STATE OF WASHINGTON

Department of Conservation and Development

E. F. BANKER, Director
OLYMPIA

DIVISION OF GEOLOGY
H. E. CULVER, Supervisor

BIENNIAL REPORT

OF

Division of Geology

April 1, 1933, to November 30, 1934

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DIVISION OF GEOLOGY

Honorable E. F. Banker Director,
Department of Conservation and Development,
Olympia, Washington.

Sir: I have the honor to submit herewith the biennial report for the Division of Geology covering the period from April 1, 1933, to November 30, 1934. During this time the work of the Division has been considerably enhanced through the allocation of relief funds from both state and federal sources. In accordance with your request, a special report of the Mineral Survey by Mr. J. D. Hull, in charge, is included.

I wish to acknowledge with gratitude the courteous cooperation extended to the Division of Geology by members of the faculties of the University of Washington and the State College of Washington.

Very respectfully,

HAROLD E. CULVER,
Supervisor.

College Station, Pullman, Washington,
December 8, 1934.

BIENNIAL REPORT OF THE SUPERVISOR OF THE DIVISION OF GEOLOGY

The time covered by this report is readily divided into two periods: the first extending from April 1 to September 30, 1933, and the second from the latter date to December 1, 1934. In the first period the activities of the Division of Geology were necessarily restricted by the limitation imposed by a reduced budget allotment. During the second period, the scope of activities of the Division of Geology was enlarged in connection with a systematic survey of the natural resources of the State undertaken by the Department of Conservation and Development.

For the purpose of carrying out the general survey of natural resources more efficiently, and to provide employment for unemployed engineers, technical men, and laborers, both in making the survey and through opportunities that might be developed by the survey, the Washington State Emergency Relief Commission granted the sum of $80,000 to the Department of Conservation and Development, making particular reference to stream gauging, river surveys, topographic mapping and geological and mineral investigations.

There was allocated from this fund to the Water Resources Branch of the U. S. Geological Survey for cooperation in stream measurements the sum of $20,000, and to the Conservation Branch of the U. S. Geological Survey for cooperative work in river surveys the sum of $10,000, leaving a balance of $50,000 for geological and mineral investigations and research and for topographic mapping. Supplementing this fund were allocations for C. W. A. and W. E. R. A. projects under which there was expended in mineral and oil and gas investigations the sum of $29,962.36 and for topographic mapping the sum of $14,546.50.

ACTIVITIES

The work of the Division of Geology constitutes one of the fundamental activities of the State. In compiling accurate information as to the character and mineral worth of all the land of the State, it is providing basic information for a large number of the important branches of state government. The relation between geology and mining is generally understood, but it is not as commonly recognized that other activities such as reforestation, water resource investigations, land classification, and land use have an equally close dependence upon geology.

In a general sense, the activities of the Division of Geology may be grouped to combine (1) those related to topography, (2) those related to basic geology, and (3) those of an economic character. In considering this subdivision, it must be recognized that the third group—the economic studies—is the objective of all the geologic work. Other activities are of value to the Division of Geology itself only as they help this program. It is to be recognized, also, that economic studies can be efficiently undertaken only on a foundation of basic geology. In the same way, a topographic base is essential to geologic work.

