BIENNIAL REPORT NO. 2
of the
DIVISION OF MINES
AND GEOLOGY
For the Period Commencing October 1, 1946
and Ending September 30, 1948
Including a Report on Washington’s Mineral Industry

By
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Supervisor

OLYMPIA
STATE PRINTING PLANT
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DIVISION OF MINES AND GEOLOGY

SHELDON L. GLOVER, Supervisor

BIENNIAL REPORT NO. 2

PART I

ADMINISTRATION

GENERAL STATEMENT

The following report applies to the organization and activities of the Division of Mines and Geology for the period October 1, 1946, to September 30, 1948.

The staff consisted of Sheldon L. Glover, supervisor; W. A. G. Bennett, Grant Valentine, and Marshall T. Hunting, geologists; C. Phillips Purdy, Jr., geologist and draftsman; Stephen H. Green, mining engineer; and the clerical staff, Dorothy Rinkenberger and Vera Fischer. Toward the end of the biennium Mrs. Fischer resigned, being replaced by Gay Hemphill. Temporary additions to the staff, for specific projects, were George Becraft and George Simmons, field assistants. Also, Melvin Schroeder, geologist, was temporarily associated with the staff through a special cooperative arrangement with the State College of Washington, Department of Geology.

The objective of most activities, as in previous years, has been to conduct investigations and obtain information on the state's mineral resources, aid in their development and production, and, through correspondence, conferences, and the publication of bulletins, further their use by industry. The basic importance of the mineral industry to the economy of the state is indicated by part II of this report. It becomes obvious, when the magnitude and value of this industry is considered, that every possible assistance should be rendered as a function of State Government to those engaged in prospecting, mining, and mineral utilization.

CONTINUING ACTIVITIES

It is increasingly evident that the Division is properly considered by the general public and by the mineral industry as the principal repository of factual data bearing on the geology of the state, on the mineral occurrences of present and potential value, and on industrial possibilities along mineral lines. Responding to a voluminous correspondence pertaining to these subjects accounts for a considerable part of the time of the staff. Similar requests for information are made during office visits by those who can conveniently call and particularly by representatives of industry whose inquiries or problems are too involved to be handled by correspondence. In caring for this phase of the Division's activities every available source of information is drawn upon. Of chief value is the intimate personal knowledge, centered
FACILITIES OF THE DIVISION OF MINES AND GEOLOGY

A. Display of metallic minerals.
B. A part of the library.
C. Petrographic instruments.
D. Display of industrial minerals.
E. Microphotometer.
F. Corner of the laboratory.
G. Spectrograph and D. C. are reeifier unit.
in the Division, of the state’s mineral position. This knowledge, gained through long experience, is at the service of all who can use it, as is also the material in files and field notes that has been accumulating since the initiation of this branch of the State Government in 1901.

Inquiries cover a surprising variety of subjects. Many deal with prospecting: where are geological conditions suitable, how do various minerals appear and how are they identified, what are indications of mineral occurrence, and what steps should be taken in the development and disposal of properties. Very common are inquiries dealing with such subjects as the present status of old mining properties, mineral rights, lease and sale of mineral deposits, and various phases of mining law. The economic possibilities in mineral discoveries, new or old, often occasion questions that may lead to worth-while development. Particularly important are inquiries regarding the availability within the state of mineral materials needed by industry. These requests emanate from local and out-of-state concerns needing a new material or a new source of an old material, from Eastern organizations planning branch factories in the Northwest, and from new or long-established companies who may be considering new lines of products. Generally they are initiated by correspondence, are followed up by one or more office conferences, and then quite commonly field trips are arranged, whereby a member of the Division’s staff accompanies the industrialist or his engineers to occurrences of the mineral in question.

A continuing activity is the attention given to oil and gas prospecting. Until a law is enacted, making it obligatory for the drilling concerns to file the desired data with the Division, a member of the staff must call on all these operators and, through their good will, obtain location information, drilling logs, samples of cores and cuttings, and the results of the exploration. Usually these data, invaluable as matters of record and in future exploration, can only be obtained while the work is in progress. The files of the Division are available to all operators—new or old—and aid in formulating the suggestions and advice asked for by the operators.

Throughout the year information on the status of prospect development and on mining operations is collected and filed. Each fall a property-by-property canvass is made in the field to supply information for the directory of mining operations that is published annually. This report is very well received by the mineral industry and has an extensive country-wide circulation.

Cooperation with various Federal agencies is maintained, particularly with the U. S. Geological Survey in topographic mapping and in geological studies of mutual interest, and with the U. S. Bureau of Mines in the collection of statistics of mineral production. The Division is always able and willing to give aid to other State agencies in matters where knowledge of geology and mineral resources is required, a service that is used quite generally.

Continuing attention is given, also, to the maintenance and improving of its technical library, where professional and scientific books and journals dealing with geology, mineralogy, and mining, as well as reports of other states and of Federal agencies, are available for reference purposes to the
staff and, during office hours, to the public. Displays of ores and industrial minerals and aggregates are maintained and constantly revised for use in conferences, for general interest, and for educational purposes. Maps of the state, of special areas, and of mining properties are collected and filed for use of the staff or anyone who may wish to consult them.

**Laboratory Research**

The laboratory of the Division is well equipped for conducting the research and general investigative work that is a basic part of all field studies. Ordinary qualitative chemical analyses are made, and certain preliminary quantitative tests as well. Use is made of commercial assayers and chemists for the occasional more detailed testing that may be desirable. Full equipment is available for making thin sections and polished sections and for the study of ores and minerals through binocular, petrographic, and metallographic microscopes. A small laboratory-type furnace capable of reaching 1,900° F. has been installed for determinations where heat treatment is necessary. The latest addition to the equipment is an Applied Research Laboratories' 1.5 meter grating spectrograph and a microphotometer for the rapid interpretation of spectrograms on a qualitative and semi-quantitative basis. This makes possible a faster and more accurate determination of mineral samples, obviates the possibility of overlooking unusual or accessory components of ores, and provides a rapid means of making a preliminary estimate of the worth of special materials.

