DIVISION OF MINES AND GEOLOGY

MARSHALL T. HUNTTING, Supervisor

BIENNIAL REPORT NO. 10

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, 1962 to June 30, 1964.

INTRODUCTION

The Division of Mines and Geology is a service agency; its function is to promote maximum utilization of the State's mineral resources. Its only regulatory activities are those in administering the Oil and Gas Conservation Act. It acts as a clearing house of information on the geology and mineral resources of the State. Known mineral deposits are evaluated through field and office research, and through geologic mapping the basic information is provided that is needed in the search for new ore deposits. The Division collects statistics concerning the occurrence and production of minerals economically important in Washington; publishes bulletins on the geology, mineral resources, and mineral statistics of the State; maintains a collection of rock and mineral samples (at least 5,200 specimens) with special emphasis on those of economic importance or potential; maintains a library (approximately 13,000 volumes) of books, reports, records, and maps on geology, mineralogy, and mining, with special emphasis on material that pertains to Washington; and makes them available to the public for reference in the Division office. The Division also identifies samples of ores and minerals sent in by the public.

The Division is building up a collection of oil well cores and cuttings that are extensively used by oil companies in exploring, both in Washington and as far as 50 miles offshore. More than 200 oil test wells are represented by these samples. Increasing work is being done to build up the Division's collection of slides of microscopic-size fossils for use in oil exploration work. This is a collection of about 3,000 slides.

The Division issues permits and regulates the drilling for oil and gas and the development of underground gas storage areas. It provides observers to enforce regulations of offshore drilling, an activity that first started in 1963 and has increased considerably in 1964. Three ships required four observers in 1963; seven ships required eight observers in 1964.

Geologic maps are made and geologic and mineral-resource reports are published and sold. Sales are increasing each year. Most of the reports are written by the Division's staff geologists, but some manuscripts are obtained
free or at small cost from specialists other than those on the staff. Reports published include technical reports; directories of mineral producers; and popular reports on rocks, minerals, fossils, geology, prospecting, and archeology. Sets of rocks and minerals are prepared in cooperation with the State Department of Public Instruction and are sold to Washington schools.

Numerous requests from individuals, from large and small companies, and from other State agencies for information regarding the availability and quality of Washington mineral commodities for use in expanding existing production and for the establishment of new industries have shown the immediate need for surveys of the State’s mineral resources, including but not limited to: sand and gravel, bauxite, aggregates for radiation shielding, olivine, and building stone. There is also a demand for complete mineral-resource surveys for many of the counties of the State.

In 1964 the Division made a small start on a new program—geochemical prospecting, in which thousands of stream sediment samples are collected and analyzed in the search for ore bodies and mineralized areas.

Geologic mapping to provide a basis for further mineral-resource studies is under way in the Grays River area in Wahkiakum County, the Chewelah area in Stevens County, the Kelso area in Cowlitz County, the Wynoochee quadrangle in Grays Harbor and Mason Counties, and in two areas near Colville in Stevens County. The first three of these areas are being mapped in cooperation with the U.S. Geological Survey in projects that were started in 1963.

The Division matches funds with the U.S. Geological Survey for topographic mapping. Areas to be mapped are selected by the Division, and the mapping is done by the Federal agency. In 1963, mapping was started on three new quadrangle maps of about 600 square miles of area near Leavenworth, in Chelan County.

The Division is called upon to advise and assist in formulating policy and legislation—at county, state, and federal levels—regarding mineral industries and oil and gas exploration. For example, the Federal Area Redevelopment Administration depends upon the Division for advice and assistance in its program in this State, and the Division recently assisted in revising the zoning code for King County.

**STAFF**

Marshall T. Huntting..........................Supervisor
Vaughn E. Livingston..........................Assistant Supervisor
W. A. G. Bennett.............................Geologist IV
Weldon W. Rau.................................Biostratigrapher
Wayne S. Moen.................................Geologist III
William H. Reichert..........................Geologist-Librarian
Gerald W. Thorsen............................Geologist II
Nancy Maschner...............................Cartographer
Dorothy Rinkenberger.........................Secretary-Editor
Gloria DeRossi...............................Secretary
Sandra Anderson..............................Clerk-Typist

Dr. Joseph W. Mills, chairman of the Department of Geology at Washington State University, was hired for 3 months during the summer of
1962 and again in 1963 to map the geology and examine the mineral deposits in an area in Stevens County. Several temporary field or laboratory assistants worked for short periods during the biennium. Four offshore drilling observers were hired in 1963 and eight in 1964.