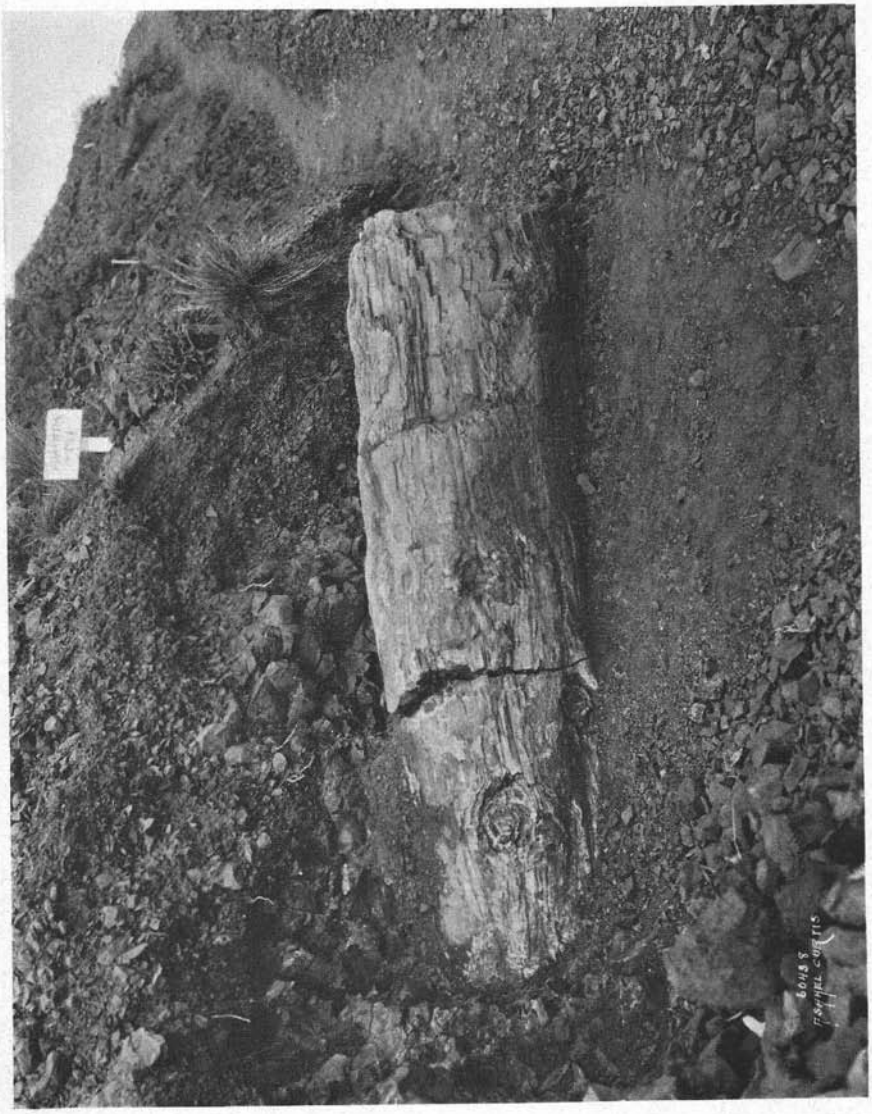
During its 34 years of continuous operation, the geologic organization has been able to do efficient work only because it has recognized this dependence of one group of activities on another.

TOPOGRAPHIC MAPPING

The United States government has long been carrying on a program of topographic survey which will eventually provide the nation with a complete topographic base map. This mapping is done in units of 15 or 30-minute quadrangles except where much greater detail is needed.

The first of this mapping in Washington was undertaken in 1893 and carried on independently by the Federal Government until 1910. Since then, under cooperative agreement of equal cost sharing, the mapping has been hastened until by the opening of this biennium about 53 per cent of the State had been mapped. For the purposes of calculation, it is convenient to consider that the total area of the State of Washington is equivalent to approximately eighty-eight 30-minute quadrangles. Of this number, forty-two quadrangles remained unmapped at the close of 1932 and four and one-half additional quadrangles have been mapped during this biennium. The Topographic Branch of the U. S. Geological Survey completed the mapping of the Mt. Constance quadrangle in the Olympic Peninsula, an area of special importance on account of the presence of manganese deposits. In addition, the Eatonville quadrangle in the coal fields south of Tacoma, the Metaline quadrangle in the zinc area of Pend Oreille County, and the Ft. Simcoe quadrangle southwest of Yakima were mapped. Primary control was completed in a fifth quadrangle, Marcus, in a mineralized area of Stevens and Ferry counties.

Under a special agreement with the U. S. Geological Survey, the State has cooperated in mapping two 15-minute quadrangles in western Washington during 1934. Funds for State participation in this work were allocated from Grant 14, which were supplemented by C. W. A. and W. E. R. A. funds. The work of the regular trained topographers of the U. S. Geological Survey was undertaken by engineers without special topographic training. The



Section of fir log completely fossilized—Ginkgo Fossil Forest.

uniformly high standards of topographic mapping were maintained, nevertheless, through the close supervision of the work by Mr. Gerald Fitzgerald, Topographic Engineer, who was detailed from the Alaskan Branch for this particular service during the winter season, and by Mr. R. C. Seitz, Topographic Engineer, U. S. Geological Survey, later. Although the expense of this undertaking was considerably in excess of the usual costs, it must be recognized that the dual purpose of providing topographic maps and unemployment relief was accomplished.

