

DIVISION OF MINES AND GEOLOGY

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BIENNIAL REPORT NO. 11

PART I

ADMINISTRATION

The following report applies to the organization and activities of the Division of Mines and Geology, Department of Conservation, for the period July 1, 1964 to June 30, 1966.

HISTORY OF THE DIVISION

Geologic investigations as a function of the State Government were established by the first State Legislature in 1890, with office in Tacoma. After 2 years work was discontinued for lack of appropriations. It was resumed in 1901 with the establishment of the Board of Geologic Survey. For 20 years the office of the Washington Geological Survey was maintained at the University of Washington, Seattle. On April 1, 1921, the Administrative Code was adopted by the Legislature, and the duties and functions of the Board of Geologic Survey devolved upon the Director of the Department of Conservation and Development, the activities to be carried on by the Division of Geology. Throughout the 24-year period from 1921 to 1945 the Divisional office was maintained at the State College of Washington, Pullman.

In 1935 the Legislature passed the Mines and Mining Act, whereby the Director of the Department of Conservation and Development was given the duty, through an appointed supervisor, of carrying on what, in effect, were nearly the identical activities of the original State Geologic Survey and its successor agency, the Division of Geology. The office was in the quarters of the Department of Conservation and Development, Olympia.

For 4 years thereafter (from November 1, 1941 to October 1, 1945) these two divisions of the Department of Conservation and Development were concurrently engaged in the investigation of the State's mineral resources, studying all phases of geology that were prerequisites to a proper understanding of our mineral deposits, preparing reports for publication, and aiding in every possible way in the development and utilization of these natural resources. Through careful collaboration and coordination of activities the two supervisors prevented a duplication of field investigations and a waste of funds. However, it was impossible to operate the separate offices without a considerable amount of duplication in the matter of files, records, library, and laboratory facilities, and without some inconvenience to the public who were unaware of which office had the particular data desired.

On October 1, 1945, therefore, the two divisions were combined by administrative order. All files, records, field notes, reports, maps, library volumes, and bulletins of the Division of Geology were moved to Olympia and there added to the similar material of the Division of Mines and Mining.

DUTIES OF THE DIVISION

The Division of Mines and Geology is a service agency that has the responsibility of compiling and distributing information on the mineral resources, mineral industries, and geology of Washington. Regulatory activities of the Division are limited to those in the field of oil and gas exploration and production, as required under the Oil and Gas Conservation Act of 1951 (RCW 78.52.001 to 78.52.550).

The Division has the following duties and responsibilities as set out in RCW 43.21.070 and 43.92.010 to 43.92.080:

- (1) To examine the metallic and nonmetallic mineral deposits of the State.
- (2) To prepare and distribute, at cost of printing, geologic and mineral-resource reports and maps.
- (3) To collect, compile, publish, and disseminate statistics and information about mining, milling, and metallurgy.
- (4) To collect and assemble an exhibit of mineral specimens.
- (5) To assemble a library pertaining to mining, milling, metallurgy, and geology.
- (6) To make determinative examinations of ores, minerals, and rocks for the public.
- (7) To administer the Oil and Gas Conservation Act, regulating drilling and production of oil and gas.
- (8) To cooperate with the U. S. Geological Survey in making topographic and geologic maps and to cooperate with the U. S. Bureau of Mines and with all departments of the State Government.

ACTIVITIES OF THE DIVISION

The Division is engaged in fundamental and applied research, the purpose of which is to serve the mineral industries and the public in developing a better knowledge and understanding of the geology and a more complete utilization of the mineral resources of the State.

The statutory duties are broadly defined, providing the flexibility necessary for the proper functioning of the Division in accordance with changing economic conditions, new trends in minerals utilization, and changing demands for mineral-resource and geologic information. In formulating plans for the Division's investigative programs, it is always helpful to have the suggestions and recommendations of professional and technical people in the minerals industries. Especially valuable during the past biennium have been the recommendations of the Industrial Raw Materials Advisory Committee to the Washington Department of Commerce and Economic Development. Some of the recommendations of this committee, although directed to the Commerce Department, were for mineral resource surveys, which are a function of the Division of Mines and Geology of the Department of Conservation.

The activities of the Division in fulfilling its statutory duties are described in the following paragraphs.

MINERAL DEPOSIT EXAMINATIONS

Division geologists during the biennium continued to acquire information on the metallic and nonmetallic mineral deposits in the State. Field studies were made of known mineral deposits, new deposits were sought out, and reported occurrences were investigated. Field examinations were made of

deposits of copper, gold, iron, lead, mercury, nickel, uranium, zinc, barite, bauxite, black sand, clay, coal, diatomite, limestone, olivine, peat, pumice, saline compounds, sand and gravel, and silica. Most field studies served the dual purpose of adding to our fund of information on the State's mineral resources and aiding the prospector or owner of the claim on which the mineral deposit was located. Most of the examinations were of a preliminary nature, but some were in more detail. In examining mineral deposits at the request of their owners, Division geologists take great care not to encroach upon the field of the consulting engineer or geologist. In accordance with this policy, oral advice is given but written reports are not made for individual claim owners.