The present technical staff of 6 geologists compares with a total of 4 geologists and 1 mining engineer comprising the Division staff 16 years ago, at a time when the demands for services were substantially less than they are now.

HISTORY OF THE DIVISION

Geologic investigations as a function of the State Government were established by the first State Legislature and began with the appointment of George A. Bethune as State Geologist in 1890, with office in Tacoma. After 2 years this early work was discontinued for lack of further appropriation. It was resumed in 1901 with the establishment of the Board of Geologic Survey and the appointment, by the Board, of Henry Landes as State Geologist. 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. The first supervisor of this newly formed Division was Solon Shedd. He retired in 1925, to be succeeded by Harold E. Culver, but throughout the whole 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 first supervisor of the Division of Mines and Mining was Thomas B. Hill; the office was in the quarters of the Department of Conservation and Development, Olympia. In 1941 he was succeeded by Sheldon L. Glover, formerly the assistant supervisor of the Division of Geology, and the Olympia office and staff were enlarged to carry on the activities specifically authorized by the Mines and Mining Act.

For four 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 considerable 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. The supervision of the combined Division of Mines and Geology was given to Sheldon L. Glover. Upon Mr. Glover's retirement in February 1957, Marshall T. Huntting was appointed supervisor.

**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:

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. A program that was proposed by the committee and was carried on by the Division during the biennium was that of mapping and sampling to determine the location, size, and quality of barite deposits in the State.

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. Preprints 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 the 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 col-
lection 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 13,000 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, and a few texts and reports of especial interest are purchased through limited funds available for the purpose. 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 1,398 samples. This indicates a very large interest in Washington's mineral resources and shows increased 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; blow-pipe equipment for qualitative tests; sieves for making screen analyses of sands; laboratory crusbeer and grinder; a Superpanner; Geiger counters and a scintillation detector for radiometric tests of uranium-bearing samples; ultra-violet lamps for fluorescence tests; 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. 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, 1964, a total of 194 drilling permits were issued, of which 28 were issued during the 1962-64 biennium. This is an increase of two permits over those of the preceding biennium.

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. Also needed is a petroleum geological engineer to assist in the administration of the Oil and Gas Conservation Act and to help develop information that will be useful to oil and gas exploration groups.

As required by law and rules and regulations, the Division furnishes State drilling observers to work on oil company ships that drill holes as much as
1,000 feet deep to obtain bottom samples for study in connection with off-shore oil and gas exploration. In 1963 four observers served on ships working for three oil companies. In 1964 eight observers worked on ships that were used by seven companies or groups of companies.

**REPORTS PUBLISHED**

Geologic investigations are of little value to the public unless the results are made easily available. The demand is increasing each year for information on geology, mineral resources, and the status of the mining industry of Washington. This information is dispensed through office and field conferences, by correspondence, and, most effectively, through distribution of published reports. Most of the Division's reports are written by staff geologists, but some manuscripts are obtained free or are purchased from specialists other than those on the staff. As required by law, the entire cost for printing of reports will eventually be returned to the State's General Fund through income from sale of the reports.

During the biennium the following reports were published and made available for distribution:

- Preliminary Geologic Map of the Hobart and Maple Valley Quadrangles, King County, Washington, by James D. Vine, Geologic Map GM-1, 75¢.
- Preliminary Geologic Map of the Cumberland Quadrangle, King County, Washington, by A. A. Wanek and H. D. Gower, Geologic Map GM-2, $1.00.
- Fossils in Washington, by Vaughn E. Livingston, Jr., Information Circular 33, 33 pages, 1 plate, 17 figures, 25¢. (Reprinted)
- A Geologic Trip Along Snoqualmie, Swauk, and Stevens Pass Highways, by University of Washington Geology Department Staff, revised by Vaughn E. Livingston, Jr., Information Circular 38, 51 pages, 50¢.
- Mineralogy and Geochemistry of the Read Magnetite Deposit, Southwestern Stevens County, Washington, by W. A. G. Bennett; and Ludwigite from the Read Magnetite Deposit, Stevens County, Washington, by Waldemar
PROJECTS IN PROGRESS

During the biennium the following projects were in progress and reports on most of these were in preparation:

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 biennium. The western Washington report is in preparation and should be ready to print some time in 1965.