In addition to the four and one-half 30-minute quadrangles of the usual type noted above, an area of approximately one and one-quarter 30-minute quadrangles was completed by the U. S. Army, Corps of Engineers, in the northwestern part of the Olympic Peninsula. This was a part of an aerial mapping program, most of the flight work having been completed in 1933 while the ground work was largely completed in 1934.

BASIC GEOLOGY

Under the heading of Basic Geology are included all those Divisional activities relating to studies which yield fundamental data as to the nature of rock masses making up the State. Here are all stratigraphic and structural studies, either detailed or reconnaissance in character, upon which any and all applications of geology must be based. In a state of such varied and complex geologic relations as Washington, this phase of necessity includes a wide range of specialized lines of investigation. Space does not permit even listing the varied and interrelated technical features which have been followed in prosecuting the investigations in basic geology.

It should be pointed out that in the technological subdivisions there is of necessity a high degree of specialization involving not only trained technicians but specialized equipment. By way of illustration of the complexity of this work in fundamental geology, we may consider the several aspects of one portion of these fundamental studies—those relating to subsurface geology.

Material for this work mainly comes from drilling operations in all parts of the State. The examination yields detailed facts on each formation below the surface. Both the mineral composition and the fossil content are determined with special apparatus by operators using controlled temperature, polarized light of specific wave length, and microscopes of high magnification.

By way of summarizing the accomplishment in these subsurface studies, it may be noted that in the present biennium over 1,500 samples have been received and studied from wells ranging in depth from approximately 100 feet to nearly 7,000 feet. At the present time a continual series of samples is coming in from all of the important drilling operations now under way. Correlated with these are the logs of several hundred additional water and test wells for which samples are not available. By means of this examination, the character and position of a number of identifiable rock formations distributed fairly over the whole State (in seventeen counties) has been completed.

In general, the information comprises detailed descriptions of every formation penetrated by the drill, so that it is possible to identify equivalent formations from one place to another even though their position and character are different.

These results, useful in all geologic work, are particularly valuable in oil prospecting because of the accuracy by which structures can be determined on relatively little drilling expense. Present day practice in the production of oil by the control of water and gas conditions is wholly dependent on detailed information of porosity and other features of the oil-bearing strata obtained from such subsurface studies.

The importance of these studies is attested by the readiness with which well records are submitted by operators. This wholehearted cooperation is assured by the Division's guarantee of confidential handling of private data.

In addition to subsurface studies, many other phases of basic geology must be followed in order to provide an adequate foundation for economic work. This whole field of work leads to an inventory of all rock formations of the State of Washington, furnishing such details as the character of each formation, its component parts, its fossil record, thickness and lateral extent, and, finally, its relations to other formations.

This information, combined with the structural determination based thereon, becomes an organized statement of the geologic history of the State.

Only a practical application of a knowledge of the close relations between a given mineral deposit and the rocks surrounding it makes possible an advance determination of what to expect. Efficient plans for mining operation, estimates of tonnage, and, most important of all, financial arrangements can only be made after these facts are known.

To make some of these results of basic investigations available for economic work, they are presented in a geologic map which shows by a series of colors and symbols all of the geologic formations of the State. Such a map is of inestimable value in the search for mineral deposits.

For example, it shows the zones of granitic rocks which are mainly the source of ore minerals and the nearby rocks in which ore deposits may be expected. Conversely it shows those areas in which prospecting is relatively useless. In the search for oil and gas, this map shows at a glance the districts that should be investigated carefully and those in which there is no hope of production.

The preparation of a State map was systematically undertaken by the Division of Geology in 1925, and during the past biennium it has been completed. Data from many reports of Federal and State governments, from reports of the Canadian Geological Survey, from published or manuscript reports prepared by geologists connected with the University of Washington and the State College of Washington, and in addition, particularly in the vicinity of certain mineral deposits, reports prepared by mining engineers and others have been drawn upon. Some of these are available to the general public, but many are out of print or never have been printed. Careful search has revealed a surprising number of such reports which when combined on a unit map provided information for about 40 per cent of the State.

As the compilation progressed, the size and position of geologically unknown parts of the State became apparent, and during the past nine years, as funds have permitted, field parties have been engaged in securing information on these areas. Painstaking comparison has resulted in an accurate mapping of the whole State. The field work has included large areas in the inaccessible portions of the Cascade Mountains, most of the mountainous section of the Olympic Peninsula, and extensive areas of eastern Washington, both in the Okanogan Highlands and the Columbia Plateau. It has

been necessary to visit every county in the State to secure adequate information to supplement previous work.