MINING AND MILLING STATISTICS

The Division cooperates with the U. S. Bureau of Mines in collecting production data on all minerals produced in Washington. These data are published in the annual Minerals Yearbooks of the Bureau of Mines. Reprints of the Washington chapter on mineral production are available from the Bureau.

At least once in each 2 years, Division geologists visit the State's active mining operations—metallic, nonmetallic, and sand and gravel—in order to compile the Directory of Washington Mining Operations. These directories are among the most popular reports published by the Division.

MINERAL EXHIBITS

A rather complete labeled collection of all metallic and nonmetallic minerals of known economic importance is maintained in the Division office for the use of prospectors, miners, and industrialists. Also included in the display are mineral substances that may have future value but that are not now being mined.

Characteristic samples from mineral deposits and geologic formations throughout the State are collected during the course of field work. In the office they are classified and added to an extensive collection of several thousand specimens that is maintained for staff reference and for the use of visiting geologists who may be working in the State. An attractive collection of fluorescent minerals and a small collection of agates and other specimens of interest to hobbyists are on display for anyone wishing to refer to them. A special display of uranium minerals is maintained. Two sets of minerals and rocks are kept in special traveling cases for occasional display at expositions or to illustrate talks made before various groups and organizations. A supply of bulk minerals and rocks is used to fill requests for samples.

Samples of cuttings and cores from oil and gas test wells are collected, examined, labeled, and added to an extensive collection of similar materials maintained for study and reference. These samples are of particular value to the geologists of companies exploring for oil in the State.

LIBRARY

A fairly large, specialized reference library of approximately 14,000 publications is maintained for the use of the staff, other State agencies, and for public reference. It includes authoritative texts on mining, metallurgy, mineral resources, and geology, and nearly complete collections of the reports of the U. S. Geological Survey and U. S. Bureau of Mines. Included also are pertinent reports of the U. S. Atomic Energy Commission and other Federal agencies, as well as the publications of Canadian and other foreign

geological surveys and the reports of other state geological surveys and mining bureaus. The U. S. Geological Survey and the U. S. Bureau of Mines place unpublished reports on Washington areas and mineral deposits on open file for public inspection in the Division library. The Division subscribes to a number of geology, mining and metallurgy, and oil periodicals to assist staff members in keeping informed of current developments in those fields and for the benefit of anyone else who may wish to consult the publications in the Division offices.

Full sets of all topographic maps of Washington are maintained for the use of the staff and for public reference. Similarly available are aerial mosaics, planimetric maps, special geologic maps, mine maps, and various other maps. The Division's map collection is constantly being enlarged.

Most of the library material is acquired without cost on an exchange basis from other State and Federal agencies and from educational institutions. A few volumes are acquired by private donations. Library acquisitions are increasing rapidly as a result of increased mineral-resource exploration activity nationally and publication of the results of these studies, and as a result of greatly increased numbers of publications distributed by the Federal agencies and other state geological surveys.

MINERAL IDENTIFICATION SERVICE

The Division provides a free mineral identification service for the public. Samples of ores, rocks, minerals, and clays from Washington localities are examined and identified. The senders are advised of the possible value of submitted samples, and suggestions are given for further prospecting or analysis whenever such action appears warranted. Through this service new occurrences of potential value are occasionally found and brought to the attention of those who are seeking new sources of mineral raw materials in the State. Sample identification does not include assays or quantitative chemical analyses, as these services are available from commercial concerns.

During the biennium the Division of Mines and Geology received and reported upon 720 samples. This indicates an active interest in Washington's mineral resources and shows public dependence upon help and advice from the Division in developing these resources.

The laboratory of the Division is equipped for most of the mineralogical studies required. Equipment consists of a diamond saw and laps for making thin sections and polished sections of rocks and ores; binocular, petrographic, and metallographic microscopes; a small laboratory electric furnace for high-heat tests; an electric drying oven; a spectrograph and densitometer for qualitative and quantitative examinations of rock and mineral specimens; blowpipe equipment for qualitative tests; sieves for making screen analyses of sands; laboratory crusher and grinder; a Superpanner; Geiger counters and a scintillation detector for radiometric tests of uranium-bearing samples; ultra-violet lamps for fluorescence tests; X-ray unit; and a high-intensity magnetic separator.

A piece of equipment greatly needed for use in identification of minerals and rocks is an X-ray diffractometer, which attaches to the X-ray unit. This tool is especially useful in identifying small grains of intermixed minerals in ore, mill concentrates, drilled cores, and exploration samples.