Ferruginous Laterite in 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 the 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 some time during 1965.

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 two years.

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.
Black Sand at Grays Harbor, by Gerald W. Thorsen. Numerous inquiries about black sands, both as a possible source of iron and as a source of titanium, have emphasized the need for detailed information on the mineralogic composition of these sands. Laboratory analyses of samples from the mouth of Grays Harbor have been completed, and a report is in preparation.

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 single-handedly, 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 1964-66 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.

Geology of the Wynoochee Area, Grays Harbor County, Washington, by Weldon W. Rau. Field and laboratory studies of the rocks and their contained fossils were continued throughout the biennium. A geologic map and report should be ready for publication in 1965.

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 1965.

Introduction to Washington Geology and Resources, by Charles D. Campbell, Information Circular 22R, 44 pages, 5 figures, 25c. This popular report, which was reprinted once during the biennium, went out of print again and had been sent to the printer to be reprinted again at the biennium's end. It was ready for distribution again early in the following biennium.

Stone in 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 essentially completed during the biennium. A report of this work should be published some time in 1965.

Mineral Resources of King County, by Vaughn E. Livingston, Jr. Mineral production in King County leads that for all other counties in Washington. An investigation of these resources was started during the biennium, but because of other demands on the investigator's time it may be several years before the project is completed.
Geochemical Investigations in Washington, by Wayne S. Moen. Late in the biennium a small start was made on a proposed 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.

Mineral Resources in the North Cascade Mountains, by Marshall T. Hunting, Vaughn E. Livingston, Jr., and Wayne S. Moen. During the biennium a study was made of the North Cascade mineral resources and the potential for their development. This was done in cooperation with the U. S. Geological Survey and was part of a larger study of all the resources of this area being conducted by a five-man study team made up of representatives of the U. S. Departments of Interior and Agriculture. A report was written, but, although the possibility of publishing the report was discussed, no definite plans have yet been made for its publication.

Pegmatites in Washington, by Ted Ross. All the known pegmatite deposits in the State were being 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, and a detailed report is expected to be ready for publication some time in 1965.

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 two 15-minute quadrangles, the mapping of which was started during the previous biennium. Three new map projects were started in July 1963. The names, locations, and estimated publication dates of these maps are:

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<thead>
<tr>
<th>Names of quadrangles</th>
<th>Counties in which located</th>
<th>Estimated publication date</th>
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<tbody>
<tr>
<td>Mazama</td>
<td>Okanogan</td>
<td>July 1964</td>
</tr>
<tr>
<td>Doe Mountain</td>
<td>Okanogan</td>
<td>December 1964</td>
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<tr>
<td>Chiwaukum 4</td>
<td>Chelan</td>
<td>June 1966</td>
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<tr>
<td>Chiwaukum 3</td>
<td>Chelan</td>
<td>June 1967</td>
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<tr>
<td>Chiwaukum 2</td>
<td>Chelan</td>
<td>June 1967</td>
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Also during the biennium sixteen 7½-minute quadrangles and ten 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 1964 is
$452,217, and 78 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.

The Industrial Raw Materials Advisory Committee has pointed out that topographic maps are an indispensable tool for the development of Washington's natural resources and are an important aid in overall economic development in the State. These maps are required by planners, builders, engineers, geologists, foresters, farmers, soil conservationists, hydrologists, river-resource developers, and hunters and fishermen. The committee has recommended that greatly increased funds be made available to augment the cooperative program so that topographic mapping of the State may be completed in the next 10 years.

It has been recommended that eighty-seven 15-minute quadrangles (of 200 square miles each) be mapped. This, in addition to areas already being mapped, would give complete coverage of the State with topographic maps published since 1945. At an estimated cost of $20,000 per quadrangle, this would be a total cost of $1,790,000 to the State, which would be matched by the Federal government.

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 quadrangle in Stevens County. The last two areas were chosen for investigation because of the diverse, widespread mineralization present in these areas. These are 3-year projects; the geologic maps and reports of this work should be completed by July 1966.

By making use of expert geologists from the Federal Geological Survey staff and 50 percent Federal matching funds, we have been able to complete much more work of excellent quality than we could have accomplished without this help.

Geologic mapping is needed as a foundation from which private industry can extend its search for mineral resources, is needed to evaluate fully the State's mineral-resource potential, is needed in order to appraise water resources and to locate such construction materials as sand, gravel, and
stone, and is needed to provide information on which to select, plan, and
design sites for engineering structures and highways and to evaluate such
natural hazards as landslides and earthquakes.