**Mineral Identification Service**

During the biennium 491 samples were submitted to the Division for mineral identification. This material is from prospectors, miners, farmers, and others who, for one reason or another, are interested in, or become curious about, some rock or mineral that they have discovered. They may merely wish the samples named, but usually they suspect a value and wish confirmation. Assays and chemical analyses are not made, but the sender receives a prompt reply identifying the material and suggesting further steps in prospecting or analysis whenever such procedure appears warranted.

This free service is greatly appreciated. It saves the prospector from spending his time and money on material that has no promise of value and encourages work on minerals that have economic possibilities. No other organization in the state is so well equipped to conduct this work. The University of Washington and State College of Washington, of course, can make the identifications, but the Division of Mines and Geology probably has a better practical knowledge of the mining geology of the state to draw upon in estimating the worth of the discovery and is the only organization that is prepared to follow up with a field study of the occurrence when that procedure appears desirable. Also, it is in touch with markets and so is in position to bring worth-while minerals to the attention of possible purchasers.

The specimens submitted have endless variety, covering the whole gamut of metallic and non-metallic minerals, rocks, and aggregates. Much of the material proves to have no value, but occasionally worth-while discoveries
are made. Recently, excellent specimens of a rare tantalum mineral were submitted for identification, giving the first intimation that an ore of this valuable element might exist here. Some prospectors regularly submit representative samples so as to maintain a check on the progress of their work. In late months an understandable increase in interest in uranium minerals has caused many samples to be received for radioactivity tests. The possibility is always present that discoveries of economic importance to the prospector—and hence to the state—may result from this identification service.

Mineral Exhibits

Several displays of minerals are maintained by the Division. No attempt is made to follow museum procedure, whereby the observer is commonly confused by the vast number of specimens shown. Rather, the collections are kept small and easily accessible, though they include excellent specimens of all mineral substances of economic value known to occur in the state. One small collection is of gem and fluorescent minerals, appreciated by those who collect, cut, and polish agates and other ornamental stones. Three compact general collections are in portable cases for use at expositions where it is desirable to advertise the state’s mineral resources and at school or other gatherings where talks have been requested on some phase of Divisonal work. The principal economic collection is newly housed in one large well-lighted cabinet so that everything is readily accessible for handling and detailed inspection.

SPECIAL PROJECTS AND INVESTIGATIONS

Coal

During the biennium considerable attention was given to the probability that eventually Washington’s coal, instead of being used for fuel as mined, will be used for the various products that may be made from it. Through carbonization, hydrogenation, gasification, or other process, coal may supply the products now obtained from petroleum. It cannot be predicted when this time will come—it may be a long way off. However, consideration of what the state has to offer against the probability of future needs deserves immediate attention.

As an approach to this problem, a contract was entered into between the Department of Conservation and Development and the Battelle Memorial Institute of Columbus, Ohio, a nonprofit research organization well qualified to conduct the desired study. The Institute was commissioned to make a comprehensive investigation of the fuel situation in the state. This comprised a complete market survey to estimate the availability and potential efficiencies of the various fuels; the economic utilization, comparative convenience, ease of use, cost, and desirability of such fuels; the potential effects of changes in the present fuel-oil situation; and the probable effects of cheap and abundant electric power on the future development of Washington’s coal resources. The study also involved an analysis of fuel consumption, including electricity, and requirements and supplies of carbon for metallurgical and
chemical uses. The resultant report became available early in 1947 and was widely distributed to libraries and to interested parties and agencies (see Publications, page 10).

A further step in reaching conclusions as to possibilities inherent in coal involves a study of the low-cost mining area of southwest Washington, where there are very large reserves of subbituminous coal. These coals are well adapted to hydrogenation or other processing, but more information is needed on the actual amount of coal present, the thickness and character of the beds, and the possibility of opening new mines where stripping or cheap machine-mining would be feasible. The U. S. Geological Survey well appreciated this fuel situation and expressed a willingness to be of service to the state in the long-range planning that was underway. As a result, the Survey now has a field party in the Thurston-Lewis County coal area obtaining the stratigraphic and structural data that are vital to a proper and complete utilization of this valuable resource. It is expected that this work will be followed by a similar investigation in Cowlitz County, thus rounding out the information that is necessary on the whole southwest Washington coal reserves.

Antimony

In line with the long-established policy of investigating Washington’s more important mineral occurrences on a state-wide basis, a survey of antimony resources has been underway by the Division during the past year or so. Several deposits were known; eight have had considerable development, some antimony having been produced from each. In addition, vague information on a large number of reported and rumored occurrences has gradually been accumulated over the years. The need for reliable data on every possible source of this strategic metal became increasingly evident as imports dwindled and domestic supplies were found to be inadequate.

The field work on this project has just been completed. In all, some 30 locations were investigated where there was even a remote possibility that a minable amount of antimony ore might exist. As was to be expected, many of these had but little merit though a few gave promise of definite commercial possibilities. At six places it was possible to be of considerable service to property owners by working with them on the geology of the occurrence and aiding in planning a logical development program.

Much laboratory and office work remains to be done on the material obtained in the field. This will be completed as soon as possible, so the resultant bulletin will be available for distribution in the summer of 1949.

Perlite and Other Volcanic Glasses

Perlite is a peculiar form of volcanic glass that expands to a white porous lightweight material when rapidly heated to near-fusion. It is relatively new to industry, but the treated glass is already in great demand as an aggregate for various forms of thermal and acoustical plasters and blocks and as a wallboard filler. Apparently the material will find many other valuable uses as it becomes more generally available and as present experimental techniques become standardized.
It became desirable, therefore, to determine whether perlite is among the state's resources of industrial minerals. No deposits were known in Washington, but certain geological formations were known to be favorable for the occurrence of this material. Also, recent perlite discoveries made in Oregon suggested the possibility that it occurred in Washington. The investigation undertaken by the Division was strictly a prospecting venture with no assurance of success. However, whether perlite were found or not, the study would supply information on the nature and availability of related glassy volcanic rocks about which little is known and which might have industrial value at some future time.