OIL AND GAS

Since the early 1930's the Division has collected and cataloged all available information on the progress and results of oil and gas test drilling. These data are on open file for all geologists and oil men who desire to see or copy them.

In 1951 the Oil and Gas Conservation Act was passed by the Legislature. The Act and the rules and regulations drawn up under its authority govern the drilling, testing, and other operations that comprise exploration and production of oil and gas in Washington. In January, 1954 the Oil and Gas Conservation Committee appointed the Supervisor of the Division of Mines and Geology to be Oil and Gas Supervisor for the State and gave him the duty of administering the Act.

From January 18, 1954, through June 30, 1966, a total of 214 drilling permits were issued, of which 20 were issued during the 1964-66 biennium. This is a decrease of eight permits from that of the preceding biennium. This drop is largely accounted for by the temporary shift of interest by major companies from onshore to offshore exploration.

The Oil and Gas Conservation Act and rules and regulations require that all logs, drilling histories, cuttings and core descriptions, and records of tests that are made for each well must be filed with the Oil and Gas Supervisor (who is Supervisor of the Division of Mines and Geology) within 30 days after completion or abandonment of the well (6 months are allowed for filing electric logs). These logs are kept confidential for a period of 1 year after the filing deadline, after which they are released for public inspection.

No new personnel were hired when the administration of the Oil and Gas Conservation Act was turned over to the Division in 1954. In order to provide some of the greatly increased services demanded by oil and gas exploration groups, the Division needs funds to hire a laboratory helper full time rather than part time as at present.

REPORTS PUBLISHED

- Mineralogy of Black Sands at Grays Harbor, Washington, by Gerald W. Thorsen, Report of Investigations 23, 29 pages, 6 figures. 50¢.
- Origin of Cascade Landscapes, by J. Hoover Mackin and Allen S. Cary, Information Circular 41, 35 pages, 11 figures. 50¢.
- 1964 Directory of Washington Mining Operations, by Wayne S. Moen and Gerald W. Thorsen, Information Circular 42, 86 pages, 3 maps. Free.
- Mineral and Water Resources of Washington, prepared by the U. S. Geological Survey in cooperation with the Washington State Department of Conservation, Division of Mines and Geology and other agencies, Reprint 9, a reprint of a Report to the United States Senate Committee on Interior and Insular Affairs, 436 pages, 90 figures. \$2.00.
- Washington Mineral Deposits, by Marshall T. Hunting, Reprint 10, reprinted from Canadian Institute of Mining and Metallurgy Special Volume No. 8, 6 pages, 1 figure. 50¢.
- Biennial Report 10 of the Division of Mines and Geology, July 1, 1962-June 30, 1964, 18 pages. Free.
- Geochemical maps and analyses for parts of Whatcom, Snohomish, King, Pierce, Lewis, and Skamania Counties, by Wayne S. Moen. These maps and analysis reports were open-filed in May 1966. Copies may be made at private expense.

Mineral alteration zones in the North Cascade Mountains, by Marshall T. Hunting. This map was open-filed in April 1966. Copies may be made at private expense.

A publications list is available from the Division. Listed are all the Bulletins, Reports of Investigations, Information Circulars, administrative reports and reprints that have been published by the Division of Mines and Geology and its predecessor agencies.

PROJECTS IN PROGRESS

In addition to the projects described above that were completed during the biennium, the following projects were in progress and reports on most of these were in preparation:

Geology and Mineral Resources of the South Half of the Colville Quadrangle, Stevens County, Washington, by W. A. G. Bennett. Field work for this study was essentially completed during the last biennium. A small amount of additional field work was accomplished during this biennium. It is expected that the geologic map and report will be completed and published during the next 2 years.

Geology and Mineral Resources of the Kelso-Cathlamet Area, by Vaughn E. Livingston, Jr. A mineral resource not now being utilized but having very great potential value is the iron-rich bauxite that occurs in northwestern Oregon and in the Kelso-Cathlamet area in Washington. Geologic mapping to outline the areas that are favorable for the occurrence of this material was conducted and ten core holes were drilled during a previous biennium. Preparation of the report of this work was continued during this biennium, and the report should be ready to send to the printer soon after the end of the biennium.

Geology of the Northern Cascade Mountains, by Peter Misch, professor of geology at the University of Washington. Dr. Misch, in a period of about 20 years, has mapped, almost singlehandedly, an area of more than 2,000 square miles in the northern Cascades, the most rugged and inaccessible terrain in the State. The Division is pleased to have arranged to publish his maps and a report describing the rocks in this area. The report and maps are in preparation and should be ready for publication some time during the 1966-68 biennium.