The Industrial Raw Materials Advisory Committee, recognizing these
needs in 1958, recommended a program of geologic mapping and mineral
resource investigations and recommended that $500,000 be appropriated for
such work in the following biennium. In 1960 the Committee again recom-
mended a major program of geologic mapping in cooperation with the U.S.
Geological Survey and recommended the appropriation of $450,000 for that
purpose during the next biennium. In 1962 the Committee once more recom-
mended cooperative geologic mapping that was estimated to cost $382,000
annually for a period of 10 years. In 1964 the Committee still was convinced
of the value of geologic mapping as a vital part of the State's economic
development program and again recommended a very large increase over
the current rate of mapping.

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 oper-
ations 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 clay and bauxite col-
lected by Division geologists in conjunction with geologic mapping projects
described on previous pages.

The Division cooperates with the U. S. Coast and Geodetic Survey by
maintaining in Olympia for the Survey a strong-motion accelerograph. Peri-
odic 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 pur-
pose of making quantitative analyses of uranium ores.

During the past biennium the Division has had occasions to provide infor-
mation 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.

In 1962 and 1963 Division geologists devoted about 3.6 man-months in
working with the King County Planning Department and with representatives
of King County sand, gravel, stone, and clay industries in developing a new
county zoning code. This code provides some protection from the encroach-
ment of other industrial and housing developments that would destroy valuable
deposits of sand, gravel, stone, and clay that will be critically needed as
construction materials in the years to come.
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 1963 produced minerals having a raw product value of $71,431,000\(^\circ\) which is more than one-tenth of the value of unprocessed agricultural products for that year, about one-fourth of the value of the logging industry's output, and more than three times the value of the products of the commercial fisheries. Likewise, the value of mineral production in Washington exceeded that of Oregon and Alaska during 1963 by about $10 million each, and lagged behind Idaho by an equal amount. During the past 10 years (1954-1963), mineral production in Washington had a total value of $633 million, an increase of more than $190 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.

![Graph showing value of Washington's mineral production, 1900-1963](image)

King County was the leading mineral producer for the third year; however, Walla Walla, Stevens, Pend Oreille, Pierce, Spokane, and Skagit Counties each produced more than $3 million worth of mineral products in 1963 (see table on page ......).

\(^\circ\) All mineral production figures in this report were compiled by the U. S. Bureau of Mines.
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, and uranium accounted for approximately 18 percent of the State’s mineral production value during 1963. This is about a 1-percent increase over the 1962 total.

VALUE OF MINERAL PRODUCTION IN WASHINGTON, BY COUNTIES

[Thousand dollars]

