E)	....	2.00	....	......	19	18	....	......	....	....	....	....	....	....
King 15	14, (21-6E)	....	....	....	......	....	12	....	......	....	....	....	....	....	....
King 16	14, (21-6E)	....	....	....	......	....	8	....	......	....	....	....	....	....	....
King 17	17, (21-7E)	....	....	....	......	....	12	....	......	....	....	....	....	....	....
King 18	17, (21-7E)	....	....	....	......	....	14	....	......	....	....	....	....	....	....
King 19	8, (21-7E)	....	....	....	......	....	8-	....	......	....	....	....	....	....	....
King 20	18, (21-7E)	....	....	....	......	....	7	46	14	31	6	....	1	1	1
King 21	28, (21-7E)	86.3	.7	....	......	....	12	....	......	....	....	....	....	....	....
King 22	32, (24-6E)	74.1	1.4	....	......	....	8-	....	......	....	....	....	....	....	....
King 23	31, 32, (24-6E)	68.3	2.1	....	......	....	16	39	31	21	7	....	1	....	1
King 24	31, 32, (24-6E)	58.3	5.3	....	......	....	5+	....	......	....	....	....	....	....	....
King 25	26, (24-6E)	83.0	.7	....	......	72	16	60	16	16	4	1	2	....	1
King 26	19, (23-5E)	88.8	.11	....	......	16	23	67	8	16	3	1	3	....	2
King 27	19, (23-5E)	....	....	....	......	....	12	....	......	....	....	....	....	....	....
King 28	19, (23-5E)	....	....	....	......	....	7	....	......	....	....	....	....	....	....
King 29	1, (19-7E)	90.1	.5	....	......	....	32-33	76	13	6	2	....	2	....	1
King 30	5, (22-11E)	79.2	1.8	....	......	....	10	51	5	35	3	2	1	....	3
King 31	5, (22-11E)	79.6	4.2	....	......	....	10	....	......	....	....	....	....	....	....
King 32	25, (26-11E)	66.0	3.4	....	......	....	5+	....	......	....	....	....	....	....	....
King 33	25, (26-11E)	....	....	....	......	....	5+	47	3	28	11	5	....	....	6
King 34	Swauk Formation	55.0	5.3	....	......	....	6	....	......	....	....	....	....	....	....
King 35	29, (24-4E)	61.3	4.7	....	......	....	<10	36	16	13	17	12	2	....	4

* Determined on washed sand.

Silica Rock

Only one silica rock quarry, the old Denny-Renton quarry, is currently (1969) being operated in King County. The rock is being used, not for its silica content, but for its color, in making facing chips. The quarry is near the

FIGURE 66.— Denny-Renton silica quarry, in King County, Washington. Purest rock is in center of quarry. Dark color of rock at right and left edges of quarry is caused by oxidation of iron.

center of sec. 1, T. 19 N., R. 8 E., on the Stink Lake road about 0.6 miles from its junction with U.S. Highway 410. The property belongs to the Weyerhaeuser Timber Company, of Tacoma, and is operated by Manufacturers Mineral Co., Seattle.

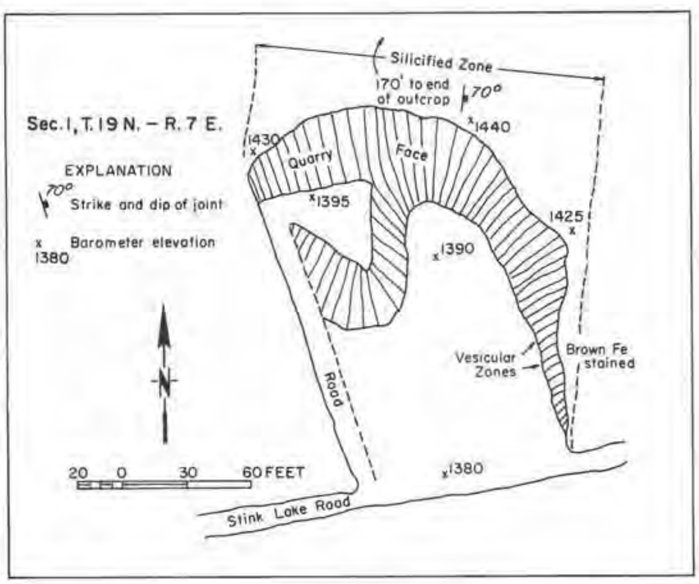


FIGURE 67.— Plan view of Denny-Renton silica quarry, in King County, Washington.

The quarry is in massive andesite that has been bleached and silicified. The silicified rock is very porous, and the vugs are lined with drusy quartz. It is light gray on weathered surfaces and cream colored on fresh surfaces. The silica deposit stands as a bold knob above the valley floor. Wilson and others (1942, p. 36) report that analysis of a sample taken from the quarry showed 90.1 percent SiO_2 and 0.5 percent Fe_2O_3. Hodge (1938a, p. 22) reports an analysis showing 97.52 percent SiO_2, 0.41 percent Fe_2O_3, 2.05 percent Al_2O_3, 0.03 percent CaO, and 0.23 percent loss on ignition.

Similar silicified zones occur in the vicinity of the Denny-Renton quarry and should be checked more thoroughly to determine their size, silica content, color of rock, and other important characteristics. These are the same silicified zones that are associated with the alunite deposits.

Stone

Basalt, andesite, granodiorite, and diorite are the only rocks, other than silica, that are currently (1969) being quarried in King County. Sandstone and marble have been quarried in the past, but no production has been recorded in recent years (Moen, 1967). Only crushed and broken stone is currently produced in the county, and it is used for riprap, crushed rock, chicken grit, rubble, and landscape rock. In the past, dimension stone has also been produced, but the total production amounted to less than 2,000 tons, having an estimated value of $20,000. From 1919 to 1964, total production from the county of all types of stone, from all sources, is estimated to be 19,368,000 tons, valued at $25,970,000.

Most of the stone produced in urban areas of the county is fairly soft, a property that limits the number of purposes for which it can be used. The best rock is situated along the foothills of, and in, the Cascade Mountains, and, except for special purposes, is usually beyond the present limits of economic transportation to the consumer areas. Rocks produced from the Puget Lowlands are almost all volcanic in origin. Granodiorite, produced from the Cascade Mountains in the eastern part of the county, is

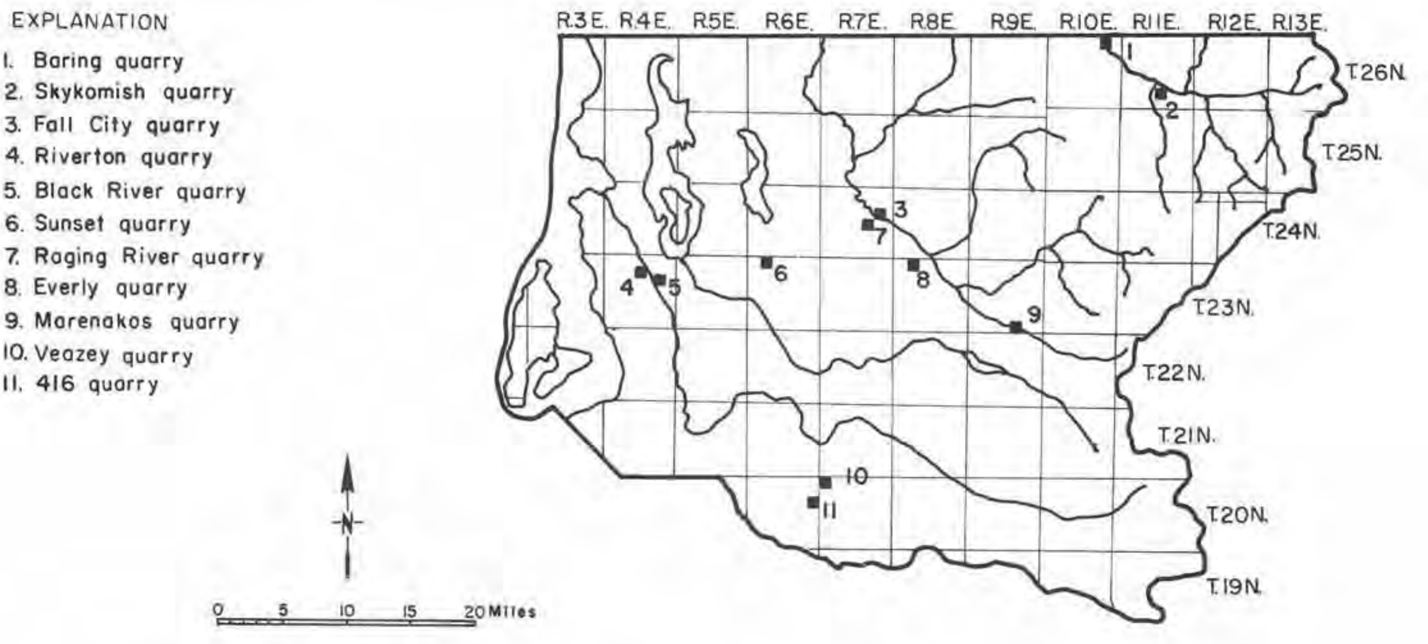


FIGURE 68.—Commercial rock quarries in King County, Washington, that were active during 1969.

suitable for almost every use, but because it is so far from the market area, its uses are limited to specialty products such as poultry grit, large riprap, and special landscaping stone.

Baring quarry.—The Baring quarry is at Baring, in the NE¼NW¼ sec. 2, T. 26 N., R. 10 E. It is owned and operated by Hemphill Brothers, Inc., of Seattle. Quartz diorite from the quarry is crushed to make poultry grit.

Two quarries have been operated on this property. The upper quarry was abandoned when the face was advanced into an altered zone. Only the lower quarry is being operated at the present time (1969). The rock is massive and has characteristic blocky jointing. The size of material taken from the quarry is controlled by shot hole distribution. Shot holes are on about 20- to 30-inch centers.

The mill is almost entirely gravity feed, and is capable of producing grit in four sizes.

Black River quarry.—The Black River quarry is in the E½SE¼ sec. 14, T. 23 N., R. 4 E., in south Seattle along the Chicago, Milwaukee, St. Paul and Pacific Railway tracks between Renton and Tukwila. It is owned and operated by the Black River Quarry, Inc., of Seattle. At the present time (1969) the quarry produces crushed rock, riprap, and landscape rock. The capacity of the crushing plant is 3,000 tons per shift.

The quarry is in black basalt(?), some of which is too soft for most uses. Several fault planes that have served as channelways for ascending hydrothermal solutions have been exposed in the quarry faces. Alteration is most severe next to the faults, and decreases outward. The best material is obtained from the northern part of the quarry, where the rock is a fairly hard and reasonably tough breccia. In the southern part of the quarry the rock has been subjected to so much alteration and deep weathering that it is soft and of little value. Jointing is random and irregular and, as a result, rock in various sizes, from 4- to 5-foot blocks down to that suitable for crusher feed, is readily available.

The quarry is currently (1969) being worked on six levels. The shallow glacial overburden that covers the rock is pushed aside by dozer and does not present a removal problem.

Scale approximately 1 inch = 2,000 feet

FIGURE 69.—Aerial view of Black River and Riverton quarries near Tukwila, King County, Washington.

Everly quarry.—The Everly quarry is in a bedrock knob that stands about 120 feet above the valley floor in the SW¼NE¼ sec. 5, T. 23 N., R. 8 E. It is about 1.5 miles northwest of North Bend and is adjacent to the Great Northern Railway tracks and the paved road that connects U.S. Highway 10 with State Highway 203 and Snoqualmie. The property is owned by Alberg & Associates, Inc., of Seattle. The quarry has been operated by lease arrangements with contractors. Rock from the quarry has been used chiefly for riprap and rubble.

The quarry is in fine-grained black basalt that has been intruded by coarse-grained gray diorite. In some parts of the quarry the basalt and diorite have been deeply altered and are quite soft and crumbly. Metamorphic minerals (garnet and epidote), as well as a small amount of malachite, are present in the diorite.

Sheared basalt in the northwest part of the quarry has abundant slickensided surfaces. When struck with a hammer, the sheared basalt tends to break along joints into fist-size pieces. Material adjacent to the sheared basalt breaks with a slightly conchoidal fracture, but is not very tough. Along the southeast face of the knob the basalt is tougher because of less shearing. In both the northwest and northeast parts of the quarry, loose rock varies in size from a few inches to 4 feet in diameter.

Diorite is in contact with hornfels on the southwest part of the knob. The contact appears to trend east to southeast, the diorite being on the south side. Most of the diorite is hard, massive, and tough. At the south end of the quarry face it has been altered and breaks down very easily. The fresh material breaks out in medium-size blocks (2 to 3 feet in diameter). Only about 50 feet of diorite has been exposed across the face of the quarry. Because the diorite is limited on the north by the contact with the basalt, and on the south it has been altered, there probably is not a very large tonnage of good material left in this part of the quarry; a few properly placed drill holes would readily determine the extent of the diorite. Only a thin layer of overburden covers the bedrock at the quarry site.

FIGURE 70.— Jointing in basalt of the Fall City stone quarry, in King County, Washington.

Fall City quarry.— The Fall City quarry is in a small bedrock knob that protrudes from the valley floor in the SW¼SW¼ sec. 14, T. 24 N., R. 7 E., about half a mile southeast of Fall City. It is owned by Willis Campbell, of Fall City, and operated by Louis Muth, of Everett. Rock is produced from the quarry intermittently; there are no permanent processing facilities on the property.

The rock is a fine-grained, dense, hard, slightly brittle basalt porphyry. It breaks with a conchoidal fracture and has fair columnar jointing. The most distinctive jointing is horizontal and normal to the columnar jointing, which characteristic makes the rock a natural flagstone. The slabs, formed by the horizontal jointing, range from 1 inch to 2 feet in thickness. The rock is homogeneous throughout the quarry, except for a few places where it appears to be altered.

The rock appears to be well suited for rockery and decorative use. The size of the fragments in the quarry would also make them excellent for crusher feed. The quarry is fairly small, having only about 175,000 tons of rock in place.

Two working levels have been developed in the quarry— one at the base of the hill, and the other near the top.

416 quarry.— The 416 quarry is about 1.5 miles northeast of Enumclaw, in the NE¼NE¼ sec. 13, T. 20 N., R. 6 E. The quarry is at the north end of Mount Forest,

FIGURE 71.— 416 quarry, near Enumclaw, King County, Washington. Face is 180 feet high.

a 350-foot-high bedrock mass that stands isolated on the glacial plain. The quarry is owned by S. S. Stephenson, of Enumclaw, and is leased by Louis Muth, of Everett.

The rock is a dense, brittle, fine-grained, slightly porphyritic andesite that breaks with a conchoidal fracture. Columnar-jointed rock is exposed in the quarry, but most of the andesite is massive and is cut by joints of random orientation. The columns are tilted to the southeast. The quarry has three levels along a 300-foot face. The lower, or main, face has been advanced about 50 feet since the quarry was opened in 1949. The diameter of most of the material is between 1 and 2 feet, but that of the largest blocks is about 6 feet. There is no overburden to contend with. Room for crushing equipment is ample, but there is no space for stockpiles. Reserves in this quarry are estimated to be more than 4 million tons.

Raging River Quarry.—The Raging River quarry is along the west valley wall of the Raging River in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 22, T. 24 N., R. 7 E., about 1.5 miles southwest of Fall City. The quarry is owned and operated intermittently by Howard Carlin, of Preston. Most of the rock produced from the quarry has been used for riprap and landscaping.

The quarry exposes three beds that strike N. 20° W. and dip 60° NE. The best rock, a dark andesite flow breccia, has been stripped from the face for about 200 feet, leaving a dip slope of underlying rock exposed. Beneath the breccia, which is about 40 feet thick, is about 5 feet of mudstone underlain by a soft dark volcanic rock.

Jointing in the upper breccia is random and not very closely spaced. Stone as much as 5 feet in diameter has been taken from the quarry. The stone is not very hard or tough, but material that has been exposed to the elements for several years does not seem to have been much affected by weathering. The quarry has been opened along a 400-foot face that is about 100 feet high. Unless better rock is found beneath the lower breccia, the reserves in this quarry are small.

Riverton quarry.—The Riverton quarry is owned and operated by the Riverton Division of Lockheed Shipbuilding and Construction Co., Seattle. It is in the NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 10, T. 23 N., R. 4 E., on the west bank of the Duwamish River just east of Allentown (Fig. 69, on p. 123). Operation of the quarry was begun in 1930.

The quarry is in soft dark-gray basalt that is well jointed and, in some places, occurs in columns about 2 feet in diameter. Apparently, this quarry is in a bedrock remnant that stood above the valley floor and was partly covered by glacial drift during the ice age.

The rock is porphyritic and contains zeolites that weather out after short exposure to the elements; in some areas it contains finely disseminated pyrite. The largest rocks are about 3 feet in diameter.

Of the several working levels, the lowest is below the grade of the highway on the quarry's eastern border.

The quarry has permanent crushing facilities and produces crushed rock, landscape rock, and rubble. At the present production rate, an estimated 1,200 tons per day, the quarry's rock supply should last from 5 to 7 years.

Skykomish quarry.—The Skykomish quarry is in the NE$\frac{1}{4}$ sec. 28, T. 26 N., R. 11 E., and has a floor elevation of about 900 feet above sea level. The quarry is owned by Arthur D. Friends, of Skykomish, and operated by Morrison-Knudsen Company, Inc., Seattle, for the Great Northern Railway Company. All rock from the quarry is presently being used by the railroad for riprap.

The quarry has been dug into the east valley wall of the Miller River, and the face has been advanced 75 to 100 feet over a length of more than 500 feet. A floating track in the quarry is moved as the face is advanced.

FIGURE 72.—Working face of the Skykomish quarry, in King County, Washington. Quarry is in granodiorite. Quarry is worked only periodically, and broken rock is stockpiled on quarry floor.

The rock is granodiorite that is fresh and hard. The main joint system trends N. 45° W. and dips 80° SW. The average size of quarried fragments is about 2 to 3 feet in diameter; the largest pieces are more than 10 feet in diameter.

Sunset quarry.— The Sunset quarry is owned by the Northern Pacific Railway Company and operated by Sunset Quarries, Inc., of Issaquah. The quarry is in the NW$\frac{1}{4}$ sec. 5, T. 23 N., R. 6 E., on the east side of the Renton-Issaquah highway. Rubble, crushed rock, and landscape rock are produced.

FIGURE 73.— Sunset quarry, near Issaquah, King County, Washington. Quarry is being worked on several levels in an andesite breccia.

The quarry is in andesite breccia containing minor sandstone. The formation strikes N. 50° W. and dips 40° NE. The rock varies in composition and consists of fragments from a variety of different volcanic rock types. The breccia fragments are fine grained and are predominantly dark purple and green in color. The rock breaks easily and is fairly soft.

Fracturing is random, and most of the rubble in the quarry is in the 6- to 12-inch size. Some material as large as 3 feet in diameter is produced. Slickenside surfaces are common in the quarry face, and some local hydrothermal activity has altered the rock to clay.

The quarry is opened on several levels and is estimated to contain more than 10 million tons of rock.

Veazey quarry.— The Veazey quarry is owned and operated by the Northern Pacific Railway Company. It is in the E$\frac{1}{2}$SE$\frac{1}{4}$ sec. 6, T. 20 N., R. 7 E., at the northwest end of Fell Hill, and is about 3.5 miles northeast of Enumclaw. It is serviced by a paved road and the Northern Pacific Railway. This is not a commercial quarry; its rock is used primarily by the Northern Pacific Railway and is sold to the County and State highway departments on an emergency basis. The quarry contains some of the best rock in the county.

The rock is compact, fine-grained gabbro that weathers medium gray to very light brown. On fresh surfaces it is dark gray. It is brittle along the edges of fragments and breaks with a conchoidal fracture.

FIGURE 74.— Veazey quarry, near Enumclaw, King County, Washington. Columns and jointing, which are evident in the right and upper parts of quarry, control the upper limit of rock size that can be produced from the quarry.

A 1,000-foot quarry face has been opened along the northwest side of Fell Hill. Material from the quarry seems to be coming from a talus slope, but this appearance is the result of using too much blasting powder when the quarry was shot several years ago. Rock fragments vary in size from less than an inch to as much as 7 feet by 15 feet; however, most fragments are between 18 and 30 inches across.

The quarry face contains columns that are tilted about 20° from vertical to the southeast. The quarry is 450 feet high, and the face has been advanced about 150 feet during the past 17 years. Records indicate that it has been operated for over 55 years. Reserves on Northern Pacific Railway land are estimated to be about 50 million tons, and total reserves for Fell Hill are more than 100 million tons.

Talus quarries.— Rock has been produced from talus slopes in several areas in King County. The most notable are the quarries operated by William L. Marenakos, of Issaquah, who takes special landscape rock from talus piles in sec. 35, T. 23 N., R. 9 E., along U.S. Highway 10. The rock is a fine-grained diorite that is hard and fresh. Most of the material is 1 to 2 feet in diameter; however, some fragments are as much as 10 feet in diameter. This rock brings a premium price from landscapers because it has abundant moss growing on it.

METALLIC MINERAL DEPOSITS

Practically all the known metallic mineral properties in King County were first located during the late 1800's and early 1900's. Now most staking activity consists of relocating old claims and of locating new claims around known deposits. During recent years, most major exploration programs have been directed toward the finding of large low-grade disseminated copper and molybdenum deposits; comparatively little has been done to develop the known precious metal properties. Most of the deposits in the county are of the vein type, in which the minerals have been deposited along northwest to west-trending joints and shears in either Tertiary granitoid rocks or closely associated extrusive igneous and older metamorphic rocks. Some metallic occurrences are in breccia pipes, which vary in size from a few feet to several hundred feet in diameter. The best known breccia pipes or zones discovered to date (1969) are along the upper reaches of the Middle Fork of the Snoqualmie River. A few high-grade zones in the area were mined during the early days of mining in King County, but the large ore bodies, now being explored, received very little attention until about 1960.

Production of metallic minerals in King County has been limited mostly to gold, copper, and silver; however, there has also been some production of antimony, mercury, lead, and zinc. Total production of metallic minerals in the county since the turn of the century has been almost $235,000, including about $160,000 in gold, $50,000 in copper, and $25,000 in silver. Some metallic minerals were produced before 1900, but no records are available as to the amount or value.

When the examinations of mineral properties for this report were being conducted, only a few of the adits were found to be accessible. However, staff geologists of the Division of Mines and Geology and its predecessor organizations have visited many of these properties while the mine workings were still open; therefore, most of the underground information presented in the following discussion is a compilation of their work.

Buena Vista Mining District

Bear Basin Property

The Bear Basin property is in the NE$\frac{1}{4}$ sec. 23, SE$\frac{1}{4}$ sec. 14, SW$\frac{1}{4}$ sec. 13, and NW$\frac{1}{4}$ sec. 24, T. 25 N., R. 10 E., in the Buena Vista mining district. Elevations vary from about 3,800 feet in the bottom of the basin to above 5,500 feet at points along the rim (Fig. 87, on p. 137).

The property is reached by following the North Fork of the Snoqualmie River road from North Bend for 19.4 miles to Lennox Creek, then following the Lennox Creek road for 3 miles to where the Bear Basin road branches off to the left (east). In 1966 the Bear Basin road was overgrown with brush, but was passable with a 4-wheel-drive vehicle. The property is about 2$\frac{1}{2}$ miles from the Lennox Creek road—1 mile of road, then 1$\frac{1}{2}$ miles of trail beyond the end of the road.

The property is owned by the Bear Basin Mining Co., of Bremerton, and consists of 25 unpatented claims, most of which are in the amphitheater-like Bear Basin. Eight adits, totaling about 2,000 feet in length, and one open pit have been dug on the claims. The claims originally were staked in February 1905 by L. A. Nelson, Joseph Brown, and A. Loveless. The Snoqualmie Mining Company did most of the work on the Bear Basin claims, and some time around 1917 constructed a small flotation mill on Bear Creek, below the Bear Basin camp. The company also installed a 1,500-foot, two-bucket gravity tram from the millsite to the portal of the No. 3 adit. Before the mill and tram were fully utilized, the claims were sold to a Mr. Jones, who moved the tramline to the portal of the No. 6 adit. Before the tram could be put into operation, the mill burned down (about 1934).

The country rock in Bear Basin is primarily granodiorite, but the basin contains at least one, and probably more, small areas of granite. Mineralization in the basin has taken place along shear and alteration zones that trend from northwest to west. Alteration of the country rock along the zones has left them especially vulnerable to erosion; thus they appear as long topographic depressions. One of the largest shear zones trends about N. 55° W. and forms the depressions that contain the Bear Lakes. Many of the shears, especially those that trend to the northwest, are traceable for several miles.

Two main shear zones and joint sets are mineralized—one strikes essentially west, and the other about N. 45° W. The shear zones are generally composed of 2 to 6 inches of gouge and 1 to 4 feet of hydrothermally altered rock, all of which may contain lenses of sulfide minerals. Minerals in the west-trending shears are mangandolomite, ankerite, quartz, tetrahedrite, stephanite, stibnite, sphalerite, pyrite, andorite, and stannite. Minerals in the northwest-trending shears are quartz, chalcopyrite, arsenopyrite, galena, high-iron sphalerite, and pyrite. The presence of the two mineral suites is strong evidence for the occurrence of two periods of mineralization in Bear Basin.

Considerable confusion exists in various private unpublished reports as to which claims the adits are on. The claim map (Fig. 75) showing the location of the adits was prepared by H. L. Bethel, who surveyed the property in 1949.

All adits were driven on shear zones that are reported to carry precious metal values, but most of the development work has been done on the No. 3, No. 4, No. 5, No. 6, No. 7, and No. 8 adits. Because of inadequate information on the No. 1, No. 2, and No. 8 adits, only the No. 3, No. 4, No. 5, No. 6, and No. 7 are described below. Most of the information presented is from Division of Mines and Geology field notes, by M. T. Huntting and C. P. Purdy. The No. 3 adit is described by Purdy (1951, p. 85).

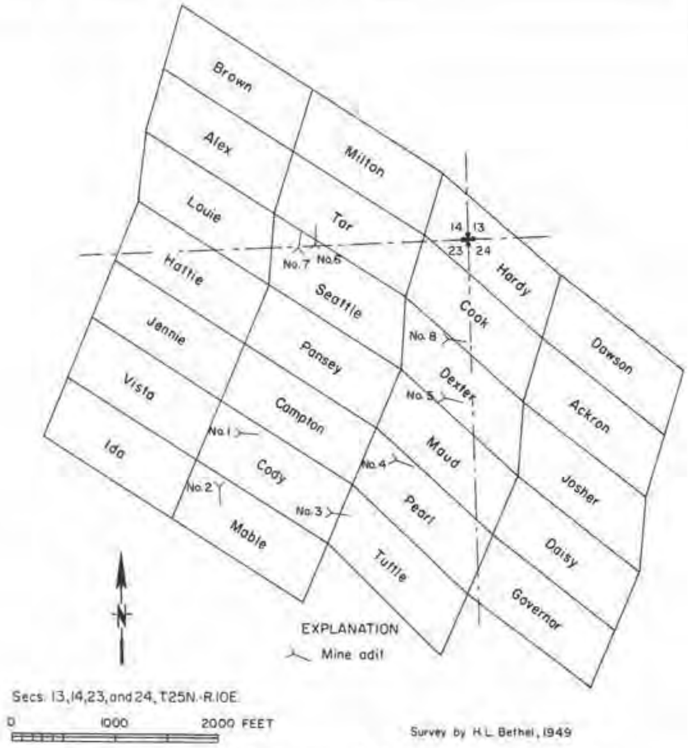


FIGURE 75.— Claim map of the Bear Basin claim group, King County, Washington.

No. 3 adit.— The portal of the No. 3 adit is at an elevation of about 4,100 feet, and is in the southeast part of the basin, about 1,200 feet below the ridge crest. The adit has a general strike of about S. 75° E., and follows a shear that dips 75° to 80° S. At the portal the shear zone is 4 feet wide, and both the hanging wall and footwall have horizontal slickensides. The central part of the zone consists of altered granodiorite for the first 40 feet of the adit, then the zone splits around a horse of slightly altered country rock. The two sections of the zone are separated by the horse for 50 feet, then they join again to form one zone. At this point, 90 feet in from the portal, alteration and mineralization are less intense, and the zone is quite narrow. Beyond this narrow place, alteration increases to a width of about 3 feet, then, at 20 feet from the horse, narrows to 1 foot and contains practically no sulfides. The alteration zone remains narrow for 65 feet, then widens to as much as 4 feet for a short distance, and then tapers to about 1 foot. It remains narrow for 175 feet (or to 408 feet from the portal), where it is intersected by a 3-inch mineralized zone striking N. 45° W. and dipping 42° S. From this intersection the amount of sulfides increases for about 10 feet, and then diminishes, even though the alteration zone remains fairly wide for another 17 feet. Beyond this,

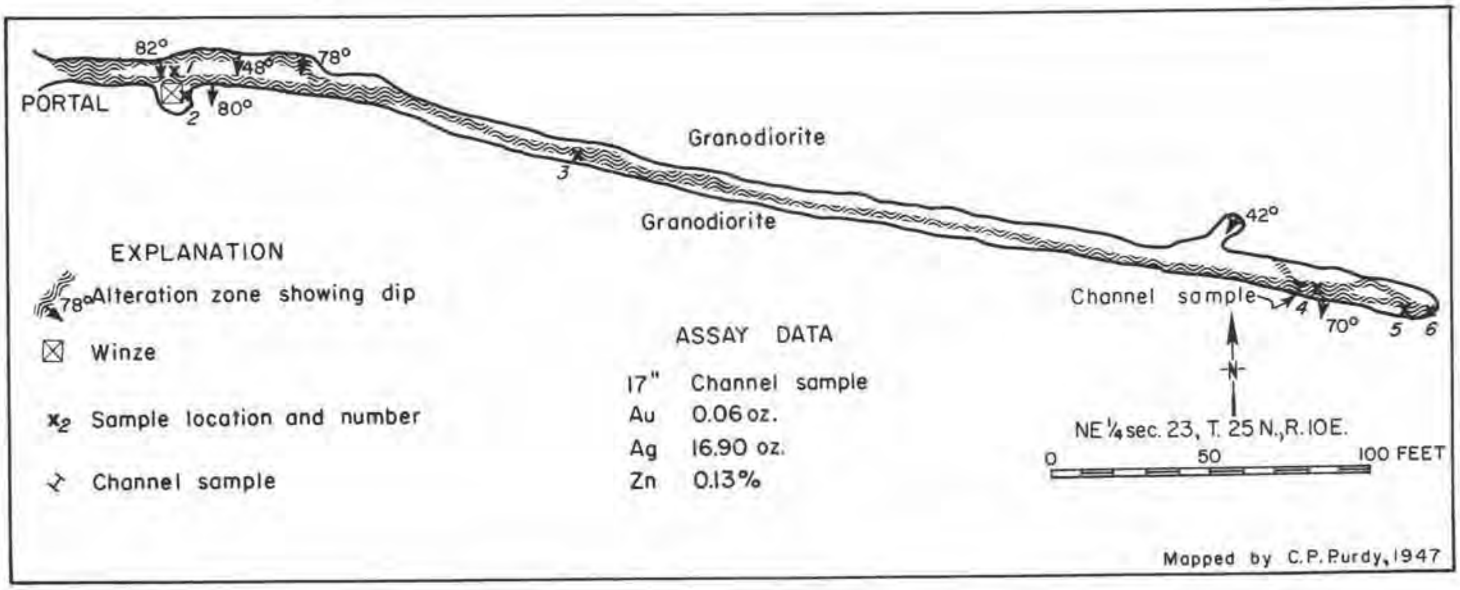


FIGURE 76.— Sketch map of the Bear Basin Mining Company No. 3 adit, in King County, Washington.

the zone narrows to the face, where there is about 1 foot of gouge having little alteration and few sulfides. About 40 feet back from the face, where a channel sample was taken for assay (results are shown on Fig. 76), the mineralized zone has the following characteristics from hanging wall to footwall: 3 inches of gouge, 6 inches of sulfides, 7 inches of kaolinized granodiorite, and 1 inch of sulfides. Ore minerals are tetrahedrite, stephanite, sphalerite, and pyrite. A 20-foot winze was sunk on the south side of the adit, 40 feet from the portal. Mr. Ed Sauers, one of the officers of the Bear Basin Mining Co., reported that the alteration zone at the bottom of the winze is 8 feet wide. Mr. Sauers reported the assays shown in Table 25.

TABLE 25.— Assays from the Bear Basin Mining Co. No. 3 adit, in Bear Basin, King County, Washington [1]

No. [2]	Width	Au oz/ton	Ag oz/ton
1	Stringers above winze	0.05	11.80
2	Grab sample from winze	0.13	92.60
3	4 feet	0.08	32.00
4	12 inches	0.12	90.50
5	2 feet	0.02	14.30
6	12 inches	0.03	22.60

1/ Assays by the Colorado Assaying Co.

2/ Numbers correspond to sample numbers on Figure 76.

No. 6 adit.— The portal of the No. 6 adit is on the north wall of Bear Basin at an elevation of about 4,350 feet, and is approximately 2,000 feet N. 15° W. from the portal of the No. 3 adit. A crosscut was driven 65 feet almost due north into the basin wall, where it intersects a narrow gouge zone that strikes N. 64° W. At 80 feet from the portal, another zone is intersected; this zone strikes N. 50° W., dips 80° SW., and carries 1 to 4 inches of sulfides (pyrite and chalcopyrite) in the footwall. A 335-foot drift was driven along this seam. In the first 80 feet, the drift cuts a series of small west-striking, south-dipping fractures that carry pyrite and minor chalcopyrite in a quartz gangue. The wall rock between the fractures has been subjected to more intense hydrothermal alteration than has the wall rock along the northwest-striking seam. The seam along which the drift was driven forms the northeast wall of the adit and contains from 1 to 4 inches of sulfides and from 1 to 4 inches of gouge. The wall rock has undergone only minor alteration. At the face of the adit the seam dips 80° SW.

About 162 feet from the portal, a short crosscut in the northeast wall of the drift affords an excellent exposure of alaskite. The alaskite contains clots of pyrrhotite that average about 1 inch in diameter. At 231 feet from the portal, the contact between the alaskite and the granodiorite is exposed in the main adit. The contact is sharp, showing little or no gradation, and strikes approximately west and dips about 60° S.

At 180 feet from the portal, a crosscut was driven due west for 70 feet. Some west-trending sulfide stringers are exposed at 35 feet along the crosscut, and a vertical shear zone paralleling the main adit is cut at 65 feet. The shear zone, which carries sulfides, was drifted on for about 40 feet. The zone averages 3 to 4 feet in width for the first 30 feet, then narrows to about 1.5 feet at the face. From the southwest wall to the northeast wall, where the alteration is most intense, the zone is composed of 36 inches of kaolinized alaskite, 16 inches of gouge, and 18 inches of massive sulfides (pyrite, chalcopyrite, arsenopyrite, galena, and high-iron sphalerite) in a quartz gangue. The sulfide masses are lenticular, being about 15 feet long and 20 feet high. The granodiorite-alaskite contact is 27 feet back from the face of the drift. It strikes N. 45° E. and dips 35° SE. Quartz lenses that contain pyrite and molybdenite are scattered along the contact.