Geology and Mineral Resources of the Methow Quadrangle, Okanogan County. Dr. Julian D. Barksdale, professor of geology at the University of Washington, has devoted many years to the study of the geology of a large area in Okanogan County, including the area within the Methow quadrangle, and the Division has made arrangements to publish his geologic map and report on the geology of the area. In 1959, G. W. Thorsen examined most of the known mineral deposits in the area, and the results of his examinations also will be published. The U. S. Bureau of Mines has cooperated by compiling a record of production for all the mines in the area.

Limestone in Washington—an investigation to determine the size and quality of stone available in the largest and most accessible deposits in both eastern and western Washington. The deposits are concentrated in the northern tier of counties from San Juan to Pend Oreille. Two geologists and five field assistants were assigned to the job. The western Washington

survey was supervised by Dr. W. R. Danner, professor of geology at the University of British Columbia, and the eastern Washington survey by Dr. Joseph W. Mills, Chairman, Department of Geology at Washington State University. Topographic and geologic maps of the best deposits were made. About 750 samples were taken for complete chemical analysis. Field work was done in 1959 and was continued and completed in the fall of 1960. The results of the survey will be published in two reports. The first of these reports, "High-Calcium Limestones of Eastern Washington," by Joseph W. Mills, was published during the last biennium. The western Washington report was in preparation during the current biennium, and the manuscript was sent to the printer just prior to the end of the biennium.

Stratigraphy and Foraminifera of the Satsop River area, southern Olympic Peninsula, Washington, by Weldon W. Rau. This study records basic geologic data heretofore unavailable to the public. It will make possible a more accurate and complete interpretation of possible oil-bearing strata of southwestern Washington. The report is completed and is to be printed early in the coming biennium.

Geology of the Wynoochee Valley quadrangle, by Weldon W. Rau. Field and laboratory studies of the rock strata and contained fossils were continued throughout the biennium. This study will provide a comprehensive report and geologic map of the area. Such information is particularly desirable in connection with oil and gas exploration because substantial shows of petroleum in eight test wells drilled within the area indicate that the area is favorable for the production of oil and gas.

Bibliography and Index of the Geology and Mineral Resources of Washington, 1957-1962, by William H. Reichert. This is part of a continuing project to maintain an up-to-date bibliography and index to articles, both published and unpublished, on geology and mineral resources of the State. This report will be completed and published during the next 2 years.

Building Stone of Washington, by Wayne S. Moen. Decorative stone for use in buildings, floors, patios, etc., has become more and more popular in recent years, and the need for information about the sources of such stone in Washington has become quite apparent. An appraisal of the building and decorative stone industry in the State and an examination of Washington stone deposits were completed during the biennium. A report of this work should be published some time in 1966.

Geology and Mineral Resources of the East Half of the Kettle Falls Quadrangle, Stevens County, Washington, by Joseph W. Mills. Field work was commenced in 1961 and continued through 1964. A geologic map and report of this work should be completed and ready to print some time in 1967.

Mineral Resources of King County, by Vaughn E. Livingston, Jr. Mineral production in King County leads that of all other counties in Washington. An investigation of these resources was started during the last biennium, but because of other demands on the investigator's time it may be several years before the project is completed.

Mineral Resources of Whatcom County, by Wayne S. Moen. A knowledge of the mineral resources of Whatcom County is of particular importance

at the present time so that the data can be used in evaluating various recommendations for the management of Federal lands in the North Cascade Mountains that are in the county. Field investigations were started early in the biennium, and a report of the work was nearly completed at the end of the 2-year period. The report should be ready for publication some time in 1967.

Andalusite Deposits in Stevens County, by Gerald W. Thorsen. Field work for this report was done during the biennium as part of geologic studies in connection with a Master of Science thesis project. A report of this work should be ready for publication during the coming biennium.

Ore Deposit Controls in the Northern Cascade Mountains, by Alan R. Grant. Mr. Grant was hired as a special consultant to make field and laboratory investigations into the environmental conditions that acted to control the deposition of ore minerals in the Cascades. This is a continuation of work of a similar nature that he had been conducting during the previous 6 years as a geologist for a major mining company. A report of his findings is due during the first part of 1967.

Mineral Resources of the Puget Sound Basin, by Vaughn E. Livingston, Jr. A Task Force of Federal and State agency personnel is studying the resources and present and projected future resource requirements in the area adjacent to Puget Sound to make plans for water-resource management in the area. The Division was called upon to furnish a report and maps showing locations of and giving brief descriptions of the more important mineral resources in the area. The report and maps were completed during the biennium and will be used in an appendix to the Task Force report, Puget Sound and Adjacent Waters study.

Geochemical Investigations in Washington, by Wayne S. Moen. Late in the last biennium a small start was made on a reconnaissance geochemical survey to determine the copper, lead, zinc, and molybdenum contents of stream sediment samples in the areas of the State in which it is expected that ore deposits may be found. More than 550 samples were collected and analyzed. Some of these showed results which indicated that additional sampling should be done. The maps and analyses were released for public inspection and use. Additional sampling and analyses will be completed during the next 2 years.