The great variety and complexity of the geologic formations are shown by the necessity of designating more than three hundred different formations on the preliminary map. There still remains the very difficult task of reducing the number of formations to be mapped to come within the limitations set by the mechanical process of lithographing. Present progress indicates that the map will be ready for publication shortly after January 1, 1935.

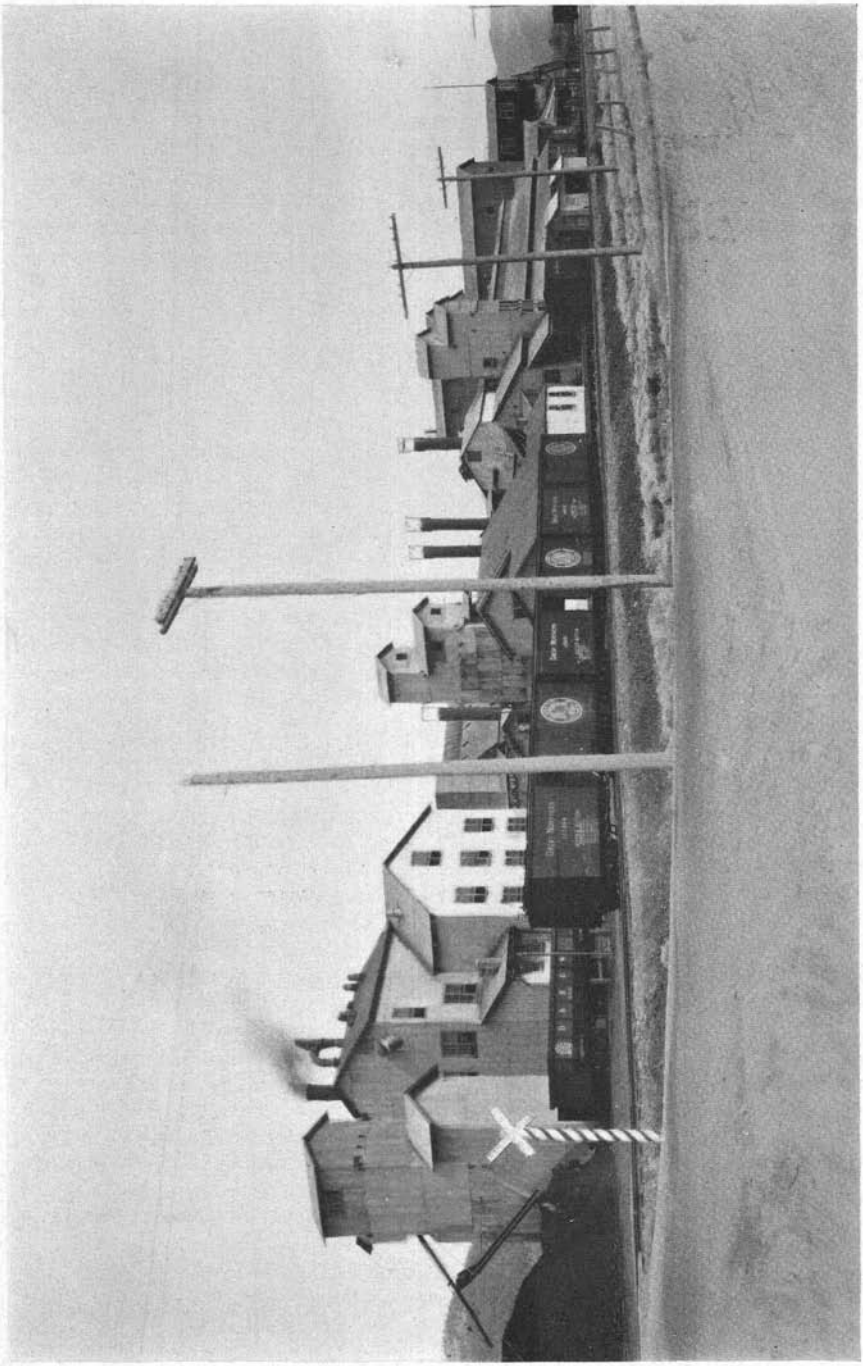
ECONOMIC STUDIES

Economic studies constitute the major objective of all divisional activities. During this biennium this work has been readily divisible into two major sections: The first including the mineral investigatons which were provided for by C. W. A. and W. E. R. A. funds, the second including those investigations of broader scope which have been continuously followed by the Division of Geology. The report on the first part of the economic studies—that designated the "**Mineral Survey**"—is presented herewith substantially as submitted by Mr. J. D. Hull, who was in charge of these investigations.