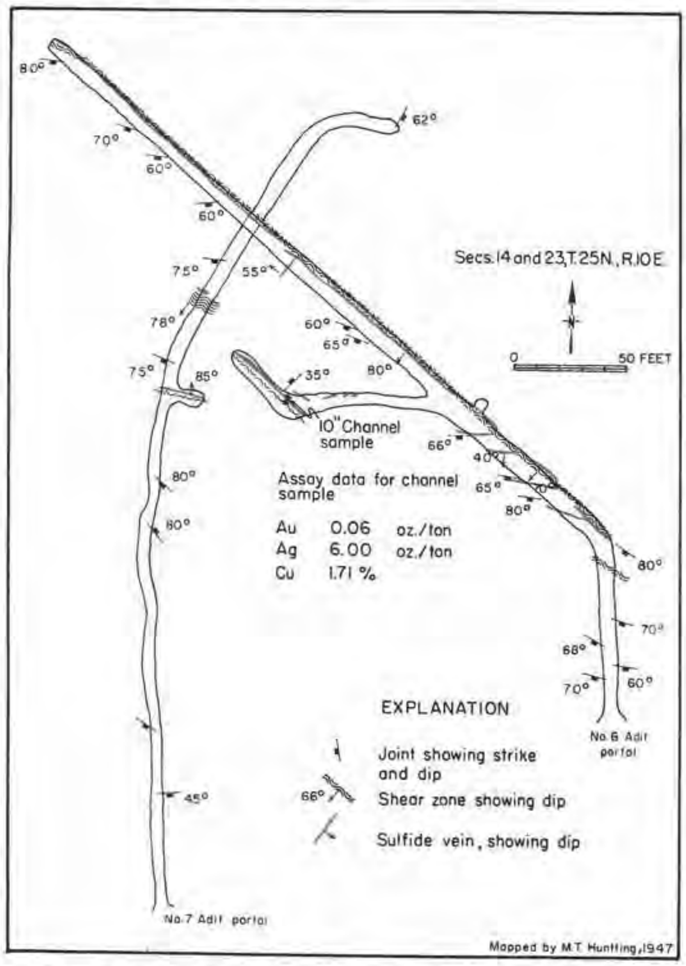


FIGURE 77.— Sketch map of the Bear Basin Mining Company No. 6 and No. 7 adits, in King County, Washington.

No. 7 adit.— The portal of the No. 7 adit is on the north side of Bear Basin, at an elevation of about 4,290 feet, and is about 220 feet southwest of and 60 feet lower than the portal of the No. 6 adit. The whole adit is a crosscut that trends almost due north for the first 230 feet, at which point it cuts a shear zone that strikes N. 65° W., dips 85° NE., and is 3.5 feet wide. The zone contains a 2- to 3-inch sulfide seam. About 40 feet beyond the first zone is a second fault zone that strikes N. 58° W. and dips 78° SW. The alteration zone along the fault is 10 feet wide and carries a few very lean sulfide stringers.

The full length of the adit is in alaskite. The rock exposed in the adit contains abundant clots of sulfides (chalcopyrite and pyrite) and quartz that range in size from 1 inch to 6 inches in diameter.

No. 4 adit.— The No. 4 adit is reported to have been driven 400 feet along a west-striking vertical shear. No values have been reported from the shear zone.

No. 5 adit.— The No. 5 adit is reported to have been driven 325 feet along a northwest-striking shear zone. Values are apparently spotty, and the actual sulfide zone rarely exceeds 6 inches in width.

Dawson prospect.— The Dawson prospect is in the northeast corner of the Bear Basin Mining Co. claim group, in the NW¼ sec. 24, T. 25 N., R. 10 E., at an elevation of 5,350 feet. The prospect is within the basin, just below the ridge crest. The prospect pits were dug on a northwest-trending shear zone that has been subjected to fairly intensive alteration. The alteration zone is about 11 feet wide. Purdy (1951, p. 84) found manganese and antimony minerals in the prospect pits.

Beaverdale Property

The Beaverdale property, in the SE¼ sec. 8 and SW¼ sec. 9, T. 25 N., R. 10 E., is in the Buena Vista mining district along the west wall of Illinois Creek. The property is reached by 2 miles of dirt road up the North Fork of the Snoqualmie River from Lennox Creek and 1 mile of trail up Illinois Creek. The property was not visited by the writer, and the description of the property is paraphrased from Bethel (1951, p. 210).

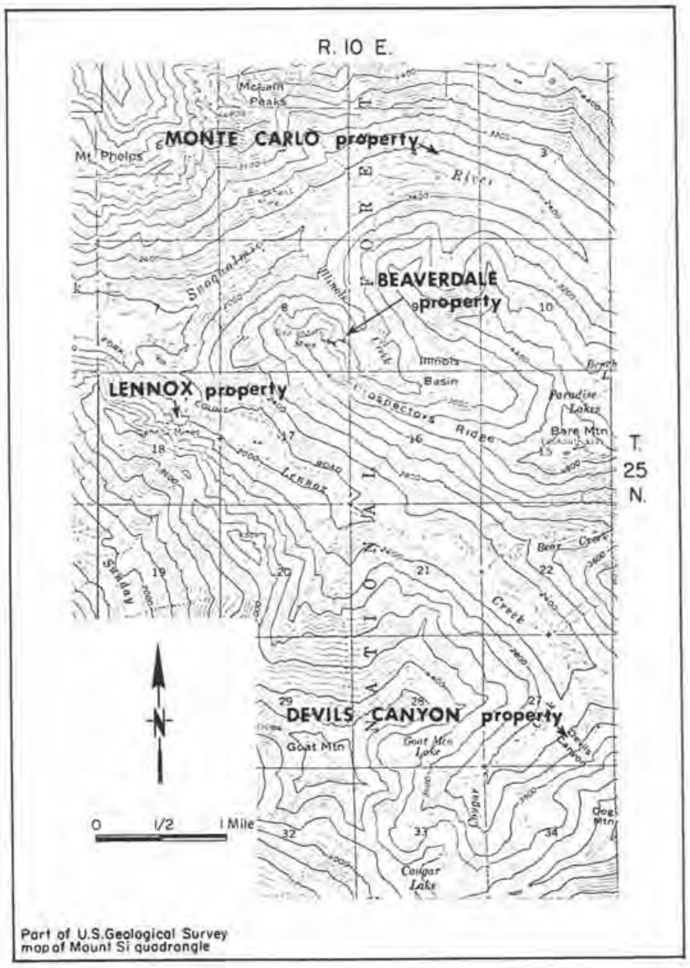


FIGURE 78.— Locations of the Beaverdale, Devils Canyon, Lennox, and Monte Carlo properties, in King County, Washington.

The property consists of six patented claims owned by A. S. Ryland, of Seattle. Development work on the property consists of three adits. At one time there were camp buildings on the claims, but all that remains is a partially collapsed cabin at an elevation of 2,800 feet. The vein on which the adits were driven crops out about 1,000 feet above the cabin, in a narrow canyon that enters Illinois Creek valley from the west. The lowest adit, at an elevation of 3,280 feet, is caved and inaccessible. The next higher adit, at an elevation of 3,580 feet, was driven into the north wall of the gully for 55 feet. The top adit, at an elevation of 3,720 feet, was driven along a shear zone for 140 feet.

Mineralization has taken place along a shear zone in brecciated and altered granodiorite. Bethel (1951, p. 211) reports that the zone is composed of a series of short en echelon shears. Some sections of the zone are mineralized to as much as 20 inches in width. The sulfide minerals, which carry gold, are pyrite and arsenopyrite.

The middle adit has been driven along a vein that strikes N. 80° W. and dips 78° S. The footwall has 12 inches of gouge and 16 inches of altered granodiorite breccia. A 16-inch vein of granular quartz and fine-grained sulfides is on the hanging wall. The sulfides are pyrite and arsenopyrite, in decreasing order of abundance.

The portal of the top adit exposes 20 inches of vuggy quartz containing pyrite and arsenopyrite. At 3 feet from

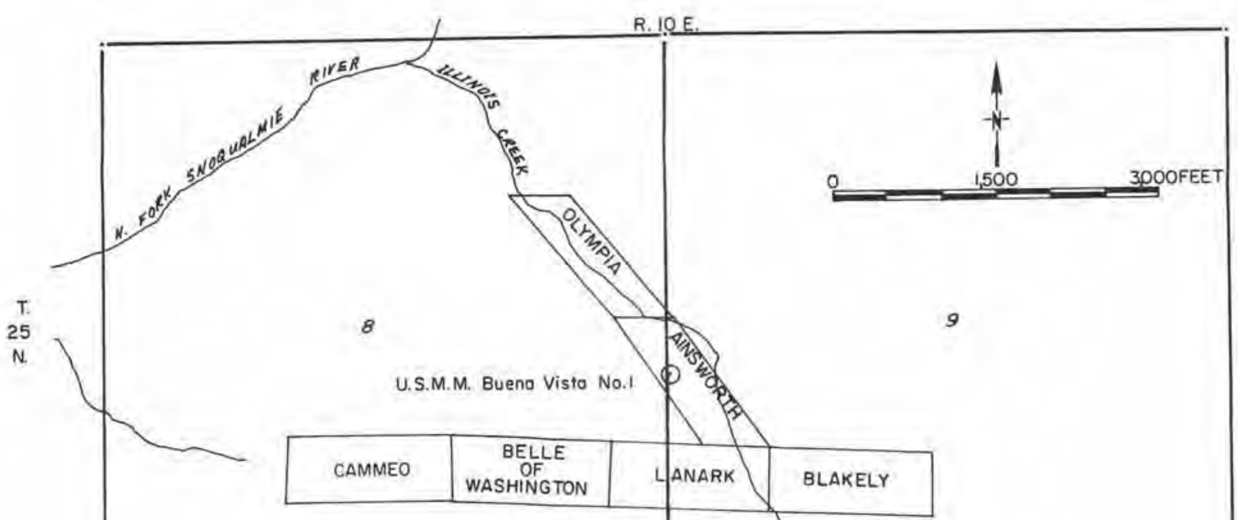


FIGURE 79.— Beaverdale claim group, Buena Vista mining district, King County, Washington.

the portal the vein narrows to 10 inches, and at 50 feet it is only 6 inches wide. At 80 feet the vein pinches out entirely, and the adit turns left and continues for about 35 feet to where it intersects another vein parallel to the first (Fig. 80). At the face of the drift (140 feet from the portal), the second vein contains 12 inches of quartz and sulfides (pyrite and arsenopyrite), and 12 inches of altered granodiorite cut by numerous veinlets of sulfide. Both veins strike about N. 65° W. and dip 80° SW.

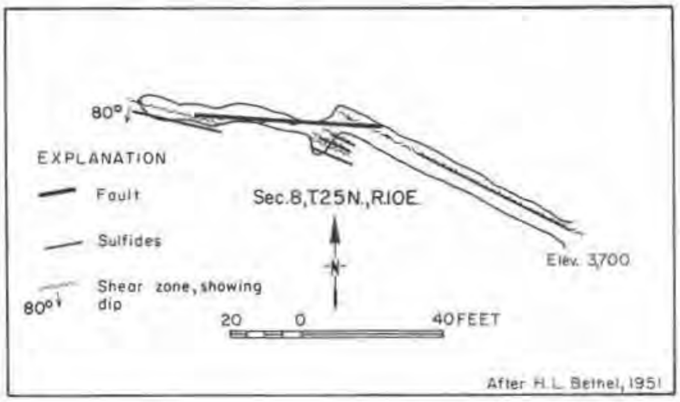


FIGURE 80.— Sketch map of the top adit of the Beaverdale property, Buena Vista mining district, King County, Washington.

Devils Canyon Property

The Devils Canyon property, in the Buena Vista mining district, is in the SE¼ sec. 27, T. 25 N., R. 10 E. (Fig. 78, on p. 131), at an altitude of about 3,280 feet. The property is reached by following the North Fork of the Snoqualmie River to Lennox Creek, then following Lennox Creek to Cougar Creek. From the bridge over Lennox Creek at Cougar Creek the road winds uphill for about half a mile to its end. The property is about half a mile by trail beyond the end of the road and is 900 feet above the east bank of Cougar Creek in Devils Canyon.

In 1966 the property consisted of 4 unpatented claims — the Devils Canyon, Vera, Cougar, and Royal Flush. They are controlled by Target Mines, Inc., whose president is Derair N. Hagopian, of Vancouver, B. C., Canada.

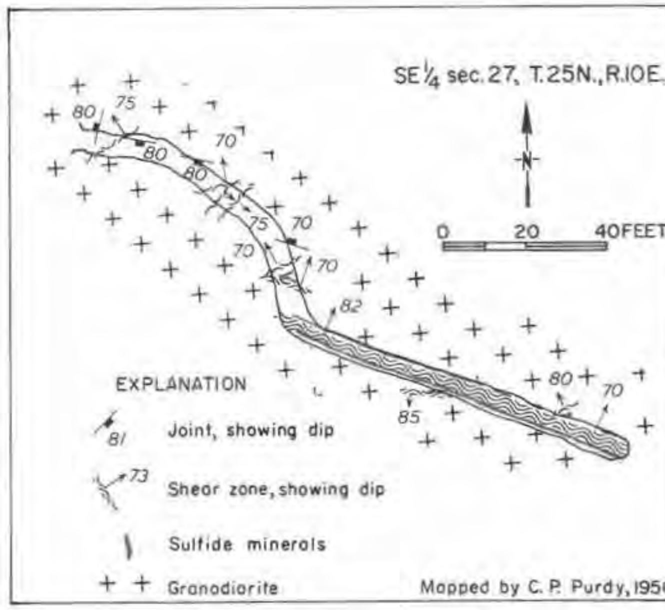


FIGURE 81.— Sketch map of the Devils Canyon adit, Buena Vista mining district, King County, Washington.

It appears that no significant development work has been done since before 1950, when C. P. Purdy examined it. Purdy (1954, p. 29) reported as follows:

> The rock of the Devils Canyon area is a biotite-hornblende granodiorite. The canyon itself has been carved along parallel, vertically dipping, mineralized shear zones that strike approximately N. 70° W. and are arranged in an en echelon fashion. These mineralized shear zones parallel the regional strike of the most prominent jointing in this part of the Snoqualmie granodiorite. [Rapid erosion along the shear zone has formed] an extremely steep-walled canyon, having a width between 50 and 100 feet and a general trend of about N. 40° W.
>
> [At the mouth of the canyon] there is an adit on the northeast bank of the creek. It is the only underground development on the property and is 159 feet long. The first 76 feet is in granodiorite. The last 83 feet is along one of the mineralized shear zones . . . . As exposed underground, the zone strikes N. 70° W., dips 80° to 85° N., and is composed of altered granodiorite containing a few quartz stringers. At the west end of the shear zone the footwall is composed of a gouge seam 5 to 12 inches thick containing a dark-colored claylike streak less than 1 inch thick composed of gouge with pyrite and molybdenite. The hanging wall is a slickensided surface along which there is in places a quartz stringer fluctuating in thickness between that of a knife blade and 1½ inches. It contains a small amount of

molybdenite. The 2 feet of altered granodiorite between these planes of movement has been silicified and contains small quartz veinlets throughout, together with some pyrite, and molybdenite. At the face of the adit the hanging-wall shear plane is barely visible, whereas the footwall contact has developed into a strong fault zone containing quartz and molybdenite. The shears are still about 2 feet apart at this place. A sample across the face contained 0.11 percent molybdenite . . . . As can be determined from the description of the adit, the en echelon pattern of the joint planes is a local as well as a regional feature,having shown up within a strike length of 83 feet . . . .

About 725 feet slope distance and 400 feet vertical distance above the adit in the southwest wall of the canyon, which here strikes N. 50° W., is a mineralized zone striking N. 70° W. and dipping 87° S. This zone, which can be traced for about 200 feet along its strike, is about 3 feet thick and contains several quartz veins, twelve in one place ranging from $\frac{1}{2}$ inch to 8 inches in thickness. All these veins carry some molybdenite, but the greatest quantity of the mineral seems to be in a 6- to 8-inch vein just south of the zone's major plane of movement, now represented by a 2- to 3-inch gouge seam of crushed granodiorite and molybdenite. This vein is the largest of the twelve. It carries molybdenite and minor amounts of chalcopyrite and scheelite. As in the other veins, the molybdenite occurs along the vein borders in crystals from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. There are more of the former size than the latter. A small amount of scheelite also occurs in places along with the molybdenite in the other veins. The center of the large vein is composed of slightly vuggy quartz. About 100 feet beyond this exposure the zone thins appreciably and [cannot be traced farther because of] a cliff . . . .

. . . in 1944 [a Division of Mines and Geology staff geologist climbed] some 2,000 feet above the adit, and attempted to go down the canyon. He was able to descend about 400 feet, beyond which place it was too steep. Nevertheless, he was able to find a shear zone, perhaps the same shear zone, 6 to 8 feet thick and containing several mineralized quartz veins. Also, several quartz veins, striking N. 45° E. and dipping 20° SE., were seen that appeared to cross the shear zone. One of these contains some molybdenite, about 1/8 inch frozen on one side of a quartz vein 1 inch thick.

Lennox Property

The Lennox property, in the Buena Vista mining district, is near the mouth of Lennox Creek, mostly in sec. 18, T. 25 N., R. 10 E. (Fig. 78, on p. 131). It consists of at least 27 claims (Fig. 82) that are reached by graveled road from North Bend up the North Fork of the Snoqualmie River to Lennox Creek. Most of the claims are on the west side of Lennox Creek. The property is owned by the Lennox Mining and Development Co., Seattle. W. W. Felger is president of the company.

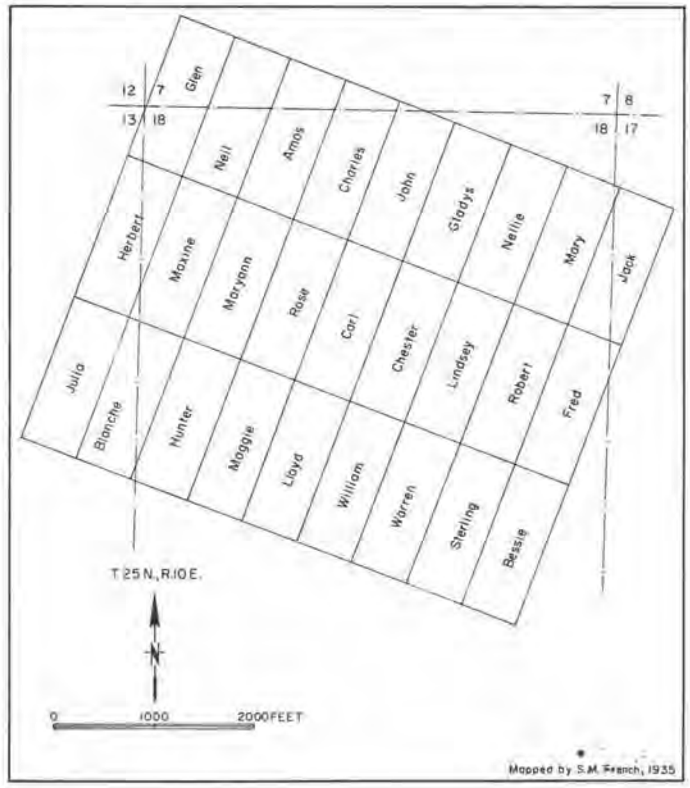


FIGURE 82.— Claim map of the Lennox property, Buena Vista mining district, King County, Washington.

Eleven adits and three open cuts are reported on the property; however, only five adits and two open cuts were examined. No apparent additional work has been done on the property since 1947, when Marshall T. Huntting, of the Division of Mines and Geology, examined the prospect. Most of the information given here is from Huntting's unpublished field notes. At the present time (1969), the property is in a poor state of repair, and the camp that once existed to serve the property has been torn down.

Mineralization of the property is controlled by steeply dipping shear zones that trend northwest in granodiorite. The zones are irregular and contain lenses and stringers of quartz containing pyrite, sphalerite, arsenopyrite, chalcopyrite, and galena. The shear zones are

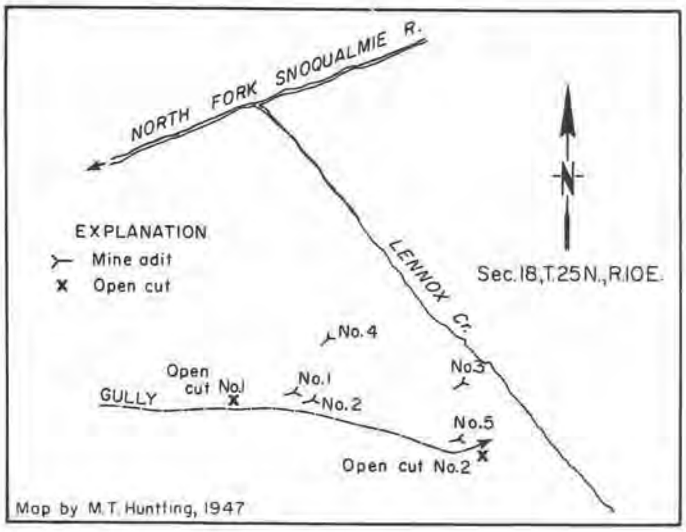


FIGURE 83.— Sketch map showing general spatial relations of the Lennox property adits and open cuts, Buena Vista mining district, King County, Washington.

persistent for several hundred feet, both in length and depth. Sulfide content is irregular and spotty, the best mineralization being along the footwall side of the zones.

The portal of adit No. 2 is on the north side of a small steep gully at an elevation of about 2,680 feet. It was collared on the footwall side of a 15-foot-wide shear zone, and was driven to the southwest, but curves slightly toward the south, so that at the face it is probably in the hanging-wall side of the shear (Fig. 84). Sulfides are sparsely scattered in the first 90 feet of the adit. At 90 feet a 3-foot-wide part of the shear zone carries abundant narrow stringers of crushed pyrite. Near the face of the adit a 9-foot shear zone was cut; it contains an 18-inch sulfide-rich core. Sulfides are pyrite, sphalerite, and arsenopyrite.

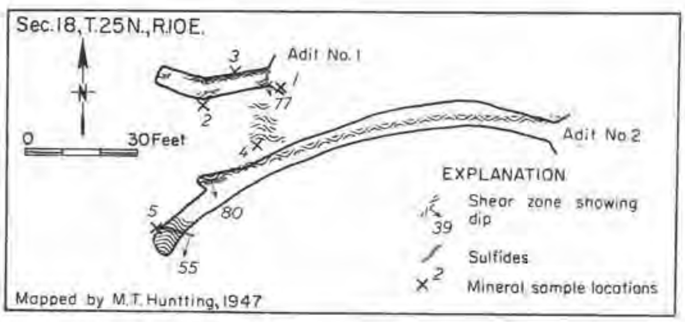


FIGURE 84.— Sketch map of the Lennox property No. 1 and No. 2 adits, Buena Vista mining district, King County, Washington.

The portal of adit No. 1 is about 35 feet higher and 75 feet west of the No. 2 adit, and is on the same shear zone as adit No. 2. The adit has been driven 30 feet into the hill on the footwall side of the shear. It follows a well-defined sulfide stringer, 2 to 6 inches thick, that strikes approximately west and dips 77° S. The sulfide minerals in the stringer, in decreasing order of abundance, are pyrite, sphalerite, arsenopyrite, chalcopyrite, and galena. At the face, a 3-foot alteration zone contains quartz veins and disseminated pyrite. At the right roof of the portal, a stringer of nearly solid sulfides, which has a maximum thickness of 6 inches, splits from the footwall sulfide stringer. It remains practically parallel with the main stringer, but dips only 30° S. A 2,380-pound sample of picked ore from adit No. 1 was shipped to the Tacoma smelter in 1938. It contained 1.58 percent copper, 1.2 percent lead, 8.3 percent zinc, 6.18 percent arsenic, 0.67 percent antimony, 1.14 ounces of gold, and 10.42 ounces of silver per ton. The payment for gold, silver, and copper returned $51.07, minus smelter charges of $22.53, leaving a net payment of $28.54.

About 17 feet south of the footwall exposure in the portal of adit No. 1, and near the bottom of a gully, a 1-foot-wide vertical shear plane strikes west. It is fairly well mineralized with pyrite, sphalerite, and arsenopyrite, and appears to be the hanging wall of the shear zone exposed in the portal of adit No. 1. The whole 17-foot width between portal and the outcrop in the gully has been hydrothermally altered, and is cut by numerous joints and small stringers of pyrite.

Open cut No. 1 is in the same gully, but is 150 feet higher than adit No. 1. This cut is 22 feet wide and crosses the shear zone that is exposed in adit No. 1. Where exposed by the cut, the zone strikes west and dips 55° S. Hydrothermal alteration in the zone has been intense, and moderate amounts of disseminated pyrite and arsenopyrite are present.

About 500 feet north of adit No. 2 and about 80 feet lower in elevation, adit No. 4 was driven into the mountain for 20 feet. No mineralization was encountered in that distance, and the crosscut was abandoned.

Whereas adits Nos. 1, 2, and 4, and open cut No. 1 are well up on the northeast slope of Mount Webster, the portal of No. 3 adit is east of them at the foot of the slope, at an altitude of 1,830 feet, about 15 feet above the bed of Lennox Creek. The adit is only 30 feet long, and was driven on a set of calcite stringers in a shear zone that strikes about S. 80° W. and dips 55° SE. It appears that where calcite is abundant, sulfide minerals are scarce. At the face, the shear is about 3.5 feet wide and contains fairly abundant pyrite and arsenopyrite.

Open cut No. 2 is on the south side of a west-trending gully, approximately 800 feet south of and 290 feet higher than adit No. 3. It cuts a west-trending fault zone that dips 50° S. The zone, which is 2 feet wide, is considerably brecciated and contains abundant disseminated pyrite and arsenopyrite.

Adit No. 5 is 90 feet higher and diagonally across the gully from open cut No. 2. The adit was driven on the fault zone cut by open cut No. 2. The zone was drifted on for 100 feet before the adit was abandoned. At the face the zone is 2 feet wide, and consists of crushed and broken quartz with narrow stringers and lenses of fine pyrite, arsenopyrite, and sphalerite. Over the length of the adit, the width of the gouge zone ranges from 10 to 30 inches, and averages 16 inches.

Samples taken by the owners in 1947 and assayed by the Lambert-McKamey Laboratories, Seattle, showed the results given in Table 26. Sample locations 1 through 5 are shown on Figure 84.

TABLE 26.—Assay results on samples from the Lennox property, King County, Washington 1/

Sample no.	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)	Total value per ton
1	0.30	17.75	3.90	6.40	3.80	$63.91 2/
2	0.22	3.24	0.50	4.75	1.85	29.38
3	0.24	2.34	0.70	4.00	tr.	20.66
4	0.10	1.12	0.30	3.45	none	12.49
5	0.06	0.14	0.10	7.50	0.55	27.30
6	0.10	0.38	0.05	1.70	tr.	7.51
7	0.14	0.26	tr.	2.00	tr.	9.30
8	0.16	0.42	0.25	2.75	none	12.45

1/ Assays by Lambert-McKamey Laboratories, Seattle.

2/ Metal prices (1947) used to calculate total values were: gold, $35 per oz.; silver, 75 cents per oz.; lead, 15 cents per lb.; zinc, 10½ cents per lb.; and copper, 21 cents per lb.

The sample locations are described as follows:

Sample No. 1, from adit No. 1, was from sulfide stringer at sill level, on south side of adit, at the portal.

Sample No. 2, from adit No. 1, was 19 feet in from portal, across a 1-foot width.

Sample No. 3, from adit No. 1, was 10 feet in from portal, from footwall sulfide seam, across a 6-inch width.

Sample No. 4, from an outcrop 30 feet south of portal of adit No. 1, was from near the hanging-wall side of shear zone.

Sample No. 5, from adit No. 2, was 116 feet in from portal, across a 16-inch width.

Sample No. 6, from an open cut 700 feet east of adits No. 1 and 2, was across a 30-inch width.

Sample No. 7, from adit No. 3, was 21 feet in from portal, across a 3-foot width.

Sample No. 8 was from dump of adit No. 5.

Monte Carlo Property

The Monte Carlo claims were not visited during this study, but they were examined by M. T. Huntting, of the Division of Mines and Geology, in 1947. The Monte Carlo property is along the north valley wall of the North Fork of the Snoqualmie River, in the NW¼ sec. 4, T. 25 N., R. 10 E. (Fig. 78, on p. 131). The property is in the Buena Vista mining district, and is reached by going up the road along the North Fork of the Snoqualmie River for about 3 miles above Lennox Creek, and then following a trail uphill to the portal on the north side of the valley. The property consists of 13 unpatented claims (Fig. 85) that are held by E. P. Courtney, of Seattle.

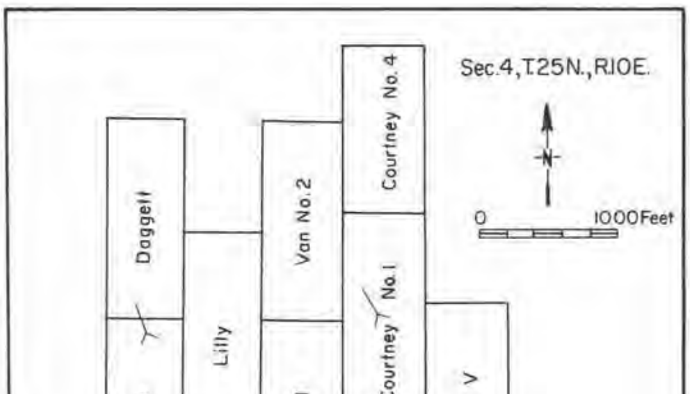


FIGURE 85.— Monte Carlo claim map, Buena Vista mining district, King County, Washington.

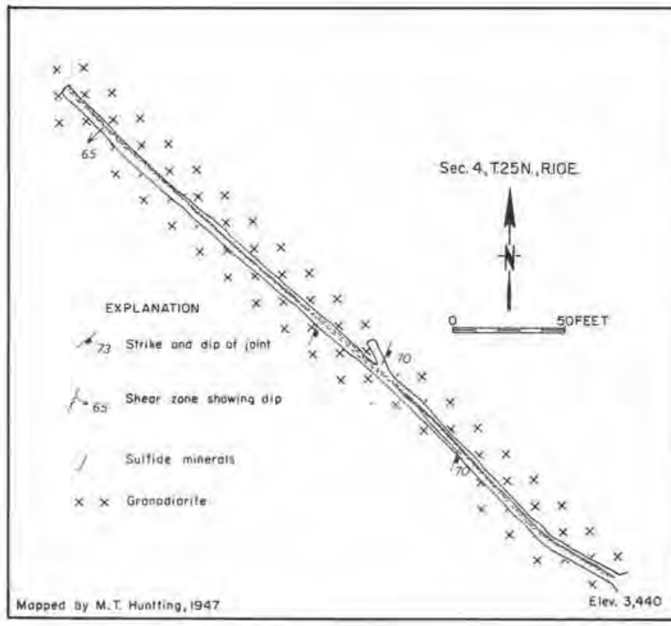


FIGURE 86.— Sketch map of the main adit of the Monte Carlo property, Buena Vista mining district, King County, Washington.

Development work consists of a main 335-foot adit (Fig. 86), driven in the 1890's, and three shorter adits that were not examined in 1947. The main adit, which is on the Courtney No. 1 claim, was driven on a vein associated with a shear zone in granodiorite. For the first 86 feet, the vein averages about 5 inches in width. The vein is composed of pyrite and quartz, also some arsenopyrite and malachite in crushed granodiorite gouge that is as much as 16 inches thick. About 65 feet from the portal, the vein expands to 14 inches, then pinches down to 1 inch at 106 feet. Between 91 and 113 feet from the portal, a series of prominent joints in the hanging wall strike N. 20° E. and dip 80° SE. They do not extend across the gouge zone into the footwall, so are assumed to be pre-faulting in age. The vein is on the footwall side of the gouge seam for 106 feet from the portal; at that point, mineralization on the hanging wall begins, then swells to a width of 14 inches in 5 feet, at 111 feet from the portal. At 119 feet from the portal the hanging wall vein is 7 inches thick and the footwall vein is 10 inches thick; there is 6 inches of intervening gouge. At 136 feet from the portal, the veins merge and are brecciated by faulting. A 15-foot crosscut was driven into the footwall at that point and follows a joint set. The joints strike and dip the same as the joints in the hanging wall at 91 to 113 feet from the portal, and are assumed to be their continuation. Horizontal displacement along the fault appears to be on the order of 45 feet. From 136 to 191 feet the vein is brecciated; sulfides are scarce— they average only about 1 inch in width. At 196 feet from the portal, the vein has swelled to 3 inches and is less brecciated. At 206 feet it is 12 inches wide and contains abundant pyrite. At 236 feet it has narrowed to 7 inches and there is 3 inches of gouge in the hanging wall. A tourmaline stringer converges with the main vein at 256 feet and continues to the face, at 335 feet from the portal.

Assays from the property are reported by the owner to have run as high as $55 per ton in gold and silver. The gold and silver is associated with the pyrite.

Miller River Mining District

Aces Up Property

The Aces Up property is in the Miller River mining district, in the SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 30, T. 25 N., R. 11 E., on the Eastern Star claim of the Cleopatra group (Fig. 88, on p. 139). This group consists of 24 unpatented claims owned by the heirs of John Maloney and leased to Henry E. Trenk, of Skykomish. It is reached by turning south from the Stevens Pass highway (U.S. 2) onto the Miller River road at the Money Creek campground, 2.9 miles west of Skykomish.

At 4.5 miles from the highway, an unimproved road

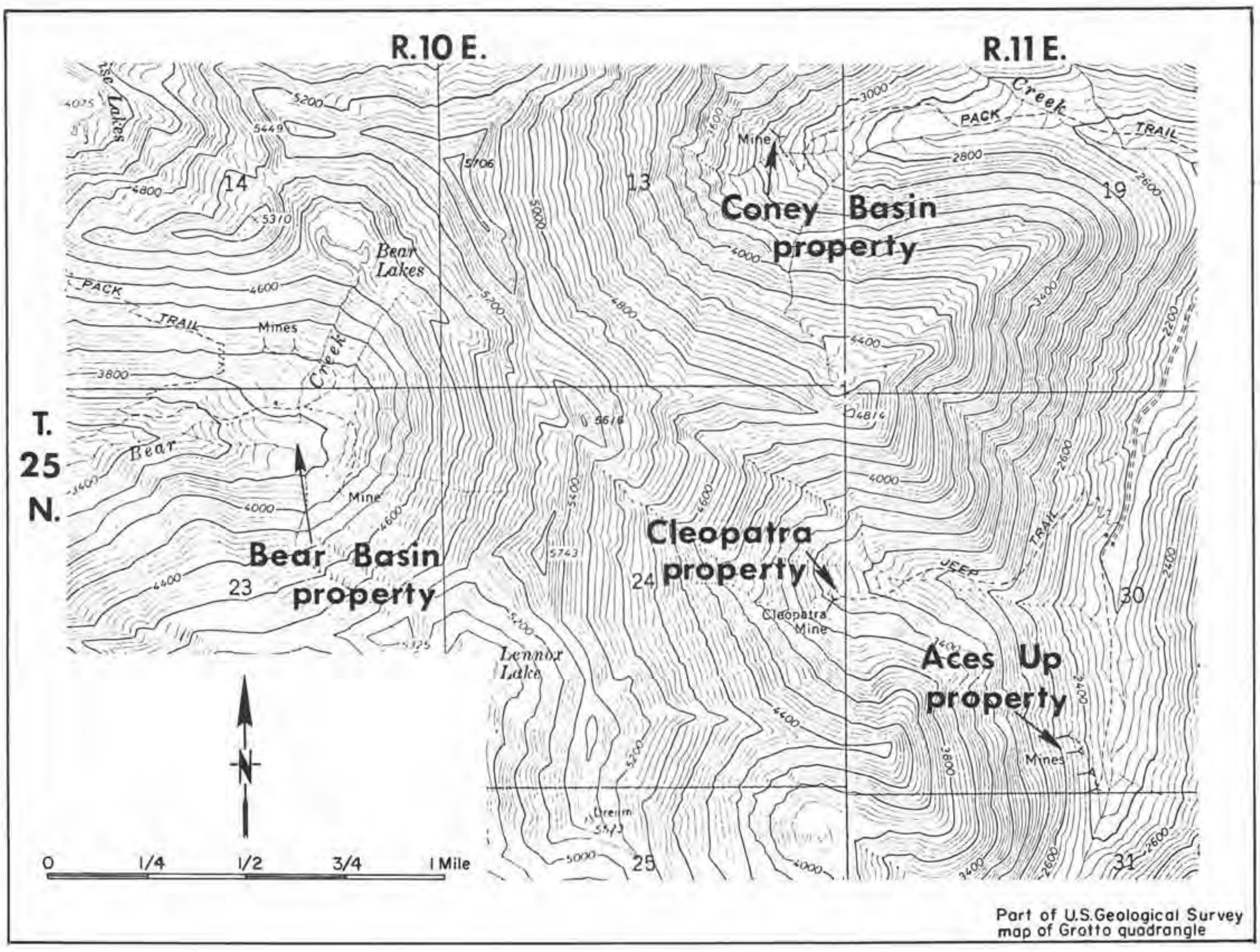


FIGURE 87.— Locations of the Bear Basin, Aces Up, Cleopatra, and Coney Basin properties, in King County, Washington.

branches off to the right and follows up the West Fork of the Miller River. The Aces Up is 4.2 miles up the West Fork road, 0.6 mile beyond the Cleopatra camp. The property has four adits, the lowest of which is at an altitude of 2,360 feet, and about 30 feet above river level. The adits have been driven into the steep, thickly timber-covered west valley wall of the West Fork of the Miller River.