<table>
<thead>
<tr>
<th>County</th>
<th>1962</th>
<th>1963</th>
<th>Minerals produced in 1963 in order of value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>$ 194</td>
<td>$ 229</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>Asotin</td>
<td>16</td>
<td>19</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>Benton</td>
<td>108</td>
<td>179</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>Chelan</td>
<td>1,043</td>
<td>0</td>
<td>Gold, stone, sand and gravel, silver, pumice</td>
</tr>
<tr>
<td>Clallam</td>
<td>242</td>
<td>279</td>
<td>Sand and gravel, stone</td>
</tr>
<tr>
<td>Clark</td>
<td>580</td>
<td>1,206</td>
<td>Stone, sand and gravel, clay</td>
</tr>
<tr>
<td>Columbia</td>
<td>1,435</td>
<td>171</td>
<td>Stone, sand and gravel, clay</td>
</tr>
<tr>
<td>Cowitz</td>
<td>217</td>
<td>791</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>Douglas</td>
<td>791</td>
<td>0</td>
<td>Gold, silver, stone, copper, lead</td>
</tr>
<tr>
<td>Ferry</td>
<td>874</td>
<td>580</td>
<td>Sand and gravel, stone</td>
</tr>
<tr>
<td>Franklin</td>
<td>102</td>
<td>164</td>
<td>Stone</td>
</tr>
<tr>
<td>Garfield</td>
<td>1,687</td>
<td>1,591</td>
<td>Diatomite, stone, lime, sand and gravel</td>
</tr>
<tr>
<td>Grays Harbor</td>
<td>393</td>
<td>338</td>
<td>Sand and gravel, stone</td>
</tr>
<tr>
<td>Island</td>
<td>337</td>
<td>0</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>Jefferson</td>
<td>11,363</td>
<td>317</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>King</td>
<td>9,418</td>
<td>493</td>
<td>Sand and gravel, stone, coal, peat, clay</td>
</tr>
<tr>
<td>Kitsap</td>
<td>219</td>
<td>1,020</td>
<td>Coal, sand and gravel, stone</td>
</tr>
<tr>
<td>Kittitas</td>
<td>4,290</td>
<td>742</td>
<td>Stone, sand and gravel, carbon dioxide</td>
</tr>
<tr>
<td>Lewis</td>
<td>618</td>
<td>688</td>
<td>Stone, sand and gravel, coal, clay</td>
</tr>
<tr>
<td>Lincoln</td>
<td>318</td>
<td>122</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>Mason</td>
<td>15</td>
<td>133</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>Okanogan</td>
<td>126</td>
<td>175</td>
<td>Stone, sand and gravel, silver, copper, gold, epsomite, lead</td>
</tr>
<tr>
<td>Pacific</td>
<td>303</td>
<td>387</td>
<td>Stone</td>
</tr>
<tr>
<td>Pend Oreille</td>
<td>0</td>
<td>0</td>
<td>Zinc, cement, lead, stone, sand and gravel, silver, copper</td>
</tr>
<tr>
<td>Pierce</td>
<td>3,402</td>
<td>4,470</td>
<td>Sand and gravel, lime, stone, clay</td>
</tr>
<tr>
<td>San Juan</td>
<td>5</td>
<td>0</td>
<td>Sand and gravel, stone</td>
</tr>
<tr>
<td>Skagit</td>
<td>3,323</td>
<td>3,754</td>
<td>Cement, olivine, stone, sand and gravel, talc and soapstone, peat</td>
</tr>
</tbody>
</table>
VALUE OF MINERAL PRODUCTION IN WASH, BY COUNTIES—continued
[Thousand dollars]

<table>
<thead>
<tr>
<th>County</th>
<th>1962</th>
<th>1963</th>
<th>Minerals produced in 1963 in order of value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skamania</td>
<td>341</td>
<td>87</td>
<td>Stone, sand and gravel, gold, silver, copper</td>
</tr>
<tr>
<td>Snohomish</td>
<td>4,106</td>
<td>2,313</td>
<td>Sand and gravel, stone, peat, clay, gold</td>
</tr>
<tr>
<td>Spokane</td>
<td>3,540</td>
<td>3,773</td>
<td>Cement, sand and gravel, stone, clay</td>
</tr>
<tr>
<td>Stevens</td>
<td>3,938</td>
<td>4,364</td>
<td>Uranium, magnesite, stone, sand and gravel, clay, grinding pebbles</td>
</tr>
<tr>
<td>Thurston</td>
<td>469</td>
<td>314</td>
<td>Stone, sand and gravel, coal, peat</td>
</tr>
<tr>
<td>Wahkiakum</td>
<td>116</td>
<td>46</td>
<td>Stone</td>
</tr>
<tr>
<td>Walla Walla</td>
<td>855</td>
<td>4,593</td>
<td>Sand and gravel, stone</td>
</tr>
<tr>
<td>Whatcom</td>
<td>Σ</td>
<td>128</td>
<td>Cement, stone, sand and gravel, clay</td>
</tr>
<tr>
<td>Whitman</td>
<td>437</td>
<td>1,085</td>
<td>Stone, sand and gravel</td>
</tr>
<tr>
<td>Yakima</td>
<td>1,798</td>
<td>1,568</td>
<td>Sand and gravel, lime, stone, clay</td>
</tr>
<tr>
<td>Undistributed</td>
<td>21,236</td>
<td>24,582</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$68,474</td>
<td>$71,431</td>
<td></td>
</tr>
</tbody>
</table>

*Figure withheld to avoid disclosure of individual company confidential data; included with undistributed.*

**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 19 counties. Metallic minerals are mined in 7 counties.

**METALLIC MINING**

The value of metallic mineral products increased about $1 million over the 1962 total, to $12.7 million in 1963.