REPORT OF MINERAL SURVEY

"Field investigations were made of deposits carrying different minerals and metals. Many old reports on different properties, made by reputable mining engineers in the past, were made available to and reviewed by the Mineral Survey. Much other information was secured from engineers and operators familiar with different deposits in the State. The Mineral Survey cooperated with the United States Bureau of Mines and the Mining Departments of the Washington State College and University of Washington, and secured valuable assistance from these agencies.

"A limited amount of special research work was conducted, dealing with market conditions, metallurgical and chemical engineering problems. An assay department was established, utilizing both private laboratories and the laboratory facilities of the State institutions; over 900 samples of a wide variety of minerals, secured by field engineers of the Mineral Survey, were tested. The market research showed that the pulp mills of the State of Washington use in excess of $3,000,000 worth of mineral products annually, of which less than 10% are produced in the State. The principal metallurgical work was in connection with the manganese ores of the Olympic Peninsula and the gold ores of the Republic District. Special electric furnaces were constructed to treat the manganese silicate ores of the Olympic Peninsula, which had previously been considered of little commercial importance because of the chemical combination of the manganese and silica. Several tests were made, showing satisfactory results as far as they went. From these tests, a commercial grade of ferromanganese was produced. Considerable work was done at the Mines Department of the Washington State College, in cooperation with Dean Drucker, to find an economic method of recovery of the values of the gold ores of the Republic District. Such a process would do much toward re-establishing the operations of this district on a permanent basis. While the tests were not completed, much valuable information was secured that should be carried to final conclusion later.



Magnesite plant.

The chemical-engineering research division had to do with the recovery of elemental sulphur from pyrite deposits, and a method of economically recovering the products from the saline deposits of Central Washington.

"Possible additional markets for Washington coal were investigated and reported upon. Field examinations were made of deposits carrying precious and base metals, gold, silver, copper, lead, zinc, etc.; of the ferrous metals, iron, manganese, chrome, tungsten, molybdenum, etc.; of the light metals, aluminum, magnesium, and beryllium; and of a large number of the nonmetallics, including clays and diatomite, limestone, magnesite, sulphur, silica sand, barite, asbestos, graphite, sodium carbonate, sodium sulphate, magnesium sulphate, soapstone, talc, strontium, and many others. Many reports covering separate deposits and districts have been made as a result of these investigations.

"Many of these have been examined and reported upon, including the extensive manganese deposits of the Olympic Peninsula, the chrome deposits of the Sisters Mountains, tungsten, molybdenum and silicon in different sections of Eastern and Central Washington, zinc deposits of Pend Oreille County, the diatomite scattered over a wide area in Central Washington, soapstone and talc in eastern Skagit County, the large lode deposits of the precious and base metals in various sections of the Cascades and North-Central Washington, the important high-alumina clays in Eastern Washington, and many others.

"As a result of the tests made by the Mineral Survey on the benches and bars, for placer gold, along that portion of the upper Columbia River which will be flooded by the Coulee Dam, several operations are now under way, providing gainful employment to over 250 men, and recovering in excess of $1,000 per day.

"The Mineral Survey has investigated a number of properties in various stages of development, and found that many of them, formerly believed to be of little commercial significance, offer opportunities for profitable production, under present-day conditions. This is attributable chiefly to the increased price of the precious metals, substantial improvements in mining and metallurgical methods, availability of cheap power, and improved transportation conditions.

"Many properties were found that could be profitably operated now, if provided with relatively short roads to connect them with existing highways, to permit transportation of ore and supplies at reasonable cost.

"Much valuable information has been secured from old reports made on properties that were worked 30 or 40 years ago, which are now impossible to examine because the workings are flooded or the portals caved in.

"The Mineral Survey has recognized the importance of the abundant supply of cheap electric power that will be available and the desirability of finding a market for the utilization of this power in the mineral industry. Large quantities of power could be used in the production of the ferro alloys, chiefly of the ferromanganese, ferrochrome, ferrotungsten; in the recovery of zinc and copper by electro-metallurgical processes; in the mining operations of some of the so-called large low-grade deposits; in the production of calcium carbide and other electro-chemical processes. Aluminum, magnesium and iron offer future possibilities for power consumption.