The lower adit, Aces Up No. 3 (Pl. 3), is partially caved at the portal and inaccessible. Purdy (1951, p. 80) reported the following about the lower adit:

> According to Mr. Mike Kinney, of Skykomish, the ore was followed for about 300 feet to where it died out; then, back from the face about 200 feet, a 90-foot crosscut to the north was driven to intersect the particular mineralized joint on which the next adit up the hillside was driven. A raise was driven up this joint, and it is estimated to have come within 14 feet of holing into a winze that dropped down from the adit immediately above. No accurate information could be obtained as to the quantity or grade of ore present in the lowest adit.

The Aces Up No. 2 adit (Pl. 3) is about 70 feet higher up the valley wall, and has been driven along a mineralized joint that strikes N. 50° W. and dips 65° to 75° SW. The adit is 400 feet long, and at 200 feet from the portal a winze has been sunk along the mineralized zone. At 190 feet, a 15-foot stope was taken out where the vein widened to about 2 feet. It is reported that high-grade ore came from this winze; however, the winze was full of water at the time the author visited the property. It was also full of water when Purdy (1951, p. 80) inspected the mine. The mineralized zone varies to as much as 2 feet in thickness; the average over the length of the adit is about 10 inches. The vein pinches and swells at various places along the adit, and near the face it branches into numerous tiny barren veinlets. Alteration along the vein consists mostly of chloritization of the biotite in the country rock, but in a few places sericitization was intense enough to work a few inches out into the granodiorite wall rock. Sulfide emplacement apparently was mostly by replacement along joints and fractures in the granodiorite and a small amount of cavity filling. Purdy (1951, p. 81) thought there had been no movement along the joints, as there does not appear to be any shattering in the zone. Sulfide minerals in the vein are argentiferous galena, chalcopyrite, arsenopyrite, sphalerite, pyrite, and jamesonite. The gangue is composed of quartz, calcite, and silicified granodiorite.

At 150 feet up the hill from adit No. 2, the Aces Up No. 1 adit (Pl. 3) has been driven into the hillside for 175 feet on a mineralized zone that bears N. 55° W. and dips 65° to 70° S. About 25 feet from the portal a winze has been sunk on the vein. The winze is filled with water, and no information is available regarding its dimensions or grade of ore. Purdy (1951, p. 81) made a polished-section study of the minerals in this adit and reached the following conclusions regarding the history of mineralization:

> First, as shown by their usual mutual boundaries with one another, pyrite, arsenopyrite, and sphalerite have been almost simultaneously deposited along the joint, replacing the granodiorite. In two places, the sphalerite appears to be eating into the pyrite, as evidenced by a long narrow embayment bordered with many minute islands of pyrite. The sphalerite shows scattered blebs of chalcopyrite, some of which have a linear arrangement. Second, and clearly later than the first stage of deposition, was an introduction of quartz. Apparently there had been minor movement preceding the introduction of the quartz, as it fills fractures in the pyrite, arsenopyrite, and sphalerite. At the close of the quartz deposition there were some open spaces, as evidenced by many euhedral quartz crystals. Closely following this quartz deposition, and perhaps in part simultaneous with it, silver-bearing galena and jamesonite were deposited, in that order. Both of these minerals fill fractures in the quartz, and the jamesonite surrounds islands of the galena. This second period of mineralization may have taken place at a somewhat lower temperature than the first.

The vein in the No. 1 adit averages about 4 inches in thickness over its entire exposed length of 175 feet. It pinches and swells at various places, and reaches a maximum of 18 inches in thickness near the middle of the adit. Near the face, the vein pinches out.

The fourth adit is 60 feet uphill from adit No. 1. It was driven along a vein for 20 feet, at which point the vein pinched out. Purdy (1951, p. 81-82) reports that Mr. Henry Trenk, the leaseholder, said that the vein in the top adit consists of a few inches of high-grade sulfides, including argentiferous galena, close to the portal. A shipment of 500 pounds of vein material from this adit to the Tacoma smelter contained too much antimony to be acceptable. Purdy (p. 82) thought that the mineral jamesonite was contributing to the high antimony content, but that, unfortunately, the amounts of jamesonite and galena were too small to make a commercial lead-antimony concentrate.

Cleopatra Mine

The Cleopatra mine is in the Miller River mining district, in the NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 24, T. 25 N., R. 10 E. (Fig. 87, on p. 137). The mine is on the Silver Star and Silver Star No. 1 claims of the Cleopatra group of 24 claims (Fig. 88).

It is reached by turning south from the Stevens Pass highway (U.S. 2) onto the Miller River road at the Money Creek campground, 2.9 miles west of Skykomish; at 4.5 miles from the highway, an unimproved road branches off to the right and follows up the West Fork of the Miller River. The Cleopatra camp is 3.6 miles up the West Fork road. The camp is connected with the mine by a 1$\frac{1}{2}$-mile cat road. The mine is at an elevation of about 3,400 feet, on the south wall of the Cleopatra Basin.

The Cleopatra mine was one of the earliest properties worked in the Miller River district. Ore was produced from the property intermittently between 1897 and 1941. Most of the ore was moved from the mine by pack animals; however, in 1940 a 4,100-foot tramline was built, connecting the mine with the Cleopatra camp on the valley floor. A reported total of $250,000 worth of ore was taken from the property by 1941, at which time the Cleopatra was classified as a nonessential mine and closed down because of World War II. The property is now controlled by Cleopatra Mines, Inc., whose president is Joe Cashman, of Index.

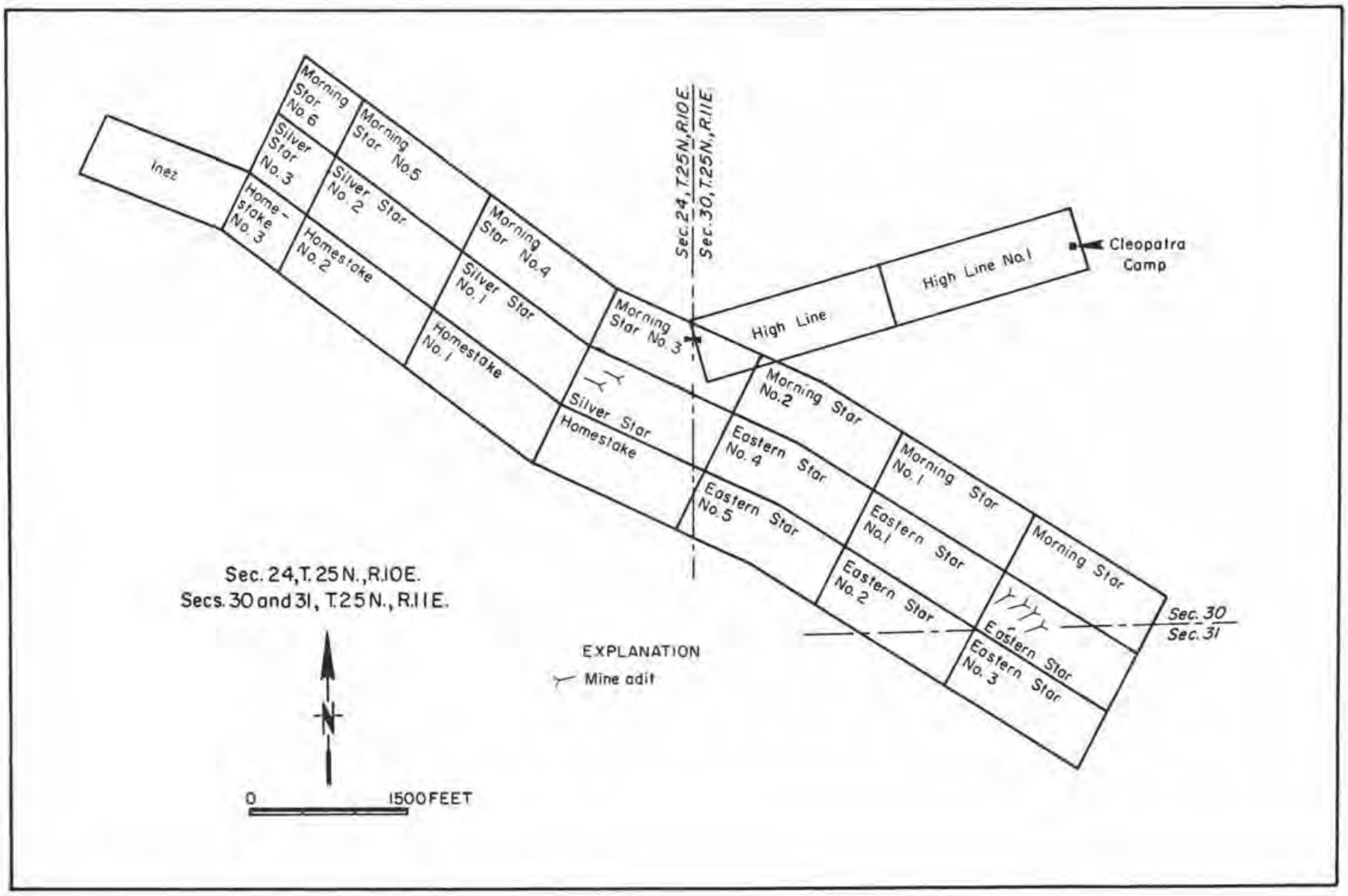


FIGURE 88.— Claim map of the Cleopatra claim group, Miller River mining district, King County, Washington.

The property was not visited during the course of this investigation. Information from the Division's files and from private reports indicates that the adits are in a poor state of repair, and that the main adit has collapsed on the portal side of the main ore zone. Information reported here comes from Division of Mines and Geology field notes by J. W. Melrose and C. Phillips Purdy, and from private reports by C. C. M. Gregory and Willis T. Batcheller.

The Cleopatra mine is about 4,000 feet northwest of the Aces Up property, and is on the same system of mineralized joints. The workings extend about 2,100 feet, and consist of crosscuts, drifts, winzes, a raise, and a shaft (Pl. 4). Two adits are on the property— the main one and another 200 feet higher.

The lower, or main, adit is a 340-foot crosscut in granodiorite that trends S. 47° W. and cuts two steeply southward-dipping, highly altered zones. The first is cut at 210 feet, and the second at 270 feet. Both strike N. 45° W. and average about 5 feet in thickness. The first was drifted on for about 45 feet in both directions from the adit. The second has been drifted on for 65 feet to the southeast and 100 feet to the northwest. Kaolinization of the country rock has been thorough along both zones. Sericitization is common, though not widespread; sulfides are scattered and consist mostly of pyrite and chalcopyrite. At 120 feet from the portal, a system of almost vertical joints striking N. 68° W. has been followed for 290 feet, the last 20 feet of which is in a highly altered zone. At 270 feet along the joint system, a crosscut bearing S. 23° W. was driven for 110 feet. A zone of strong alteration that strikes N. 60° W. and dips about 75° SW. occurs from 40 to 77 feet along the crosscut. The zone is strongly kaolinized and has minor sericite and scattered sulfides. At 55 feet, a drift following the strike of the zone was driven 55 feet to the southeast and 595 feet to the northwest. At 40 feet northwest from the crosscut and drift intersection, a 200-foot raise connects with the upper adit. At 65 feet from the intersection, a 35-foot crosscut has been driven to the southwest. The No. 1 winze is 110 feet from the intersection; no information is available concerning its dimensions. At 395 feet from the intersection, a crosscut has been driven to the north for 45 feet, where it exposed a zone of alteration paralleling the main drift. This zone was drifted on for 65 feet to the southeast and 120 feet to the northwest. At 430 feet along the main drift, a 75-foot winze was sunk along the dip of the ore zone.

The 200-foot raise to the upper adit follows a system of en echelon mineralized joints that dip about 75° SW. and strike about N. 60° W. Four short exploratory drifts driven from the raise are equally spaced from the lower to the upper adit. Sulfides are fairly plentiful in the mineralized parts of the raise and in the faces of the short drifts. The upper adit was driven for 160 feet along a strongly altered zone that contains scattered sulfides.

Mineralization in the Cleopatra, judging from an assay map, is spotty. Argentiferous galena, chalcopyrite, tetrahedrite, arsenopyrite, pyrite, jamesonite, and sphalerite are reported to be the principal sulfides. The mineralization is along a shear zone that trends to the northwest and can be traced for several miles on aerial photographs. Purdy (1951, Fig. 5, p. 79) shows that the Aces Up property, Cleopatra mine, and Dawson prospect are on the same large shear zone.

Coney Basin Mine

The Coney Basin property is in sec. 13, T. 25 N., R. 10 E., and sec. 19, T. 25 N., R. 11 E., at an elevation of 3,120 feet on the west wall of Coney Basin, a hanging cirque valley, in the Miller River mining district (Fig. 87, on p. 137).

The property is reached by following an old mine-to-market road up the northwest bank of the West Fork of the Miller River for about 2.5 miles from the Miller River road. From this point, a cat road leads up the valley wall into the basin. The property consists of 15 unpatented claims (Fig. 89) owned by Coney Basin Gold Mines, Inc., Seattle. At one time, three buildings and a 2,000-foot tramline were on the property; however, the ravages of time have obliterated them.

The claims were first staked in 1892, and development work was begun in 1894. The lower adit was begun in 1895. An explosion outside the mine in 1897 (Biderbost, 1939, p. 5; Van Ornum, 1937, p. 7) killed several men, and the resulting litigation forced the operators to close the mine.

Development work consists of about 3,000 feet of adits on two levels and about 100 feet of shafts and raises. Also, several open cuts are scattered over the property. At

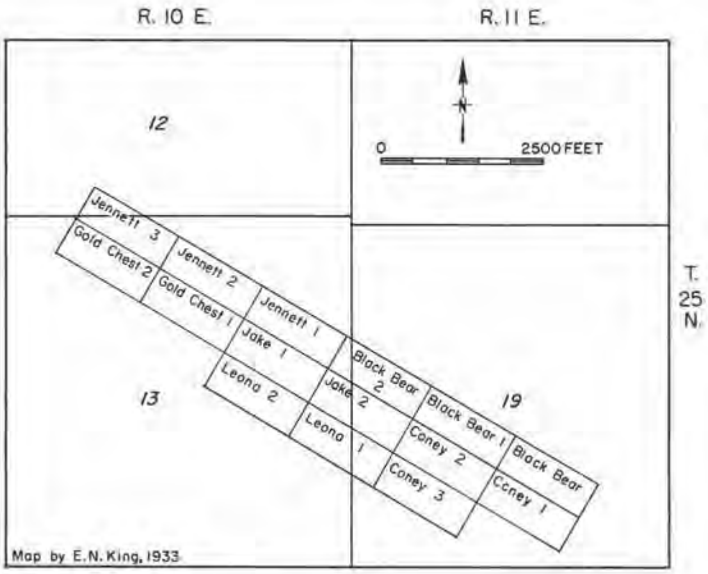


FIGURE 89.— Claim map of the Coney Basin claims, Miller River mining district, King County, Washington.

the present time (1969), both adits are caved. Information below is from unpublished Division of Mines and Geology field notes by Ward Carithers, and from University of Washington student theses by Van Ornum (1937), Biderbost (1937), and Mills (1949).

The lower adit was driven 55 feet on a bearing of N. 20° W., where a small vein was cut. This vein was followed for about 175 feet; at that place a crosscut was driven for 35 feet to the northeast, where three small quartz veins were cut. Two of these strike N. 70° W. and dip 80° SW. The other vein strikes N. 55° W. and dips 50° SW. About 155 feet from the face of the adit, another crosscut was driven S. 70° W., and at 50 feet encountered a 15-foot silicified zone containing pyrite stringers. The adit followed a small stringer for another 90 feet, where it encountered a 60-foot mineralized zone. A raise was started on the ore shoot, and about 100 tons of ore was removed. About 25 feet from the face a winze was sunk; its depth is not known.

The upper portal is about 150 feet in elevation above the lower adit. It follows a mineralized zone containing pyrite, sphalerite, galena, chalcopyrite, and tetrahedrite, and bears S. 80° W. for about 200 feet. At the portal and for 50 feet into the adit the zone was stoped to the surface. About 200 feet from the portal, the adit cuts a siliceous zone striking N. 70° W. This zone contains sulfides and may be the zone that was cut in the lower adit. From here the adit follows a general southwest direction for another 1,800 feet; however, no significant mineralization has been reported in the back part of the adit.

A report from the Tacoma smelter on returns from a 7.5-ton shipment of ore in 1941 shows $41.18 in gold and silver, 10 percent lead, and 6 percent zinc. The Kellogg, Idaho, smelter returned an assay on a hand sample that ran as follows: Gold, 0.64 ounce per ton; copper, 0.5 percent; iron, 11.8 percent; sulfur, 14.9 percent; antimony, 0.6 percent; bismuth, 0.074 percent; silver, 20.2 ounces per ton; lead, 6.9 percent; zinc, 4.5 percent; and arsenic, 2.03 percent. An average of 22 samples was 0.38 ounce per ton in gold, 11.97 ounces per ton in silver. A 40-ton ore shipment was made from the property in 1895, and shipments were reported to have been made in 1934, 1937–1939, and 1941.

Great Republic Mine

The Great Republic property is in the Miller River mining district, in the N$\frac{1}{2}$SW$\frac{1}{4}$ sec. 33, T. 26 N., R. 11 E. It is at an altitude of about 1,200 feet at the first falls on Happy Thought Creek, about half a mile from the Miller River.

The property can be reached by following a poor trail that starts at the Miller River road about 1.5 miles from its junction with Highway 2 at the Money Creek campgrounds.

The property is owned by Charles Wible, of Tacoma, and consists of five unpatented claims. The claims were originally staked in 1892, and had been held by several owners before Mr. Wible acquired the property. All underground work was done between 1900 and 1905, when the Great Republic Mining Co. worked the property. This company also built a tramline and a stamp mill.

The underground workings consist of two adits connected by a raise (Fig. 90). The lower adit is on the south side of Happy Thought Creek, and the upper adit is on the north side of the creek about 20 feet higher than and 240

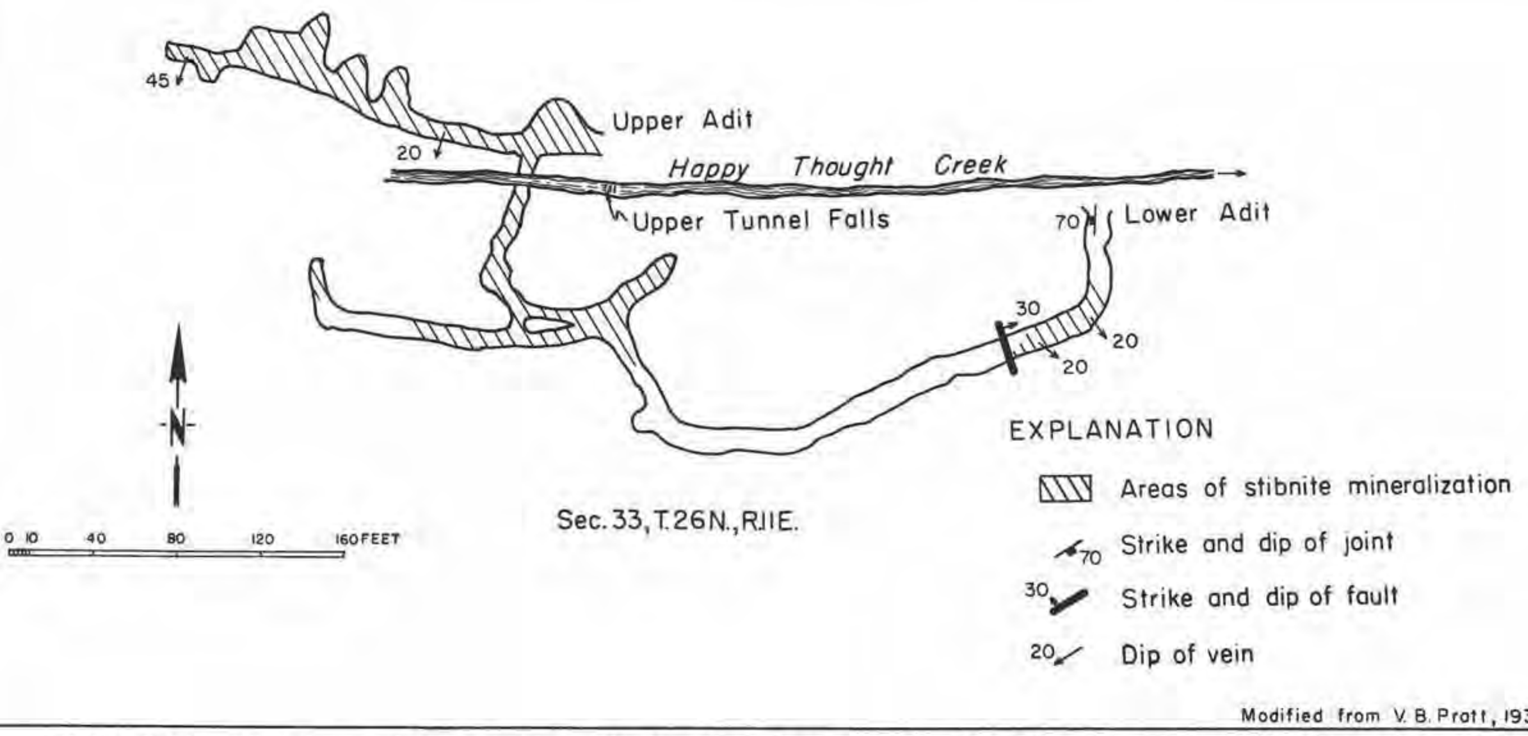


FIGURE 90.— Sketch map showing areas of stibnite mineralization at the Great Republic Mine, Miller River mining district, King County, Washington.

feet west of the lower adit. No significant development work has been done on the property since it was visited and described by C. P. Purdy (1951, p. 75) when he was a staff geologist of the Division of Mines and Geology.

Most of the development work was done along a gently dipping fault in andesitic rocks that are informally called the Temple Mountain andesite by Galster (1956, p. 56). The upper adit was driven along the vein, which strikes generally west and dips about 15° to 20° S. The best stibnite mineralization exposed on the property is at the portal of the adit, where a 2.5-foot thickness is exposed on the south wall over a strike length of 4 feet. Four stopes are along the north wall of the adit (Fig. 90). The lenses of the stibnite that was mined could not have exceeded 3 feet in width, and the stopes extend no farther than 25 feet north, the average being 15 feet. The stopes are only about 4 feet high. About 15 feet beyond the last stope the vein splits and is barren of sulfides.

The raise from the lower adit enters the upper adit at the first stope. The part of the vein exposed in the raise contains scattered stibnite. Happy Thought Creek, because of debris damming its channel just below the upper adit, at one time flowed into the adit, down the raise, and out the lower adit. As a result, most of the lower adit is filled with sand and gravel.

The lower adit heads south along a west-dipping joint for 50 feet, where it cuts a westward-striking vein that dips 20° S. The vein is about 3 inches wide and contains pyrite, quartz, and stibnite. It is not known whether this is the downward extension of a vein in the upper workings. The adit turns west, and the vein pinches out in the floor, but another small vein starts to show in the roof. At 45 feet beyond the turn, the second vein is cut off by a small fault, and the adit is barren to within about 80 feet of the raise, where the downward extension of the vein exposed in the upper portal is encountered.

Purdy (1951, p. 77-78) describes the mineral deposition sequence of the property and also gives more details on vein structure. V. B. Pratt (1939) reports on concentrating ores from the Great Republic.

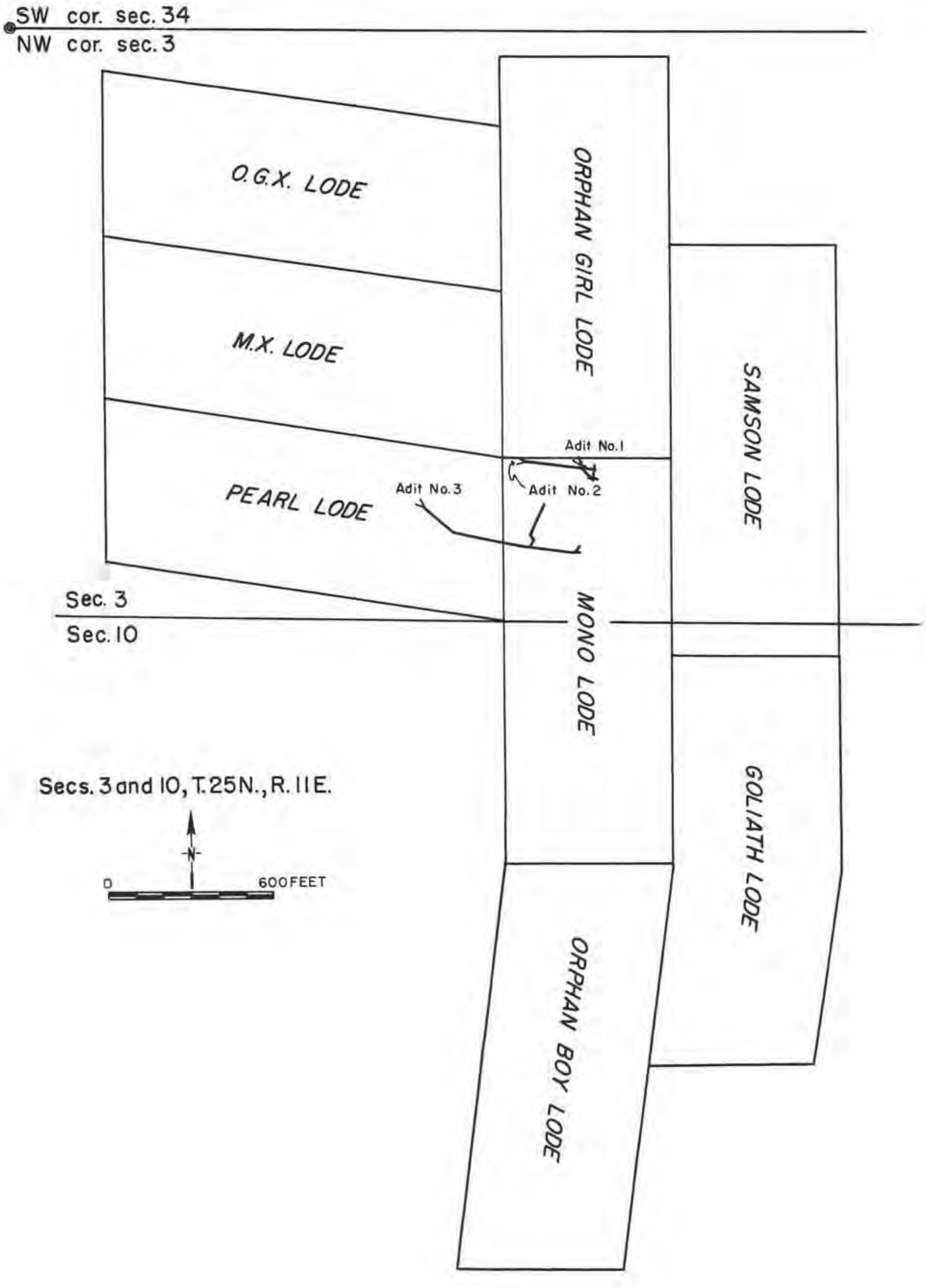


FIGURE 91.—Claim map of the Mono claim group, Miller River mining district, King County, Washington.

Mono Mine

The Mono claim group consists of four patented claims, the Mono, Orphan Boy, Orphan Girl, and Pearl, and fourteen adjoining unpatented claims (Fig. 91). The claims are controlled by Mono Mine, Inc., whose president is Joe. B. Cashman, of Index.

The property is in the Miller River mining district, in the $S\frac{1}{2}$ sec. 3 and $N\frac{1}{2}$ sec. 10, T. 25 N., R. 11 E., on the east wall of the Miller River valley, about 2.5 miles up the Miller River from its confluence with the Skykomish River. It is reached by following the Miller River road for 2.5 miles from the junction at the old Miller River townsite, then turning east on an unimproved road that crosses the Miller River and leads to the lowest portal.

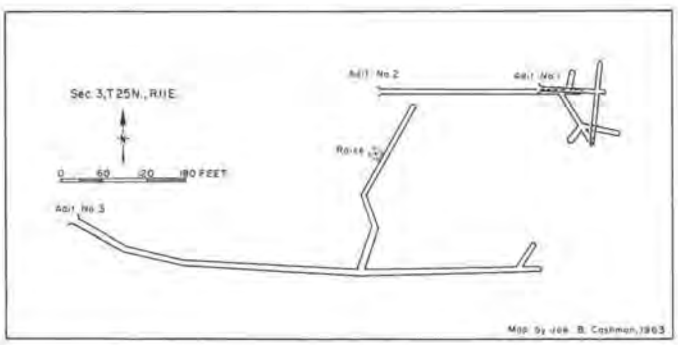


FIGURE 92.— Spatial relations of the three adits in the Mono mine, Miller River mining district, King County, Washington.

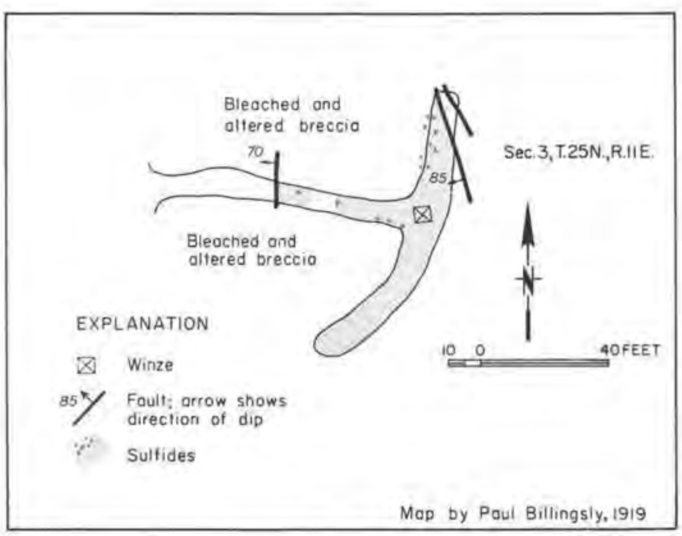


FIGURE 93.— Sketch map of the Mono mine No. 1 adit, Miller River mining district, King County, Washington.

Three adits are on the property; the top two cut sulfide mineralization, and the lower one is chiefly a crosscut. The upper, or No. 1, adit is a crosscut in bleached siliceous andesite to about 40 feet from the portal, where a small fissure was cut and the sulfides begin. Chalcopyrite, sphalerite, and pyrite are in bleached and brecciated andesite. The adit was driven 55 feet into the sulfide zone, where drifts were driven 40 feet to the north and 55 feet to the southwest. At the junction of the three

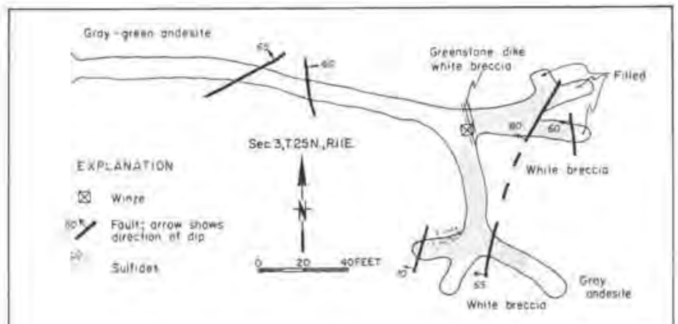


FIGURE 94.— Sketch map of the Mono mine No. 2 adit, Miller River mining district, King County, Washington.

drifts a 60-foot winze was sunk. The adit driven to the north cut, at 40 feet, a vertical fault that apparently ended the sulfides. The face of the southern drift is still in sulfides.

The middle, or No. 2, adit was driven eastward into the mountain for 180 feet, where it cut the mineralized zone. Most of the crosscut is in gray andesite. At 180 feet the adit splits, one branch continuing eastward for 35 feet, where it splits into two drifts, and the other branch heading south for 50 feet, where it splits into three short drifts. A 60-foot winze was sunk on a greenstone dike where the main drift branches 180 feet from the portal. Beginning about at this fork in the main adit, the country rock has been bleached, silicified, and brecciated. The ore minerals are limited to the breccia zone, although not all of the breccia contains sulfides.

The lowest, or No. 3, adit was driven about 760 feet into the mountain in an easterly direction. Some spotty and poor sulfide mineralization is scattered along its length. The adit originally was planned to cut the ore body at depth;

however, it was abandoned before this goal was accomplished. In 1966 a crosscut was begun at 440 feet from the portal, on a bearing of N. 35° E. It was driven for 150 feet, where it cut a section of rock that has been altered almost completely to talc. Because of difficulty in holding the ground, a raise was started in solid rock about 20 feet back from the talc zone and was driven for a slope distance of about 500 feet toward the bottom of the winze in the No. 2 adit. The vertical distance in the raise is estimated to be 250 feet. The raise is reported to have cut a good sulfide zone; however, it cut the talc zone also, and at the time the property was last visited, so much mud was coming down the raise that no attempt was made to examine it.

A 4,900-pound sample from the No. 2 adit assayed as follows:

Copper	1.87 percent
Gold	0.04 oz./ton
Silver	1.5 oz./ton

A 2,000-pound composite sample from the property assayed as follows:

Copper	1.57 percent
Gold	0.042 oz./ton
Silver	1.7 oz./ton

Samples assayed in 1955 by the Tacoma smelter at the request of a private individual gave the following results:

Copper	1.21 percent
Gold	0.03 oz./ton
Silver	0.68 oz./ton

The bleached and silicified breccia in which the sulfides occur is reported to contain as much as 80 percent silica.