This field investigation has now been completed and most of the laboratory and office work finished, so a report should be available for distribution this coming spring. Unfortunately, the results of the work were rather disappointing; 13 perlite bodies were found, but none was the equal of the excellent rock being mined in Oregon and Nevada. However, one or two deposits may have some commercial value, and the information obtained on the whole subject makes a useful addition to the data already available on industrial minerals.

Inventory of Washington Minerals

In the years since 1901, when this agency was originally established as the Washington Geological Survey, an immense amount of information has been accumulated on the metallic and nonmetallic mineral occurrences of the state. Many years ago this was incorporated into a voluminous card file that has been expanded as new discoveries were made until it now comprises many thousand items. Most of the recorded data are authentic and complete; some are probably authentic but doubtfully accurate; and some are vague and questionable. However, these must all be considered, whatever their probable status, when an investigation of occurrences of a given mineral substance is undertaken.

To make these data more readily available to the mineral industry, a series of outline maps of the state has been prepared. On these maps are shown by symbols the location of the many mineral substances—one material to a map when occurrences are numerous, several materials to each map when only a few deposits are known. An accompanying very brief explanatory text for each map gives, so far as known, the legal land description of the occurrence, a few pertinent descriptive facts, the estimated importance of the deposit, and references to such further information as may be available.

The report is to be published in two parts; the one dealing with industrial minerals is in nearly completed manuscript form, the maps have been printed, and distribution should be possible toward the end of the current year. Considerable work has been done on the second part, dealing with metallic minerals, and, although its completion is some distance in the future, the compilation will be finished as soon as possible.
Saline-Lake Deposits

The investigation of the valuable but largely undeveloped resources of sodium sulphate, sodium carbonate, and related salines in Washington was completed in the preceding biennium and was described in Biennial Report No. 1 of the Division of Mines and Geology. Time-consuming laboratory and office work in connection with the great number of samples taken and the interpretation of acquired data have delayed the resultant formal report, but it will probably be ready for distribution within two or three months.

This delay has not been allowed to interfere with any possible development of these resources, as detailed facts and figures have been made available to all industrialists expressing interest in the subject. A considerable number of engineers and chemists have availed themselves of this opportunity to evaluate the various deposits for their uses. It has recently been announced that Industrial Enterprises, Inc., of Seattle, has completed plans for an operation employing about 20 men and in which an initial daily production of 50 tons of anhydrous sodium sulphate will be made. As this is one of the organizations with which the Division cooperated in supplying data, it is believed that some worth-while assistance has been rendered to the development of the saline resources.

PUBLICATIONS

The results of investigations of general or more than individual interest are published as expeditiously as possible and made available to the public. Copies of these reports are sent to all the principal state libraries, where they may be consulted by those interested. Copies are also sent to many of the larger libraries throughout the United States and, on an exchange basis, to Federal agencies and to other State Geological Surveys. The less-expensive reports are mailed without charge to anyone requesting them; more formal presentations are sold for a small charge that covers the cost of printing. The following reports were distributed during the biennium or are in preparation and nearly ready for distribution:

Pumice and pumicite occurrences of Washington, by Ward Carithers. 1946. 78 pp. 6 pl. 25¢.


Note: The complete report of 369 pages was distributed without charge to libraries and other places where it could be generally consulted; personal copies are sold for $10.00.


Division of Mines and Geology


Saline-lake deposits of Washington, by W. A. G. Bennett. (In preparation.)

Perlite occurrences of Washington, by Marshall T. Huntting. (In preparation.)

Antimony resources of Washington, by C. Phillips Purdy, Jr. (In preparation.)

Inventory of Washington minerals. Part I, Industrial minerals, by Grant M. Valentine. (In preparation.)


DIVISION OF MINES AND GEOLOGY BIENNIAL REPORT NO. 2

PART II

WASHINGTON'S MINERAL INDUSTRY

INTRODUCTION

The importance of the mineral industry to Washington's economic welfare is rather casually taken for granted by those connected with the industry, and hardly appreciated at all by others. The reaction is almost invariably one of astonishment when the average citizen is informed of the volume and value of the state's mineral production. Prospectors are usually interested in occurrences of a peculiarly few metallic minerals and seldom consider others that may be of equal or greater importance. Those engaged in developing properties are so involved in financing the operation, obtaining supplies and equipment, and carrying on exploration work to the best advantage that they have no time for other considerations. The producer has his own specific problems of ore extraction, treatment, transportation, and marketing that may obscure the regional picture. The "man of the street," completely occupied with his own affairs, has only the vaguest ideas of mining; if he thinks of it at all, it is to attach a false glamour based on stories of fabulous "strikes" of long ago, or to condemn all aspects of it because of activities of the occasional unscrupulous promoter.

Actually, minerals constitute one of Washington's most valuable resources, and the mineral industry is of basic importance to the economic welfare of the state. Few states have more diversification in mineral wealth. Few are so advantageously situated to obtain the maximum benefit from such resources. The rapid industrial development of the state is in large part due to availability of needed metallic and nonmetallic minerals and aggregates. That near industrial self-sufficiency is possible when more complete advan-
tage is taken of these resources, through integrated reduction and fabrication, is promised by the results of many years of investigation and research.

MINERAL PRODUCTION

Mining in the state began in 1853 with the production of coal in the Bellingham area of the present Whatcom County and was given a pronounced impetus in 1859 when gold was discovered in gravels of the Similkameen River in what later became Okanogan County. For a considerable time placer gold received the principal attention of miners, but lode discoveries were soon made—first of gold, then of other metallic minerals—at various places in the north half of the state. The inevitable result was the development of properties in one mining camp after another, so that by the latter part of the 1800’s “hard-rock” mining had become a well-established industry.