**Zinc and lead**—Zinc production, valued at $5.12 million for 1963, was greater than that of any other metal. This represents an increase of $144,000 over the 1962 total. Lead production, with a total value of $1.16 million, was slightly higher than in 1962. Only two large zinc properties were in operation—Pend Oreille Mines & Metals Company's Pend Oreille mine and the American Zinc, Lead & Smelting Company's Grandview mine, both in Pend Oreille County. In Washington, lead has been produced mainly as a byproduct of the big zinc operations. Only a few small properties were operated exclusively for their lead value.

**Gold and silver**—Gold and silver production attained a 4.6- and a 6-percent increase, respectively, over that of 1962. As in past years, Knob Hill Mines, Inc., in Ferry County, and L-D Mines (formerly Lovitt Mining Co.), in Chelan County, were the principal gold and silver producers. One additional lode property and one placer property reported production in 1963; however, their production represented only a very small fraction of the total value.
Lead-zinc properties produced 8 percent of the silver output, having an average of 5.6 ounces of silver recovered per ton of lead processed in 1963.

**Uranium**—Uranium concentrate \((U_3O_8)\) production in 1963 was up 5.7 percent over the 1962 total, with a value of $2.5 million. Dawn Mining Company continued to be the principal producer. In late 1963 the Midnite Company's mine was closed, but stockpiles of ore are sufficient to keep the mill at Ford operating through 1966, when the Atomic Energy Commission's uranium oxide purchasing contract is due to expire. The company reported substantial reserves at the mine for possible future operation.

**Copper**—Copper production showed a 10-percent decrease from that of 1962—only 37 tons were produced in 1963. Most of the metal was recovered as a byproduct of smelting of the lead-zinc ores from the two big Pend Oreille County mines. Small quantities of copper were mined from the Borderline No. 6 mine, in Okanogan County, and the Lucky Joe mine, in Pend Oreille County. Exploration of copper properties was being carried out in the northern Cascade Mountains by Bear Creek Mining Co. and Phelps Dodge Corp. Bear Creek was mapping and core drilling the Clipper claims, on the Middle Fork of the Snoqualmie River in King County, and Phelps Dodge was working in the Cascade Mountains northeast of Snoqualmie Pass.

**Aluminum**—One aluminum company continued exploration and research work on the ferruginous bauxite deposits in Cowlitz and Wahkiakum Counties during the biennium. These deposits conceivably may be the State's best iron ore reserve. The aluminum and iron content of these deposits is low, but the fact that these metals occur together may give the deposits enough value to render them economically workable.

**NONMETALLIC MINING**

Production of industrial minerals was valued at $58.7 million in 1963. This was an increase of almost $2.5 million over the 1962 total. Sand and gravel, clay, talc and soapstone, carbon dioxide, cement, lime, magnesite, and olivine all made production gains during 1963, whereas the output of coal, peat, stone, diatomite, and pumice fell slightly.

The coal industry in the State received a setback when the decision was made to utilize the waste heat at the Hanford atomic works for steam-electric generation, thus postponing construction of the proposed coal-fired steam-electric-generation plant in Kittitas County. Results of this change were the closure of the Northern Pacific Railway's Cle Elum mines and the abandonment of the hydraulic-coal-mining experiments.

Lime production during 1963 was more than twice that of 1962. The increase was due mostly to the opening of the Pacific Lime, Inc. plant in Tacoma. Limestone was calcined for captive use in sugar refineries and paper mills in the State. A substantial amount of lime is recycled at pulp mills.

Processed olivine sales were 44 percent greater than in 1962. Crude material was mined by Northwest Olivine Co., Pacific Olivine, and Scheel Stone Co., in Skagit County, and by Olivine Corp., in Whatcom County.
PETROLEUM AND NATURAL GAS

Exploration drilling was carried out during the biennium in Clallam, Grays Harbor, Jefferson, Lewis, Pacific, Pierce, Spokane, Stevens, Thurston, and Whatcom Counties. Permits were issued for 27 wells, and drilling footage totaled 79,515 feet.

An attempt to develop an underground natural gas storage reservoir in the Jackson Prairie area of Lewis County was begun during the biennium. Initially, 10 wells were drilled to depths between 1,500 and 3,000 feet, and by the end of the biennium gas was being taken from El Paso Natural Gas Co.’s pipeline and injected into the underground reservoir. The estimated storage capacity of the reservoir is 10 billion cubic feet, which, if the project is successful, will make it one of the largest subsurface gas storage reservoirs in the United States. The venture is being sponsored jointly by Washington Water Power Co., Washington Natural Gas Co., and El Paso Natural Gas Co.