Money Creek Mining District

Apex Mine

The Apex mine, in the Money Creek mining district, is along a steep southwest-trending ravine on the south side of Money Creek valley, in the SW¼SW¼ sec. 34, T. 26 N., R. 10 E., and is controlled by Cleopatra Mines, Inc., whose president is Joe B. Cashman, of Index. The property is reached by following the Money Creek road for about 5.5 miles from its junction with the Miller River road, then hiking up a trail for about 1 mile. The trail starts at the point where the road makes its first switchback turn to the right, at an elevation of about 2,480 feet. The mine is at an elevation of about 3,600 feet.

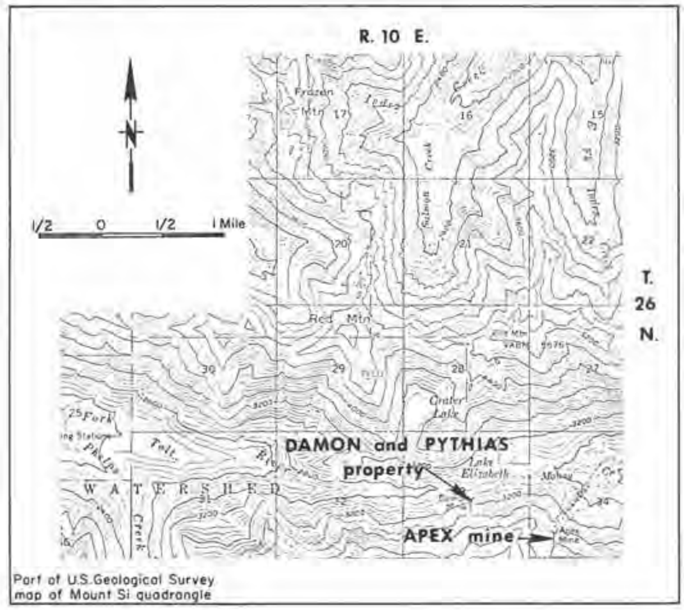


FIGURE 95.— Locations of the Apex mine and the Damon and Pythias property, Money Creek mining district, King County, Washington.

The Apex property is reported to have been discovered by John Maloney in 1892. Coats (1932, p. 3) states that between the time of discovery and 1901, about $80,000 worth of ore was produced. It was transported to the railroad terminal at Berlin (now Miller River) by pack train. In 1901 a wagon road was built to the property. During the early days of the mine a tramline was built from the lowest adit (No. 4) to the valley floor. Total production from the mine, which was closed in 1943, amounted to about $300,000. The closure was reportedly effected because of the mine's "nonessential industry" classification during World War II.

The mine was opened on four levels, between elevations of 3,150 and 3,610 feet (Pls. 5 and 6). All adits that cut ore are connected by raises and chutes; however, at the present time (1969) the adits are inaccessible because of caving. A crosscut, driven into the mountain 300 feet below the No. 4 adit in an unsuccessful attempt to intersect the main vein, is also closed.

TABLE 27.—Assay results on samples from the Apex mine, in King County, Washington

Sample number 1/	Width (inches)	Au (ounces)	Ag (ounces)	Sample number 1/	Width (inches)	Au (ounces)	Ag (ounces)
1	12	2.04	18.12	47	16	2.56	10.60
2	12	3.01	3.00	48	16	0.73	5.90
3	36	0.98	7.40	49	7	1.25	4.00
4	8	2.00	3.16	50	10	0.80	0.16
5	10	0.65	tr.	51	30	0.24	2.50
6	11	0.44	2.16	52	10	0.80	0.16
7	16	0.30	0.34	53	13	1.62	4.00
8	24	1.00	4.68	54	19	1.20	4.11
9	10	3.15	3.20	55	7	2.50	9.20
10	16			56	9	2.50	3.00
11	6	1.16	38.40	57	24	0.26	tr.
12	5			58	10	2.08	tr.
13	14	2.05	10.00	59	7	2.30	2.70
14	6	1.91	32.40	60	24	0.13	2.57
15	10	0.78	63.70	61	42	0.20	0.40
16	8	1.92	28.40	61A	14	1.20	2.40
17	14	1.16	3.60	62	19	0.50	1.50
18	6			63	9	1.75	7.20
19	14	1.01	1.10	64	7	1.68	0.60
20	6			65	8	1.94	1.62
21	16	1.46	1.12	66	9	1.92	6.56
22	7			67	10	0.96	1.12
23	6	2.60	10.01	68	10	2.25	5.50
24	24	0.38	2.32	69	8	1.94	1.62
25	15	0.99	2.93	70	8	1.51	8.00
26	6			71	16	1.72	3.64
27	8	0.59	3.40	72	30	0.24	1.28
28	6			73	14	4.25	4.00
29	16	0.66	8.32	74	24	0.76	2.10
30	30	0.60	1.88	75	6	1.30	3.50
31	7	2.32	3.84	76	24	0.71	3.10
32	22	4.98	4.00	77	13	0.83	5.00
33	7	1.95	6.13	78	10	1.44	1.20
34	7	1.65	8.50	79	20	0.88	18.00
35	20	0.30	0.75	80	24	0.44	12.60
36	24	0.46	4.40	81	10	1.08	2.60
37	6	1.78	0.40	82	30	1.08	2.60
38	7	1.70	0.40	83	24	0.16	30.00
39	24	1.02	12.00	84	75	0.16	14.96
40	12	0.22	1.32	85	14	0.40	12.60
41	6	2.60	10.01	86	16	0.12	14.80
42	19	0.20	tr.	87	22	0.19	14.20
43	48	0.22	0.14	88	19	0.08	18.00
44	gob	0.32	1.30	89	12	0.19	12.50
45	gob	0.28	0.30	90	10	0.21	6.20
46	gob	0.32	0.80	91	24	0.24	0.70

1/ Sample numbers correspond to those on Plate 5.

The mineralization occurs in a narrow but persistent vein in granodiorite country rock. The vein strikes generally N. 70° E., and the dip is about 60° SW. Coats (1932, p. 18) observed that where the strike of the vein swings more to the north, the ore grade decreased. Patty (1921, p. 303) states that "when the dip flattens out, rich lenses of ore usually occur." Width of the ore zone ranges from 5 inches to 6 feet. Sulfides in the vein consist of arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite. Gangue minerals are quartz, tourmaline, and calcite. Fault gouge is present also. Gold, which was associated with the arsenopyrite, was the principal mineral produced from the mine. Near the east end of the ore zone in the No. 4 adit, rich argentiferous galena was encountered. The footwall of the vein is sharp, but on the hanging wall the ore grades out into the country rock.

All ore mined from the Apex came from a zone about 500 feet high by 500 feet long. The ore was stoped above the No. 4 adit; the high-grade ore was sorted out, and the low-grade material was backfilled into the stope. Patty (1921, p. 305) reports that stope fill averaged $5.00 to $7.00 per ton in gold. Table 27 gives some idea as to the values reported from the mine.

Damon and Pythias Property

The Damon and Pythias property, in the Money Creek mining district, is on the north wall of the valley at the top of the divide between Money Creek and the South Fork of the Tolt River. It consists of 18 unpatented claims west of and abutting the Apex claims. The Damon and Pythias claims are principally in sec. 33, T. 26 N., R. 10 E., at an elevation of 3,160 feet. The property is reached by following the Money Creek road past Lake Elizabeth (Fig. 95, on p. 145) to the top of the above-mentioned divide, then continuing on a jeep road that follows the south wall of the valley for about 0.5 mile.

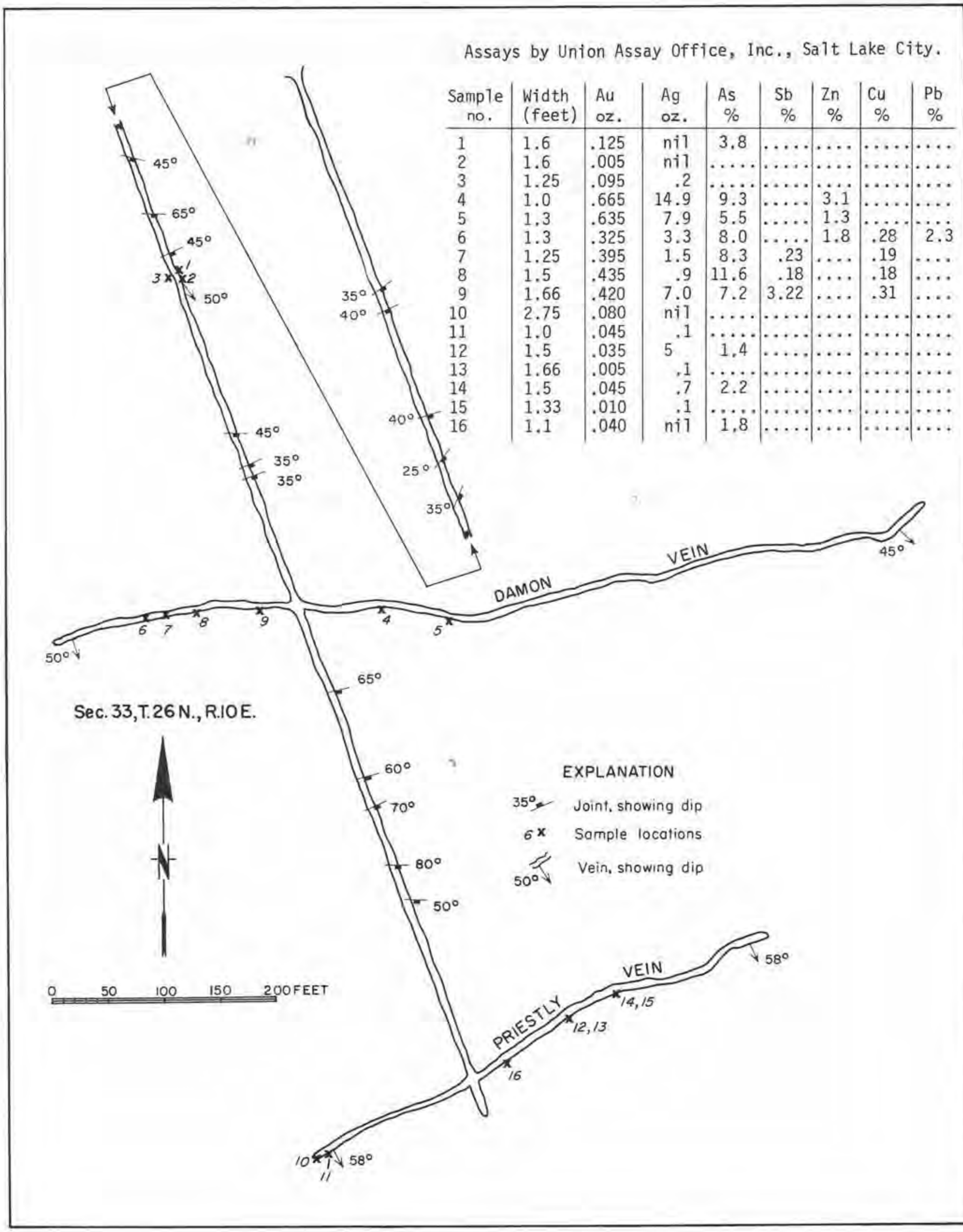
The Damon and Pythias property was probably discovered during the 1890's, about the same time as the Apex. Most of the development work on the Damon and Pythias was done by W. J. Priestly before World War II. The property is now controlled by Cleopatra Mines, Inc., whose president is Joe Cashman, of Index.

Test shipments made from the property totaled 23 tons, and contained 0.87 ounce of gold per ton, 9.0 ounces of silver per ton, and 4 percent lead. Although it is not mentioned, the shipments probably contained a considerable amount of arsenic, because arsenopyrite is the most abundant sulfide mineral. Other sulfides in decreasing order of abundance are pyrite, galena, and sphalerite.

Several adits and prospect pits are on the property, but only the main adit was examined. The main adit (Fig. 96) consists of 1,425 feet of crosscut and 1,350 feet of drift driven in granodiorite country rock. The crosscut was driven into the hill on a bearing of N. 15° W., and cut several joints and small shear zones that contain widely disseminated pyrite. At 580 feet a 3-foot shear was cut that carries low values in gold and silver. At 900 feet the crosscut intersects the Damon vein, which was drifted on for 200 feet west and 620 feet east. The vein strikes about N. 85° E., and dips about 45° to 50° SE. It is composed of brecciated and leached country rock, white vein quartz, and sulfide minerals. The vein pinches and swells considerably over short distances, varying in thickness from just a little more than an inch to over 5 feet. In spite of this, it is very persistent along the strike over the distance it is exposed by the drift. The vein is somewhat less persistent along its surface outcrop, although it can be traced for several hundred feet before being covered by overburden and brush. In the wide zones the quartz forms a boxwork with random splitting and joining of the the stringers.

At 450 feet beyond the Damon vein and 1,400 feet from the portal, the crosscut intersects the Priestley vein. It is a slightly wider vein than the Damon, but definitely contains fewer sulfides.

It is composed almost totally of quartz that has been fractured and recemented by quartz. This vein was drifted on for 150 feet to the southwest and 300 feet to the northeast from the crosscut. The vein strikes N. 65° E. and dips 58° SE. Like the Damon, the Priestly vein is very persistent underground. Pinching and swelling is common, but does not appear to be as extreme as in the Damon vein.



Assays by Union Assay Office, Inc., Salt Lake City.

Sample no.	Width (feet)	Au oz.	Ag oz.	As %	Sb %	Zn %	Cu %	Pb %
1	1.6	.125	nil	3.8	.....	....	.....	....
2	1.6	.005	nil	.....	.....	....	.....	....
3	1.25	.095	.2	.....	.....	....	.....	....
4	1.0	.665	14.9	9.3	.....	3.1	.....	....
5	1.3	.635	7.9	5.5	.....	1.3	.....	....
6	1.3	.325	3.3	8.0	.....	1.8	.28	2.3
7	1.25	.395	1.5	8.3	.23	....	.19	....
8	1.5	.435	.9	11.6	.18	....	.18	....
9	1.66	.420	7.0	7.2	3.22	....	.31	....
10	2.75	.080	nil	.....	.....	....	.....	....
11	1.0	.045	.1	.....	.....	....	.....	....
12	1.5	.035	5	1.4	.....	....	.....	....
13	1.66	.005	.1	.....	.....	....	.....	....
14	1.5	.045	.7	2.2	.....	....	.....	....
15	1.33	.010	.1	.....	.....	....	.....	....
16	1.1	.040	nil	1.8	.....	....	.....	....

FIGURE 96.— Sketch map of the Damon and Pythias property main adit, showing sample locations and assay data. Money Creek mining district, King County, Washington.

Snoqualmie Mining District

Quartz Creek Mine

The Quartz Creek property (also known as Rainy), in the Snoqualmie mining district, is reached by following a graveled road 16 miles up the Middle Fork of the Snoqualmie River and the Taylor River, then a short access road up Quartz Creek from the Taylor River. In 1969 this access road was passable only by a 4-wheel-drive vehicle because of a washout just below the property. The property is in the NW$\frac{1}{4}$ sec. 16, T. 24 N., R. 10 E., at an altitude of 1,760 feet.

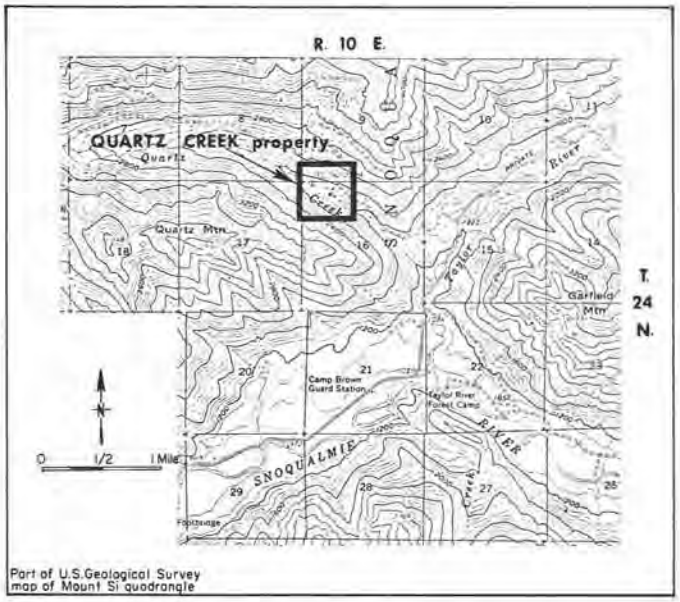
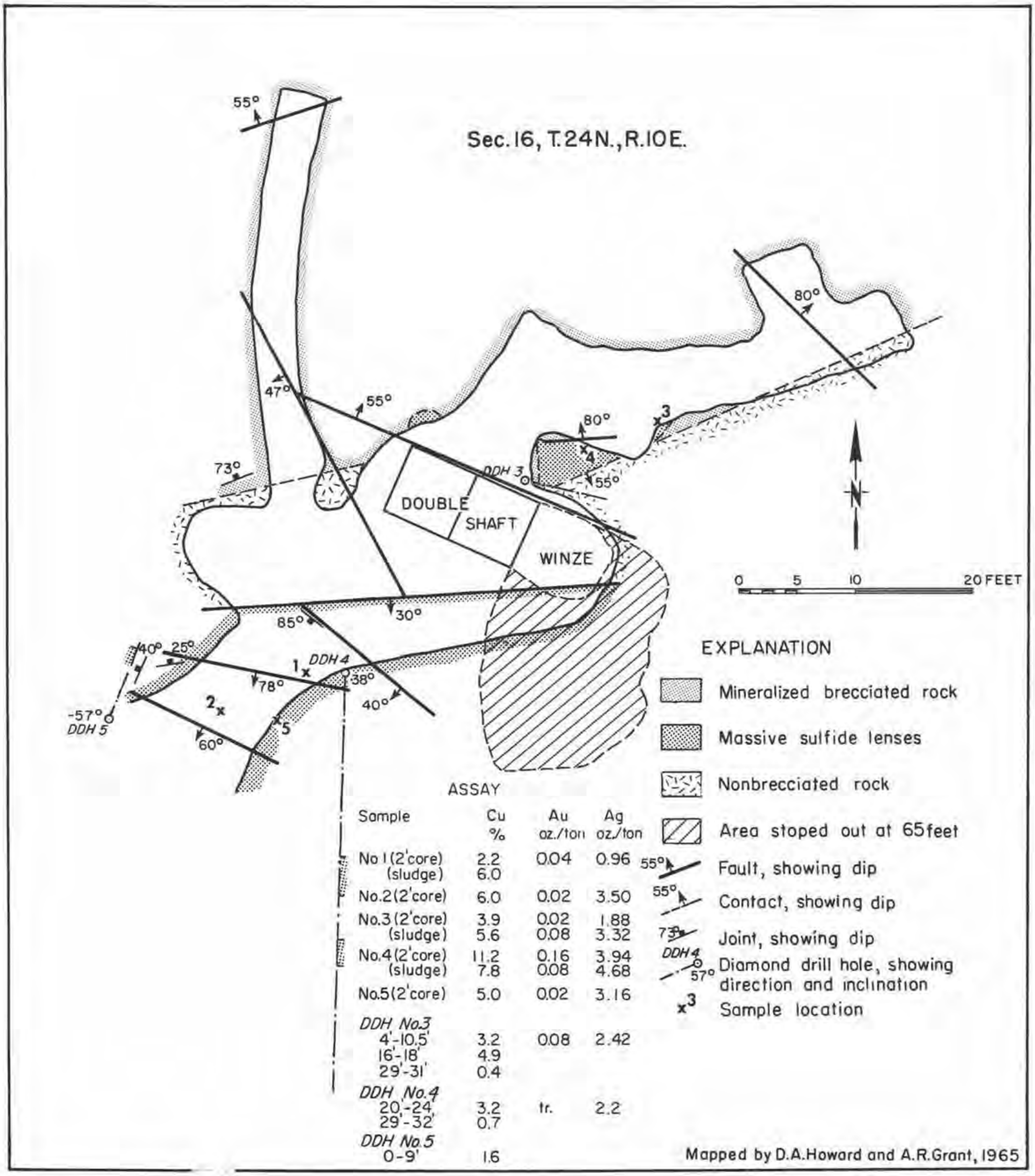


FIGURE 97.— Location of the Quartz Creek property, Snoqualmie mining district, King County, Washington.

The property is owned by M. F. Gilbreath and Associates, of Seattle, and consists of six lode claims and three fractions, all unpatented. The claims were originally located in the early 1900's. In 1946 Gilbreath relocated the original claims and subsequently staked more. In 1951 a 50-ton mill was built on the property; it was used until 1954 to process a few test shipments of ore. The mill has been idle since 1954 and is in a state of complete disrepair.

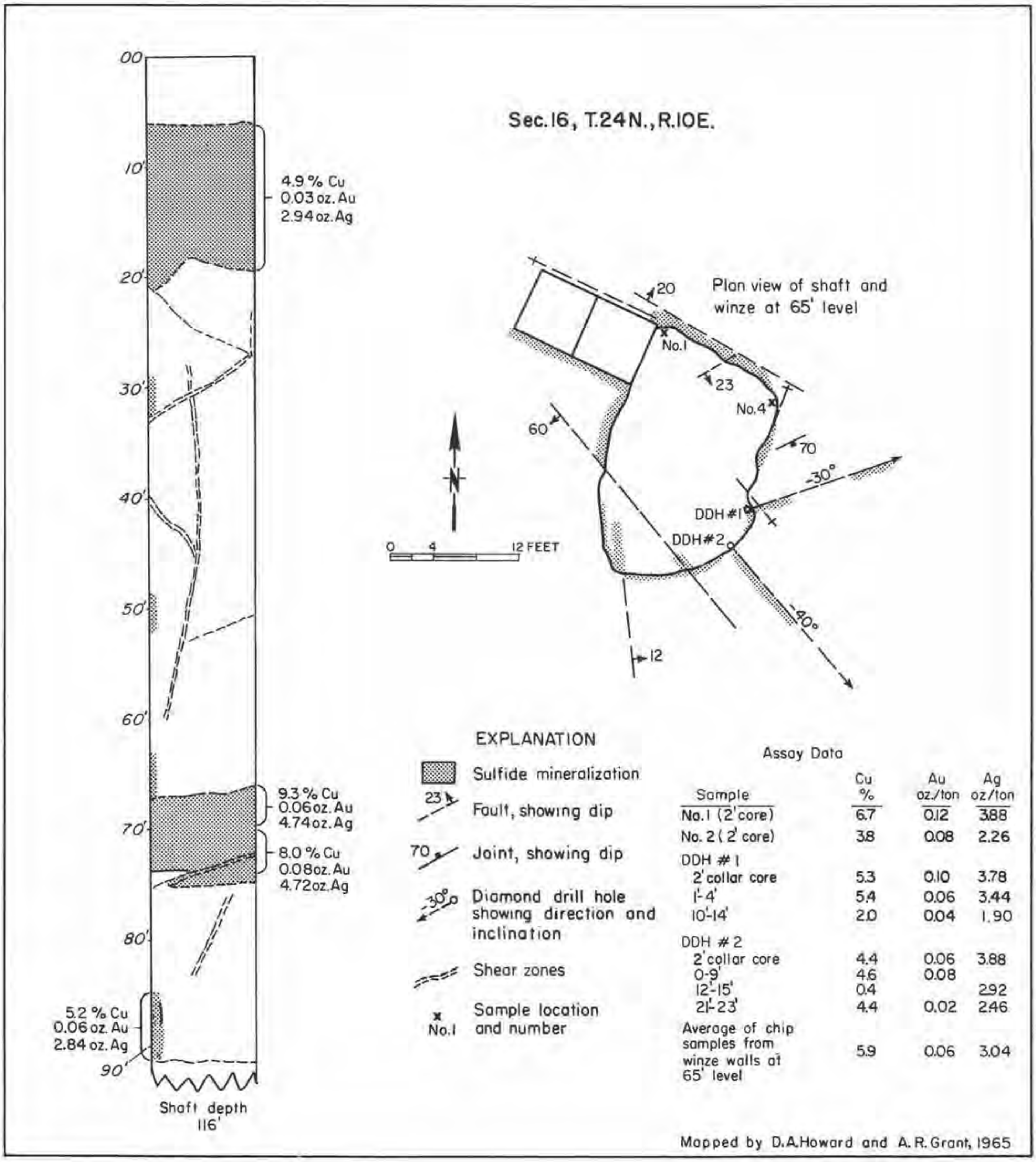
The property has two mineralized zones about 800 feet apart. The east zone, called the "east pipe," is a breccia pipe that has an elliptical shape on the surface. A. R. Grant (oral communication, 1966), who has done a considerable amount of work on the property, estimates that the pipe's surface dimensions are 300 by 600 feet. The pipe consists of biotitized quartz diorite rock fragments and a matrix of quartz and minor sulfide. The breccia is composed of angular fragments that vary from a few inches to several feet in size. In the less mineralized parts of the pipe the sulfides are finely divided, and they are scattered through the breccia fragments and concentrated along fractures. The breccia contains vugs as much as 2 inches across that are lined with quartz. In the rich parts of the pipe there is very little quartz compared with the lean parts, and it appears that sulfides have replaced the original rock fragments. The west zone is reported by Grant (written communication, 1965) to be a zone of shattering, having quartz veins along west-trending fractures in the quartz diorite. Sulfides are present in the quartz veins, and as disseminations in the quartz diorite country rock.

A short adit, a 100-foot double-compartment shaft with a stope to the east at the 60-foot level, and a 40-foot raise have been developed on the east pipe (Figs. 98 and 99). A total of 363 tons of ore has been produced from high-grade zones cut by the adit, shaft, and stope in the breccia pipe. Returns from the Tacoma smelter show that 127,974 pounds of copper, 3,377 ounces of silver, and 94 ounces of gold were produced from the property between 1952 and 1956. Sulfide minerals are pyrite, chalcopyrite, pyrrhotite, and molybdenite. The molybdenite is widely scattered and may not be of commercial value. A massive lens of pyrite is exposed on the east wall of the portal. It has replaced the wall rock and contains quartz, sericite, and partially altered quartz diorite. The west wall of the portal contains a 1-foot vein of massive chalcopyrite. Associated with the chalcopyrite are abundant light-gray prismatic crystals of sericite and chlorite, but they originally were tourmaline and have been altered to their present condition. Much of the ore taken out of this prospect



Sample	Cu %	Au oz./ton	Ag oz./ton
No. 1 (2' core)	2.2	0.04	0.96
(sludge)	6.0		
No. 2 (2' core)	6.0	0.02	3.50
No. 3 (2' core)	3.9	0.02	1.88
(sludge)	5.6	0.08	3.32
No. 4 (2' core)	11.2	0.16	3.94
(sludge)	7.8	0.08	4.68
No. 5 (2' core)	5.0	0.02	3.16
DDH No. 3			
4'-10.5'	3.2	0.08	2.42
16'-18'	4.9		
29'-31'	0.4		
DDH No. 4			
20'-24'	3.2	tr.	2.2
29'-32'	0.7		
DDH No. 5			
0-9'	1.6		

FIGURE 98.— Ea[illegible]r of the Quartz Creek property, Snoqualmie mining district, King County, Washington.



Assay Data

Sample	Cu %	Au oz./ton	Ag oz/ton
No. 1 (2' core)	6.7	0.12	3.88
No. 2 (2' core)	3.8	0.08	2.26
DDH #1			
2' collar core	5.3	0.10	3.78
1'-4'	5.4	0.06	3.44
10'-14'	2.0	0.04	1.90
DDH #2			
2' collar core	4.4	0.06	3.88
0-9'	4.6	0.08	
12'-15'	0.4		2.92
21'-23'	4.4	0.02	2.46
Average of chip samples from winze walls at 65' level	5.9	0.06	3.04

FIGURE 99.—Plan and cross-section view of shaft in the east adit of the Quartz Creek property, Snoqualmie mining district, King County, Washington.

was massive. Grant (oral communication, 1966) dewatered the shaft in 1965 and found massive sulfides in it. However, two short drifts out of the main stope of the adit did not cut high-grade material similar to that found in the shaft.

FIGURE 100.— West adit of the Quartz Creek property, Snoqualmie mining district, King County, Washington.

Development on the west zone consists of an adit (Fig. 100) driven 100 feet into the mountainside. Sulfides in the west zone are pyrrhotite, arsenopyrite, and chalcopyrite, the most abundant being arsenopyrite. The adit was driven on a quartz stockwork that contains abundant arsenopyrite having small chalcopyrite veinlets. A small amount of molybdenite is associated with the quartz stockwork, and a minor amount of fine-grained chalcopyrite is also disseminated through most of the quartz diorite around the adit.

More information on this property is presented by Grant (1969), who did detailed geologic mapping and had access to core hole and blast pit data. Howard (1967) also discusses the property.

Middle Fork Property

The Middle Fork property is in the Snoqualmie mining district, and is primarily along the Middle Fork of the Snoqualmie River above its confluence with Burnt Boot Creek (Fig. 101). The area covered by the property is rugged, and all slopes below timberline are heavily vegetated. Access to the property is by 27 miles of graveled and dirt road up the Middle Fork of the Snoqualmie River valley. The road ends at Hardscrabble Creek, which is about in the center of the claim block.

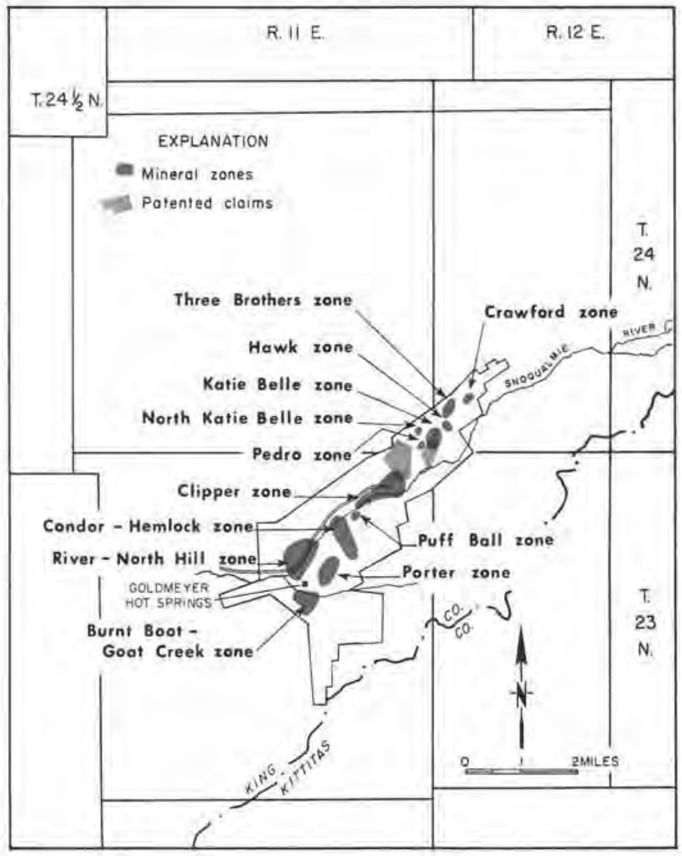


FIGURE 101.— Mineralized zones and outline of claims of the Middle Fork property, in King County, Washington. [Data from unpublished map by A. R. Grant, 1966.]

The Middle Fork property is made up of several prospects that date back to the late 1800's, when the initial discoveries were made. In about 1912, the Clipper Mining Company patented 11 claims around the Clipper adit in sec. 36, T. 24 N., R. 11 E., and sec. 1, T. 23 N., R. 11 E. About the same time, the Snoqualmie Copper Company patented four claims about half a mile east of the Clipper adit in sec. 36, T. 24 N., R. 11 E.; sec. 34, T. 24 N., R. 12 E.; sec. 1, T. 23 N., R. 11 E.; and sec. 3, T. 23 N., R. 12 E. These two groups of patented claims have, over the years, become known as the Clipper Group. M. F. Gilbreath and Associates acquired the claims in 1939 and, through subsequent work by themselves and several companies that have examined the property, expanded the claim block, which now consists of 15 patented claims and 238 unpatented claims. The property covers parts of secs. 1, 2, 3, 10, 11, 12, 13, 14, 15, 16, 22, 23, and 24, T. 23 N., R. 11 E.; sec. 3, T. 23 N., R. 12 E.; sec. 36, T. 24 N., R. 11 E.; and secs. 26, 27, and 34, T. 24 N., R. 12 E. It is by far the largest claim block in King County. The property surrounds the patented Goldmeyer placer claim but does not include it.

Nineteen adits with a total aggregate footage of 2,150 feet were driven during the early days. Several thousand linear feet of core drilling was done on the property by the Anaconda Copper Co. and the Bear Creek Mining Co. between 1957 and 1965. More recently, Westland Mines Ltd., of Vancouver, B. C., has done a considerable amount of core drilling in an attempt to solve some of the structural and lithologic problems and to locate minable ore zones. The total aggregate core hole footage is more than 20,000 feet.

The Middle Fork mineralized zone trends north-northeast from Goldmeyer Hot Springs to Crawford Creek (Fig. 101), a distance of about 6 miles. The width of the zone ranges from 400 to 2,500 feet (Grant, 1969, p. 85). The sulfide minerals were deposited in breccia zones in the Snoqualmie Granodiorite country rock. These breccia zones, which include both breccia pipes and shatter pipes, at one time may have been a continuous belt that has since been offset by faulting. A. R. Grant (oral communication, 1966) determined that the degree of mineralization generally has a direct relation to the degree of brecciation. He also discovered evidence indicating that the amount of sulfide mineralization is related to the presence of potassium-bearing minerals in the host rock (Grant, 1969, p. 50).

The several mineralized zones included in the Middle Fork property all seem to contain widespread low-grade (less than 0.5 percent) copper, and at least one zone, the Porter, has an interesting molybdenite showing. The main objective of Westland Mines Ltd. is to find within the various zones ore bodies that will be economic to operate, both from the standpoint of mineral value and of tonnage available. To date they have found shear zones that range in width from 1 to 20 feet and that have copper contents ranging from 1 to 3 percent. Westland has reported copper concentrations of 0.5 to 0.7 percent in breccia zones containing 5 to 10 million tons of reserves.

Green River Area

Royal Reward Mine

The Royal Reward property, in the Green River area, is in the SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 8, T. 21 N., R. 7 E., on a small terrace on the south bank of the Green River. The terrace, which is about 50 feet above river level, was used for mine buildings and facilities. At present (1969), the buildings are starting to fall apart and the retort furnace has sustained some damage, probably by vandals. The retort facility is a 4-stack furnace and a 12-bank condensing system capable of handling 25 tons per day.

The property is owned by the Washington Mining Corporation, Tacoma. The property was first discovered in the late 1800's. Early records in the King County Recorder's office indicate that these mercury claims on the Green River were among the first properties staked in the county. Some time around 1954, cinnabar was rediscovered in the Green River Gorge, and the Royal Reward mine was opened.

The mine workings consist of a two-compartment, 168-foot shaft; a 100-foot south-trending drift; and a 50-foot, west-trending crosscut. All workings are presently (1969) filled with water to river level.

Bedrock of the region consists of indurated Eocene sediments of the Puget Group. In the immediate area of the prospect, a 15-foot-thick andesite dike is present. The sedimentary rocks are predominantly sandstone and interbedded carbonaceous to coaly shale. About 150 feet of glacial drift overlies the bedrock in the area.