The total production of minerals and mineral aggregates in Washington since the beginning of mining had reached a value of slightly less than a billion dollars in 1946 and was increasing annually at a rate of about 30 million dollars. The smallest production since 1906 was in the depression year of 1933, when the mineral output amounted to $9,387,645. The largest production in any one year was in 1943, when the value amounted to $37,-583,000. During the 20-year period from 1927 to 1946 inclusive, which of course includes the depression years, the annual production averaged $24,-178,896. The average annual production from 1936 to 1941, after the depression may be considered to have ended and before World War II, was more than $26,000,000, and from 1941 to 1946 (the latest year for which complete statistics are available) was $33,790,570. These production trends, reflecting periods of industrial adversity and prosperity are shown graphically for the years 1900 to 1946 on the following chart.

The tabulation of production statistics for the years 1939 to 1946 inclusive, shown on page 13, indicates the relative value of the principal mineral products and also the trends in development, extraction, and utilization. Un-

1Production figures based on statistics of the U. S. Geological Survey and U. S. Bureau of Mines, as shown in Mineral Resources and Minerals Yearbooks for various years.
<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>1939 Quantity</th>
<th>1940 Value</th>
<th>1941 Quantity</th>
<th>1941 Value</th>
<th>1942 Quantity</th>
<th>1942 Value</th>
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<td>1,650,000</td>
<td>$1,085,659</td>
<td>1,650,352</td>
<td>$1,258,333</td>
<td>1,841,271</td>
<td>$1,235,737</td>
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<td>6,250,000</td>
<td>2,231,177</td>
<td>7,529,674</td>
<td>1,935,393</td>
<td>7,549,332</td>
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<tr>
<td>Coke</td>
<td>10,000</td>
<td>44,188</td>
<td></td>
<td>6,250</td>
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<tr>
<td>Copper</td>
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<td>6,250</td>
<td>5,593</td>
<td>4,449,424</td>
<td>666,392</td>
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<td>2,555</td>
<td>255,500</td>
<td>62,300</td>
<td>666,392</td>
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<td>10,600</td>
<td>11,060</td>
<td>10,600</td>
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<td>Sand and gravel</td>
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<th>1945 Quantity</th>
<th>1945 Value</th>
<th>1946 Quantity</th>
<th>1946 Value</th>
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<tr>
<td>Tungsten ore (90% cone.)</td>
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<td></td>
<td>11,560</td>
<td></td>
<td>11,560</td>
<td></td>
</tr>
<tr>
<td>Zine</td>
<td>10,131</td>
<td>9,011,753</td>
<td></td>
<td></td>
<td>9,011,753</td>
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<tr>
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<td>$38,506,882</td>
<td>$38,506,882</td>
<td>$33,076,000</td>
<td>$33,076,000</td>
</tr>
</tbody>
</table>

2 Not included in state total, in order to avoid duplication.
3 Includes minerals indicated by "v" above, also, in various years, the following: arsenious oxide, diatomite, magnesite, magnesia, magnesium, magnesium carbonate, silica, silica, and other minerals.
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fortunately, the figures for some major items such as portland cement and magnesite cannot be given specifically but only in the total for the state; otherwise individual operations would be disclosed, contrary to the policy of the U. S. Bureau of Mines, from whom the statistics are obtained.

Minerals are commonly divided into two broad groups: metallic and nonmetallic or industrial. The metallic minerals are those having a metallic element as a prominent component or those which are sought chiefly for their metal content. The nonmetallic or industrial minerals, on the other hand, are not used as a source of metals but are employed, after possibly some beneficiation or treatment, in nearly their original condition. Until recently, coal, portland cement, lime, clay products, sand and gravel, stone, magnesite, and other less important nonmetallic minerals and aggregates have generally accounted for about 90 percent of the state's total mineral output. The ores of gold, silver, copper, lead, zinc, and a few other metallic elements have accounted for the other 10 percent. In late years, however, this proportion has changed somewhat. In 1946, for example, the value of industrial minerals amounted to $26,189,252 or 79 percent of the total output; the value of metallic minerals, $6,886,748 or 21 percent; and the production of both, $33,076,000. This relationship is shown graphically on the chart on page 12. There the difference between total mineral production and the total production of the five major metals shown for any given year from 1900 to 1946 is the amount of industrial minerals produced in that year plus a relatively minor amount of other metals such as mercury, manganese, tungsten and iron.

In 1946 Washington ranked 31st among the states of the Union, producing 0.43 percent of the total United States mineral output. For comparison with adjacent states, Idaho was 26th in rank with 0.58 percent and Oregon was 40th in rank with 0.15 percent of the total national production. This ratio is surprisingly close to the average for the 35-year period 1911-1946, which shows Idaho to rank 26th with 0.74 percent; Oregon, 40th with 0.15 percent; and Washington, 30th with 0.51 percent.

MINING OPERATIONS

Minerals or mineral aggregates are produced from all counties in the state, as at least sand, gravel, and common stone are obtained in what are usually considered as nonmining counties. These three construction materials are commonly produced from temporary pits and quarries for road metal and ordinary building purposes and, although of marked importance in amount and value, may be disregarded in considering the principal mineralized areas of the state. Commercial minerals other than sand, gravel, and common stone are produced from 26 counties. The number and kind of operations change from year to year, but those of 1948 provide a useful indication of general activity in the various mining counties. For this purpose it will be considered that operating properties are those in actual production, those that have produced very recently and can resume operation, and those whose development indicates that production may be expected in the near future.
Metallic Minerals

On the basis mentioned, metallic minerals of one kind or another are being produced from 95 operations scattered through 13 counties.

<table>
<thead>
<tr>
<th>COUNTIES AND NUMBER OF OPERATIONS PRODUCING METALLIC MINERALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stevens            22</td>
</tr>
<tr>
<td>Okanogan           17</td>
</tr>
<tr>
<td>Ferry              13</td>
</tr>
<tr>
<td>Pend Oreille       11</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

In some metal mines the ore is complex and a number of metals are recovered; however, in most instances some one or two metals are usually predominant and may be indicated to classify the operation. A simple classification, such as this, is questionably applicable to an operation like the Holden mine of the Howe Sound Co., that is properly listed as a copper property but which produces gold, silver, and zinc in amounts comparable with mines in which those are the dominant metals.