1966 Directory of Washington Mining Operations, by Wayne S. Moen. Every 2 years the Division publishes a directory of the active mining properties in the State. These directories are among the most popular reports published by the Division. Compilation of data for this report is continued throughout the biennium.

Pegmatites in Washington, by Ted Ross. All the known pegmatite deposits in the State were examined in detail in the field and in the laboratory in 1963 and 1964 by Mr. Ross, a candidate for the degree of Doctor of Philosophy in Geology at Washington State University. The field examinations were financed in part by the Division. Additional laboratory work was done during the biennium, and a detailed report is expected to be ready for publication some time in 1967.

COOPERATIVE PROJECTS

Topographic Mapping

The Division continued to cooperate with the U. S. Geological Survey in topographic mapping within the State. The mapping is conducted by the Survey, the State contributing half of the funds through a cooperative, matching agreement. Additional topographic mapping is carried on and paid for solely by the Federal agency.

As a part of our continuing cooperative topographic mapping program with the U. S. Geological Survey, work was continued during the biennium on five 15-minute quadrangles, the mapping of which was started during previous bienniums. Two new map projects were started early in 1965. The names, locations, and estimated publication dates of these maps are:

<i>Names of quadrangles</i>	<i>Counties in which located</i>	<i>Estimated publication date</i>
Mazama	Okanogan	1
Doe Mountain	Okanogan	1
Chiwaukum 4	Chelan	December 1966
Chiwaukum 3	Chelan	June 1967
Chiwaukum 2	Chelan	June 1967
Colville 4	Stevens	June 1969
Tieton Reservoir	Yakima	June 1969

¹Published during the biennium.

Also during the biennium seventy-nine 7½-minute quadrangles and fifteen 15-minute quadrangles were completed and published by the U. S. Geological Survey using Federal funds only.

The first topographic quadrangle map in Washington was published in 1895 by the U. S. Geological Survey. In order to speed up the mapping program, the State Legislature of 1903 authorized expenditure of State funds on a 50-50 matching basis, and the Legislature of 1909 appropriated \$10,000 for this purpose. Since that time the State has provided matching funds almost every year. The total amount expended from 1909 through 1966 is \$499,443, and 80 quadrangle maps have been completed or are in progress under this cooperative program. In spite of greatly increased mapping in recent years by the U. S. Geological Survey independent of the cooperative program, there still remain large areas in the State for which no topographic maps are available, and there are other large areas for which the available maps are of inadequate scale or accuracy.

Geologic Mapping

An agreement was first made with the U. S. Geological Survey to conduct geologic mapping in Washington on a cooperative basis in 1958. The work was done by geologists of the Federal agency, and the cost was shared equally by the State and the Federal government.

The first year's contract provided for mapping that was used in the compilation of the State Geologic Map that was published in 1961. Later contracts initiated studies that resulted in the publication by the Division of Mines

and Geology of a bulletin detailing the coal reserves of Washington, a report on the stratigraphy of coal-bearing rocks in King County, and two geologic maps with brief texts describing coal- and clay-producing areas in King County.

In July 1963 three new geologic mapping projects were started—the Grays River quadrangle in Pacific County (an area of interest primarily for its potential for oil and gas and nonmetallic mineral development), the Loomis quadrangle in Okanogan County and the Chewelah 1 quadrangle in Stevens County. The last two areas were chosen for investigation because of the diverse, widespread mineralization present in these areas; the geologic field work was completed by the end of the biennium. Geologic maps and reports of these areas will be published by the Division. Geologic mapping was commenced late in the biennium in the Conconully quadrangle, which is adjacent to the southern edge of the Loomis quadrangle. It is tentatively planned that the Division will publish a report of a geochemical investigation of the Loomis and Conconully quadrangles and the adjacent Oroville and Tonasket quadrangles. This geochemical field work should be completed in 1966. The Grays River project required a small amount of additional field work in 1966 after the end of the biennium. Upon completion of the field work it is anticipated that a map and brief text will be published.

Other Cooperative Projects

Cooperation is maintained with the U. S. Bureau of Mines in the collection of mineral-production statistics in Washington. Information on mining operations and mineral producers, obtained separately by the Bureau and the State Division of Mines and Geology, is exchanged in the interest of complete coverage. Assistance is given the Bureau in exchange for copies of detailed production records. The Bureau has tested samples of bauxite collected by Division geologists in conjunction with geologic mapping projects described on previous pages.

In 1965 the Division cooperated with the Bureau of Mines in an investigation of materials in Washington that might be suitable for use as pozzolan. Division geologists made brief field examinations and collected samples from 14 deposits. These samples will be tested by the Bureau, and the results will be reported in a publication on pozzolan resources of the United States.