Mineralization is along the crest of a small, tightly folded N. 9° W.-trending, asymmetrical anticline. An east-dipping fault cuts the crest of the anticline where the mineralization is greatest. The fault plane is in a coaly shale bed on the east limb of the anticline, and as a result the shale is thoroughly contorted. Where the fault cuts the andesite dike and sandstone, the rocks are brecciated. Sulfide minerals consisting of closely associated realgar, orpiment, and cinnabar are confined to the contorted and brecciated zones. The cinnabar mineralization occurs as pods and veins, mostly in the shale. The largest pod contained about 300 pounds of pure cinnabar. However, most of the mineralization is along narrow veins. The property produced about 20 flasks of mercury during its 3 to 4 years of development before being abandoned. Arsenic contamination plus spotty ore were the problems that closed the property, the latter reason being the most decisive.

Cardinal Reward Property

The Cardinal Reward property, in the Green River area, is in the NE$\frac{1}{4}$ sec. 17, T. 21 N., R. 7 E., about half a mile southwest of the Royal Reward mine. The property is owned by the Northern Pacific Railway Company and is leased to the Washington Mining Corporation, Tacoma.

Development on the property consists of two adits with several crosscuts. Mineralization occurs along the crest of a north-trending anticline that has been brecciated by faulting. Sulfide minerals are primarily realgar and orpiment, including a small amount of cinnabar. The property has no record of production.

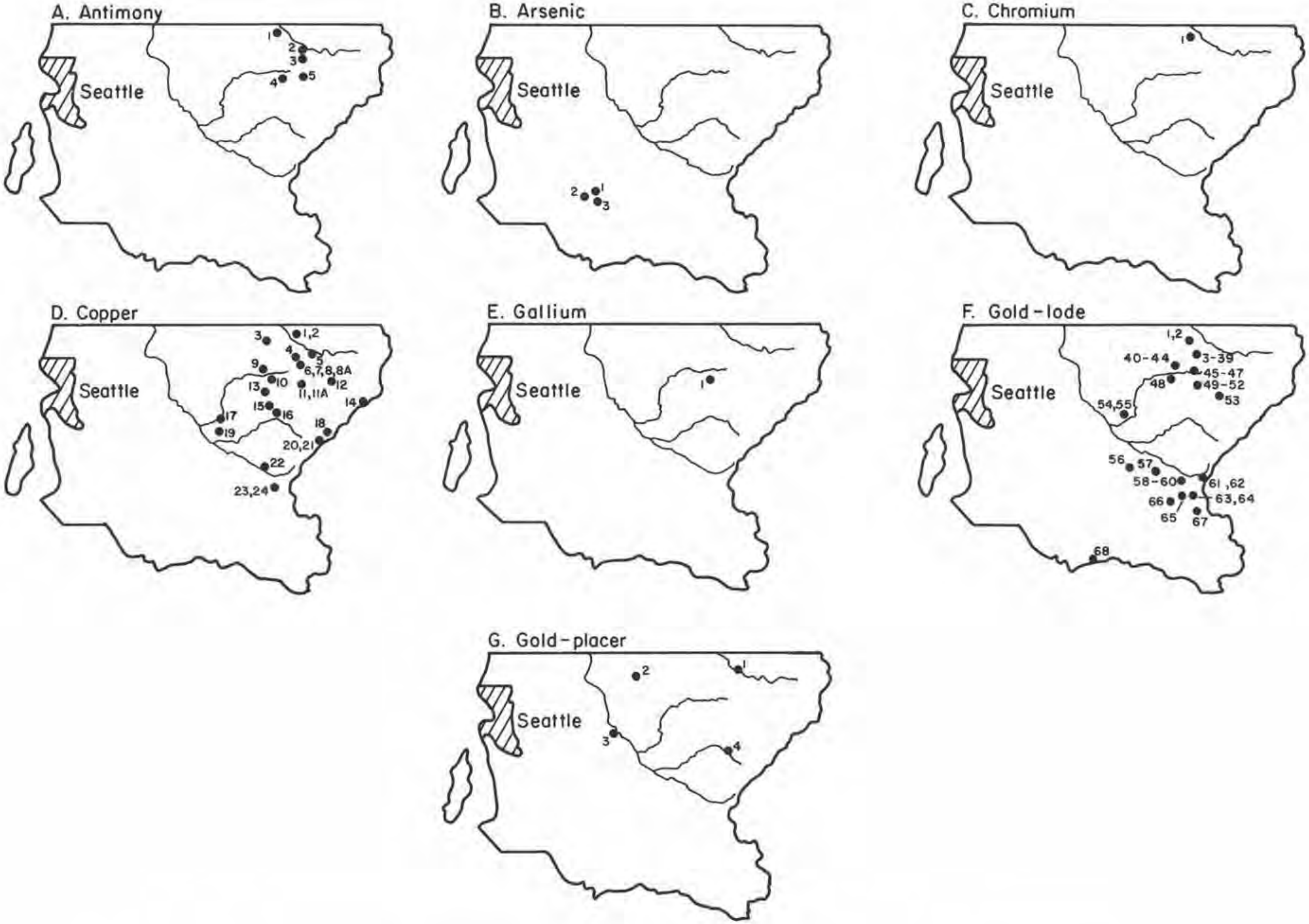


FIGURE 102.—Maps showing locations of antimony, arsenic, chromium, copper, gallium, lode gold, and placer gold properties in King County, Washington. [Map numbers correspond to numbers in Table 28.]

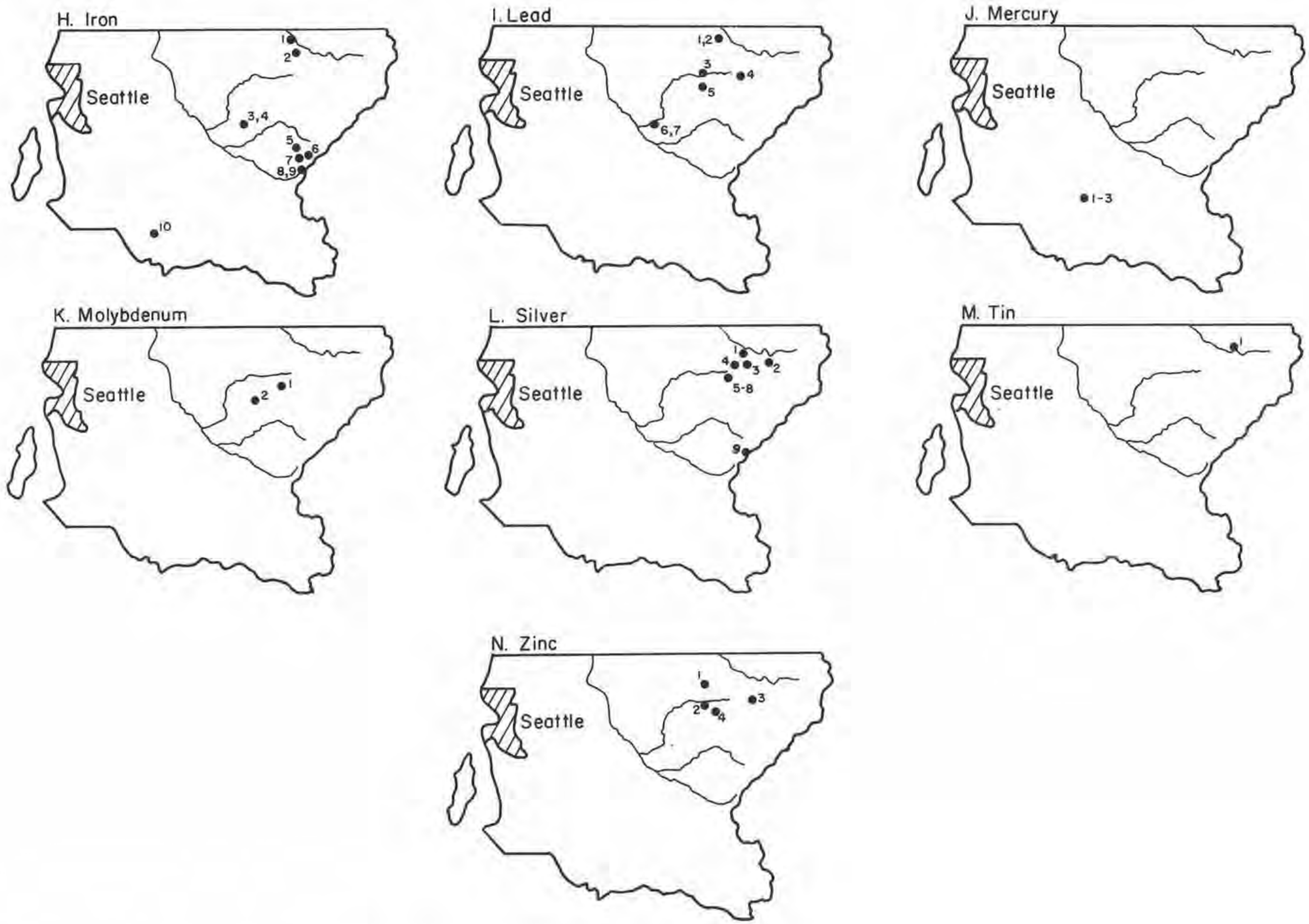


FIGURE 103.— Maps showing locations of iron, lead, mercury, molybdenum, silver, tin, and zinc properties in King County, Washington. [Map numbers correspond to numbers in Table 28.]

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity 1/

Map no. 2/	Property name	Location 3/	Owner	Geology	References and remarks 4/
			ANTIMONY		
4	Dawson	Buena Vista dist. NW$\frac{1}{4}$ sec. 24, (25-10E), near head of Bear Creek. Elev. 5,350 ft.	Bear Basin Mining Co., Bremerton, Wash.	Pyrite, stibnite, stibiconite with wad, rhodochrosite, and altered granodiorite gangue. Altered zone 11 ft. wide in granodiorite is mineralized for 1$\frac{1}{2}$ ft. along hanging wall. Mostly pyrite with some $\frac{1}{2}$-in. clusters of radiating stibnite crystals.	(Purdy, 1951, p. 83-84). Part of 25 claims in the Bear Basin group.
5	Grand Central	Money Creek dist. Sec. 29, (26-11E), S. of Money Creek.	Gold Mountain Mining Co. (1915).	Stibnite (in upper adit) and pyrite in narrow veinlets of quartz and calcite in a 40-ft.-wide zone in andesite.	(Mineral Resources of the U.S., 1908, p. 578; Northwest Mining News, 1907, no. 7, p. 13; W. S. Smith, 1915, p. 171). Assays av. $4.00/ton (probably gold). Production in 1908.
2	Great Republic (Happy Thought)	Miller River dist. N$\frac{1}{2}$SW$\frac{1}{4}$ sec. 33, (26-11E), at first falls on Happy Thought Creek. Elev. 1,200 ft.	Charles Wible, Tacoma, Wash. (1949); Great Republic Gold Mining Co. (1902-1905).	Stibnite and pyrite in a quartz, calcite, and andesite gangue. Occurs along a flat-lying mineralized fault in andesite.	(Landes and others, 1902a, p. 84; Patty and Glover, 1921, p. 59; Purdy, 1951, p. 75-78; Shedd, 1924, p. 50; Washington Bur. of Statistics, Agriculture, and Immigration, 1903, p. 135). Five unpatented claims. Ore contains gold and silver values also.
	Happy Thought				See Great Republic, above.
3	Mohawk	Miller River dist. Sec. 9, (25-11E), N. of Seattle Cascade property.			(Northwest Mining Jour., 1909, no. 5, p. 112).
1	Salmon Creek	S$\frac{1}{2}$ sec. 10, (26-10E), about 1 mi. S. of Baring.	W. R. Anderson, Baring, Wash.		

1/ The data on properties shown in Table 28 have been compiled from Washington Division of Mines and Geology Bulletin No. 37, Inventory of Washington Minerals, Part II— Metallic Minerals, by Marshall T. Huntting (1956).

2/ The map numbers correspond to those shown in Figures 102 and 103.

3/ The location of the property is designated, wherever possible, by legal land description, and by some supplementary information such as geographic area and mining district. The legal description is abbreviated; thus, sec. 16, (24-10E) indicates Section 16, Township 24 North, Range 10 East, Willamette Meridian.

4/ More complete citations of the references shown are listed in the bibliography.

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
				ARSENIC	
2	Black Diamond	NE¼ sec. 14, (21-6E), about ½ mi. NE. of Black Diamond. Elev. 700± ft. at well-head.		Realgar along joint planes in massive arkosic sandstone.	Encountered at 3,274 to 3,284 ft. in oil test well drilled by Shell Oil Co. in 1947.
	Franklin				See Red Crystal, below.
3	Green River	Center sec. 17, (21-7E), in cliff along Green River.	Northern Pacific Railway Co.	Small pods, lenses, and fillings of realgar and orpiment along 4- to 10-ft.-wide shear zone in sandstone. Exposure length is 50 ft. and depth is 50 ft. (down cliff face). Mineralization is probably related to intrusion of andesite dikes.	(Northern Pacific Railway Co., 1941, p. 5). Four assays av. 1.64 percent arsenic. Adit 75 ft. long on property.
1	Red Crystal (Franklin)	N½ sec. 8, (21-7E), at river level on W. bank of Green River. Elev. 500 ft.		Realgar and orpiment occur as stringers and pockets along fractures in a sheared sandstone and coal seam. Mineralization is probably related to andesite dikes.	(Evans, 1912, p. 46; Patty and Glover, 1921, p. 60). Adit 10 ft. long on property.
				CHROMIUM	
1	Baring	Money Creek dist. N½SE¼ sec. 10, (26-10E), 1¼ mi. S. of Baring.	W. R. Anderson, Baring, Wash.		(Industrial West Foundation, 1944, Div. II-C, p. 23).
				COPPER	
1	Annex	Money Creek dist. Secs. 13 and 24, (26-10E), near Lowe Creek.	John Maloney, Skykomish, Wash.		One patented claim.
19	Annie	Snoqualmie dist. NE¼ sec. 2, (23-8E).		A 7-ft. vein. Ore minerals are chalcopyrite and pyrite.	(Hodges, 1897, p. 42). Assays gave $28 in gold and silver.

4	Bobtail	Miller River dist. NW$\frac{1}{4}$ sec. 31, (25-11E).		A 6-ft. vein containing an 8- to 16-in. stringer of high-grade ore.	(Hodges, 1897, p. 38). Contains values of gold and silver also.
6	Brooklyn	Buena Vista dist. Secs. 11 and 13, (25-10E).		Two veins, 25 and 10 ft. wide, containing 2- and 4-ft. paystreaks.	(Hodges, 1897, p. 37). Assays gave \$10 to \$20 in gold and silver, 8 to 12 percent in copper.
23	Brown Bear	Cedar River dist. NW$\frac{1}{4}$ sec. 33, (22-10E), across Bear Creek from Earhart property.		Chalcopyrite, argentite, pyrite, and bornite in a 4- to 16-in. quartz vein in granodiorite.	(Hodges, 1897, p. 47). Carries silver values also.
9	Chicago	Miller River dist. Sec. 36, (26-10E).		Chalcopyrite, bornite, native copper, and pyrite in an 8-ft. vein in diorite.	(Hodges, 1897, p. 39-40). Assays ran 20 percent copper.
	Christina	Cedar River dist. T. 22 N., R. 10 E.		Chalcopyrite and quartz in a 15-ft. brecciated zone in slate.	(Hodges, 1897, p. 48). Assays of \$6 to \$20 in gold; 5 to 75 percent copper reported.
17	Cleveland	Snoqualmie dist. SE$\frac{1}{4}$ sec. 25 (24-8E).		Chalcopyrite and pyrite in a 20-ft. vein. Ore on hanging wall.	(Hodges, 1897, p. 42). Assays report \$40 in gold also.
3	Climax	Money Creek dist. Sec. 20(?), (26-10E). $4\frac{1}{2}$ mi. SW. of Baring on S. end of Little Index Mountain.		Principal minerals are bornite and chalcopyrite carrying silver as well as copper.	(Landes and others, 1902a, p. 85-86). A 200-ft. adit and a large number of surface cuts were made. 10 tons were assayed and gave values of \$50 to \$100. All work was done prior to 1901. Group of eight claims.
	Clipper				See Middle Fork, p. 161.
	Copper Chief	Foss River area.			(McIntyre, 1907, p. 247).
20	Copper Chief	Snoqualmie dist. SW$\frac{1}{4}$ sec. 14, (23-11E).	Cascade Gold Mining & Milling Co. (1892).	Chalcopyrite and silver-bearing galena in vein deposits.	(Bethune, 1892, p. 168; Hodges, 1897, p. 42). Copper ore assays said to be as high as \$103 per ton in copper, silver, and gold; lead-silver ore assayed \$50 to \$130 per ton.
14	Dutch Miller (Dutch Millers Lode)	Snoqualmie dist. NE$\frac{1}{4}$ sec. 20, (24-13E), at head of the Middle Fork of the Snoqualmie River. Elev. 5,700 ft.	Cougar Development, Inc. (1967). A. B. Crain, Cascade Development Co. (1942). Dutch Miller Mining & Smelting Co. (1918).	Three parallel en echelon veins along shear zones in granodiorite. Ore occurs as segregations 25 ft. long and 12 ft. thick in one of the veins. Primary ore minerals are chalcopyrite, arsenopyrite, tetrahedrite, and pyrite. Gangue is quartz, tourmaline, siderite, and pink chlorite.	(Copper Handbook, 1907, p. 360; Landes and others, 1902a, p. 86). Two patented and five unpatented claims, a 65-ft. adit, a 25-ft. adit, and two shafts. Smelter returns av. \$37.65 per ton after deduction of smelter charges (reported in 1901).
	Dutch Millers Lode				See Dutch Miller, above.
21	Emma	Snoqualmie dist. Sec. 14, (23-11E), in Gold Creek area.			(Hodges, 1897, p. 42).

TABLE 28.—Summary of metallic mineral properties, in King County, Washington, by commodity—Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			COPPER—Continued		
	Etta	Miller River dist. E. of Cleopatra Basin.			(Hodges, 1897, p. 37).
24	Eureka	Cedar River dist. NW$\frac{1}{4}$ sec. 33, (22-10E).		Copper-gold-silver ore.	(Hodges, 1897, p. 47).
	Eureka	Miller River dist.		Copper-gold-silver ore.	(McIntyre, 1907, p. 247).
16	Fathers Day (probably the Quartz Creek claims)	Snoqualmie dist. Sec. 16, (24-10E), on Quartz Creek about $\frac{1}{4}$ mi. above its mouth. Elev. 1,600 ft.	John Jarvis (1950).	Silicified and mineralized zone 10 ft. wide in andesite or fine-grained intrusive rock. Ore minerals are chalcopyrite, arsenopyrite, and pyrite. Gangue is quartz.	An open cut and an 84-ft. adit.
12	Foss River	Sec. 30, (25-12E).		Copper-gold-silver ore.	(McIntyre, 1907, p. 238-250).
22	Geo. W. Tinkle	Snoqualmie dist. Secs. 7 and 8, (22-10E).		Mineralized veins that carry values in copper, gold, silver, and lead.	
2	Golden Tunnel	Sec. 6, (26-11E), near head of Eagle Creek.		Copper-gold-silver ore.	(Hodges, 1897, p. 35).
	Ironsides	Miller River dist. Cleopatra Basin.			(Hodges, 1897, p. 35).
13	Joamco	Buena Vista dist. Sec. 6, (24-10E) and secs. 31 and 32, (25-10E).	R. R. Jones, Seattle, Wash. (1941).	Reported copper and silver ores.	
	John Stevens				See Una, p. 162.
	Katie Belle				See Middle Fork (remarks), p. 161.
	King David	Miller River dist. Summit of Cleopatra Basin.			(Hodges, 1897, p. 37).
7	King and Kinney	Miller River dist. SW$\frac{1}{4}$ sec. 17, (25-11E), on W. side of Miller River, about 5 mi. from its mouth. Elev. 400 to 800 ft.	Mike Kinney, Skykomish, Wash. (1952).	Fractured and hydrothermally altered brecciated zone in granodiorite in which are quartz stringers containing chalcopyrite, pyrite, galena, sphalerite, and malachite. Zone pinches and swells from a few inches to as much as 7 ft. in width.	A lower adit and a 525-ft. upper adit.
	Kinney				See King and Kinney, above.
	Lucky Boy	Foss River area.			(McIntyre, 1907, p. 246).

8A	Lynn	Miller River dist. SE$\frac{1}{4}$ sec. 17, (25-11E).	Miller River Mining, Milling, & Smelting Co. (1915).	Copper-lead ore.	(Hodges, 1897, p. 36).
18	Middle Fork (Clipper)	Snoqualmie dist. Sec. 1, (23-11E), sec. 3, (23-12E), sec. 36, (24-11E), and secs. 27 and 34, (24-12E), on Middle Fork of the Snoqualmie River. Elev. 3,000 to 5,800 ft.	M. F. Gilbreath and and Associates, Seattle, Wash.	Mineralization along shear zone and cross-fractures. Ore minerals are chalcopyrite, pyrite, pyrrhotite, and molybdenite. Gangue is quartz, tourmaline, chlorite, and granodiorite.	(McIntyre, 1907, p. 247; Purdy, 1954, p. 28-29). 15 patented and 238 unpatented claims, including the old Snoqualmie Copper Co. holdings, Katie Belle claim, and Clipper property.
	Mona				See Mono, below.
5	Mono (Mona)	Miller River dist. Secs. 3 and 10, (25-11E), on E. side of the Miller River 2$\frac{1}{2}$ mi. from its mouth.	Wm. Ellwood, Seattle, Wash. (1952). Cooperative Mining Syndicate (1902). Phoenix Mining Syndicate (1907-1918).	Brecciated and silicified zone in andesite from 40 to 50 ft. wide. Ore minerals are principally disseminated chalcopyrite and sphalerite.	(Copper Handbook, 1907, p. 925; 1908, p. 120; Gage, 1941, p. 163; Hodges, 1897, p. 55; Landes and others, 1902a, p. 84; Mines Handbook, 1918, p. 121; Northwest Mines Handbook, p. 112; Patty and Glover, 1921, p. 59; W. S. Smith, 1915, p. 184-185; Washington Bur. of Statistics, Agriculture, and Immigration, 1903, p. 135). Eighteen claims. Three adits, 716 ft., 250 ft., and 80 ft. long.
	Pedro	Foss River area		Copper, gold, silver, bismuth, and antimony minerals.	(McIntyre, 1907, p. 246).
11	Portland	Miller River dist. Sec. 20, (25-11E).			(Northwest Mining Journal, no. 5, 1909, p. 112; W. S. Smith, 1915, p. 154-185).
15	Quartz Creek (also Rainy Fraction, Rainy Mine, and probably Fathers Day)	Snoqualmie dist. NW$\frac{1}{4}$ sec. 16, (24-10E). Elev. 1,760 ft.	M. F. Gilbreath and Associates, Seattle, Wash.	Dissemination and replacement in granodiorite breccia. Has massive pyrite zone 30 ft. in diameter in 40- by 200-ft. alteration zone that contains chalcopyrite. A 200- by 100-ft. quartz veinlet stockwork zone contains arsenopyrite, chalcopyrite, and a little molybdenite. Road cuts a 40-ft.-wide sheeted zone in which are fracture planes lined with chalcopyrite, arsenopyrite, a little molybdenite, and scheelite.	(Bethel, 1951, p. 231-233; Howard, 1967, 48 p.). Six unpatented claims and three fractions. Assays showed 0.6 percent and 1.2 percent copper, 0.2 oz. and 0.4 oz. silver, and 0.04 oz. gold. A 50-ft. adit with 40-ft. winze, a caved adit and an 80-ft. adit. Concentrates shipped to smelter in 1942. Other assays, with sample locations, are shown on Fig. 98 (p. 150) and Fig. 99 (p. 151).
10	Rainbow	Buena Vista dist. NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 17, (25-10 E), on S. side of the Lennox River. Elev. 2,460 ft.	Edwin Sauers and C. L. Johnson, Bremerton, Wash.	Quartz vein 6 in. wide, 50 to 75 ft. long in granite. Contains chalcopyrite and pyrrhotite.	(Bethel, 1951, p. 231-233). 9 unpatented claims.
	Rainy				See Quartz Creek, above.

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			COPPER— Continued		
11A	Snoqualmie	Miller River dist. Secs. 14 and 23, (25-10E).	Cascade Consolidated Mining and Smelting Co. (1934). Snoqualmie Mining Co., Inc. (1908-1926).	Gash veins in granodiorite that contain chalcopyrite and pyrite. Generally low grade; some high grade came from No. 6 vein.	(Copper Handbook, 1908, p. 1244; Mineral Resources, 1925, pt. 1, p. 558; Mines Handbook, 1925, p. 1833, 1926, p. 1595; Northwest Mining Journal, no. 5, 1909; Shedd, 1924, p. 22).
	Sphinx	Miller River dist. Cleopatra Basin.			(Hodges, 1897, p. 37).
	Stevens				See Una, below.
	Surprise	Snoqualmie dist.	Horseshoe Mining Co. (1907-1909).	Copper-gold-silver ore.	(Copper Handbook, 1908, p. 794; Mining and Scientific Press, v. 98, 1909, p. 680; Northwest Mining News, no. 7, 1907, p. 13).
	Tinkle				See Geo. W. Tinkle, p. 160.
8	Una (John Stevens)	Miller River dist. Sec. 17, (25-11E), on Miller River.	Consolidated Gold Mines Co. (1908-1909).		(Copper Handbook, 1908, p. 555; Hodges, 1897, p. 38; Yale, 1909, p. 578; Northwest Mining Journal, no. 5, 1909, p. 112; W. S. Smith, 1915, p. 184). Production in 1908. 130-ft. adit.
	Unicorn	Miller River dist. Cleopatra Basin.			(Hodges, 1897, p. 37).
			GALLIUM		
1	Prufer	Buena Vista dist. Sec. 27, (25-10E), North Fork of the Snoqualmie River.	Robert Prufer, North Bend, Wash. (1951).	Basalt dike contains trace of gallium.	
			GOLD (Lode)		
3	Aaron	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.

32	Apex (Bondholders Syndicate)	Money Creek dist. SW¼ sec. 34, (26-10E), near headwaters of Money Creek. Elev. 3,600 ft.	Apex Gold Mines, Inc. (1905-1922, 1934-1943). Bondholders Syndicate Mining Co. (1923-1926). National Gold Corp. (1928).	Arsenopyrite, pyrite, chalcopyrite, galena, and arsenolite in a quartz vein 2 to 6 ft. wide that fills a continuous fissure in granodiorite. High-grade ore occurs in narrow streaks in the vein.	(Coats, 1932; Copper Handbook, 1907; Hodges, 1897, p. 39; Landes and others, 1902a, p. 85; Mineral Resources of U.S., 1905, 1908, 1910, 1912, 1913, 1916-1922, 1923, 1926, 1928; Minerals Yearbook, 1938-1941; Mines Hand-Book, 1922, 1925, 1926; Mines and Minerals, 1-29-35; Mining Journal, 4-30-32, p. 3-4; 9-30-33, p. 17; 7-15-34, p. 26; 12-15-34, p. 22; 12-30-36, p. 28; Northwest Mining Journal, no. 6, 1906, p. 79; 1907, p. 61-62; no. 5, 1909; Northwest Mining News, no. 4, 1908, p. 91; Northwest Mining Truth, no. 8, 1922, p. 5; Patty, 1921, p. 301-325; Patty and Glover, 1921, p. 59; Shedd, 1924, p. 22; Washington Bur. of Statistics, Agriculture, and Immigration, 1903, p. 135). Sixteen unpatented claims. Produced $300,000 total. Ore and concentrates shipped in 1920 av. 21 to 26 percent arsenic, 18 to 20 oz. silver, 1½ to 2½ oz. gold, and 4½ to 6 percent lead. Other assays, with sample locations, are shown on Plates 5 and 6.
	Arizona and Washington	Buena Vista dist. 1 mi. from the Mastodon silver property.		Gold-copper ore.	(Hodges, 1897, p. 43).
	Bear Creek				See Robinson, p. 168.
4	Beatrice	Money Creek dist. Secs. 31 and 32, (26-11E).	King County	Gold.	One patented claim.
40	Beaverdale	Buena Vista dist. Secs. 8 and 9, (25-10E), ½ mi. up Illinois Creek from the North Fork of the Snoqualmie River. Elev. 3,000 to 3,720 ft.	A. S. Ryland, Seattle, Wash. (1947).	Pyrite and arsenopyrite in an altered and brecciated granodiorite along a narrow fault zone. Seams of quartz and sulfides as much as 20 in. thick.	(Bethel, 1951, p. 210-213). Six patented claims. Three adits on property, at 3,280 ft., 3,580 ft., and 3,720 ft. elev. Assays reported as high as $161 in gold.
41	Belle of Tennessee	Buena Vista dist. Sec. 8, (25-10E).		Gold-silver ore.	(Hodges, 1897, p. 43).
42	Bergeson (Normandie)	Miller River dist. Sec. 30, (26-11E). Elev. 700 ft. above the Miller River.	Arthur de Soucy, Normandy, Wash. (1941). Bergeson Mining & Smelting Co. (1915-1918).	Gold and silver in arsenopyrite and quartz.	1,200-ft. adit on property.
	Big Chief	Snoqualmie area	A. O. Larsen, Seattle, Wash. (1938).	Gold-copper ore.	(Mining Journal, 7-30-38).
5	Black Bear	Money Creek dist. Sec. 31, (26-11E).	James Campbell.		One patented claim.

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

GOLD (Lode)— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
	Black Jack	T. 26 N., R. 8 E.		Gold, silver, and copper.	(Hodges, 1897, p. 213).
	Bonanza Queen	Left bank of Money Creek.		Gold and copper.	(Hodges, 1897, p. 39).
	Bridal Veil	Cedar River dist.		Gold, copper, and silver.	(Hodges, 1897, p. 48).
61	Carmack	Snoqualmie dist. Secs. 7 and 18, (23-11E), on South Fork of the Snoqualmie River near Snoqualmie Pass.	Carmack Gold & Copper Mining Co. (1902-1918).	Gold-silver-lead-copper ore in 3 veins— 12, 2½, and 1 ft. wide.	(Copper Handbook, 1907, p. 447; Landes and others, 1902a, p. 86; Mines Handbook, p. 66). One of six patented claims. 375 ft. of tunnels and shafts. 20 tons shipped prior to 1901. Assays 1 to 1½ oz. in gold.
	Cascade Gold		Cascade Gold Mining & Milling Co. (1890).		(Mining and Scientific Press, no. 6, 1890, p. 9).
6	Charles	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
7	Clara	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
45	Coney Basin	Miller River dist. Sec. 13, (25-10E) and sec. 19, (25-11E). Elev. 2,800 to 5,200 ft.	Coney Basin Gold Mines, Inc., leasing to John Whitham, Seattle, Wash. (1950-1952).	Chalcopyrite, galena, sphalerite, pyrite, and tetrahedrite in small quartz veinlets along joint planes in granodiorite and in a mineralized zone as much as 15 ft. wide.	(Biderbost, 1939, 45 p.; Gage, 1941, p. 159-160; Hodges, 1897, p. 36; Mills, 1949, 49 p.; Mineral Resources, 1935, 1936, 1939, 1940; Mining Journal, 9-31-34, p. 22; 6-15-35, p. 28; Northwest Mining Journal, no. 5, 1909; Purdy, 1951, p. 87; W. S. Smith, 1915, p. 154-185; Van Ornum, 1937, 53 p.; Washington Bur. of Statistics, Agriculture, and Immigration, 1903, p. 135). Group of 15 claims. Production in 1895, 1934, 1937-1939, 1941. 8 tons shipped in 1941 had 0.86 oz. of gold, 19.71 oz. of silver, 0.82 percent copper, 10 percent lead, 6 percent zinc, 1.52 percent arsenic, 0.26 percent antimony.
8	Cooper	Money Creek dist. Secs. 31 and 32, (26-11E).	King County.		One patented claim.
	Copper Bell	2½ mi. from Sallal Prairie.		Gold, silver, and copper.	(Hodges, 1897, p. 42).
34	Copper Duke	Money Creek dist. Sec. 25, (26-10E), on Money Creek.		Gold, silver, and copper.	

35	Damon and Pythias	Money Creek dist. Sec. 33, (26-10E), at head of Money Creek, adjoining Apex property. Elev. 3,160 ft.	Cleopatra Mines, Inc., Index, Wash. (1959). W. J. Priestley, Skykomish, Wash. (1939-1944). National Gold Corp. (1928-1932).	Arsenopyrite, pyrite, chalcopyrite, and galena in two quartz veins in granodiorite. One vein is said to av. 3 ft. in width for a distance of 900 ft.	(Hodges, 1897, p. 93; Mineral Resources, 1928, p. 700; Mining Journal, 4-30-32, p. 3-4; Mining Truth, 9-17-28, p. 29-30; 5-1-30, p. 28). Eighteen unpatented claims. 3,000 ft. of crosscut and drifts. 23 tons,shipped prior to 1940, was reported to have 0.87 oz. in gold, 9 oz. in silver, 4 percent lead. Mine run ore is said to carry 7.86 percent arsenic, 0.245 oz. in gold, 2.2 oz. in silver. Additional assays are shown on Figure 96, p. 148.
9	De La Mar	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
56	Della Jane	Snoqualmie dist. Sec. 5, (22-9E), on Profile Mountain.			(Hodges, 1897, p. 42).
10	Dudley	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
11	Extra	Money Creek dist. Sec. 31, (26-11E).	King County.	Porphyritic dike heavily mineralized with arsenopyrite.	One patented claim.
36	Favorite Gulch	Money Creek dist. Sec. 25, (26-10E), on Money Creek.		Gold and silver.	
12	Florence	Money Creek dist. Sec. 31, (26-11E).	Lake Valley Stone & Shingle Co.		One patented claim.
	Hawkeye	Miller River dist.		Gold, silver, copper, and lead.	(Hodges, 1897, p. 38).
49	Highlander	Miller River dist. SE$\frac{1}{4}$ sec. 25, (25-10E).			(Hodges, 1897, p. 37-38).
31	J. Taylor Wright	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
13	Jay	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
14	Judge	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
15	Kimball	Money Creek dist. Secs. 31 and 32, (26-11E), and secs. 5 and 6, (25-11E), on Kimball Creek, 2 mi. from Money Creek.	A. F. Brennan, Seattle, Wash. (1939). Kimball Creek Mining Co. (1903).	200-ft.-wide porphyry dike sparsely mineralized with gold, silver, and antimony that cuts granodiorite.	29 patented claims. A 750-ft. adit.
62	Klondike	Secs. 7 and 8, (22-11E).			
58	Last Chance	Cedar River dist. Secs. 7 and 18, (22-11E).	John Maloney, Skykomish, Wash. (1941).	Gold and copper.	(Hodges, 1897, p. 48).
46	Last Chance (Sockless Jerry)	Money Creek dist. Sec. 1, (25-10E), 1 mi. S. of Money Creek.		Arsenopyrite and pyrite containing gold, silver, and antimony. Some lead and zinc mineralization.	(Hodges, 1897, p. 39).