<table>
<thead>
<tr>
<th>ORES PRODUCED AND NUMBER OF OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold-silver 30</td>
</tr>
<tr>
<td>Lead-zinc 25</td>
</tr>
<tr>
<td>Lead-silver 15</td>
</tr>
</tbody>
</table>

Thus a total of 95 metal-mining operations are currently active, have produced recently and could resume, or may be expected to be active in the near future. In addition, arsenic is being produced as a byproduct from the smelting of local ores; magnesium, in large amount, was produced during the war period and, if desired, could again be reduced from local dolomite (magnesite in extensive deposits and olivine and sea water in practically limitless amounts are also available for producing magnesium); and primary arsenic, chromite, and possibly nickel could be produced from local ores.

GOLD

The gold production of Washington, though relatively small in amount when compared with that of some western states, forms an important proportion of the total mineral output. In former years placer operations were widespread and a few areas, such as along Swauk Creek, Kittitas County, and Peshastin Creek, Chelan County, gave good returns. Statistics are not as complete as desired, but the total value of placer-gold production from 1860 to 1946 is approximately 20 million dollars. Of this amount, more than 19 million, or about 96 percent, was produced prior to the year 1900, indicating the slight value to the state of placer operations in later years. Lode-gold production, on the other hand, has continued to be important in amount with many mines in as many as 10 counties contributing to the total output. The Republic district of Ferry County has had the longest, consistent record of production and led all counties during 27 of the years since 1902. Stevens County produced the greatest amount of gold during 4 years and contributed important amounts in other years. Whatcom County, also, led during 4 years and has been an important producer at other times. Okanogan and Kittitas Counties have nearly always produced some lode gold and in certain years important amounts. Chelan County, formerly a small producer, took the lead in 1938 because of the output of the Holden mine of the Howe Sound Co. and continued to hold it until in 1947, when Ferry County again took the lead.
The total gold production of the state (both placer and lode) from 1860 to 1947 has amounted to 2,213,635 fine ounces, valued at $56,232,548. The greatest production in any single year was in 1939 when 90,420 ounces were produced, valued at $3,164,700. In 1947 the amount was 34,965 ounces, valued at $1,223,775, production being from Ferry and Chelan Counties and, in almost negligible amount, from seven other counties.

SILVER

Occasionally, mines in Washington are operated for silver alone or as the principal constituent of their ores, but it has been many years since predominantly silver properties have contributed appreciably to the total mineral production of the state. However, silver accompanies gold in virtually all gold mines and occurs as well with lead, copper, and zinc in base-metal mines, so the state has a considerable production. The total amount produced from 1860 to 1947 has been 13,123,609 fine ounces valued at $9,375,344. The largest production in a given year was in 1939 when 442,063 ounces were produced, valued at $300,067. The 1947 production, of 293,736 ounces, valued at $265,831, was principally from the Knob Hill mines, Republic district, Ferry County; the Holden mine, Chelan County; the Kaaba Silver Lead mines, Okanogan County; and, in less amount, from several properties in Stevens and Pend Oreille Counties.
COPPER

Ores of copper are very widespread throughout the mining counties of the state, and many properties at various places have been operated in different years. Very little copper was mined prior to 1900, but thereafter production rose to 2,645,022 pounds in 1916, when seven mines were in operation, the principal ones being in Stevens, Ferry, and Snohomish Counties. Following 1916, the output gradually declined to a low of only 5,524 pounds in the depression year of 1932. In 1938 the Holden mine came into production, causing the state's copper output to rise abruptly from the 128,000 pounds of 1937 to 12,034,000 pounds, valued at $1,179,332. Since then, more than 99 percent of the state's copper output has been from this one property. The total production of the state since copper mining began, in presumably 1893, to 1947 has been 162,332,000 pounds, valued at $21,641,309. The total state output for 1947 was 4,480,000 pounds, valued at $940,800. This is markedly below the usual output of recent years, as for 6 months or so in 1947 the Holden mill was idle while the company concentrated on mine-development work that had to be curtailed during the forced-draft operation of the war years. Presumably the 1948 production of copper from this mine will be in the neighborhood of 1½ million dollars in value.

The Holden mine of the Howe Sound Co. is the largest single metallic-mining operation in the entire Pacific Northwest, including Alaska. It is near the upper end of Lake Chelan in Chelan County, about 60 miles northwest
of Wenatchee. In one of the most rugged parts of the Cascade Mountains, at an elevation of 3,600 feet above sea level, the mine is surrounded by snow-capped peaks that reach altitudes of more than 9,000 feet. The geology of this district, though complex, may be simply described as characterized by a series of ancient sedimentary rocks, now greatly metamorphosed, that have been intruded in several stages by acidic and basic igneous rocks. Enclosed within the metamorphic rocks is a northwest-trending siliceous zone that is heavily mineralized in places by pyrite, pyrrhotite, chalcopyrite, and sphalerite, all carrying minor amounts of gold and silver, forming ore bodies that have mining widths of 15 to 80 feet.

Ore production at the Holden mine has been consistently at a rate of 2,000 to 2,100 tons per day and during the peak of wartime’s forced operation reached 2,500 tons. Notably efficient, economical mining methods are employed. For the first 5 years of operation most of the tonnage was broken by a powder-blast caving method, but later, by a system using diamond-drill blast holes. The tenor of the ore is low, so it is primarily the ability to mine cheaply a large tonnage that makes the operation economically feasible. The 2,000-ton concentrator at the mine is one of the most modern flotation plants in the country, producing a gold-bearing copper concentrate and a zinc concentrate. Also, a small amount of gold is salvaged from coarse mill tailings by cyanidation. Approximately 491,400 tons milled in 1946 averaged 0.992 percent copper, 0.597 percent zinc, 0.076 ounce of gold, and 0.278 ounce of silver per ton. The Holden mine’s record copper production was in 1940, when it produced 18,577,400 pounds; thereafter the output has shown a steady, rather small decline, but in 1946 was 8,987,000 pounds, valued at $1,455,894.