The Division cooperates with the U. S. Coast and Geodetic Survey by maintaining in Olympia for the Survey a strong-motion accelerograph. Periodic checks are made to be sure that the instrument is in good operating condition and to determine whether or not the instrument has recorded any strong-motion earthquakes.

Cooperation with the U. S. Atomic Energy Commission is maintained through distribution of A. E. C. literature by the Division. The A. E. C. has provided the Division with a "radiometric assayer" instrument for the purpose of making quantitative analyses of uranium ores.

During the past biennium the Division has had occasions to provide information and be of assistance to the U. S. Forest Service and other Federal agencies as well as such State agencies as the Department of Commerce and Economic Development, Department of Highways, Commissioner of Public Lands, Pollution Control Commission, Department of Employment Security, Tax Commission, and Department of Licenses.

During the biennium the Division was invited to participate with the U. S. Geological Survey in preparing a report on mineral and water resources of Washington. This report was requested by the Chairman of the U. S. Senate Committee on Interior and Insular Affairs and was published by the Committee. Reprints of the report are available for distribution by the Department of Conservation. Division geologists Bennett, Huntting, Livingston, Moen, Reichert, and Thorsen each authored one or more chapters on various metallic and nonmetallic mineral commodities. A total of 6½ man months of time by Division geologists was expended on this project.

An additional 4 man months was used in a report and maps of the mineral resources of northwestern Washington—all the area that is drained by streams that flow into Puget Sound. The report was prepared by Vaughn E. Livingston, Jr. for the Puget Sound and Adjacent Waters Task Force of the Columbia Basin Inter-Agency Committee for inclusion in an appendix of a report on a comprehensive plan for development of water resources of the Puget Sound Basin and adjacent areas.

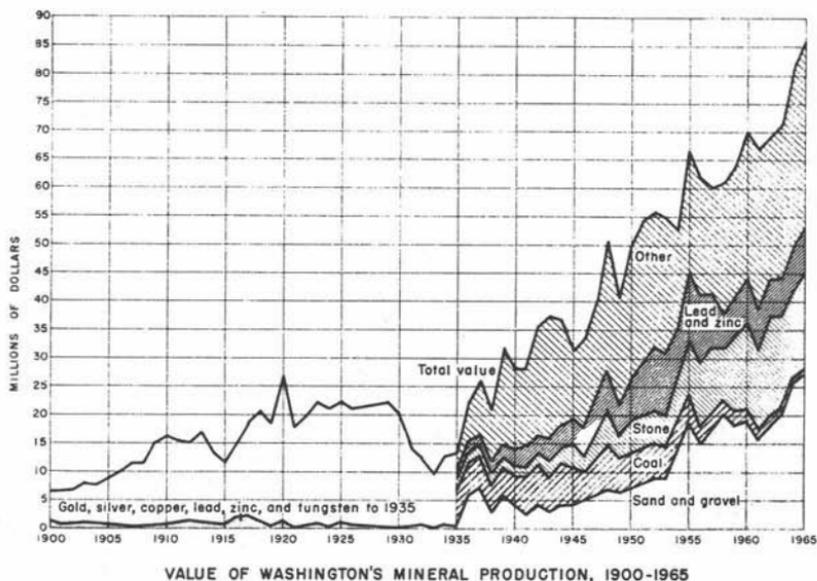
Toward the end of the biennium the Division was asked to participate in a similar study of mineral resources in the rest of the State not covered by the above-described report. This was for the Columbia-North Pacific study by the Columbia Basin Inter-Agency Committee.

PART II
MINERAL INDUSTRY OF WASHINGTON

VALUE OF MINERAL PRODUCTION

The wealth of the world is derived from the earth—indirectly in the form of agricultural and forest products, and directly and by far most importantly in the form of mineral products.

The mineral industry of Washington comprises an important part of the overall economy of the State—more than is commonly recognized. In comparison with the other extractive industries in the State, mining in 1965 produced minerals having a raw product value of \$85,971,000¹ which is more than one-eighth of the value of unprocessed agricultural products for that year, a little less than half of the value of the logging industry's output, and more than four times the value of the products of the commercial fisheries. Likewise, the value of mineral production in Washington during 1965 exceeded that of Oregon and Alaska by \$18 million and \$3 million, respectively, and lagged behind that of Idaho by \$10 million. During the past 10 years (1956-1965) mineral production in Washington had a total value of \$684 million, an increase of more than \$189 million over production in the previous 10 years. With minor fluctuations, the State's mineral production has been steadily increasing since the depression year of 1933, when it was valued at just over \$9 million. This is shown graphically below.



¹All mineral production figures in this report were compiled by the U. S. Bureau of Mines.

King County was the leading mineral producer for the fifth year; however, 15 counties produced more than \$2 million worth of mineral products in 1965 (see Table I).