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity—Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			GOLD (Lode)— Continued		
57	Last Chance Nos. 1 and 2	Snoqualmie dist. Sec. 1, (23-11E).		Gold and silver.	(Hodges, 1897, p. 42).
	Laura Lindsay	Snoqualmie area.		Gold and silver.	(Hodges, 1897, p. 42).
54	Legal Tender	Snoqualmie dist. SE¼ sec. 25, (24-8E).		Gold and copper.	(Hodges, 1897, p. 42).
48	Lennox	Buena Vista dist. Secs. 7 and 18, (25-10E) and sec. 13, (25-9E). Elev. 1,830 to 2,870 ft.	Lennox Mining & Development Co., Seattle, Wash.	Sphalerite, chalcopyrite, pyrite, arsenopyrite, and galena in quartz and calcite gangue in shear zones in granodiorite. Zones persist to depths and lengths of several hundred feet. Mineralization is irregular.	(Bethel, 1951, p. 213-222; Smyth, 1941, 44 p.). At least 27 claims held by possessory title. Eleven adits and three open cuts. A low crosscut 670 ft. long. Three diamond drill holes totaling 1,240 ft. A 120-ft. drift and a 20-ft. drift. A 1-ton lot of picked ore (1938) contained 1.14 oz. in gold, 10.42 oz. in silver, 1.5 percent copper, 1.2 percent lead, 8.3 percent zinc, 6.18 percent arsenic, and 0.07 percent antimony. In 1947, eight samples ranged from $251 to $63.91 in gold, silver, lead, zinc, and copper. A 1-ton test shipment was made in 1947.
50	Le Roi	Miller River dist. SW¼ sec. 30, (25-11E).		Gold, silver, and copper.	(Hodges, 1897, p. 38).
55	Leta	Snoqualmie dist. SE¼ sec. 26, (24-8E).		Gold, silver, and copper.	(Hodges, 1897, p. 42).
16	Lillian Leone	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
	Little Una	Miller River dist. Adjoining Lone Star.		Gold and copper.	(Hodges, 1897, p. 38).
47	Lone Star	Money Creek dist. Sec. 1, (25-10E), on Money Creek placer claims across Fall Creek.		Gold, silver, and lead.	(Hodges, 1897, p. 38).
42A	Lucky Strike	Buena Vista dist. Secs. 9 and 10, (25-10E). Elev. 3,000 to 4,000 ft.	George and Gary Rutherford, Seattle, Wash. (1947-1951).	Pyrite, arsenopyrite, and chalcopyrite, in quartz veins as much as 12 in. thick in an 8-ft. ledge traceable for 500 ft. in granodiorite.	(Bethel, 1951, p. 207-210). 3 unpatented claims. 30-ft. shaft. Assays reported $20 to $30 in gold, silver, and copper.
	May Earhart				See Robinson, p. 168.

51	Metropolitan	Miller River dist. On W. side of the Miller River, 9 mi. from its mouth. Adjoins Cleopatra property in sec. 30, (25-11E).		16-ft.-wide mineralized zone.	(Landes and others, 1902a, p. 84).
17	Mitchell	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
37	Monarch	Money Creek dist. Sec. 25, (26-10E), on Money Creek.		Gold and silver.	
43	Monte Carlo	Buena Vista dist. NW¼ sec. 4, (25-10E), near head of the North Fork of the Snoqualmie River. Elev. 3,440 ft.	E. P. Courtney, Seattle, Wash. (1947).	Pyrite, malachite, arsenopyrite, and molybdenite in quartz and tourmaline in shear zone in granite. Zone ranges in width from 1 to 16 in.	A 335-ft. adit and a 15-ft. crosscut. Two other adits reported. 13 unpatented claims. Assays reported $25 to $55 in gold and silver.
	Mountain Gem	Miller River dist. Cleopatra Basin.		Gold and silver.	(Hodges, 1897, p. 38).
18	Napoleon	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
38	Neptune	Money Creek dist. Secs. 25 and 26, (26-10E), on Money Creek.		Gold, silver, and lead.	
	Normandie				See Bergeson, p. 163.
19	Norwood	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
20	Oliver	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
63	Online	Cedar River dist. NE¼ sec. 35, (22-10E).		Gold and copper.	(Hodges, 1897, p. 47).
59	Ophir	Cedar River dist. NE¼ sec. 21, (22-10E).		Gold and silver.	(Hodges, 1897, p. 48).
67	Oriole	Cedar River dist. NW¼ sec. 13, (21-10E).			(Hodges, 1897, p. 48).
21	Owen	Money Creek dist. Secs. 31 and 32, (26-11E).	King County.		One patented claim.
22	Paradise	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
	Paymaster	Miller River dist. Parallel to San Francisco property.		Gold and silver.	(Hodges, 1897, p. 39).
23	Pennsylvania	Money Creek dist. Sec. 32, (26-11E).			One patented claim.

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			GOLD (Lode)— Continued		
	Pythias				See Damon and Pythias, p. 165.
24	Ray	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
66	Robinson (May Earhart, Bear Creek)	Cedar River dist. Sec. 4, (21-10E).	Robinson Mines Co. (1935).	Gold, silver, and copper.	(Hodges, 1897, p. 47). Two patented claims. A 60-ft. shaft and a 600-ft. adit.
	Romeo	Miller River dist. Summit of Cleopatra Basin and extending down both the Snoqualmie River and Miller River sides of the ridge.		Gold, silver, and copper.	(Hodges, 1897, p. 37).
44	Rushing	Buena Vista dist. Secs. 8 and 9, (25-10E), on Illinois Creek.	James Campbell, Seattle, Wash. (1935).	Ore vein reported to be 8 ft. wide.	Six patented claims. Three adits— 300, 400, and 500 ft. long. Assays as high as $161 in gold reported.
1	Salmon Creek	$S\frac{1}{2}$ sec. 10, (26-10E), about 1 mi. S. of Baring.	W. R. Anderson, Baring, Wash.	Gold, silver, lead, and zinc.	
39	San Francisco	Miller River dist. Secs. 25 and 36, (26-10E).		Gold and silver.	(Hodges, 1897, p. 39).
65	San Jose	Cedar River dist. $SE\frac{1}{4}$ sec. 27, (22-10E).		Gold and copper.	(Hodges, 1897, p. 47-48). A 10-ton shipment in 1894 av. $12 per ton.
25	Sara	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
26	Sara Williams	Money Creek dist. Sec. 31, (26-11E).	King County.		One patented claim.
	Seattle	Snoqualmie dist. $SW\frac{1}{4}$ sec. 15, (22-10E).		Gold and silver.	(Hodges, 1897, p. 48).
27	Skookum	Money Creek dist. Secs. 31 and 32, (26-11E).			One patented claim.
	Sockless Jerry				See Last Chance, p. 165.
28	Solomon	Money Creek dist. Sec. 31, (26-11E).	King County.	Gold, silver, and lead.	(Hodges, 1897, p. 39). One patented claim.
	Square Deal	Snoqualmie area.	A. O. Larsen, Seattle, Wash. (1938).	Gold and copper.	(Mining Journal, 7-30-38).
60	Stemwinder	Cedar River district. $SE\frac{1}{4}$ sec. 21, (22-10E).		Gold and silver.	(Hodges, 1897, p. 48).

29	Teddy R.	Money Creek dist. Sec. 32, (26-11E).	King County.		One patented claim.
	Triune	Miller River dist.		Gold, silver, and lead.	(Hodges, 1897, p. 38).
	Twin Lakes	Miller River dist. 8 mi. from mouth of the Miller River.		Gold and copper.	(Hodges, 1897, p. 38).
53	Valley Queen	Miller River dist. Sec. 33, (23-11E).	Monte Cristo Mining Co.		One patented claim.
	Vandalia	East Fork of Money Creek.		Gold and silver.	(Hodges, 1897, p. 40).
30	Ventura	Money Creek dist. Secs. 31 and 32, (26-11E).	King County.		One patented claim.
	Victoria	Cedar River dist.		Gold and copper.	(Hodges, 1897, p. 48).
52	War Eagle	Miller River dist. Sec. 19, (25-11E).		Gold, silver, and copper.	(Hodges, 1897, p. 38).
	Washington				See Arizona and Washington, p. 163.
	Western States Copper				See Quartz Creek, p. 161.
68	White River	Approx. sec. 6, (19-8E), on S. side of Quartz Mountain.		Silicified and altered volcanic rocks associated with alunite deposits.	Two adits, one said to be 300 ft. long. Assay reported 54 cents to $1.40 in gold.
64	Woodline	Cedar River dist. Center sec. 35, (22-10E).			(Hodges, 1897, p. 47).
2	Yellow Jacket	Sec. 15, (26-10E), on W. side of East Fork of Salmon (Index) Creek.		Vein containing free-milling gold ore and some sulfide ore.	(Landes and others, 1902a, p. 85). Ten claims. Av. assay value is about $16, mostly in gold, but also some silver.

GOLD (Placer)

1	Money Creek Placer	Money Creek dist. Secs. 20 and 29, (26-11E).			
3	Raging River Placers	Along Raging River.			(Bethune, 1892, p. 172).
	Seattle Placer	Vicinity of Seattle.		Magnetite, chromite, monazite, gold, and platinum in black sand deposit.	(Day and Richards, 1906, p. 156). U.S. Geological Survey took samples that contained 10.82 lb. magnetite, 1.18 lb. monazite, 0.28 lb. chromite, and 31 cents in gold per ton.
4	Snoqualmie Placer	On the Middle Fork of the Snoqualmie River.			(Bethune, 1892, p. 167).

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			GOLD (Placer)— Continued		
	Snoqualmie River Placers	Along the Snoqualmie River.			(Bethune, 1892, p. 172).
2	Tolt River Placer	SE¼ sec. 29, (26-8E), on the Tolt River.		Fine gold reported to occur in the top 18 in. of gravel in river bars in this vicinity.	
			IRON		
1	Anderson (Baring)	S½ sec. 10 and near SE. cor. sec. 11, (26-10E), 1 mi. from railroad at Baring. Elev. 1,200 ft.	Theodore Anderson, Everett, Wash. (1943).	Magnetite ore body in limy quartzite; probably contact-replacement deposits. Exposure shows lenticular mass 25 to 30 ft. in height and 15 ft. in width.	(Glover, 1942, p. 9; Shedd and others, 1922, p. 92-93; Shedd, 1924, p. 66). Known tonnage is 2,000. Assays reported 35 to 60.70 percent iron, 9.51 to 10.20 percent silica, 0.75 percent aluminum, 4.53 percent calcium, 1.15 percent magnesium, 0.65 percent phosphorus, 0.09 percent sulfur, and trace to 0.94 percent titanium. One carload is said to have been shipped.
	Bald Hornet	Snoqualmie dist. Secs. 31 and 32, (24-9E).	Henry Wrightman, Clinton, Wash.		(Todd, 1961). Three patented claims.
3	Baring				See Anderson, above.
	Chair Peak				See Kelly, p. 171.
	Chief	Sec. 31, (23-11E).	James Taylor, Seattle, Wash.		One patented claim.
8	Cliff	Snoqualmie dist. Sec. 31, (23-11E).			Two patented claims. Reported to have had some production.
9	Climax	Snoqualmie dist. Sec. 31, (23-11E).			Two patented claims.
7	Denny	Snoqualmie dist. Secs. 6 and 7, (22-11E), 2 mi. NW. of Snoqualmie Pass. Elev. 3,500 ft.		Magnetite and pyrite occur as ovoid lenses, 20 ft. or more across, in a contact metamorphic deposit between limestone and intrusive granodiorite. Gangue minerals are garnet, quartz, actinolite, and calcite.	(Bethune, 1892, p. 42; Glover, 1942, p. 8; Hodges, 1897, p. 41; Northern Pacific Railway Co., 1941, p. 7; Patty and Glover, 1921, p. 70; Shedd, 1902, p. 25-27; Shedd and others, 1922, p. 86-90; Shedd, 1924, p. 66; G. O. Smith and Calkins, 1906, p. 13; Whittier,

(continued on following page)

	Denny (continued)				1917, p. 25-26; Zapffe, 1949, p. 22-24). Four patented claims. Known tonnage, 5,000. Assays: 55.48 to 68.54 percent iron, 1.89 to 7.99 percent silica, 0.021 percent phosphorus, and 0.089 percent to 0.25 percent sulfur (assays from 3 fairly representative samples).
10	Dobroff	S½NW¼SE¼ sec. 3, (20-6E).	Mrs. Clarabelle Dobroff, Enumclaw, Wash. (1944).	Bog iron (limonite) deposit said to cover a fair-size area.	20 acres of deeded land.
4	Green Mountain	Snoqualmie dist. SE¼ sec. 33, (24-9E), on Green Mountain, 6 mi. from Sallal Prairie.		Hematite and magnetite ore.	(Glover, 1942, p. 10; Hodges, 1897, p. 41).
	Green River	Snoqualmie dist.			(Bethune, 1892, p. 48; Glover, 1942, p. 10). Assays showed 45.51 percent iron, 10.12 percent silica, 0.05 percent sulfur, trace of phosphorus.
6	Guye (Mt. Logan, Summit)	Snoqualmie dist. Secs. 28, 32, and 33, (23-11E), about 2½ mi. from Rockdale. Elev. 4,600 ft.	J. F. Hubbart, Auburn, Wash. (1928). Guye (1884-1928).	Deposits are contact-metamorphic in origin. Contains magnetite, pyrite, galena, and sphalerite. Near the center of deposit is a 6-ft.-wide mineralized vein of galena and sphalerite.	(Bethune, 1892, p. 45; Glover, 1942, p. 8-9; Hodges, 1897, p. 41; Northern Pacific Railway Co., 1941, p. 7; Patty and Glover, 1921, p. 70; Shedd, 1902, p. 25-26; Shedd and others, 1922, p. 90-92; Shedd, 1924, p. 66; G. O. Smith and Calkins, 1906, p. 13; Whittier, 1917, p. 26-27; Zapffe, 1949, p. 22-24). 12 patented claims. Two representative analyses show 59.94 to 64.31 percent iron, 2.0 to 2.64 percent alumina, 4.07 to 6.71 percent silica, 0.32 to 0.93 percent calcium, 0.37 to 0.39 percent magnesia, 0.019 to 0.020 percent phosphorus, 0.013 to 0.016 percent sulfur, 0.11 to 0.24 percent titanium, 0.39 to 0.58 percent manganese. Other assays report as high as $138 per ton in lead, zinc, gold, and silver.
5	Kelly (Chair Peak)	Snoqualmie dist. NW¼ sec. 30, (23-11E), on Chair Peak.		Magnetite ore; has some copper.	(Bethune, 1892, p. 42; Glover, 1942, p. 10; Hodges, 1897, p. 41).
	Mt. Logan				See Guye, above.
	Smith				See Williams-Smith, below.
	Summit				See Guye, above.
2	Williams-Smith	Miller River dist. Secs. 35 and 36, (26-10E), 5 mi. from railroad at Miller River. Elev. 2,900 ft.		Magnetite ore body is probably contact replacement in limestone. Magnetite crops out in three places, the largest exposure being 51 ft. across.	(Glover, 1942, p. 9; Shedd and others, 1922, p. 93-94; Shedd, 1924, p. 66). Two claims. Assays were 66 to 67 percent iron, 2.70 to 4.10 percent silica, 0.0264 to 0.37 percent phosphorus, and no sulfur.

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			LEAD		
4	Dawson	Buena Vista dist. NE¼ sec. 18, (25-11E), on a tributary to Miller River.		Strong vein of galena, sphalerite, chalcopyrite, arsenopyrite, and pyrite in a 12-ft. leached zone.	(W. S. Smith, 1915, p. 184). Assays 3.5 to 41 percent lead, 0.4 to 4.06 oz. in gold, 4.0 to 30.0 oz. in silver, and nil to 3.12 percent copper.
6	Ellis	Snoqualmie dist. N. side of Mount Si, 3½ mi. from North Bend.			(Hodges, 1897, p. 42).
	Galena Chief	Snoqualmie dist.	R. L. Blackburn (1892).	Galena in quartz gangue.	(Bethune, 1892, p. 167). Assays reported $18 to $140 per ton.
5	Goat Mountain	Buena Vista dist. Sec. 31, (25-10E), on west side of Goat Mountain, 1 mi. S. of Sunday Lake.	Robert Prufer, North Bend, Wash., and George Wagner, Seattle, Wash. (1944-1952).	Shear zone in granodiorite, 35 ft. wide and traceable for about 600 ft., contains stringers of mineralized quartz, most of which are only a few inches wide. Zone contains pyrite, chalcopyrite, arsenopyrite, galena, sphalerite, and molybdenite.	(Bethel, 1951, p. 202-204). 15 claims, 8 open prospect trenches. 17 samples av. 0.08 oz in gold, 15.48 oz. in silver, 9.35 percent zinc, 7.08 percent lead, and 1.63 percent copper. 6 samples av. 0.81 percent molybdenum.
	Ingersoll	Snoqualmie dist.	R. L. Blackburn.	Galena in quartz gangue.	(Bethune, 1892, p. 167). Assays reported $18 to $140 per ton.
	Katie	Miller River dist.		Lead and copper.	(Hodges, 1897, p. 38).
1	Mohawk	Money Creek dist. Sec. 27, (26-10E), on Money Creek.		Lead and zinc.	
7	Mount Si	Snoqualmie dist. N. side of Mount Si, 3½ mi. from North Bend.	Fred Ellis and Albert Kelly.	Galena in veins.	(Hodges, 1897, p. 41). A 70-ft. adit. Assays as high as $20 reported.
3	Philippi Lake	Buena Vista dist. Sec. 8, (25-11E).	Philippi Lake Mining Co., Seattle, Wash., 1951.	Lead and zinc.	
	Seven-Twenty	Snoqualmie dist.	R. L. Blackburn (1892).	Galena in quartz gangue.	(Bethune, 1892, p. 167). One claim. Assays reported $18 to $140 per ton.
2	Treasury Lead	Money Creek dist. Sec. 10, (26-10E), about 1 mi. S. of Baring, on Index Creek.	William R. Anderson, Baring, Wash. (1943).	Small fractures in granodiorite that have been mineralized locally with galena and sphalerite.	80 acres of patented land.

MERCURY

1	Byrd	Black Diamond area. Sec. 9, (21-7E), near Byrd.			
2	Cardinal Reward	Black Diamond area. NE¼ sec. 17, (21-7E).	Northern Pacific Railway Co., Seattle, Wash., leasing to the Washington Mining Corp., Tacoma, Wash.	Mineralized breccia zone in sandstone. Sulfides are realgar and orpiment, including some cinnabar.	Two adits and several crosscuts.
3	Royal Reward	Black Diamond area. SW¼ sec. 9, (21-7E), on a small terrace on the S. bank of the Green River.	Washington Mining Corp., Tacoma, Wash.	Mineralized breccia zone in sandstone, shale, and andesite. Sulfide minerals are realgar, orpiment, and cinnabar.	A two-compartment, 168-ft. shaft; a 100-ft. drift; and a 50-ft. crosscut. Produced about 20 flasks of mercury from 1957 to 1960.

MOLYBDENUM

1	Devils Canyon	Buena Vista dist. Sec. 26 and S½ sec. 27, (25-10E). Elev. 3,200 to 3,700 ft.	Leased by Target Mines, Inc., Vancouver, B. C., Canada (1966). Consolidated Molybdenum, Inc., Seattle, Wash. (1948). Vernon M. Osterberg (1912-1926).	Shear zone as much as 25 ft. wide in altered granodiorite laced by 1- to 6-in. quartz veinlets. Zone can be traced 600 ft. and has a depth of at least 400 ft. Some of the quartz veinlets are well mineralized with molybdenite. Other minerals are powellite, pyrite, chalcopyrite, and scheelite.	(Bethel, 1951, p. 222-231; Culver and Broughton, 1945, p. 27; Patty and Glover, 1921, p. 82; Purdy, 1954, p. 29-31). Four unpatented claims. 1 adit, 159 ft. long. A 4-ft. channel sample across face of the adit av. 0.11 percent molybdenite. Samples across 1-ft. width on surface reported 0.40 percent molybdenum and 0.29 percent tungsten.
2	Lost Lode	Snoqualmie dist. Sec. 21, (24-9E).		Galena and molybdenite.	(Hodges, 1897, p. 42).

SILVER

5	Aces Up	Miller River dist. SE¼SW¼ sec. 30, (25-11E), 4,200 ft. SE. of the Cleopatra mine. Elev. 2,360 to 2,800 ft.	E. C. Maloney, Skykomish, Wash., leasing to Henry Trenk, Skykomish, Wash. (1966).	Joints in granodiorite have been mineralized over a width of a few inches to 2 ft. with pyrite, arsenopyrite, sphalerite, chalcopyrite, argentiferous galena, jamesonite, and quartzite.	(Hodges, 1897, p. 38; Purdy, 1951, p. 79-83). One of the unpatented claims in the Cleopatra group. Four adits. Some streaks carry 20 oz. in silver. A 500-lb. shipment was sent to the Tacoma smelter. Assays are shown on Plate 3.
3	Alexander	Miller River dist. SE¼ sec. 8, SW¼ sec. 9, NW¼ sec. 16, and NE¼ sec. 17, (25-11E).	Mrs. A. J. Akishin, Seattle, Wash.	Narrow mineralized joints in granodiorite contain sphalerite, pyrite, galena, and chalcopyrite in quartz-calcite-clay gouge.	(R. E. Smith, 1953, 31 p.). 2 adits totaling 1,117 ft. Assays as high as 6.13 oz. in silver.

TABLE 28.— Summary of metallic mineral properties, in King County, Washington, by commodity— Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			SILVER— Continued		
6	Bear Basin	Buena Vista dist. SE¼ sec. 14, NE¼ sec. 23, SW¼ sec. 13, and NW¼ sec. 24, (25-10E). Elev. 3,800 to 5,500 ft.	Bear Basin Mining Co., Bremerton, Wash. (1956). Snoqualmie Mining Co. (1933). Cascade Mines, Inc.	Fault zone in granodiorite that pinches and swells from thin seams to 4 ft. in thickness and contains pyrite, arsenopyrite, freibergite, jamesonite, stibnite, andorite, stannite, sphalerite, galena, tetrahedrite, stephanite, chalcopyrite, molybdenite in mangandolomite, and quartz gangue.	(Bethel, 1951, p. 190-202; Purdy, 1951, p. 83-87). 25 unpatented claims. 8 adits and a winze totaling 2,000 ft. A 17-in. channel sample assayed 0.06 oz. in gold, 16.90 oz. in silver, and 0.13 percent zinc (Fig. 76). A 10-in. channel sample assayed 0.06 oz. in gold, 6.00 oz. in silver, and 1.71 percent copper (Fig. 77).
	Cascade				See Seattle-Cascade, p. 175.
7	Cleopatra	Miller River dist. NW¼SE¼ sec. 24, (25-10E). Elev. 3,400 ft.	Cleopatra Mines, Inc., Index, Wash. E. C. Maloney, Skykomish, Wash., leased to Henry Trenk, of the Cascade Mining Co. (1949).	Altered and mineralized zones along joints in granodiorite. Ore minerals are argentiferous galena, chalcopyrite, tetrahedrite, arsenopyrite, pyrite, dyscrasite(?), jamesonite, and sphalerite.	(Engineering and Mining Journal, 1898, p. 260; Hodges, 1897, p. 37; Mineral Resources of the U.S., 1939, p. 490; 1941, p. 473; Northwest Mining Journal, 1909, no. 5; Patty and Glover, 1921, p. 59; Purdy, 1951, p. 79-83; Shedd, 1924, p. 50; Wash. Bur. of Statistics, Agriculture, and Immigration, 1903, p. 135). Two claims. 2 adits totaling 2,100 ft. Produced intermittently prior to 1914. Also in 1938, 1940, 1941. Maximum assay 581 oz. in silver, $10 in gold. Ore zone 100 ft. long and 2½ ft. wide av. 20 oz. in silver. Other assays are shown on Plate 4.
9	Commonwealth	Snoqualmie dist. Sec. 34, (23-11E).		Silver, copper, and gold in granodiorite.	(Hodges, 1897, p. 42).
	Copper Plate				See Seattle-Cascade, p. 175.
1	Gold Mountain	NE¼SE¼ sec. 20, (26-11E).	Weyerhaeuser Co. (1936).	Pyritized and kaolinized andesite in which are reportedly two well-defined veins. Ore minerals are pyrite, argentiferous stibnite, and minor chalcopyrite.	(Purdy, 1951, p. 74-75).
	Helmke				See Lucky Day, below.
2	Lucky Day (Helmke)	Miller River dist. Sec. 5, (25-12E), in the Foss River area.	Lucky Day Mining & Milling Co., Inc., Everett, Wash. (1938).		Eleven unpatented claims.
	Mastodon	Buena Vista dist. Near head of the North Fork of the Snoqualmie River.		Silver, gold, and copper.	(Hodges, 1897, p. 43).

4	Seattle-Cascade (Triple S, Silver Dollar and Copper Plate)	Miller River dist. Center N½ sec. 17, (25-11E), on W. side of the Miller River.	Seattle-Cascade Mining Co. (1908-1909).	Several shear zones in granodiorite. Best mineralized zone has av. width of 18 in. Ore occurs in bands, widest of which is 8 in. Ore minerals are sphalerite, galena, pyrite, arsenopyrite, and chalcopyrite in quartz gangue.	(Crary, 1912, 26 p.; Gage, 1941, p. 161-162; Mineral Resources of the U.S., 1941, p. 473; Mining and Scientific Press, no. 20, 1902, p. 680; Northwest Mining Journal, 1909, no. 5, p. 112; Northwest Mining News, 1908, no. 6, p. 158; W. S. Smith, 1915, p. 184).
	Silver Dollar and Copper Plate				See Seattle-Cascade, above.
8	Silver Star	Miller River dist. NW¼ sec. 24, (25-10E).		Silver, gold, lead, zinc, and antimony.	Assay showed 5 percent antimony.
	Sunday	Miller River dist. On King Solomon Creek, a little below the Cleopatra Basin.		Silver, gold, and copper.	(Hodges, 1897, p. 37).
	Triple S				See Seattle-Cascade, above.

THORIUM

	Snoqualmie	Near Snoqualmie Pass, in eastern King County.		A little allanite occurs as an accessory mineral in the Snoqualmie granodiorite.	(G. O. Smith and Calkins, 1906, p. 9).

TIN

1	Skykomish	Road cut on Stevens Pass highway at E. end of Skykomish, probably in sec. 26, (26-11E).		Cassiterite in conglomerate of the Swauk Formation.	(Wilson and others, 1942, p. 37). Reported 1 percent cassiterite.

ZINC

4	Jack Pot	Buena Vista dist. SW¼ sec. 27 and S½ sec. 28, (25-10E), on W. side of Cougar Creek. Elev. 4,740 ft.	Robert Prufer, North Bend, Wash. (1947).	Discontinuous mineralized fractures. Best showing is a lenticular vein that ranges from 2 to 10 ft. in width over a 50-ft. vertical exposure. Ore minerals are sphalerite, scheelite, pyrite, and chalcopyrite.	(Bethel, 1951, p. 204-207). Eight unpatented claims. Seven samples av. 0.03 oz. in gold, 0.57 oz. in silver, 5.67 percent zinc, and 0.89 percent lead.
2	Langer	Buena Vista dist. Sec. 17, (25-10E), on N. side of Lennox Creek, about ½ mi. above its mouth.		4-in. seam of sphalerite and some chalcopyrite and pyrrhotite in metasediments near granodiorite contact.	(Bethel, 1951, p. 231-232).

TABLE 28.—Summary of metallic mineral properties, in King County, Washington, by commodity—Continued

Map no.	Property name	Location	Owner	Geology	References and remarks
			ZINC—Continued		
1	Mount Phelps	Buena Vista dist. Secs. 5, 6, 7, and 8, (25-10E), on S. slope of Mount Phelps. Elev. 1,900 to 2,400 ft.	Priestley Mining & Milling Co. (1947).	Dark dike rock cutting granite is mineralized along joints. Ore minerals are sphalerite, chalcopyrite, magnetite, pyrite, and arsenopyrite.	Reported value of about $5 in gold, silver, lead, and zinc.
	Ryland	Buena Vista dist. Secs. 8 and 9, (25-10E).	Dwight W. Johnson, Kent, Wash. (1956). Rushing Milling & Mining Co. (1903).		Six patented claims.
3	Three S Gulch	Miller River dist. NW¼ sec. 16, (25-11E).	Alexander Mining Co., Seattle, Wash. (1952).	Shear zone in granodiorite mineralized with sphalerite, galena, and chalcopyrite. Vein is 6 to 9 in. thick.	

LIST OF PATENTED CLAIMS IN KING COUNTY, WASHINGTON

Claim	Survey no.	Patent no.	Location		
			Section	Township North	Range East
A					
Aaron	749	41815	31	26	11
Ainsworth	709	41002	8	25	10
Akishin	1286 A & B	1181686	16	25	11
Alexander Nos. 3, 4, 5	1286 A & B	1181686	16, 17	25	11
Annex	938	242743	13, 24	26	10
B					
Bald Hornet No. 1	90	22518	31, 32	24	9
Bald Hornet No. 2	91	22520	31	24	9
Bald Hornet No. 3	92	22521	31 36	24 24	9 8
Beatrice	749	41815	31, 32	26	11
Belle of Washington	709	41002	8	25	10
Bessemer	98	22524	33	24	9
Black Bear	749	41815	31	26	11
Blakeley	709	41002	9	25	10
Buckeye Nos. 9, 10, 11, 12, 13, 14, 15, 16	846 A & B	46115	4	26	10
C					
Calcite Placer	909	35267	13	26	10
Cammeo	709	41002	8	25	10
Carbonate Placer	909	35267	13	26	10
Carmack	856 A	197184	7, 18	23	11
Charles	749	41815	31	26	11
Chief	43	21454	31	23	11
Clara	749	41815	32	26	11
Cliff	41	23606	31	23	11
Cliff	42	23604	31	23	11
Climax	44	23605	31	23	11
Climax	45	23606	31	23	11
Clipper Nos. 1, 2	923	282184	1	23	11
Cooper	749	41815	31, 32	26	11
Crested Butte	97	22523	33	24	9
Crystal	1129 A & B	819103	36	25	11

LIST OF PATENTED CLAIMS IN KING COUNTY, WASHINGTON—Continued

Claim	Survey no.	Patent no.	Location		
			Section	Township North	Range East
D					
De La Mar	749	41815	31	26	11
Denny	37	11921	6	22	11
Denny	38	21451	6	22	11
Denny	39	21452	6	22	11
Denny	40	21453	6, 7	22	11
Dudley	749	41815	32	26	11
Dutch Millers Lode	806	29204	20	24	13
E					
Ed Bahoster	806	29204	20	24	13
Everlasting	94	22527	33	24	9
Extra	749	41815	31	26	11
F					
Florence	749	41815	31	26	11
Franklin	86	22528	33	24	9
G					
Gellivara	303	24377	33	23	11
Glacier Hill	1129 A & B	81903	36	25	11
Gold King	856 A	452078	18	22	11
Gold Queen	856 A	452078	18	22	11
Golden Fleece	856 A	452708	7, 18	22	11
Good Luck	95	22522	33	24	9
Gray Eagle	52	20287	21	20	10
H					
Hardscrabble	93	24441	33	24	9
I					
Industry	48	24199	28	23	11
Industry	88	22525	28, 32, 33	23	11
Industry	50	24201	28	23	11
Industry	51	24202	28	23	11

LIST OF PATENTED CLAIMS IN KING COUNTY, WASHINGTON—Continued

Claim	Survey no.	Patent no.	Location		
			Section	Township North	Range East
J					
J. Taylor Wright	749	41815	31	26	11
Jay	749	41815	32	26	11
Judge	749	41815	31	26	11
Jumbo	1129 A & B	819103	36	25	11
Jumbo No. 1	1129 A & B	819103	36	25	11
K					
Katie Belle	915	120874	34	24	12
Kimball	749	41815	31	26	11
Kola	912	369136	11	26	10
L					
Lanark	709	41002	8, 9	25	10
Last Chance	856 A	452708	7, 18	22	11
Last Chance Nos. 1, 2	923	282184	1	23	11
Lillian Leone	749	41815	31	26	11
Lucky	1058	459621	3	21	10
Lucky Extension	1058	459621	3	21	10
M					
M.X.	928	245177	3	25	11
Mammoth	46	24197	28, 33	23	11
Mammoth	47	24198	28	23	11
Mammoth	89	22526	33	23	11
Mammoth	49	24200	28	23	11
Marble Beauty	948	424698	13	26	10
Marble Cliff	948	424698	13	26	10
Marble Dale	948	424698	13	26	10
Marble Gem	997	299741	13	26	10
Marble Gulch	948	424698	13	26	10
Marble Jack	997	299741	13	26	10
Marble King	997	299741	13	26	10
Marble Mount	948	424698	13	26	10
Marble Quarry	948	424698	13	26	10
Marble Wonder	948	424698	13	26	10

LIST OF PATENTED CLAIMS IN KING COUNTY, WASHINGTON—Continued

Claim	Survey no.	Patent no.	Location		
			Section	Township North	Range East
Marmot	303	24377	33	23	11
Mitchell	749	41815	6	25	11
Mono	928	245177	3, 10	25	11
Monte Cristo Nos. 1, 2, 3	923	282184	{ 1 36	23 24	11 11
Mountain Chief 1, 2	923	282184	1	23	11
N					
Napoleon	749	41815	32	26	11
Norwood	749	41815	32	26	11
O					
O.G.X.	928	245177	3	25	11
Oliver	749	41815	31	26	11
Olympia	709	41005	8	25	10
Orifeno	87	22519	28	23	11
Orphan Boy	928	245177	10	25	11
Orphan Boy No. 1	1129 A & B	819103	10	25	11
Orphan Girl	928	245177	3	25	11
Oso	812	369136	11	26	10
Owen	749	41815	31, 32	26	11
P					
Paradise	749	41815	32	26	11
Pearl	928	245177	3	25	11
Pedro	195	120874	36	24	11
Pennsylvania	749	41815	32	26	11
Q					
Quartzite Lode	1310	1235208	17	25	10
R					
Ray	749	41815	32	26	11
Robinson	1057	724812	4	21	10
Robinson Extension	1057	724812	4	21	10
S					
Sara	749	41815	31	26	11

LIST OF PATENTED CLAIMS IN KING COUNTY, WASHINGTON — Continued

Claim	Survey no.	Patent no.	Location		
			Section	Township North	Range East
Sara Williams	749	41815	31	26	11
Sherwood No. 2	298	28468	4	22	7
Skookum	750	41815	31, 32	26	11
Solomon	749	41815	31	26	11
Star	915	120874	36	24	11
T					
Teddy R.	749	41815	32	26	11
Tombstone	942	242473	13	26	10
Tracy	915	120874	34	24	12
U					
U & I No. 1	923	282184	36 1	24 23	11 11
U & I No. 2	923	282184	1	23	11
V					
Valley Queen	303	24377	33	23	11
Ventura	749	41815	31, 32	26	11
Vine Maple	1192 A & B	819103	31	25	12
Vulcan	941	225572	13, 24	26	10

INDEX OF MINERAL PROPERTIES IN KING COUNTY, WASHINGTON

INDEX OF MINERAL PROPERTIES IN KING COUNTY, WASHINGTON—Continued

INDEX OF MINERAL PROPERTIES IN KING COUNTY, WASHINGTON—Continued

INDEX OF MINERAL PROPERTIES IN KING COUNTY, WASHINGTON—Continued

BIBLIOGRAPHY

Abernethy, R. F.; Aresco, S. J.; Hartner, F. E., 1958a, Analyses of mine, tipple, and delivered samples. In Daniels, Joseph; and others. Analyses of Washington coals; supplement to Technical Papers 491 and 618: U.S. Bur. Mines Bull. 572, p. 26-47.

Abernethy, R. F.; Hartner, F. E., 1958b, True specific gravities of Washington coals. In Daniels, Joseph; and others. Analyses of Washington coals; supplement to Technical Papers 491 and 618: U.S. Bur. Mines Bull. 572, p. 80-83.