LEAD

The first recorded production of lead in Washington was in 1898; since then some lead has been produced each year and large amounts in various years. The largest annual output was in 1944, when 11,650,000 pounds, valued at $932,000, were produced. The total production from the time lead mining began to 1947 was 162,244,000 pounds, valued at $11,690,416. The 1947 production amounted to 10,718,000 pounds, valued at $1,543,392.

Some production at various times has come from each of 10 different counties—the principal mining counties of the state—but in late years the chief production has been from the Metline district of Pend Oreille County, followed by Stevens and Okanogan Counties. The principal producing companies in 1947 were the American Zinc Lead & Smelting Co., Pend Oreille Mines & Metals Co., and Metline Mining & Leasing Co., all of Pend Oreille County; the Kaaba Silver Lead Mines, Inc., of Okanogan County; and the Goldfield Consolidated Mines Co., Bonanza Lead (Co-partnership), Young America Mine, Base Metals, Inc., and Admiral Consolidated Mining Co., all of Stevens County.

ZINC

Little attention was paid to zinc during the early days of mining in Washington except to deplore its presence in the ore that was being mined. It had but little value, gave trouble in treatment processes, and was the cause of penalties imposed by some smelters on ores containing it. The
whole economic situation gradually changed when prices improved as new uses and demands for the metal arose, as improvements in ore-dressing and metallurgical processes were made, and as old sources of zinc in other states became depleted. Now zinc is a metal zealously sought and of marked economic importance.

Early statistics are somewhat vague, but some zinc was produced in Washington in 1906, more in 1911, and continuous production (except for the one year 1919) began in 1915. The total production to 1947 has been 303,-230,000 pounds, valued at $25,552,648. The largest annual output was in 1942 when 28,796,000 pounds were produced, valued at $2,678,028, though the 1947 output of 27,600,000 pounds had a higher value ($3,174,000) owing to a rise in the price of zinc.

Zinc ores occur quite commonly throughout the mining counties of the state, but the principal production is from the same properties as those previously mentioned as being prominent producers of lead. In addition, the Holden mine of the Howe Sound Co. produces a large amount of zinc during normal operation.

The future of both lead and zinc mining is good indeed. Investigations by the U. S. Geological Survey and the U. S. Bureau of Mines in northern Pend Oreille County and adjacent northeastern Stevens County have shown large areas to be potentially productive of these ores. A reserve of more
than 20 million tons of lead-zinc ores has been proved by diamond drilling in Pend Oreille County alone. The old, established mines in both counties are increasingly active, and new properties are being prospected and developed throughout the northeastern part of the state.

**CHROMIUM**

Some 30 separate occurrences of chromite, the ore of chromium, are known in Washington. These are all relatively small lenticular masses or, in a few instances, what appear to be zones of disseminated mineral. However, in general, the grade is good, and some of the deposits merit development, which becomes more obvious when it is realized that few occurrences of chromite having a large minable tonnage are known anywhere in the United States. The relatively small deposits thus gain importance. Of the various ones known in the state, those of the Twin Sisters Mountains, of Skagit and Whatcom Counties, appear to have the best economic possibilities, although at the present time they are difficultly accessible. Probably not more than 100 tons in all have been mined from the chromite occurrences of the Twin Sisters Mountains, Cypress Island, and the Mount Hawkins area of Kittitas County. Chromite in Washington may be considered a more or less unproven resource; it has definite possibilities of commercial value, but detailed geologic and metallurgical research will be required before its value as a resource is known.

**IRON**

More than 40 occurrences of iron, in the form of magnetite, hematite, limonite, and siderite, are known, widely scattered over the state, but it is probable that no individual occurrence contains more than 18 million tons and most of the deposits are much smaller. This indicates that insufficient ore exists for blast-furnace operation; however it would appear that electric-furnace production of special steels is entirely feasible. As most of the deposits consist of magnetite, and some have unusual characteristics, such as a relatively high nickel and chromium content, a considerable metallurgical problem would be involved in utilizing the materials.

Iron ore has been mined for special uses at Buckhorn Mountain in eastern Okanogan County and, to a lesser extent, at a few other places. Some is used in the manufacture of portland cement, and, during the war, a moderate tonnage was mined for ballasting ships. The total iron ore production has been approximately 100,000 long tons, and the greatest amount mined in any one year, approximately 14,000 tons.

**MANGANESE**

Manganese minerals occur as lenticular masses, occasionally of considerable size, at many places on the north, east, and south side of the mountains of the Olympic Peninsula. More than 60 occurrences are known, but insufficient development has taken place to give accuracy to estimates of ore reserves. The extent and persistence of the showings, however, indicate that a reasonably large amount of ore exists. Most of the deposits so far discovered consist of bementite, a low-grade silicate of manganese. This is not an acceptable mineral for orthodox usage, but that battery-grade manganese
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dioxide and metallic manganese can be produced from it has been proved by research work of the U. S. Bureau of Mines, the University of Washington, and the State College of Washington. In fact, a plant at Hoodsport operated for a short time, producing a 99+ percent pure metallic manganese for steel-alloying use. Apparently, this was an entirely successful operation, metallurgically, and its failure was due to other than technological factors.

Haussmannite, a high-grade manganese oxide, also occurs at a few places in the Olympic Peninsula manganese belt. It has been mined at only one place—near Lake Crescent, Clallam County—but this property in two periods of operation has produced approximately 44,275 tons of ore containing about 52 percent manganese and valued, probably, in excess of 1½ million dollars. This ore was mined shortly after World War I by Jamison and Peacock, and during World War II by the Sunshine Mining Co., Manganese Division. During this later period of operation it is said to have been the highest grade of any then being produced in the United States.