"The Mineral Survey has cooperated with the State Land Commissioner

in securing data regarding mineral deposits and mineral royalties on certain State lands. This work has revealed the importance of a classification of mineral occurrences on State lands, and of an effective method of securing the full royalties from the operation of such deposits.

"The marked increase in public interest in mining development since the Mineral Survey started has been demonstrated in many ways. Information has been given in response to a great number of inquiries from people located in various sections of the State regarding a variety of mineral deposits; chambers of commerce and other civic organizations have not only sought information, but have rendered very material assistance to the Mineral Survey, in many cases; industrial concerns have called upon the Mineral Survey to supply them with information regarding the possible sources of raw material required by them from the mineral field. The attention of engineers and mine operators from different sections of the country, desirous of securing authentic information from unbiased sources, has been directed to the mineral deposits of the State by the work of the Mineral Survey. This interest of the mining public is evidenced by the large number of inquiries received.

"Many reports dealing with the various mineral resources of the State have been made and are available for reference in the offices of the Department of Conservation and Development. No reports have as yet been published."

DIVISIONAL INVESTIGATIONS

The second part of the economic studies, those of a strictly geologic character, under the close supervision of the Division of Geology, comprises (1) a group of special investigations, (2) a group of cooperative investigations, and (3) certain miscellaneous activities.

SPECIAL INVESTIGATIONS

The special investigations are (a) an inventory of mineral resources, (b) oil and gas resources of certain areas, and (c) magnesite resources of Stevens County.

INVENTORY OF MINERAL RESOURCES

Since the first organization of the Geologic Division in 1900, one of the important activities has been the cataloging of the mineral resources of the State of Washington. On four occasions this information has been published as bulletins in the regular geologic series. Since the last one was released in 1924, a card index system has been maintained recording all known and reported occurrences of both metals and non-metals. Additions to this file are constantly being made as new discoveries are examined or reported. This index constitutes a current catalog of mineral resources and is an invaluable source of information in handling the inquiries constantly being received from all parts of the United States. These data supplemented by later field examinations will be the basis for another bulletin planned for early publication. The tabulation below shows the number of listed occurrences, which include those for which field examinations have been made by the Geological Division and also those which have been reported but not yet investigated. Some of these are commercial; some are in small quantities and of only scientific interest at present; but the fact that even a small

amount of a given mineral is known to occur stimulates and encourages prospecting to meet a known demand. Publication of such information has frequently resulted in the discovery of commercial deposits.

NUMBER OF RECORDED OCCURRENCES OF MINERAL SUBSTANCES

NON-METALLIC RESOURCES

Asbestos	5
Barium	3
Beryl	1
Brucite	1
Chalk	2
Diatomite	41
Dolomite—1 operated; many others	
Feldspar	2
Fluorite	2
Fuller's Earth—some reported	
Garnet	3
Graphite	6
Gypsum	1
Kaolin—with Spokane clays	
Limestone { Eastern Washington	101
Limestone { Western Washington	38
Lithium	2
Magnesite	11
Magnesium sulphate (Epsomite)	2
Marble—see Limestone	
Marl	4
Mica	4
Mineral pigments	10 plus
Mineral waters	20 "
Natural alum—some reported	
Natural gas—abundant	
Oil, seeps and tests	8
Phosphate rock	1
Potash (reported)	1
Sand, foundry	2
Sand, glass	2
Semi-precious stones	
Serpentine	6
Silica (quartz)	5
Sillimanite	1
Slate	3
Soapstone	9
Sodium carbonate	1
Sodium sulphate	2
Sulphur	2
Talc	9
Travertine	7
Vesuvianite	4
Vivianite	2
Volcanic ash—abundant	

METALLIC RESOURCES

Aluminum—from Spokane clays	
Antimony	13
Arsenic	14
Bentonite	1
Bismuth	4
Chromite	5
Cerium	2
Cobalt	2
Copper	67
Gold (lode)	95
Gold (placer)	55
Iridium	1
Iron	23
Lead	60
Manganese	24
Mercury	10
Molybdenum	23
Nickel	6
Platinum	18
Pyrite	19
Pyrrohotite	15
Selenium	2
Silver	53
Strontium	2
Tin	7
Tungsten	19
Uranium	2
Vanadium	1
Zinc	16