Minerals are divided into two broad groups: metallic and nonmetallic. The metallic minerals are mined for the metals that can be extracted from their ores. The nonmetallic, or industrial, minerals are not commonly mined for their elemental content but rather for some quality that they have in their natural state or acquire through beneficiation or treatment. The metallic minerals gold, silver, copper, lead, zinc, mercury, tungsten, and uranium accounted for just over 16 percent of the State's mineral production value during 1965. This is about a 7-percent decrease from the 1964 total.

TABLE I
VALUE OF MINERAL PRODUCTION IN WASHINGTON, BY COUNTIES
[Thousand dollars]

County	1964	1965	Minerals produced in 1965 in order of value
Adams	\$ 65	\$ 405	Stone, sand and gravel
Asotin	62	8	Sand and gravel
Benton	283	1,112	Stone, sand and gravel
Chelan	1,445	①	Gold, sand and gravel, silver, pumice, copper
Clallam	231	577	Stone, sand and gravel, gold
Clark	968	1,440	Sand and gravel, stone, clay
Columbia	2,203	1,808	Sand and gravel, stone
Cowlitz	447	1,329	Stone, sand and gravel, clay
Douglas	178	189	Stone, sand and gravel, clay
Ferry	①	①	Gold, silver, sand and gravel, stone, copper, lead
Franklin	916	326	Sand and gravel, stone
Garfield	71	271	Stone, sand and gravel
Grant	1,786	2,124	Sand and gravel, diatomite, lime, stone
Grays Harbor ..	634	758	Sand and gravel, stone
Island	72	211	Stone, sand and gravel
Jefferson	①	551	Stone, sand and gravel
King	12,826	14,144	Cement, sand and gravel, stone, coal, clay, peat
Kitsap	372	296	Sand and gravel, peat
Kittitas	255	142	Stone, sand and gravel, gold
Klickitat	1,507	795	Stone, sand and gravel, carbon dioxide
Lewis	649	483	Stone, sand and gravel, coal, clay, mercury
Lincoln	230	244	Stone, sand and gravel
Mason	234	173	Stone, sand and gravel, peat
Okanogan	223	322	Sand and gravel, stone, zinc, lead, silver, copper

① Withheld to avoid disclosing individual company confidential data.

VALUE OF MINERAL PRODUCTION IN WASH., BY COUNTIES—continued
[Thousand dollars]

County	1964	1965	Minerals produced in 1965 in order of value
Pacific	143	175	Stone
Pend Oreille ...	①	8,202	Zinc, cement, lead, stone, sand and gravel, silver, copper
Pierce	4,327	5,179	Sand and gravel, lime, stone, clay, peat
San Juan	①	531	Sand and gravel, stone
Skagit	4,441	6,508	Cement, stone, olivine, sand and gravel, soapstone, peat
Skamania	169	186	Stone, sand and gravel
Snohomish	3,358	2,672	Sand and gravel, stone, peat, clay
Spokane	6,292	4,550	Cement, sand and gravel, stone, clay, uranium
Stevens	5,294	6,744	Zinc, uranium, stone, magnesite, lead, sand and gravel, clay, silver, cop- per, barite
Thurston	347	302	Sand and gravel, coal, peat
Wahkiakum	12	2	Stone
Walla Walla ...	4,038	2,530	Sand and gravel, stone
Whatcom	①	①	Cement, stone, sand and gravel, oli- vine, clay
Whitman	364	1,895	Sand and gravel, stone
Yakima	1,356	1,610	Sand and gravel, lime, stone, clay
Undistributed②	25,512	17,177	
Total	\$81,310	\$85,971	

①Withheld to avoid disclosing individual company confidential data.

②Includes value of mineral production that cannot be assigned to specific counties and values indicated by footnote 1.

MINING OPERATIONS

Minerals or mineral aggregates, including sand, gravel, and common stone, are produced from each of the 39 counties in the State. Commercial minerals other than sand, gravel, and common stone are produced from 24 counties. Metallic minerals are mined in 9 counties.

METALLIC MINING

The value of metallic mineral products decreased from \$15.5 million in 1964 to \$13.9 million in 1965. Almost all of the metals dropped in value, especially uranium, which decreased \$1.8 million. Mercury and tungsten were produced in the State for the first time since 1961.

Zinc and lead—Zinc production, valued at \$6.5 million for 1965, was greater than that of any other metal. This represents a drop of \$118,000 from the 1964 total. Lead production, with a total value of \$1.97 million, was \$472,000 higher than that of 1964. Only two large zinc mines were in production—Pend Oreille Mines & Metals Co.'s Pend Oreille mine and American Smelting and Refining Company's Van Stone mine. Approximately 60 percent of the lead and zinc ore milled came from the Pend Oreille mine. In Washington, lead has been produced mainly as a byproduct of the large zinc operations—only a few small properties were operated exclusively for their lead value. American Zinc, Lead and Smelting Company is continuing to do development work on the Calhoun zinc property, which it hopes to have in production by fall of 1966. The Bunker Hill Company, another large lead-zinc mining firm, has been doing exploration work in Stevens County.