MERCURY

Although cinnabar, the ore of mercury, is known to occur in several counties, the only mining of commercial consequence has been in the Morton district of Lewis County. The first production there was of 75 flasks in 1916, but active development of the district did not begin until 1926 and was then continued until 1942. In all, some 6,500 flasks (75 to 76 pounds each) of mercury were produced, valued at nearly $700,000. Work in the district has been sporadic since 1942, and there has been no production; but ample evidence indicates that commercial production can be resumed when the market price for mercury warrants, providing proper consideration is given to the geology of the ore deposition.

TUNGSTEN

Many occurrences of tungsten minerals are known in Washington, and several have been in production at various times. The most constant and largest output has been from the Germania mine and adjacent properties in southwestern Stevens County. The Germania mine was originally operated by a German syndicate. During World War I, after the seas were closed to the surface shipping of the Central Powers, tungsten concentrates were shipped to Germany on the famous submarine Deutschland. Following the entry of the United States into the war, the mine passed out of foreign control and thereafter had a long record of production for the benefit of American industry. Very little tungsten is produced at present, but with a bettering of price that would follow increased demand various properties would doubtless come into production.

OTHER METALS

Aluminum is produced in large amount in plants at Spokane, Tacoma, Longview, and Vancouver, but as no local ores are used these operations are considered as manufacturing enterprises rather than as a part of the state's mining industry (see page 23 [high-alumina clays]). No magnesium is produced currently, though its production from local ores during World War II was a major industry (see page 25 [dolomite]). Small amounts of
antimony and molybdenum have been produced in the past and many occurrences are known, some of which appear to have definite commercial possibilities. In the early 1920’s some arsenic was produced, and several undeveloped occurrences of arsenic minerals are known; however, this metal is obtained as a byproduct of smelter operations in sufficient quantity for usual market demands. Many occurrences of nickel minerals are known and are being investigated to ascertain if any have promise of economic importance. On the whole, these several metals are a part of the undeveloped but potential resources of the state and will require detailed study to determine if their mining would be justified by present or future market needs.

Industrial Minerals

For convenience the same basis is used in listing active industrial-mineral operations as is employed in the consideration of metallic operations. Currently, there are some 1,038 pits and quarries scattered through all 39 counties of the state where sand, gravel, or common stone are being produced. Aside from these items, industrial minerals and aggregates are produced from 165 operations distributed throughout 24 counties.

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>King</td>
<td>46</td>
</tr>
<tr>
<td>Chelan</td>
<td>14</td>
</tr>
<tr>
<td>Lewis</td>
<td>9</td>
</tr>
<tr>
<td>Spokane</td>
<td>9</td>
</tr>
<tr>
<td>Stevens</td>
<td>9</td>
</tr>
<tr>
<td>Kittitas</td>
<td>8</td>
</tr>
</tbody>
</table>

COUNTIES AND NUMBER OF OPERATIONS IN EACH ON INDUSTRIAL MINERALS (not including sand, gravel, and common stone)

In these many operations 22 different varieties of substances are produced. Some of this output is in very large amount by prominent and long-established concerns; some is small in quantity and value but represents a growing industrial development.

INDUSTRIAL MINERALS AND NUMBER OF OPERATIONS

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>44</td>
</tr>
<tr>
<td>Clay and/or clay products</td>
<td>35</td>
</tr>
<tr>
<td>Pumice</td>
<td>19</td>
</tr>
<tr>
<td>Limestone</td>
<td>14</td>
</tr>
<tr>
<td>Mineral waters</td>
<td>9</td>
</tr>
<tr>
<td>Diatomite</td>
<td>3</td>
</tr>
<tr>
<td>Portland cement</td>
<td>6</td>
</tr>
<tr>
<td>Portland cement</td>
<td>6</td>
</tr>
<tr>
<td>Soapstone</td>
<td>4</td>
</tr>
<tr>
<td>Silica</td>
<td>7</td>
</tr>
<tr>
<td>Portland cement</td>
<td>6</td>
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<td>Portland cement</td>
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<td>Portland cement</td>
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</table>

In addition, many substances are available for production when sufficient market demand arises to justify developing the properties and installing whatever equipment may be necessary for treatment. These include saline deposits (sodium sulphate and carbonate), mineral pigments, flake mica, feldspar, barite, and others.

CLAY AND CLAY PRODUCTS

Clays of many varieties occur in Washington and support an industry of considerable importance. Common red-firing clays are most abundant and are used at 13 plants for the manufacture of common brick, partition tile, and drain tile. Red-firing pottery clays are used at 4 plants for the manufacture of flower pots. Higher quality light-firing clays, some having excellent refractory
properties, are mined at about 12 places and supply 3 large plants where face brick and fire brick and shapes are manufactured. These plants also manufacture sewer pipe. The production statistics of clay products are not complete, but the annual value of the various wares commonly amounts to a million dollars and in some years to as much as 3 million dollars. The 1946 output of both clay (sold or used as raw clay) and clay products (exclusive of pottery and refractories) had a value of $2,443,594.

High-alumina clays suitable for the production of aluminum occur in large amounts in Cowlitz, King, and Spokane Counties. They are not used for this purpose but have been explored and tested, so that if the need ever arises and bauxite, the accepted ore of aluminum, should become unavailable, these clays may be utilized. All aluminum that has been and is being produced in Washington is made from alumina shipped into the state and produced originally from out-of-state domestic and imported bauxite. Recently discovered ferruginous bauxite (laterite) of Cowlitz County gives more promise of economic value as aluminum ore than do the high-alumina clays, and it is probable that this, together with similar material occurring in Oregon, will some day be used as a source of alumina.

COAL

The earliest recorded discovery of coal in the state was in 1833 when Dr. William Fraser Tolmie, an English surgeon in the employ of the Hudson’s Bay Co. and later Factor of Fort Nisqually, reported coal as occurring near the junction of the Cowlitz and Toutle Rivers in what is now Cowlitz County. The first mine to be opened was on Bellingham Bay in 1853. From then on coal mining increased in importance until in 1918, when a peak annual production of 4,138,424 tons, valued at $14,564,445, was reached. Production decreased somewhat thereafter, owing partly to the increased use of oil and electricity and partly to changed economic conditions; but in most years coal still leads all other mineral substances in total value. The total output of coal since mining began has been approximately 139 million tons. The production in 1946 was 990,000 tons, valued at $5,465,000.