Abernethy, R. F.; Hartner, F. E., 1958c, Sulfur forms in Washington coals. In Daniels, Joseph; and others. Analyses of Washington coals; supplement to Technical Papers 491 and 618: U.S. Bur. Mines Bull. 572, p. 84-85.

Abernethy, R. F.; Cochrane, E. M., 1960, Fusibility of ash of United States coals: U.S. Bur. Mines. Inf. Circ. 7923, p. 11-12, 15, 287-294.

Abernethy, R. F.; Cochrane, E. M., 1961, Free-swelling and grindability indexes of United States coals: U.S. Bur. Mines Inf. Circ. 8025, p. 65.

Adams, M. F., 1961, Water resources of the State of Washington: Washington State Inst. Technology Bull. 237, Supplement A, 11 unnumbered pages.

Aguinaldo, P. D., 1924, Concentration of arsenic ore by flotation: Univ. of Washington B.S. thesis, 21 p.

Allen, V. T., 1946, Some U.S. boehmite localities [abs.]: Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1173.

Allen, V. T., 1947, Some U.S. boehmite localities [abs.]: Am. Mineralogist, v. 32, nos. 3-4, p. 195.

Anderson, C. A., 1965, Surficial geology of the Fall City area, Washington: Univ. of Washington M.S. thesis, 70 p.

Anderson, J. Q., 1959, Puget Sound area has several prospective oil and gas basins: World Oil, v. 149, no. 1, p. 111-113, 117, July 1959; Washington Div. Mines and Geology Reprint 5, 4 unnumbered pages.

Anderson, N. R., 1950, Multiple glaciation in the White River valley near Enumclaw, Washington [abs.]: Geol. Soc. America Bull., v. 61, no. 12, pt. 2, p. 1519-1520.

Anderson, N. R., 1954, Glacial geology of the Mud Mountain district, King County, Washington: Univ. of Washington M.S. thesis, 48 p.

Aresco, S. J.; Hartner, F. E., 1958, Description of tipple and delivered samples. In Daniels, Joseph; and others. Analyses of Washington coals; supplement to Technical Papers 491 and 618: U.S. Bur. Mines Bull. 572, p. 72-79.

Aresco, S. J.; Haller, C. P.; Abernethy, R. F., 1960, Analyses of tipple and delivered samples of coal (collected during the fiscal year 1959): U.S. Bur. Mines Rept. Inv. 5615, p. 37.

Aresco, S. J.; Haller, C. P.; Abernethy, R. F., 1962, Analyses of tipple and delivered samples of coal (collected during the fiscal year 1961): U.S. Bur. Mines Rept. Inv. 6086, p. 24.

Ash, S. H., 1929, Mining operations at the new Black Diamond mine of the Pacific Coast Coal Company: Univ. of Washington Engineer of Mines thesis, 67 p.

Baadsgaard, Halfdan; Folinsbee, R. E.; Lipson, J. I., 1961, Potassium-argon dates of biotites from Cordilleran granites: Geol. Soc. America Bull., v. 72, no. 5, p. 691, 694, 695, 697, 698.

Bagley, C. B., 1929, History of King County (Volume 1): S. J. Clarke Publishing Co., Chicago-Seattle, p. 280-301.

Barkley, J. F.; Burdick, L. R., 1941, The various B.t.u. values of a coal: U.S. Bur. Mines Inf. Circ. 7193, p. 23.

Bateman, E. S., 1951, Seattle locality [agate occurrence]: The Mineralogist, v. 9, no. 1, p. 16.

Beikman, H. M.; Gower, H. D.; Dana, T. A. M., 1961, Coal reserves of Washington: Washington Div. Mines and Geology Bull. 47, p. 33-63.

Bennett, W. A. G., 1939, Bibliography and index of geology and mineral resources of Washington, 1814-1936: Washington Div. Geology Bull. 35, p. 101-102.

Berryhill, L. R.; Averitt, Paul, 1951, Coking-coal deposits of the western United States: U.S. Geol. Survey Circ. 90, p. 6-7.

Bethel, H. L., 1951, Geology of the southeastern part of the Sultan quadrangle, King County, Washington: Univ. of Washington Ph.D. thesis, 244 p.

Bethune, G. A., 1891, Mines and minerals of Washington: Washington State Geologist, Ann. Rept., 122 p.

Bethune, G. A., 1892, Mines and minerals of Washington: Washington State Geologist, 2nd Ann. Rept., 183 p.

Biderbost, T. A., 1939, Mineralogy and ore treatment of Coney Basin mine: Univ. of Washington B.S. thesis, 45 p.

Binon, L. C., 1959, Iron ore resources of the Pacific Northwest: Northern Pacific Railway Co., Properties and Industrial Development Department unpublished rept., 132 p.

Bond, J. G., 1959, Sedimentary analysis of the Kummer Formation within the Green River Canyon, King County, Washington: Univ. of Washington M.S. thesis, 113 p.

Bravinder, K. M., 1932, Stratigraphy and paleontology of the Oligocene in the eastern portion of the Puget Sound Basin: Univ. of Washington M.S. thesis, 38 p.

Bretz, J H., 1913, Glaciation of the Puget Sound region: Washington Geol. Survey Bull. 8, 244 p.

Brown, R. W., 1939, Fossil leaves, fruits, and seeds of Cercidiphyllum: Jour. Paleontology, v. 13, no. 5, p. 485-499, [mentions Steel's Crossing flora on p. 486].

Brown, R. W., 1940, New species and changes of name in some American fossil floras: Washington Acad. Science Jour., v. 30, no. 8, p. 344-356, [mentions Steel's Crossing flora on p. 345].

Browne, J. R., 1869, Resources of the Pacific slope: D. Appleton and Co., New York, p. 572-573.

Byers, H. G., 1902, The water resources of Washington; potable and mineral water: Washington Geol. Survey Ann. Rept. No. 1, pt. 5, p. 2, 6, 7, 8, 9, 26.

Byrd, M. F., 1955, Potash occurrences in the United States: U.S. Geol. Survey Min. Inv. Resource Appraisals Map MR-3.

Campbell, M. R.; and others, 1915, Guidebook of the western United States, Part A—The Northern Pacific route with a side trip to Yellowstone Park: U.S. Geol. Survey Bull. 611, p. 184-196.

Carmichael, V. W., 1959, The coal fields of Washington— supplement: Northern Pacific Railway Co. unpublished rept., 68 p.

Carr, F. E.; Bagshaw, E. W., 1908, Geology of Squak Mountain: Univ. of Washington M.A. thesis, 34 p.

Cartwright, Keros; Sherman, F. B., 1969, Evaluating sanitary landfill sites in Illinois: Illinois Geol. Survey Environmental Geology Notes No. 27, 15 p.

Cary, A. S.; Carlston, C. W., 1937, Notes on Vashon stage glaciation of the South Fork of the Skykomish River valley, Washington: Northwest Science, v. 11, no. 3, p. 61-62.

Cary, A. S., 1954, Eagle Gorge dam site, Washington [abs.]: Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1335-1336.

Chelikowsky, J. R., 1935, Geologic distribution of fire clays in the United States: Am. Ceramic Soc. Jour., v. 18, no. 12, p. 87-88.

Chew, R. T., III; Boyd, G. A., 1960, A preliminary investigation of clay deposits in Minnesota, North Dakota, Montana, northern Idaho, and Washington: Northern Pacific Railway Co., Geol. Div. unpublished rept., 161 p.

Christensen, F. C., 1937, Mining methods and washing practice at the Elk coal mines: Univ. of Washington B.S. thesis, 30 p.

Coats, R. R., 1932, Ore deposits of the Apex gold mine, Money Creek, King County, Washington: Univ. of Washington M.S. thesis, 50 p.

Cole, C. F., 1942, Land utilization on Vashon Island: Univ. of Washington M.A. thesis, 111 p.

Coombs, H. A., 1953, A summary of Washington earthquakes: Seismological Soc. America Bull., v. 43, no. 1, p. 1-5.

Copper Handbook, 1907, 1908.

Corey, T. B., 1893, Coal fields of western Washington: Illinois Mining Inst. Jour., v. 2, p. 14-30.

Corey, T. B., 1896, The coal resources of Washington: Mining, v. 1, p. 231-239.

Crandell, D. R.; Waldron, H. H., 1956, A Recent volcanic mudflow of exceptional dimensions from Mt. Rainier, Washington: Am. Jour. Science, v. 254, p. 349-362.

Crandell, D. R.; Mullineaux, D. R.; Waldron, H. H., 1958, Pleistocene sequence in southeastern part of the Puget Sound Lowland, Washington: Am. Jour. Science, v. 256, no. 6, p. 384-397.

Crandell, D. R.; Gard, L. M., Jr., 1959, Geology of the Buckley quadrangle: U.S. Geol. Survey Geol. Quad. Map GQ-125.

Crandell, D. R., 1963, Surficial geology and geomorphology of the Lake Tapps quadrangle, Washington: U.S. Geol. Survey Prof. Paper 388-A, 84 p.

Crary, H. H., 1912, Seattle Cascade mine and methods for treatment of the ore: Univ. of Washington B.S. thesis, 26 p.

Culver, H. E.; Broughton, W. A., 1945, Tungsten resources of Washington: Washington Div. Geology Bull. 34, 89 p.

Curran, T. A., 1965, Surficial geology of the Issaquah area, Washington: Univ. of Washington M.S. thesis, 57 p.

Dachnowski-Stokes, A. P., 1930, Peat profiles in the Puget Sound Basin of Washington: Washington Acad. Science Jour., v. 20, no. 11, p. 199-202, 206-207.

Daneš, Z. F., 1963, Gravity survey in the Cascade Mountains [abs.]: Am. Geophys. Union Trans., v. 44, no. 1, p. 209.

Daniels, Joseph, 1958, Description of mine samples. In Daniels, Joseph; and others. Analyses of Washington coals; supplement to Technical Papers 491 and 618: U.S. Bur. Mines Bull. 572, p. 48-69.

Danner, W. R., 1955, Some fossil worm tubes of western Washington: Rocks and Minerals, v. 30, nos. 9-10, p. 456.

Danner, W. R., 1957, A stratigraphic reconnaissance in the northwestern Cascade Mountains and San Juan Islands of Washington State: Univ. of Washington Ph.D. thesis, 562 p.

Danner, W. R., 1959, Permian microfossils of northwestern Washington: Rocks and Minerals, v. 34, nos. 3-4, p. 99-104.

Danner, W. R., 1966, Limestone resources of western Washington: Washington Div. Mines and Geology Bull. 52, p. 359-386.

Dart, J. O., 1953, Renton-Sumner lowland of western Washington: Univ. of Washington Ph.D. thesis, 215 p.

Darton, N. H., 1909, Structural materials in parts of Oregon and Washington: U.S. Geol. Survey Bull. 387, p. 27.

Davies, Ben, 1943, Correlation between the clay mineral content and the sulfuric acid extraction of alumina from some Pacific Northwest clays: Univ. of Washington M.S. thesis, p. 44-45.

Davis, D. E., 1923, Ore deposits and geology of region around Mount Si: Univ. of Washington B.S. thesis, 26 p.

Day, D. T.; Richards, R. H., 1906, Investigations of black sands from placer mines: U.S. Geol. Survey Bull. 285, p. 156.

Deacon, R. J., 1961a, Washington driller aims to hit oil pay: Oil and Gas Jour., v. 59, no. 6, p. 182, 184-185.

Deacon, R. J., 1961b, Washington, Oregon having active exploration year: Oil and Gas Jour., v. 59, no. 23, p. 135-136.

Deacon, R. J., 1962, Pacific Northwest headed for active year: Oil and Gas Jour., v. 60, no. 13, p. 168-169, 171-172, 175-176, 178.

Deevey, E. S.; Gralenski, L. J.; Hoffren, Vaino, 1959, Yale natural radiocarbon measurements IV: Am. Jour. Science Radiocarbon Suppl., v. 1, p. 151.

Dehlinger, Peter; Berg, J. W., Jr., 1962, The Portland earthquake of November 5, 1962: Oregon Dept. Geology and Mineral Industries The Ore Bin, v. 24, no. 11, p. 185-188.

Dehlinger, Peter; Bowen, R. G.; Chiburis, E. F.; Westphal, W. H., 1963, Investigations of the earthquake of November 5, 1962, north of Portland: Oregon Dept. Geology and Mineral Industries The Ore Bin, v. 25, no. 4, p. 53-68.

Diller, J. S.; and others, 1915, Guidebook of the western United States, Part D—The Shasta Route and Coast Line: U.S. Geol. Survey Bull 614, p. 9-15.

Dorisy, C. E., 1935, Index of mineral occurrences in the State of Washington: Washington State Planning Council Research Pub. 3, p. 4-5, 7, 9, 13, 17, 19, 22, 25, 29, 30-31, 35.

Dorisy, C. E., 1937, Index of mineral occurrences in the State of Washington: Washington State Planning Council Research Pub. 3 (revised), p. 7, 9, 10, 12, 16-17, 21, 23-24, 26, 30, 35, 36-37, 41.

Dorn, T. F.; Fairhall, A. W.; Schell, W. R.; Takashima, Y., 1961(?), Radiocarbon dating at the University of Washington: Univ. of Washington Dept. of Chemistry, 21 unnumbered pages, mimeographed.

Dorn, T. F.; Fairhall, A. W.; Schell, W. R.; Takashima, Y., 1962, Radiocarbon dating at the University of Washington I: Radiocarbon, v. 4, p. 1-12.

Eisner, Abner; and others, 1940, Hydrogenation and petrography of some low-rank coals from the western United States: U.S. Bur. Mines Rept. Inv. 3498, p. 2-5.

Ellis, R. C., 1959, The geology of the Dutch Miller Gap area, Washington: Univ. of Washington Ph.D. thesis, 113 p.

Ellis, R. C., 1961, Amber near Seattle, Washington: Gems and Minerals, no. 291, p. 24.

Engineering and Mining Journal, 1898.

Evans, G. W., 1912, The coal fields of King County: Washington Geol. Survey Bull. 3, 247 p.

Evans, G. W., 1914, The Issaquah coal mine: Colliery Engineer, v. 34, no. 11, p. 663-666.

Fanning, L. M., 1950, Oil resources: McGraw-Hill, New York, p. 214.

Fettke, C. R., 1910, A study of the bedrock in the vicinity of Seattle, Port Orchard, and Renton, Washington: Univ. of Washington B.S. thesis, 21 p.

Fischer, H. B., 1968, Methods for predicting dispersion coefficients in natural streams, with applications to lower reaches of the Green and Duwamish Rivers, Washington: U.S. Geol. Survey Prof. Paper 582-A, 27 p.

Fiske, R. S.; Hopson, C. A.; Waters, A. C., 1963, Geology of Mount Rainier National Park, Washington: U.S. Geol. Survey Prof. Paper 444, p. 40, 59, 63.

Foster, R. J., 1955, A study of the Guye Formation, Snoqualmie Pass, King and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 57 p.

Foster, R. J., 1957, The Tertiary geology of a portion of the central Cascade Mountains, Washington: Univ. of Washington Ph.D. thesis, 186 p.

Foster, R. J., 1960, Tertiary geology of a portion of the central Cascade Mountains, Washington: Geol. Soc. America Bull., v. 71, no. 2, p. 99-125.

Fuller, R. E., 1925, The geology of the northeastern part of the Cedar Lake quadrangle, with special reference to the deroofed Snoqualmie batholith: Univ. of Washington M.S. thesis, 96 p.

Gabriel, Alton; Dasher, John, 1942, Beneficiation of alunite: U.S. Bur. Mines Rept. Inv. 3610, p. 2, 4, 5.

Gage, H. L., 1941, Some foreign and domestic zinc-lead mines that could supply zinc concentrates to a Pacific Northwest electrolytic zinc industry; Domestic western mines, Part IV—The zinc-lead mines of Washington: U.S. Bonneville Power Administration, Market Development Section, unpublished rept., p. 159-163.

Galster, R. W., 1956, Geology of the Miller-Foss River area, King County, Washington: Univ. of Washington M.S. thesis, 96 p.

Garling, M. E.; Molenaar, Dee; and others, 1965, Water resources and geology of the Kitsap Peninsula and certain adjacent islands [including Vashon and Maury Islands in King County]: Washington Div. Water Resources Water Supply Bull. 18, 309 p.

Geer, M. R.; Yancey, H. F., 1961, Washability examinations of coals from the Rocky Mountain and Pacific Coast States: U.S. Bur. Mines Rept. Inv. 5905, p. 10-14, 24-34.

Gence, Louis, 1934, Sand and gravel deposits of King and Pierce Counties, Washington: Univ. of Washington B.S. thesis, 55 p.

Gibson, F. H.; Selvig, W. A., 1944, Rare and uncommon chemical elements in coal: U.S. Bur. Mines Tech. Paper 669, p. 9, 14.

Glover, S. L., 1936a, Preliminary report on petroleum and natural gas in Washington: Washington Div. Geology Rept. Inv. 4, p. 18.

Glover, S. L., 1936b, Nonmetallic mineral resources of Washington, with statistics for 1933: Washington Div. Geology Bull. 33, p. 135.

Glover, S. L., 1936c, Hammer Bluff Formation of western Washington [abs.]: Pan-American Geologist, v. 65, p. 77-78.

Glover, S. L., 1941, Clays and shales of Washington: Washington Div. Geology Bull. 24, 368 p.

Glover, S. L., 1942, Washington iron ores, a summary report: Washington Div. Mines and Mining Rept. Inv. 2, 23 p.

Glover, S. L., 1949, Origin and occurrence of gemstones in Washington: Washington Div. Mines and Geology Rept. Inv. 16, p. 22-23.

Glover, S. L., 1954, One hundred years of mining: Washington Div. Mines and Geology Bienn. Rept. 5, p. 11.

Goldman, H. B., 1959, Urbanization and the mineral industry: California Div. Mines Mineral Inf. Service, v. 12, no. 12, 12 p.

Goodner, E. F., 1921, Four typical refractory clays of Washington: Univ. of Washington M.S. thesis, 70 p.

Goodspeed, G. E.; Coombs, H. A., 1932, Quartz-diopside-garnet veinlets: Am. Mineralogist, v. 17, no. 12, p. 554-556.

Goodyear, W. A., 1877, The coal mines of the western coast of the United States: A. L. Bancroft & Co., San Francisco, p. 104-106.

Gould, H. R.; Budinger, T. F.; Ragan, D. M., 1956, Bathymetry and postglacial sediments of Lake Washington [abs.]: Geol. Soc. America Bull., v. 67, no. 12, pt. 2, p. 1767-1768.

Gould, J. E., 1937, Washington surveys; Transportation resources and facilities, State of Washington, King County: Bureau of Individual Studies, Inst. Transportation and Maritime Commerce, Seattle, Wash., Part VII.

Gower, H. D.; Wanek, A. A., 1963, Preliminary geologic map of the Cumberland quadrangle, King County, Washington: Washington Div. Mines and Geology Geol. Map GM-2.

Grant, A. R., 1969, Chemical and physical controls for base metal deposition in the Cascade Range of Washington: Washington Div. Mines and Geology Bull 58, 107 p.

Green, S. H., 1943, Coal and coal mining in Washington: Washington Div. Mines and Mining Rept. Inv. 4, 41 p.

Green, S. H., 1949, Industrial coal available to Pacific Northwest industries: Raw Materials Survey [Portland, Oreg.] Resource Rept. 4, p. 5, 6-7, 9.

Griffin, W. C.; Sceva, J. E.; Swenson, H. A.; Mundorff, M. J., 1962, Water resources of the Tacoma area, Washington: U.S. Geol. Survey Water Supply Paper 1499-B, 101 p.; Washington Div. Water Resources Water Supply Bull. 19, 101 p.

Hagen, C. B., 1958, Lengths of shoreline in Washington State: Washington Dept. Nat. Resources, Bur. Surveys and Maps, 12 p.

Hammond, P. E., 1963, Structure and stratigraphy of the Keechelus Volcanic Group and associated Tertiary rocks in the west-central Cascade Range, Washington: Univ. of Washington Ph.D. thesis, 264 p.

Hance, J. H., 1908, Newcastle coal mining district, King County, Washington: Univ. of Washington B.S. thesis, 23 p.

Hansen, H. P., 1938, Pollen analysis of some interglacial peat from Washington: Wyoming Univ. Pub., v. 5, no. 2, p. 11-18.

Hansen, H. P.; Mackin, J. H., 1940, A further study of interglacial peat from Washington: Torrey Bot. Club Bull., v. 67, no. 2, p. 131-142.

Hansen, H. P., 1941, Further pollen studies of post-Pleistocene bogs in the Puget Lowland: Torrey Bot. Club Bull., v. 68, no. 3, p. 133-198.

Harris, H. M.; Strandberg, K. G.; Kelly, H. J., 1962, Resources for making expanded aggregate in western Washington and Oregon: U.S. Bur. Mines Rept. Inv. 6061, 41 p.

Herdlick, J. A., 1931, Mineralogical relations and flotation properties of a complex gold ore from the National Gold mine, Miller River, Washington: Univ. of Washington B.S. thesis, 47 p.

Hewitt, D. B., 1962, Urban expansion and the mineral industries in the Toronto-Hamilton area: Ontario Dept. Mines Indus. Mineral Rept., no. 8, 11 p.

Hidaka, F. T.; Garrett, A. A., 1967, Evaluation of seepage from Chester Morse Lake and Masonry Pool, King County, Washington: U.S. Geol. Survey Water-Supply Paper 1839-J, 26 p.

Hittell, J. S., 1882, The commerce and industries of the Pacific Coast of North America, 2d ed.: A. L. Bancroft & Co., San Francisco, 819 p.

Hodge, E. T., 1938a, Market for Columbia River hydroelectric power using Northwest minerals; Sec. 2— Northwest silica materials; Vol. 1, pt. 1— Silica localities of the Pacific Northwest: U.S. Army Corps of Engineers, Office of the Division Engineer, North Pacific Division, Portland, Oreg., p. 1-163, 174-175.

Hodge, E. T. 1938b, Market for Columbia River hydroelectric power using Northwest minerals; Sec. 3— Northwest limestone; Vol. 1, pt. 1— Limestones of the northwestern states: U.S. Army Corps of Engineers, Office of the Division Engineer, North Pacific Division, Portland, Oreg., p. 11-131.

Hodge, E. T., 1938c, Market for Columbia River hydroelectric power using Northwest minerals; Sec. 4— Northwest clays; Vol. 3, pt. 3— Northwest sources: U.S. Army Corps of Engineers, Office of the Division Engineer, North Pacific Division, Portland, Oreg., p. 493-609, 749-804.

Hodge, E. T., 1938d, Report on available raw materials for a Pacific Coast iron industry; Vol. 5, pt. 1— Information on additional iron ores of the Northwest: U.S. Army Corps of Engineers, Office of the Division Engineer, North Pacific Division, Portland, Oreg., p. 1-28.

Hodges, L. K., 1897, Mining in the Pacific Northwest: Seattle Post-Intelligencer, Seattle, Wash., p. 35-48, 55 [Facsimile reproduction by the Shorey Book Store, Seattle, in 1967].

Holmberg, G. D., 1957, Washington. In Sayre, A. N.; and others. Water levels and artesian pressures in observation wells in the United States, 1955, Pt. 5— Northwestern States: U.S. Geol. Survey Water-Supply Paper 1408, p. 125-148.

Howard, D. A., 1967, Economic geology of Quartz Creek, King County, Washington: Univ. of Washington M.S. thesis, 48 p.

Huntting, M. T., 1955, Gold in Washington: Washington Div. Mines and Geology Bull. 42, 158 p.

Huntting, M. T., 1956, Inventory of Washington Minerals, Part II— Metallic minerals: Washington Div. Mines and Geology Bull. 37, pt. 2, 495 p.

Huntting, M. T., 1957, Uranium in Washington; an extract from Bulletin 37, Inventory of Washington Minerals, Part II— Metallic minerals: Washington Div. Mines and Geology Inf. Circ. 26, 10 p.

Huntting, M. T., 1958, Physiography of counties. In Rigg, G. B., Peat resources of Washington: Washington Div. Mines and Geology Bull. 44, p. 26.

Hurley, P. M.; Goodman, Clark, 1943, Helium age measurement, Pt. 1—Preliminary magnetite index: Geol. Soc. America Bull., v. 54, no. 3, p. 307, 317.

Industrial West Foundation, 1944, Western Economic Empire: Industrial West Foundation, Washington, D. C., Div. II, sec. B, p. 11, 23, 51; Div. II, sec. C, p. 23, 79, 117; Div. II, sec. D, p. 9, 21, 37, 40, 64.

Jannsen, N. C., 1952, Possibilities of securing auxiliary water supply for the city of Seattle along the north city limits, and Bothell road: Published by the author, Seattle, 3 p.

Johnston, V. C., 1947, Renton locality: The Mineralogist, v. 5, no. 3, p. 126, 128.

Kaarsberg, E. A.; Colcord, J. E., 1963, Geological and geodetic implications derived from a detailed gravity survey of the city of Seattle area [abs.]: Am. Geophys. Union Trans., v. 44, no. 1, p. 32.

Kauffman, A. J., Jr., 1952, Industrial minerals of the Pacific Northwest: U.S. Bur. Mines. Inf. Circ. 7641, 75 p.

Keller, W. D.; Reesman, A. L., 1963, Dissolved products of artificially pulverized silicate minerals and rocks — Part II: Jour. Sed. Petrology, v. 33, no. 2, p. 426-437.

Kelly, H. J.; Strandberg, K. G.; Mueller, J. I., 1956, Ceramic industry development and raw-material resources of Oregon, Washington, Idaho, and Montana: U.S. Bur. Mines Inf. Circ. 7752, p. 6-7, 22-49.

Kelly, H. J., 1959, Major clay basins of western Washington and Oregon [abs.]: Mining Eng., v. 11, no. 1, p. 39.

Kimball, A. L., 1961, A study of hydrothermal alteration at the Rainy mine, King County, Washington: Univ. of Washington B.S. thesis, 34 p.

King County Planning Department, 1964, The comprehensive plan for King County, Washington: Published by author, Seattle, 204 p.

Knoll, K. M., 1967, Surficial geology of the Tolt River area, Washington: Univ. of Washington M.S. thesis, 91 p.

Knowles, P. H., 1938, Dike contact reaction zone in limestone at Grotto, Washington: Univ. of Washington B.S. thesis, 31 p.

Kremer, D. E., 1959, The geology of the Preston-Mount Si area: Univ. of Washington M.S. thesis, 103 p.

Ladoo, R. B., 1948, Industrial silica for Pacific Northwest industries: Raw Materials Survey [Portland, Oreg.] Resource Rept. 1, p. 28-37.

Lambert, W. D., 1937, The external gravity-field and the interior of the earth: American Geophys. Union Trans., v. 18, pt. 1, p. 34.

Landes, Henry; Thyng, W. S.; Lyon, D. A.; Roberts, Milnor, 1902a, The metalliferous resources of Washington, except iron: Washington Geol. Survey Ann. Rept. 1901, pt. 2, p. 82-86.

Landes, Henry, 1902b, The non-metalliferous resources of Washington, except coal: Washington Geol. Survey Ann. Rept. 1901, pt. 3, p. 53.

Landes, Henry, 1902c, The coal deposits of Washington: Washington Geol. Survey Ann. Rept. 1901, pt. 4, p. 41-65.

Landes, Henry; Ruddy, C. A., 1903, Coal deposits of Washington: Washington Geol. Survey Ann. Rept. 1902, pt. 2, p. 167-277.

Landes, Henry, 1906, Cement resources of Washington: U.S. Geol. Survey Bull. 285, p. 377-383.

Landes, Henry, 1911, Road materials of Washington: Washington Geol. Survey Bull. 2, p. 99-105.

Leighton, M. M., 1919, The road building sands and gravels of Washington: Washington Geol. Survey Bull. 22, p. 179-184.

Liesch, B. A., 1955, Records of wells, water levels, and quality of ground water in the Sammamish Lake area, King County, Washington: U.S. Geol. Survey open-file rept., 193 p.

Liesch, B. A.; Price, C. E.; Walters, K. L., 1963, Geology and ground-water resources of northwestern King County, Washington: Washington Div. Water Resources Water Supply Bull. 20, 241 p.

Lindell, F. R., 1962, The feasibility of manufacturing fiber glass residential insulation in the Pacific Northwest: Univ. of Washington M.A. thesis, p. 113.

Lindquist, J. W., 1957, Molluscan paleontology of Fiddlers Bluff, Washington: Univ. of Washington undergraduate thesis, 39 p.

Lipson, J. I.; Folinsbee, R. E.; Baadsgaard, Halfdan, 1961, Periods of orogeny in the Western Cordillera: New York Acad. Sciences Annals, v. 91, art. 2, p. 459-463.

Livingston, V. E., Jr., 1958, Oil and gas exploration in Washington, 1900-1957: Washington Div. Mines and Geology Inf. Circ. 29, p. 5, 6, 28, 29.

Livingston, V. E., Jr., 1959, Fossils in Washington: Washington Div. Mines and Geology Inf. Circ. 33, 35 p.

Livingston, V. E., Jr., 1969, Geologic history and rocks and minerals of Washington: Washington Div. Mines and Geology Inf. Circ. 45, 42 p.

Livingstone, D. A., 1963, Chemical composition of rivers and lakes [Chapter G of Data of Geochemistry, 6th ed., Michael Fleischer, editor]: U.S. Geol. Survey Prof. Paper 440-G, p. 3, 17, 18, 38, 45, 48.

Love, S. K.; and others, 1959, Quality of surface waters of the United States, 1955; parts 9-14, Colorado River Basin to Pacific Slope Basins in Oregon and Lower Columbia River Basin: U.S. Geol. Survey Water-Supply Paper 1403, p. 339, 344, 353-355, 361-362, 367-368, 370-371, 373-374, 386-387.

Luther, H. E., 1941, Beneficiation of a glass sand from King County: Univ. of Washington B.S. thesis, 41 p.

Luzier, J. E., 1969, Geology and ground-water resources of southwestern King County, Washington: Washington Div. Water Resources Water Supply Bull. 28, 260 p.

MacGinite, H. D., 1941, A middle Eocene flora from the central Sierra Nevada: Carnegie Inst. Washington Pub. 534, 178 p.

Mackin, J. H., 1937, Varved clay section in the Puget Sound area [abs.]: Geol. Soc. America Proc. 1936, p. 318.

Mackin, J. H., 1941, A geologic interpretation of the failure of the Cedar Reservoir, Washington: Univ. of Washington Eng. Expt. Sta. Bull. 107, 30 p.

Mackin, J. H., 1949, Engineering geology of West Seattle: Univ. of Washington Eng. Expt. Sta., Trend in Eng., v. 1, no. 3, p. 24-26.

Mackin, J. H.; Cary, A. S., 1965, Origin of Cascade landscapes: Washington Div. Mines and Geology Inf. Circ. 41, 35 p.

Mangum, A. W., 1911, Reconnoissance [sic] soil survey of the eastern part of the Puget Sound basin, Washington: U.S. Dept. Agr., Bur. of Soils, 90 p.

Mark, Helen, 1963, High-alumina kaolinitic clay in the United States (exclusive of Alaska and Hawaii): U.S. Geol. Survey Mineral Inv. Resource Map MR-37, 1 sheet accompanied by 22 pages of text.

Marshall, N. J., 1955, A study of the fundamental properties of Puget Sound glacial clays: Univ. of Washington M.S. thesis, 81 p.

Marts, M. E., 1944, Geography of the Snoqualmie River valley: Univ. of Washington M.A. thesis, 77 p.

McCormick, G. P., 1923, Coal prospects near Renton, Washington: Univ. of Washington B.S. thesis, 52 p.

McIntyre, A. W., 1907, Copper deposits of Washington: Am. Min. Cong., 9th Ann. Sess., Rept. Proc., p. 238-250.

McKnight, E. F. T., 1923, The origin and history of Lake Washington: Univ. of Washington B.S. thesis, 61 p.

McKnight, E. T.; Ward, A. H., 1925, Geology of the Snohomish quadrangle: Univ. of Washington M.S. thesis, 92 p.

McLerran, J. H.; Krashevski, S. H., 1954, State of Washington Engineering Soils Manual, Part III—Soils of King County: Washington State Council for Highway Research, 107 p.

McManus, D. A., 1963, Postglacial sediments in Union Bay, Lake Washington, Seattle, Washington: Northwest Science, v. 37, no. 2, p. 61-73.

McNaughton, E. L.; Middleton, Campbell, 1925, Petrographic study of Admiralty sediments and Vashon till: Univ. of Washington B.S. thesis, 84 p.

Meeker, Ezra, 1921, Seventy years of progress in Washington: Allstrum Print Co., Tacoma, p. 268, 274, 275.

Mills, R. B., 1949, Study of Coney Basin mine: Univ. of Washington B.S. thesis, 49 p.

Mines and Minerals, 1935.

Mines Handbook, 1918, 1922, 1925, 1926.

Mining and Scientific Press, 1890, 1902, 1909.

Mining Journal, 1932, 1933, 1934, 1935, 1936, 1938, 1939.

Mining Truth, 1928.

Moen, W. S., 1962, Mineral rights and land ownership in Washington: Washington Div. Mines and Geology Inf. Circ. 36, 23 p.

Moen, W. S., 1967, Building stone of Washington: Washington Div. Mines and Geology Bull. 55, 85 p.

Molenaar, Dee, 1961, Flowing artesian wells in Washington State: Washington Div. Water Resources Water Supply Bull. 16, p. 9, 11, 32-42.

Mullen, J. T., Jr., 1939, Memorandum—The coal fields of Washington: Northern Pacific Railway Co., Land Dept., Geol. Div. unpublished rept., p. 22-39.

Mullineaux, D. R.; Gard, L. M.; Crandell, D. R., 1959, Continental sediments of Miocene age in Puget Sound lowland, Washington: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 3, pt. 1, p. 688-696.

Mullineaux, D. R., 1961a, Geology of the Renton, Auburn, and Black Diamond quadrangles, Washington: Univ. of Washington Ph.D. thesis, 202 p.

Mullineaux, D. R., 1961b, Geology of the Renton, Auburn, and Black Diamond quadrangles, Washington: U.S. Geol. Survey open-file rept., 202 p.

Mullineaux, D. R., 1965a, Geologic map of the Auburn quadrangle, King and Pierce Counties, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-406.

Mullineaux, D. R., 1965b, Geologic map of the Black Diamond quadrangle, King County, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-407.

Mullineaux, D. R., 1965c, Geologic map of the Renton quadrangle, King County, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-405.

Mullineaux, D. R., 1970, Geology of the Renton, Auburn, and Black Diamond quadrangles, King County, Washington: U.S. Geol. Survey Prof. Paper 672, 92 p.

Neumann, Frank, 1957, Crustal structure in the Puget Sound area: Bureau Central Seismologique International Serie A, Travaux Scientifiques, fasc. 20, (Memoires prex a la Conference de Toronto, 1957). (Fig. 6).

Neumann, Frank, 1959, Crustal structure in the Puget Sound area: Internat. Geod. Geophys. Union Assoc. Seismology, Toulouse, France, Ser. A, Travaux Sci., fasc. 20, p. 153-167.

Neumann, Frank, 1963, Crustal structure of the Puget Sound region from seismological evidence [abs.]: Am. Geophys. Union Trans., v. 44, no. 1, p. 212.

Nichols, R. L., 1946, Preliminary report on the King County, Washington, high-alumina clay deposits: U.S. Geol. Survey open-file rept., 41 p.

Noble, J. A., 1948, Evidence for a steepening of geothermal gradients in some deep mines and drill holes: Am. Jour. Science, v. 246, no. 7, p. 438.