SUBSTANCES OF MORE GENERAL OCCURRENCE

Clay
Coal
Granite and Basalt
Road metal
Sand and gravel

OIL AND GAS INVESTIGATIONS

Among the potentially important resources of the State of Washington are oil and gas. The Benton county gas field is on commercial production, the Whatcom county gas field is just becoming commercial, and a large number of tests have been made in many parts of the state. In too many instances these tests have been located without regard to geologic structures. The work of the Division of Geology provides information on structure and

character of sedimentary formations necessary to proper development. During 1934, great activity centered around Bellingham, and detailed field work was undertaken there early in the year. The investigations were completed by mid-summer, and the results are being presented in "Reports of Investigations No. 2." This is a 70-page bulletin with an accompanying geologic map covering western Whatcom county. This work was followed by investigations of the oil possibilities of western Skagit county, the report for which is now in preparation.

Supplementing these detailed regional investigations, the Division of Geology is constantly in touch with all operators who are planning or actually drilling test wells. In each case details of the geologic section as well as logs, usually supplemented by samples of the formation, are obtained. In this way complete records are on file for study and for guidance in future drilling operations.

It is the definite policy of the Division of Geology to lend every possible aid to those engaged in bona fide development work. There is ample evidence that the Division, through close contact with drilling operations, has been of real help in many instances. As such information becomes more complete, the services of the Division will become more valuable.

MAGNESITE INVESTIGATION

The proposed power development in the state has suggested the use of vast quantities of magnesite from the deposits now being worked in Stevens county. To date no means are known by which an accurate estimate of the amount of magnesite in the ground can be determined in advance of actual mining operations.

With the active cooperation of the Northwest Magnesite Company a start has been made on this problem. Using the basic geologic data already on hand, there has been completed the first part of a long term program which will include field and laboratory work.

COOPERATIVE INVESTIGATIONS

The economic investigations of the Division have been amplified and extended during this biennium as usual by cooperation with other state and federal agencies. At the request of the United States Bureau of Mines, a Divisional geologist was assigned to work with Mr. Hewitt Wilson, Ceramic Engineer for the Bureau. Fifty pound samples of talc and soapstone collected from all parts of the state are now being tested for their commercial possibilities at the Bureau's experimental station in Seattle.

Samples of high-silica sand were also obtained, and it is expected that tests will show their acceptability in local markets to replace out-of-state products. Earlier cooperation with the Bureau on clay deposits has been continued during this biennium.

In its investigation of water supplies, the Division of Geology has constantly enjoyed the active cooperation of County Engineers throughout the state. Data are being accumulated which will serve as an inventory of all water supplies, either public or private, in the State of Washington. Information is available as to the source of the water, whether from wells, lakes, or rivers, as to the amount of water available, the chemical character, and related features.

During the present biennium the compilation of data on municipal supply has been aided greatly by the active cooperation of the Department of Home Economics of the Washington Agricultural Experiment Station, which is undertaking a project dealing with the chemical character of public water supplies.

The earnest and enthusiastic response by public officials to the first request for information constitutes ample demonstration of the importance of this work.

Further cooperative work of the Division of Geology is indicated in the work with the Federal Bureau of Reclamation in finding materials for a new type of concrete mix for possible use at the Coulee Dam.

MISCELLANEOUS ACTIVITIES

One of the many incidental but important functions of the Division is the handling of inquiries regarding specimens from all parts of the state. In addition to those submitted to Divisional geologists in the field, hundreds of samples are received each year at the Pullman office. They are examined in the laboratory and the nature and possible use indicated in a personal letter to the senders.

Table No. 0—EXPENDITURES—DIVISION OF GEOLOGY

	GRANT 14	GRANT 46	C. W. A.	W. E. R. A.	TOTAL
Research and Mineral Investigation (Spokane Office)	$ 3,100.00	.....	.....	.....	$ 3,100.00
Mineral Survey (Seattle Office)	4,100.00	$ 5,300.00	$16,500.00	$11,100.00	37,000.00
Geological Investigations	15,600.00	.....	1,900.00	400.00	17,900.00
Topographic Mapping	14,400.00	.....	11,500.00	3,000.00	28,900.00
TOTAL	$37,200.00	$ 5,300.00	$29,900.00	$14,500.00	$86,900.00