The major coal fields of the state are in Whatcom, Skagit, King, Kittitas, Pierce, Thurston, Lewis, and Cowlitz Counties. All the principal ranks of coal from lignite to anthracite are present, the chief production and reserves being of subbituminous and bituminous ranks. The lignite, occurring in southern Lewis County, and the anthracite, occurring in central Whatcom County, have been explored but so far have not been put into production. The only large and commercially important supply of coking coal in the Pacific Coast States is in Pierce County—a fact that will have a significant bearing on the future expansion of the electrochemical and electrometallurgical industries of the West Coast.

LIMESTONE, DOLOMITE, LIME, AND PORTLAND CEMENT

Limestone is one of the most important industrial materials occurring in the state. It is used in the manufacture of lime and portland cement, in the sugar and paper industries, and has many other chemical and industrial applications (see page 15). The largest deposits of eastern Washington
are in Chelan, Ferry, Okanogan, Pend Oreille, and Stevens Counties. These
show great variation in composition, ranging from very pure calcium car-
bonate to high-magnesian varieties and dolomite. The principal western
Washington deposits are in King, San Juan, Skagit, Snohomish, and Whatcom
Counties. They are mostly of high-calcium content and have marked economic
value.

Portland cement manufacture accounts for the largest quantity of lime-
stone used. The state has six active plants:

Lehigh Portland Cement Co., Metaline Falls, Pend Oreille County
Northwestern Portland Cement Co., Grotto, King County
Olympic Portland Cement Co., Ltd., Bellingham, Whatcom County
Permamente Portland Cement Co., Diamond Division, Seattle, King County
Spokane Portland Cement Co., Irvin, Spokane County
Superior Portland Cement Co., Concrete, Skagit County

The production from these plants is sufficient to make portland cement
one of the most economically valuable mineral substances of the state, the
total production since the beginning of its manufacture in 1907 probably being
valued in the neighborhood of 160 million dollars. The annual output cannot
be divulged, but in general it ranks in value with, and commonly exceeds,
that of the coal produced in Washington.

The production of lime varies considerably but in recent years has
averaged 48,000 tons annually, valued at some $530,000. The building industry
formerly consumed the greatest amount, but the situation now is changed
and the expanding chemical industry is the largest user.
During World War II one of the many great dolomite deposits of eastern Washington produced the ore that was used with locally manufactured ferrosilicon to make magnesium. This process—so important during the war period—could again be carried on if economically desirable, to produce a practically unlimited amount of the light metal needed in airplane manufacture and other industries; however, at the present time, dolomite is mined only in small amount as an industrial mineral.

MANGESITE

Washington leads the United States in the production of magnesite. This mineral—a magnesium carbonate—is used, after treatment, as a basic refractory in the steel industry. The deposits are in Stevens County, where they occur as great bodies in the 23-mile belt of Stensgar dolomite extending southwestward from the vicinity of Chewelah. Production began in 1916; since then the total value of “dead-burned” magnesite from the plant of the Northwest Magnesite Co., at Chewelah has probably been in the neighborhood of 28 million dollars. The annual production cannot be divulged but generally ranks in value with that of the clay-products industry.
SAND AND GRAVEL

Sand and gravel for all ordinary construction needs are particularly abundant in Washington and, fortunately, well situated with regard to the centers of industrial activity. Despite low cost per ton, these materials are among the most important mineral substances produced in the state in point

of annual value. Since 1906, when complete statistics first became available, the total sand and gravel production has reached approximately 164 million tons, valued at some 74 million dollars. The output in recent years has run from 5 to 12 million tons annually. The 1946 production was 7,557,704 tons valued at $4,608,382.

STONE

Special stone (mostly granite) for all usual architectural and dimension purposes is abundantly available and is produced in varying but generally rather small amounts for building and monumental use. On the other hand, common stone (mostly basalt), also abundantly available, is used in very large amounts for road construction, riprap, and breakwaters. The statistics of 1946 production give a useful indication of the importance of a resource that is seldom considered when account is taken of the state's mineral position. In that quite average year were produced: 2,924,320 tons of common stone,
valued at $2,772,580; 30,560 tons of granite, valued at $83,910; and 62,270 tons of miscellaneous stone valued at $54,311. Limestone, mentioned separately on page 28, had a production of 132,400 tons, valued at $315,503; this was in addition to that used for the manufacture of lime and portland cement. The total 1946 stone production, exclusive of a relatively small amount of sandstone, was 3,149,800 tons, valued at $3,232,805.

OTHER INDUSTRIAL MINERALS

Although individually less valuable from a monetary standpoint than those already mentioned, other nonmetallic minerals and aggregates have an important place in the state’s industry. Silica, in the forms of massive quartz of high purity, quartzite, and sand, is mined for various industrial uses. Diatomite, used as thermoinsulation, as a filtering medium, and as a filler, occurs in immense quantities in several counties and has been mined and processed for many years. Natural carbon dioxide gas is produced in Klickitat County and compressed into dry ice. Magnesium sulphate from

Okanogan County has been processed to pharmaceutical-standard epsom salts. Sodium sulphate from extensive natural deposits and brines in Okanogan County is being developed for detergents and other chemical uses. Olivine from one of the largest occurrences in the United States is beginning to be mined and used as a basic refractory in the eastern steel industry. Pumice
for lightweight aggregates is being produced in increasing amount. Talc and soapstone deposits are in production. Peat and marl are being produced. Many other less well known minerals are available and doubtlessly will be produced as the need arises.

The continued and fast-expanding industrial development of the state is emphasizing the importance of the great variety of nonmetallic mineral resources of Washington. The more usual ones are supplying present needs, and their production can be expanded to meet future requirements. Some of the industrial minerals and aggregates are practically unlimited in quantity, others are available in large or small amounts or may be relatively scarce, yet a surprising number of useful materials of local origin are known and available for present and future industrial requirements.