Northern Pacific Railway Co., 1941, Tabulated summary of special geologic reconnaissance reports of Washington and northern Idaho: Northern Pacific Railway Co., Land Dept., Geol. Div., p. 1A, 5, 6, 7, 13, 17, 18, 19.

Northwest Mines Handbook.

Northwest Mining Journal, 1906, 1909.

Northwest Mining News, 1907, 1908.

Northwest Mining Truth, 1922.

Ode, W. H.; Selvig, W. A., 1950, Extractable waxes from American lignites: Indus. Eng. Chemistry, v. 42, no. 1, p. 131-135.

O'Donnell, Gretchen, 1913, Bibliography of Washington geology and geography: Washington Geol. Survey Bull. 12, 63 p.

Oles, K. F., 1951, The petrology of the Stevens Pass-Nason Ridge area, Washington: Univ. of Washington M.S. thesis, 92 p.

Oles, K. F., 1956, The geology and petrology of the crystalline rocks of the Beckler River-Nason Ridge area, Washington: Univ. of Washington Ph.D. thesis, 192 p.

Olson, E. A.; Broecher, W. S., 1959, Lamont natural radiocarbon measurements V: Am. Jour. Science, Radiocarbon Supp., v. 1, p. 18.

Pariseau, W. G.; Gooch, A. E., 1960, Geology of the Guye iron deposit, Mammoth group claims, King County, Washington: Univ. of Washington B.S. thesis, 32 p.

Parks, B. C.; O'Donnell, H. J., 1956, Petrology of American coals: U.S. Bur. Mines Bull. 550, p. 2, 7, 26-27, 29, 48-55, 69, 76, 79, 100, 113.

Pask, J. A.; Davies, Ben, 1943, Thermal analysis of clay minerals and acid extraction of alumina from clays: U.S. Bur. Mines Rept. Inv. 3737, p. 22, 23, 25.

Patty, E. N.; Glover, S. L., 1921, The mineral resources of Washington, with statistics for 1919: Washington Geol. Survey Bull. 21, 155 p.

Patty, E. N., 1921, The metal mines of Washington: Washington Geol. Survey Bull. 23, p. 22-28, 52, 300-325.

Pence, W. R., 1946, White River valley of Washington: Univ. of Washington M.A. thesis, 96 p.

Phillips, E. L., 1960, Climatological summary, Snoqualmie Pass, Washington, Station: U.S. Dept. Commerce, Weather Bur., in cooperation with the Washington State Dept. Commerce and Econ. Devel., R 60-20, 2 p.

Phillips, E. L., 1962, Climatological summary, Seattle, Washington, Station: U.S. Dept. Commerce, Weather Bur., in cooperation with the Washington State Dept. Commerce and Econ. Devel., R 62-4, 2 p.

Phillips, E. L., 1965, Climatological summary, Snoqualmie Falls, Washington, Station: U.S. Dept. Commerce, Weather Bur., in cooperation with the Washington State Dept. Commerce and Econ. Devel., R 65-2, 2 p.

Plummer, C. C., 1964, The geology of the Mount Index area of Washington State: Univ. of Washington M.S. thesis, 62 p.

Popoff, C. C., 1945, Green River high-alumina clay deposits, Project 1202, King County, Washington: U.S. Bur. Mines War Minerals Rept. 18, 55 p. [unpublished; on file at Washington Div. Mines and Geology, Olympia].

Potbury, S. S., 1937, The LaPorte flora of Plumas County, California: Carnegie Inst. Washington Pub. 465, p. 57, 58.

Poulson, E. N.; Miller, J. T.; Fowler, R. H.; Flannery, R. D., 1952, Soil Survey of King County, Washington: U.S. Bur. Plant Indus. Soil Survey Ser. 1938, no. 31, 106 p.

Pratt, R. M., 1954, Geology of the Deception Pass area, Chelan, King, and Kittitas Counties, Washington: Univ. of Washington M.S. thesis, 58 p.

Pratt, R. M., 1958, The geology of the Mount Stuart area, Washington: Univ. of Washington Ph.D. thesis, 228 p.

Pratt, V. B., 1939, Geology of the Great Republic mine, and method for concentrating the ore: Univ. of Washington B.S. thesis, 36 p.

Price, C. E.; Liesch, B. A.; Walters, K. L., 1960, Reconnaissance geology and ground-water features of northwest King County, Washington: U.S. Geol. Survey open-file rept., 282 p.

Purdy, C. P., Jr., 1951, Antimony occurrences of Washington: Washington Div. Mines and Geology Bull. 39, 186 p.

Purdy, C. P., Jr., 1954, Molybdenum occurrences of Washington: Washington Div. Mines and Geology Rept. Inv. 18, 118 p.

Reichert, W. H., 1960, Bibliography and index of the geology and mineral resources of Washington, 1937-1956: Washington Div. Mines and Geology Bull. 46, p. 365-371, 647-649, 709.

Reichert, W. H., 1969, Bibliography and index of the geology and mineral resources of Washington, 1957-1962: Washington Div. Mines and Geology Bull. 59, p. 213-218.

Richardson, Donald; Bingham, J. W.; Madison, R. J., 1968, Water resources of King County, Washington: U.S. Geol. Survey Water-Supply Paper 1852, 74 p.

Rigg, G. B., 1958, Peat resources of Washington: Washington Div. Mines and Geology Bull. 44, p. 69-95.

Riley, R. R., 1952, Pacific Northwest clays and shales for possible use as lightweight aggregates: Univ. of Washington M.S. thesis, 72 p.

Riley, R. R.; Mueller, J. I.; Shapiro, H. L., 1953, Lightweight aggregates from Pacific Northwest clays and shales: Univ. of Washington Eng. Expt. Sta. Trend in Eng., v. 5, no. 2, p. 4-9.

Roberts, Milnor, 1902, Denny Clay Company. In Landes, Henry, The non-metalliferous resources of Washington, except coal: Washington Geol. Survey Ann. Rept. 1901, pt. 3, p. 14-17.

Roberts, Milnor, 1917, Ores, coals, and useful rocks of Washington: Univ. of Washington Bull., Gen. Ser. 110, p. 15-17, 20-21, 22, 23, 27-31, 33-35, 40-43, 52-53, 53-55, 63-64, 65, 66, 67, 72, 82-84, 88.

Rubin, Meyer; Alexander, Corrinne, 1960, U.S. Geological Survey radiocarbon dates V: Am. Jour. Science Radiocarbon Supp., v. 2, p. 162-164.

Ruffner, W. H., 1889, A report on Washington Territory: N. Y., [Private report to the Seattle Lake Shore and Eastern Railway] 242 p.

Ruffner, W. H., 1893, The coal fields of Washington. In Parker, E. W., Coal: U.S. Geol. Survey Mineral Resources of the U.S., 1891, p. 334-339.

Russell, I. C., 1900, A preliminary paper on the geology of the Cascade Mountains in northern Washington: U.S. Geol. Survey 20th Ann. Rept., pt. 2, p. 83-210.

Sanderman, L. A.; Utterback, C. L., 1953, Radium content of varved clay: Am. Geophys. Union Trans., v. 34, no. 6, p. 914-920.

Sceva, J. E., 1957, Geology and ground-water resources of Kitsap County, Washington: U.S. Geol. Survey Water-Supply Paper 1413, p. 17-19.

Selvig, W. A.; Ode, W. H.; Parks, B. C.; O'Donnell, H. J., 1950, American lignites; geological occurrences, petrographic composition, and extractable waxes: U.S. Bur. Mines Bull. 482, p. 1, 2, 4, 21, 24, 29-31, 34, 37, 38, 41, 63.

Shapiro, H. E., 1952, Production of lightweight concrete aggregate from Pacific Northwest clays and shales: Univ. of Washington M.S. thesis, 64 p.

Shedd, Solon, 1902, The iron ores of Washington: Washington Geol. Survey Ann. Rept. 1901, v. 1, pt. 4, p. 7, 17, 25-27.

Shedd, Solon, 1910, The clays of the State of Washington; their geology, mineralogy, and technology: Washington State College, Pullman, Washington, p. 237-271.

Shedd, Solon, 1913, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, p. 234, 235, 240.

Shedd, Solon; Jenkins, O. P.; Cooper, H. H., 1922, Iron ores, fuels, and fluxes of Washington: Washington Div. Geology Bull. 27, p. 86-95.

Shedd, Solon, 1924, The mineral resources of Washington, with statistics for 1922: Washington Div. Geology Bull. 30, p. 1-83.

Skougstad, M. W.; Horr, C. A., 1963, Occurrence and distribution of strontium in natural water: U.S. Geol. Survey Bull. 1496-D, p. 65, 68, 69, 76, 81, 90, 94, 97.

Smith, G. O., 1902, Coal fields of the Pacific Coast: U.S. Geol. Survey 22d Ann. Rept., pt. 3, p. 473-513.

Smith, G. O.; Calkins, F. C., 1906, Description of the Snoqualmie quadrangle [Washington]: U.S. Geol. Survey Geol. Atlas, Folio 139, 14 p.

Smith, R. E., 1953, Geology and development at the Alexander mine, Skykomish, Washington: Univ. of Washington B.S. thesis, 31 p.

Smith, W. S.; Carr, D. E., 1912, Geology and economic resources of the Lake Dorothy region, Washington: Univ. of Washington B.S. thesis, 62 p.

Smith, W. S., 1913, Geology and mineral resources of northeastern King County, Washington: Columbia Univ. M.A. thesis, 35 p.

Smith, W. S., 1915, Petrology and economic geology of the Skykomish Basin: School of Mines Quarterly [Columbia Univ., N. Y.], v. 36, p. 154-185.

Smith, W. S., 1916a, Geology of the Skykomish Basin: Columbia Univ. Ph.D. thesis, 70 p.

Smith, W. S., 1916b, Stratigraphy of the Skykomish Basin, Washington: Jour. Geol., v. 24, no. 6, p. 559-582.

Smith, W. S., 1917, Physiography of the Skykomish Basin, Washington: New York Acad. Science Annals, v. 27, p. 205-214.

Smyth, S. K., 1941, Nature and treatment of a gold ore from Lennox Creek, King County: Univ. of Washington B.S. thesis, 44 p.

Snavely, P. D., Jr.; Wagner, H. C., 1963, Tertiary geologic history of western Oregon and Washington: Washington Div. Mines and Geology Rept. Inv. 22, 25 p.

Sohn, I. G., 1952, Geologic environment map of alumina resources of the Columbia Basin: U.S. Geol. Survey Circ. 158, p. 8-13, 14, 16, 17.

Sprunk, G. C.; O'Donnell, H. J., 1942, Mineral matter in coal: U.S. Bur. Mines Tech. Paper 648, p. 3, 47.

Stark, W. J.; Mullineaux, D. R., 1950, The glacial geology of the City of Seattle: Univ. of Washington M.S. thesis, 89 p.

Sterrett, C. K., 1958, Industrial silica for Pacific Northwest industries: Raw Materials Survey [Portland, Oreg.] Resource Rept. 1 [rev. ed.], p. 613.

Stevens, D. L., 1961, A geological investigation of the iron-bearing deposits on Green Mountain, King County, Washington: Univ. of Washington B.S. thesis, 33 p.

Stockwell, C. E., 1961, A geological reconnaissance of the Boring magnetite deposit, King County, Washington: Univ. of Washington B.S. thesis, 32 p.

Storch, H. H.; Hirst, L. L.; Fisher, C. H.; Sprunk, G. C., 1941, Hydrogenation and liquefaction of coal — Part I: U.S. Bur. Mines Tech. Paper 622, p. 3, 61, 70.

Tarr, R. P., 1909, The coal resources of Washington: Mines and Minerals, v. 30, no. 1, p. 17-19; no. 2, p. 108-110; no. 3, p. 135-138; no. 5, p. 311-314.

Tatel, H. E.; Tuve, M. A., 1955, Seismic exploration of a continental crust. In Poldervaart, Arie, editor, Crust of the earth—a symposium: Geol. Soc. America Spec. Paper 62, p. 43-47, 49.

Thoenen, J. R., 1941, Alunite resources of the United States: U.S. Bur. Mines Rept. Inv. 3561, p. 9, 35-36, 38.

Thompson, M. L.; Wheeler, H. E.; Danner, W. R., 1950, Middle and upper Permian fusulinids of Washington and British Columbia: Cushman Foundation for Foram. Research Contr., v. 1, pts. 3 and 4, no. 8, p. 49.

Thorndale, C. W., 1965, Washington's Green River Coal Company, 1880-1930: Univ. of Washington M.A. thesis, 168 p.

Todd, W. A., 1961, Geology of the Bald Hornet claims: Univ. of Washington B.S. thesis, 29 p.

Town, J. W.; McClain, R. S.; Stickney, W. A., 1960, Flotation of low-grade mercury ores: U.S. Bur. Mines Rept. Inv. 5598, p. 19-24, 30-34.

Town, J. W.; Link, R. F.; Stickney, W. A., 1961, Caustic sulfide leaching of mercury products: U.S. Bur. Mines Rept. Inv. 5748, p. 4, 5.

United States Army Corps. of Engineers, 1951, The synthetic liquid fuel potential of Washington: Report for the U.S. Bureau of Mines, p. 44-64, 77-82, United States Bureau of Mines, 1945, Green River high-alumina clay deposits, Project 1202, King County, Washington: U.S. Bur. Mines War Minerals Report 18, 21 p. plus 34-page appendix, 8 maps.

United States Bureau of Mines:

Mineral Resources of the United States [annual commodity data for King County]

1924 Pt. 1, p. 293 (no metallic production), pt. 2, p. 550 (coal), pt. 2, p. 611 (coke and byproducts), pt. 2, p. 191 (fuel briquets).

1925 Pt. 2, p. 418, 508 (coal), pt. 2, p. 556 (coke and byproducts), pt. 2, p. 4 (fuel briquets), pt. 1, p. 558 (no metallic production).

1926 Pt. 2, p. 310 (cement), pt. 2, p. 546 (coal), pt. 2, p. 610, 613 (coke and byproducts), pt. 1, p. 458, 459, 465, 467 (gold, silver, copper), pt. 2, p. 7 (fuel briquets).

1927 Pt. 2, p. 355, 393, 472 (coal), pt. 2, p. 617 (coke and byproducts), pt. 1, p. 592, 595, 597 (gold, silver, lead), pt. 2, p. 7 (fuel briquets).

1928 Pt. 2, p. 345, 358, 360 (cement— producing plants, price, plant capacity), pt. 2, p. 456, 555 (coal), pt. 2, p. 729 (coke and byproducts), pt. 1, p. 692, 700 (no metallic production), pt. 2, p. 7 (fuel briquets).

1929 Pt. 2, p. 406 (cement— new plants), pt. 2, p. 703, 816 (coal), pt. 2, p. 596 (coke and by-products), pt. 2, p. 29 (fuel briquets).

1930 Pt. 2, p. 405 (cement— plants), pt. 2, p. 629 (coal), pt. 2, p. 9 (fuel briquets).

1931 Pt. 2, p. 432, 285 (coal), pt. 2, p. 67 (fuel briquets).

United States Bureau of Mines:

Minerals Yearbook [annual commodity data for King County]

1932-33 [no commodity data given for King County].

1934 p. 648 (fuel briquets— plants), p. 290, 293, 294, 195, 196 (gold, silver, copper, lead); pt. 1 (Statistical Appendix), p. 291, 338 (coal).

1935 p. 715 (fuel briquets), p. 345, 347, 349, 350, 353 (gold, silver, copper, lead); pt. 1 (Statistical Appendix), p. 253, 304 (coal).

1936 p. 653 (fuel briquets— plant).

1937 Pt. 1, p. 816, 864 (coal), p. 960 (fuel briquets), p. 541, 549 (gold, silver, copper).

1938 p. 741 (coal), p. 451, 452, 453, 455, 456, 458 (gold, silver, copper).

United States Bureau of Mines:

Minerals Yearbook [annual commodity data for King County]— Continued

1939 p. 826 (coal), p. 482, 485, 486, 487, 490 (gold, silver, copper, lead).

1940 p. 826 (coal), p. 468, 471, 472, 473, 474, 477; (Review of 1940) p. 466, 469, 470, 471, 473 (gold, silver, copper, lead).

1941 p. 879, 893 (coal), p. 478, 481, 482, 483, 484, 486 (gold, silver, copper, lead).

1942 p. 900 (coal).

1943 p. 932 (coal).

1944 p. 897 (coal).

1945 p. 903 (coal).

1946 p. 311, 337 (coal).

1947 p. 293, 323 (coal).

1948 p. 312, 339 (coal), p. 1619, 1620, 1623, 1624 (silver).

1949 p. 303, 329 (coal).

1950 p. 295, 320 (coal).

1951 p. 340, 348, 373, 386 (coal), p. 1610, 1614, 1615 (gold, silver, copper).

1952 V. 2, p. 84, 111 (coal); v. 3, p. 947 (copper), 952 (gold, silver, copper), 954 (cement, clay), 955 (peat), 956 (silicon), 957 (stone), 958, 959, 961-962 (all commodities).

1953 V. 2, p. 80, 125 (coal); v. 3, p. 1054 (coal), 1055 (copper), 1057 (gold), 1059 (gold, silver, copper), 1063 (cement, clay), 1067 (stone), 1069 (coal , peat), 1071, 1074-1075 (all commodities).

1954 V. 2, p. 92 (coal); v. 3, p. 1105 (copper), 1106 (copper), 1109 (copper, gold, silver), 1110 (gold), 1113 (cement), 1114 (clay), 1115 (sand and gravel), 1118 (coal, peat), 1119, 1122-1123 (all commodities).

1955 V. 2, p. 96 (coal); v. 3, p. 1138 (copper), 1139 (copper), 1142 (gold, silver, copper), 1146 (cement, clay), 1151 (coal, peat), 1153, 1156-1158 (all commodities).

1956 V. 2, p. 96 (coal); v. 3, p. 1205 (copper), 1206 (gold, silver, copper), 1211 (cement, clay), 1212 (clay), 1213 (sand and gravel), 1215 (granite), 1216 (coal), 1218, 1221-1223 (all comodities).

United States Bureau of Mines:

Minerals Yearbook [annual commodity data for King County]— Continued

1957 V. 2, p. 114 (coal); v. 3, p. 1166, 1167 (cement, clay), 1168 (stone), 1174 (mercury), 1175 (coal), 1178, 1180 (all commodities).

1958 V. 2, p. 117; v. 3, p. 999 (clay), 1004 (mercury), 1005 (peat), 1006 (sand and gravel, cement), 1007, 1008 (all commodities).

1959 V. 3, p. 1062 (clay), 1063 (clay, sand and gravel, stone), 1069 (peat), 1070, 1071 (all comodities).

1960 V. 3, p. 1088 (clay), 1089 (sand, gravel), 1090 (stone), 1095 (peat), 1097, 1098 (all commodities).

1961 V. 3, p. 1097 (clay), 1099 (sand and gravel, stone), 1104 (coal), 1106, 1107, 1108 (all commodities).

1962 V. 3, p. 1125 (clay), 1126 (sand and gravel), 1126, 1127 (stone), 1132 (coal), 1133 (peat), 1134, 1135 (all commodities).

1963 V. 3, p. 1150 (clay), 1152 (sand and gravel), 1153 (stone), 1157 (coal and peat), 1159, 1160 (all commodities).

1964 V. 3, 1069, 1070 (clay), 1071 (sand and gravel), 1071, 1072 (stone), 1075 (coal and peat), 1076 (petroleum and natural gas), 1077, 1078, 1079 (all commodities).

1965 V. 3, p. 860 (clay), 861 (sand and gravel), 861, 862 (stone), 865 (coal and peat), 865-866 (petroleum and natural gas), 867-868 (all commodities).

1966 V. 3, p. 825-826 (clay), 826-827 (stone), 830 (coal and peat), 831, 832 (all commodities).

1967 V. 3, p. 832 (all commodities), 836 (cement, clay), 838 (sand and gravel), 838, 839 (stone), 842 (coal, peat, petroleum and natural gas), 843, 844 (all commodities).

1968 V. 3, p. 779 (all commodities), 781 (cement), 781, 782 (clay), 783 (sand and gravel), 783, 784 (stone), 787, 788, 789 (all commodities).

United States Geological Survey:

Mineral Resources of the United States [annual commodity data for King County]

1885 p. 70-71 (coal).

1886 p. 357-374 (coal).

1887 p. 367-373 (coal).

1888 p. 381-385 (coal).

United States Geological Survey:

Mineral Resources of the United States [annual commodity data for King County]— Continued

1889-90 p. 275-276 (coal).

1891 p. 331-333 (coal).

1892 p. 528-531 (coal).

1893 p. 388-390 (coal).

1894 p. 199-201 (coal).

1895 p. 363-364, 526-529 (coal).

1896 p. 460-461, 617-621 (coal).

1897 p. 377-378, 526-529 (coal).

1898 p. 391-392, 495-496 (coal).

1899 p. 420-422, 506-507 (coal).

1900 p. 445-447 (coal).

1901 p. 438-449 (coal).

1902 p. 435-437 (coal).

1903 p. 430-431 (coal), p. 195-196 (gold, silver).

1904 p. 560-563 (coal).

1905 p. 689-691 (coal), p. 331-337 (gold, silver), p. 424 (platinum).

1906 p. 734-736 (coal), p. 363-367 (gold, silver).

1907 Pt. 2, p. 196-197 (coal), pt. 1, p. 469-474 (gold, silver, copper).

1908 Pt. 2, p. 186 (coal), pt. 1, p. 574-579 (gold, silver, copper, lead), pt. 2, p. 789 (mineral waters).

1909 Pt. 2, p. 185-187 (coal), pt. 1, p. 486-490 (gold, silver).

1910 Pt. 2, p. 528-529 (cement), pt. 2, p. 212-215 (coal), pt. 1, p. 598-602, 604 (gold, silver, copper), pt. 2, p. 956 (mineral waters).

1911 Pt. 2, p. 196-197 (coal), pt. 1, p. 779-786 (gold, silver).

1912 Pt. 2, p. 586 (clay), pt. 2, p. 214-217 (coal), pt. 1, p. 915-921 (gold, silver), pt. 2, p. 1130 (mineral waters).

1913 Pt. 2, p. 914-916 (coal), pt. 1, p. 791, 793-796, 798 (gold, silver), 431 (mineral waters), pt. 2, p. 1399, 1404 (stone).

United States Geological Survey:

Mineral Resources of the United States [annual commodity data for King County]— Continued

1914 Pt. 2, p. 735-736 (coal), pt. 1, p. 647 (no metallic production), pt. 2, p. 213 (mineral waters).

1915 Pt. 2, p. 427-428 (coal), pt. 2, p. 342 (mineral waters).

1916 Pt. 2, p. 558 (clay), pt. 2, p. 985-986 (coal), pt. 1, p. 604-612 (gold, silver), pt. 2, p. 498 (mineral waters).

1917 Pt. 2, p. 1040-1042 (coal), pt. 1, p. 494, 496-500, 502 (gold, silver, copper), pt. 2, p. 518 (mineral waters), pt. 1, p. 914 (molybdenum).

1918 Pt. 2, p. 804-805 (coal), pt. 2, p. 1490 (coke), pt. 1, p. 498, 500-501, 503-504, 506 (gold, silver).

1919 Pt. 1, p. 486, 488-493 (gold, silver, copper).

1920 Pt. 1, p. 59 (arsenic), pt. 2, p. 395, 397 (coke and byproducts), pt. 2, p. 91 (fuel briquets), pt. 1, p. 262-264, 266-267 (gold, silver).

1921 Pt. 2, p. 391 (coke and byproducts), pt. 2, p. 4 (fuel briquets), pt. 1, p. 425-426 (no metallic production).

1922 Pt. 2, p. 661-663 (coal), pt. 1, p. 248, 250, 252, 254 (gold, silver).

1923 Pt. 2, p. 738-739 (coal), pt. 1, p. 411-413 (no metallic production).

United States Geological Survey, 1937, Plan and profile of Green River from a point 4 miles above mouth to mile 9, and dam sites; scale: 1:31,680.

United States Geological Survey, 1941, Plan and profile of North Fork of Tolt River and South Fork of Tolt River including Tokul Creek, and dam sites, 3 sheets; scale: 1:31,680.

United States Geological Survey, 1947, Plan of Green River and tributaries from Kanaskat to Humphrey, and Sunday Creek to Tacoma Creek, and dam sites, 2 sheets; scale: 1:24,000.

United States Geological Survey, 1954, Plan and profile of Hancock Creek and Hancock Lake, and dam site; scale: 1:12,000.

United States Geological Survey, 1957, Plan and profile of South Fork Skykomish River, and dam site, 1 sheet; scale: 1:24,000.

United States Geological Survey, 1957, Plan of Lake Isabel and Dorothy Lake, and dam sites, 1 sheet; scale: 1:12,000.

United States Geological Survey, 1962, Geologic studies in Washington. In Geological Survey Research 1962; synopsis of geologic, hydrologic, and topographic results: U.S. Geol. Survey Prof. Paper 450-A, p. 48, 1962.

United States Geological Survey, 1962, Urban geology. In Geological Survey Research 1962; synopsis of geologic, hydrologic, and topographic results: U.S. Geol. Survey Prof. Paper 450-A, p. 104.

United States Geological Survey, 1966, Mineral and water resources of Washington: Washington Div. Mines and Geology Reprint 9; Committee Print of the 89th U.S. Congress, 2d Sess., 436 p.

United States Public Health Service, 1964, 1963 Inventory of municipal water facilities, region 9 (Alaska, Arizona, California, Hawaii, Neveda, Oregon, Washington): U.S. Public Health Service Pub. 775, v. 9 (revised), p. 129-151.

United States Weather Bureau River Forecast Center [Portland, Oregon], 1965, Mean annual precipitation, 1930-1957, State of Washington: U.S. Soil Conservation Service and U.S. Weather Bureau, map sheet.

Valentine, G. M., 1960, Inventory of Washington minerals, Part I— Nonmetallic minerals, 2d ed., revised by M. T. Huntting: Washington Div. Mines and Geology Bull. 37, pt. I, 175 p.

Van Ornum, M. H., 1937, Geology and mining of Coney Basin mine: Univ. of Washington B.S. thesis, 53 p.

Van Orstrand, C. E., 1939, Observed temperatures in the earth's crust. In Gutenberg, Beno, editor, Physics of the earth—7, internal constitution of the earth: McGraw-Hill, New York, p. 137, 144-146.

Victor, F. F., 1891, Atlantis arisen: J. B. Lippincott Company, Philadelphia, p. 386-387, 390.

Vine, J. D., 1962a, Preliminary geologic map of the Hobart and Maple Valley quadrangles, King County, Washington: Washington Div. Mines and Geology Geol. Map GM-1.

Vine, J. D., 1962b, Stratigraphy of Eocene rocks in a part of King County, Washington: Washington Div. Mines and Geology Rept. Inv. 21, 20 p.

Voskuil, W. H.; Tryon, F. G.; Bennit, H. L., 1932, Coke and by-products: U.S. Bur. Mines Mineral Resources of the U.S., 1930, pt. 2, p. 511.

Wake, G. T., 1941-42, State of Washington— coal production reports [monthly reports]: Washington State Office State Mine Inspector Coal Production Rept., 2 p. each.

Waldron, H. H., 1961a, Geology of the Des Moines and Poverty Bay quadrangles, Washington: U.S. Geol. Survey open-file rept., 2 maps and 2 explanation sheets.

Waldron, H. H., 1961b, Geology of the Poverty Bay quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-158.

Waldron, H. H., 1962, Geology of the Des Moines quadrangle, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-159.

Waldron, H. H.; Liesch, B. A; Mullineaux, D. R.; Crandell, D. R., 1962, Preliminary geologic map of Seattle and vicinity, Washington: U.S. Geol. Survey Misc. Geol. Inv. Map I-354.

Waldron, H. H., 1967, Geologic map of the Duwamish Head quadrangle, King and Kitsap Counties, Washington: U.S. Geol. Survey Geol. Quad. Map GQ-706.

Warren, W. C., 1941, Relation of the Yakima Basalt to the Keechelus andesitic series: Jour. Geology, v. 49, p. 795-814.

Warren, W. C.; Norbisrath, Hans; Grivetti, R. M.; Brown, S. P., 1945, Preliminary geologic map and brief description of the coal fields of King County, Washington: U.S. Geol. Survey Prelim. Map.

Washington Bureau of Statistics, Agriculture and Immigration, 1903, State of Washington Mines and Mining: Washington Bur. Statistics, Agri., and Immigration Bienn. Rept. 1903, p. 124-138.

Washington Department of Commerce and Economic Development, 1959, Value of mineral production in Washington, 1956-57 by counties: Washington Dept. Commerce and Econ. Dev. Econ. Data Series 18, 1 p.

Washington Department of Commerce and Economic Development. Business and Economic Research Division, 1961, A brief summary of the existing market for peat moss in Pacific Northwest States: Published by author, Olympia, p. 3, 8, 9.

Washington Department of Commerce and Economic Development. Business and Economic Research Division, 1961, The case for manufacturing expanded shale lightweight aggregate from Washington resources: Published by author, Olympia, p. 5, 7, 10-12.

Washington Department of Commerce and Economic Development. Business and Economic Research Division, 1969, Directory of Washington State Manufacturers Guide: Published by author, Olympia, 374 p.

Washington State Mine Inspector, 1918, 1919, Annual report of coal mines: Washington State Mine Inspection Dept.

Washington State Mine Inspector, 1921-1922 (fiscal), 1927-1962, Annual report of coal mines: Washington State Dept. of Labor and Industries.

Washington State Mine Inspector, 1963-1966, Annual coal production report: Washington State Dept. of Labor and Industries.

Waters, A. C., 1961, Keechelus problem, Cascade Mountains, Washington: Northwest Science, v. 35, no. 2, p. 44.

Weaver, C. E., 1912a, Geology and ore deposits of the Index mining district: Washington Geol. Survey Bull. 7, 96 p.

Weaver, C. E., 1912b, A preliminary report on the Tertiary paleontology of western Washington: Washington Geol. Survey Bull. 15, 80 p.

Weaver, C. E., 1915, The possible occurrence of oil and gas fields in Washington: American Inst. Mining Eng. Trans., p. 1422.

Weaver, C. E., 1916a, Tertiary faunal horizons of western Washington: Univ. of Washington Pubs. in Geology, v. 1, no. 1, p. 3, 6, 8, 15, 16, 17, 18.

Weaver, C. E., 1916b, The Tertiary formations of western Washington: Washington Geol. Survey Bull. 13, 327 p.

Weaver, C. E., 1937, Tertiary stratigraphy of western Washington and northwestern Oregon: Univ. of Washington Pubs. in Geology, v. 4, 266 p.

Weaver, C. E., 1938, Geology and its relation to the occurrence of oil in Washington: Univ. of Washington Eng. Expt. Sta. Ser., Bull. 98, p. 13.

Weaver, C. E., 1944, Correlation of the marine Cenozoic formations of western North America: Geol. Soc. America Bull., v. 55, p. 594.

Weis, P. L.; Armstrong, F. C.; Rosenblum, Samuel, 1958, Reconnaissance for radioactive minerals in Washington, Idaho, and western Montana, 1952-1955: U.S. Geol. Survey Bull. 1074-B, p. 31.

White, C. A., 1888, On the Puget Group of Washington Territory: Am. Jour. Science, 3d ser., v. 36, p. 443-450.

Whittier, W. H., 1917, An investigation of the iron ore resources of the northwest: Univ. of Washington, Bur. Indus. Research Bull. 2, p. 25-26.

Williams, Albert, 1883, Coal: U.S. Geol. Survey Mineral Resources of the United States, p. 95-98.

Williams, Albert, 1885, Coal: U.S. Geol. Survey Mineral Resources of the United States, 1883 and 1884, p. 99-100.

Willis, Bailey, 1886, Report on the coal fields of Washington Territory: U.S. House Representatives, 47th Cong., 2d Sess., Misc. Doc., v. 13, pt. 15 (Misc. Doc. 42, pt. 15) (Serial Set 2145), p. 759-771.

Willis, Bailey, 1898a, Some coal fields of Puget Sound: U.S. Geol. Survey Ann. Rept. 18, pt. 3, p. 393-436.

Willis, Bailey, 1898b, Drift phenomena of Puget Sound: Geol. Soc. America Bull., v. 9, p. 111-162.

Willis, Bailey; Smith, G. O., 1899, Description of the Tacoma quadrangle [Washington]: U.S. Geol. Survey Geol. Atlas, Folio 54, 10 p.

Wilson, Hewitt, 1923, The clays and shales of Washington; their technology and uses: Washington Univ. Eng. Expt. Sta. Ser., Bull. 18, 224 p.

Wilson, Hewitt; Goodspeed, G. E., 1934, Kaolin and china clay in the Pacific Northwest: Univ. of Washington Eng. Expt. Sta. Ser., Bull 76, p. 98-100.

Wilson, Hewitt; Skinner, K. G.; Couch, A. H., 1942, Silica sands of Washington: Univ. of Washington Eng. Expt. Sta. Bull. 108, 76 p.

Wimmler, Norman, 1908, Geology of the east side of the Duwamish Valley, King County, Washington: Univ. of Washington B.S. thesis, 14 p.

Wodzicki, Antoni, 1963, Geology of the Green River area, central Cascades, Washington, with appendix by Glen A. Boyd and H. T. Mitten: Northern Pacific Railway Co., Geol. Div. unpublished rept., 21 p.

Wolcott, E. E., 1961, Lakes of Washington: Washington Div. Water Resources Water Supp. Bull. 14, v. 1, p. 85-201.

Wolfe, J. A.; Gower, H. D.; Vine, J. D., 1961, Age and correlation of the Puget group, King County, Washington. In Short papers in the geologic and hydrologic sciences . . . ; Geological Survey Research 1961: U.S. Geol. Survey Prof. Paper 424-C, article 233, p. 230-232.

Wolfe, J. A., 1968, Paleogene biostratigraphy of nonmarine rocks in King County, Washington: U.S. Geol. Survey Prof. Paper 571, 33 p.

Yancey, H. F.; Daniels, Joseph; McMillan, E. R.; Geer, M. R., 1943, Byproduct coke-oven tests of Washinton coals: U.S. Bur. Mines Rept. Inv. 3717, p. 6-9, 10.

Yeats, R. S., Jr., 1956, Petrology and structure of the Mount Baring area, Northern Cascades, Washington: Univ. of Washington M.S. thesis, 78 p.

Yeats, R. S., 1958, Geology of the Skykomish area in the Cascade Mountains of Washington: Univ. of Washington Ph.D. thesis, 243 p.

Yerkes, L. A.; Fursman, O. C., 1961, Refining crude aluminum by the subhalide reaction: U.S. Bur. Mines Rept. Inv. 5773, p. 4.

Young, G. E., 1924, Workable clay deposits in the City of Seattle: Univ. of Washington B. S. thesis, 23 p.

Zapffe, Carl, 1949, A review, iron-bearing deposits in Washington, Oregon, and Idaho: Raw Materials Survey [Portland, Oreg.] Rept. 5, 89 p.

Anonymous, 1941, Aluminum from alunite: Mining World, v. 3, no. 2, p. 26.

Anonymous, 1944, Bauxitic clay bed found in Washington by the U.S. Bureau of Mines: Mining World, v. 6, no. 2, p. 33.

Anonymous, 1946d, Precipitates— Northwest; reports on Washington clay deposits released: Mining World, v. 8, no. 3, p. 30.

Anonymous, 1962, Tally of wells drilled, county by county: Oil and Gas Jour., v. 60, no. 5, p. 194.