Gold and silver—Gold and silver production dipped 4 and 5 percent, respectively, from their 1964 level. As in past years, Knob Hill Mines, Inc., in Ferry County, and L-D Mines (formerly Lovitt Mining Co., Inc.), in Chelan County, were the principal gold and silver producers. Two additional lode properties—The Rocky Creek mine, in Pend Oreille County, and the Fourth of July mine, in Okanogan County—and one placer deposit, that of Gold Placers, Inc., of Kittitas County, were worked during 1965, but production from them represented only a small fraction of the total value. Lead-zinc operations produced byproduct silver amounting to 1.5 ounces per ton of concentrate smelted. Silver was recovered at a rate of 3.9 ounces per ounce of recoverable gold from the two large gold mines.

Uranium—Uranium concentrate production in 1965 was down \$1.8 million from that of 1964. Dawn Mining Company continued to be the principal producer. The company was able to meet the Atomic Energy Commission's uranium oxide purchase contract by utilizing stockpiled ore—no ore was taken from the company's Midnite mine during the biennium. The property is far from worked out, however, and when uranium demands catch up with the supply, the mine will be reopened.

Aluminum—One aluminum company did exploration and research work on the ferruginous bauxite deposits of Cowlitz and Wahkiakum Counties during the biennium. New processes being developed by federal and private research projects for the extraction of alumina and iron from these rather low-grade ores give the deposits new importance. The proximity of the deposits to established alumina reduction plants, low-cost electric power, and good transportation facilities provide added incentive for development of the resource.

Copper—Copper production dropped very slightly from the 1964 figure. Only 30 tons was produced in 1965, as compared with 35 tons for the previous year. Most of the metal was recovered as a smelting byproduct from the ores of the large lead-zinc mines in Pend Oreille and Stevens Counties. Exploration of copper properties was being carried out in the central Cascade Mountains by Bear Creek Mining Co., whose geologists mapped and did core drilling on the Middle Fork of the Snoqualmie River, in King County. Cougar Development Co. did exploration and development work on the Quartz Creek property, in King County.

NONMETALLIC MINING

Production of industrial minerals was valued at \$72 million in 1965, which is an increase of slightly more than \$6 million over that of 1964. Barite, clay, sand and gravel, stone, cement, lime and olivine all made gains during 1965, whereas the output of coal, peat, talc, carbon dioxide, diatomite, magnesite, and pumice decreased slightly. The overall increase in industrial mineral value and production is generally related to an increase in construction in the State. Production and sale of commodities such as sand and gravel, cement, and clay serve as indicators of building activity in an area. None of the minerals that suffered losses are basic to the construction industry.

The big three in Washington's mineral industry—sand and gravel, cement, and stone—all made significant gains during 1965. The gains in sand and gravel, however, were in price rather than in quantity produced. Three companies—Ideal Cement Company, Kaiser Cement & Gypsum Corporation, and Lone Star Cement Corporation—have made commitments to build new cement production facilities in the near future. Ideal and Kaiser intend to build in Seattle, and Lone Star will build at Anacortes, in Skagit County.

Olivine production increased for the eleventh consecutive year in 1965. During the biennium, olivine received considerable attention as a possible source of magnesium metal. Research done by Twin Sisters Magnesia & Chemical Corporation indicates that the possibility of economically reducing olivine to magnesium metal is very good. If production of metal from olivine becomes a reality, Washington's mineral economy will receive an added boost, as the State has the largest olivine deposit in the United States.

PETROLEUM AND NATURAL GAS

Exploration drilling during the biennium was carried out in Clallam, Grays Harbor, Jefferson, Lewis, Pend Oreille, and Whatcom Counties. Permits were issued for 20 wells, and a total of 59,114 feet of exploration drilling was completed.

The development of an underground gas storage reservoir in the Jackson Prairie area of Lewis County continued through the biennium. By June 30, 1966, a total of 24 wells had been drilled to depths of 1,500 to 3,000 feet, testing three zones of porous sandstone reservoirs. Most of the work had been concentrated on Zone 2, at depths of 1,800 to 2,200 feet. Natural gas has been taken from El Paso Natural Gas Company's pipeline and injected into the storage reservoir. Tests conducted during the winter of 1965-66, when about 340 million cubic feet of gas was withdrawn from storage and pumped back into El Paso's transmission line, were successful. The estimated ultimate storage capacity of the reservoir is more than 6 billion cubic feet. The venture

is sponsored jointly by The Washington Water Power Company, Washington Natural Gas Company, and El Paso Natural Gas Company.

Should this project prove successful, it will serve as a source of gas for the developers to meet firm peak demands on extremely cold days and, in years of moderate weather, to reduce the amount of interruption of gas service to interruptible industrial customers.