MISSOURI BUREAU OF GEOLOGY AND MINES.

H. A. BUEHLER, Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fifth General Assembly.

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

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BOARD OF MANAGERS.

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LETTER OF TRANSMITTAL.

To the President, Governor Jos. W. Folk, and the Honorable M
bers of the Board of Managers of the Bureau of Geology
Mines:

Gentlemen—I have the honor to submit herewith a report
the work of the Bureau of Geology and Mines for the years 1
and 1908.

Your obedient sir,

H. A. BUEHLER,

State Geologis

CHAPTER I.

WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1907 AND 1908.

The work of the Bureau of Geology and Mines during the past biennial period has been devoted almost exclusively to problems pertaining to the development of the mineral resources of the State.

The prime objects in maintaining a Geological Survey or Bureau of Geology and Mines are purely economic, and while much of the work of the geologist appears to be purely theoretical and lacking in practical bearing to those unacquainted with the science, it is worthy of note that, in part at least, the development of our mining, quarrying, cement, lime, clay-working and similar industries is dependent upon the information obtained by the geologist and presented to the public through published reports.

It is the province of this Bureau to direct the conservation as well as the development of our mineral resources, and there is no other department of the public service to which the citizens of the State can turn for reliable information to bring about the elimination of waste so much desired. The usefulness of this Bureau may be judged to some extent by its extensive correspondence, embodying hundreds of requests, for the published reports as well as requests for the services of the staff. The services of the Bureau are sought because information is given without bias or prejudice by men trained in the profession.

The law under which the Missouri Bureau of Geology and Mines operates specifies, in general, the investigations which shall be conducted by this Bureau. The requirements of the statutes have been briefly summarized in the biennial report to the 44th General Assembly, as follows:

1st. To ascertain the relations existing between the different rock formations at or near the surface of the earth and prepare county reports containing maps, drawings and other illustrations setting forth these facts and giving the thickness, surface distribution, structure and characteristics of each formation.

2nd. To examine the metallic and non-metallic mineral resources, including stone, clay, cement, road materials, soils, water, lead, zinc, iron, coal, petroleum, asphalt, copper, baryta, sand, etc., publishing complete reports outlining their distribution and describing their manner of occurrence.

3rd. To collect, name and arrange a collection of specimens illustrating the geology and mineral resources of the State; also to assist the colleges and schools in the making of similar collections.

4th. To examine ores, rocks, soils, clays, and other mineral specimens for citizens of the State, reporting as to the kind and value of any specimen submitted for examination.

5th. To disseminate, everywhere, correct ideas as to the occurrence, origin, and relation of ores, minerals and rocks, for the purpose of increasing the general intelligence of the public on matters pertaining to geology and mining.

6th. To answer all inquiries relative to the mineral resources of the State.

7th. To examine, upon petition of fifty freeholders, lands upon which ores, clays, stone or other mineral resources of value may be thought to exist.

8th. To co-operate with the United States Geological Survey and other bureaus of the United States Government where benefit will accrue to the State.

During the past biennial period each of these divisions has received more or less attention.

The work for the period was planned by Dr. E. R. Buckley, former Director of the Bureau, who resigned April 30, 1908, to enter the professional field. The resignation of Dr. Buckley is a distinct loss to the State and a matter of keen regret to those associated with him in the work. During his administration the efficiency of the survey has been brought to a very high plane and this Bureau is now recognized as one of the best organized of the State Geological Surveys. Under his direction a systematic method of preserving records by the card catalog system was introduced. This system tabulates the accumulating geological data, which was formerly virtually lost in a mass of note books, in such a manner as to make it easily accessible to any member of the Survey. During his administration, nine reports were prepared and published. These deal with the natural resources of the State and are extremely valuable contributions to our knowledge of the mineral wealth of Missouri.

Personnel. The following persons have been employed permanently on the Survey during the past two years:

E. R. Buckley, State Geologist (Resigned April 30, 1908).

H. A. Buehler, (Ass't State Geologist to July 1907; State Geologist since May 1, 1908).

G. W. Crane, Geologist (Resigned August 1, 1907).

Frank Gahrtz, Draftsman.

During the field season of 1907, a number of temporary assistants were employed in field work, among whom were the following:

R. R. Rowley, Geologist.

C. F. Marbut, Geologist.

O. U. Stromme, Ass't Geologist.

O. W. Wheelwright, Ass't Geologist.

V. H. Hughes, Field Assistant.

C. R. Wood, Field Assistant.

V. H. Gottschalk, Chemist.

Mrs. W. J. McCaw was employed as clerk and Edward Morse as Janitor during the biennial period.

In addition to the above, the United States Geological Survey had a number of topographers in the field working in co-operation with the Bureau in the preparation of topographic maps. This is the first time that the State has assisted, in a financial way, in the preparation of these maps, and the result has been highly satisfactory.

Reports Published. The following five reports were published during the past biennial period. In part, they are the result of several years work and include all the investigations completed at the end of Dr. Buckley's administration.

(1) "Public Roads," Vol. V, 2nd series.

This report is devoted to a discussion of the materials necessary and methods employed in the construction of city pavements and country roads. The report should be in the hands of every County Court and road overseer in the State.

(2) "Lime and Cement Resources of Missouri," Vol. VI, 2nd series.

This volume includes chapters devoted to a description of the methods employed in manufacturing lime and cement; the nature of the raw materials from which they are made, and a general description of the suitable limestones and shales occurring in each county. It also includes a brief description

of each of the lime and cement plants operating in the State and outlines, in general, those areas favorable to a further development of these industries.

(3) "Geology of Morgan Co.," Vol. VII, 2nd series.
This is the third county report published since 1900. It describes in detail the various geological formations occurring in the county and dwells particularly upon the physiography and mineral resources of the area.

(4) "Geology of Pike Co.," Vol. VIII, 2nd series.
This volume covers a detailed survey of Pike county by Prof. R. R. Rowley of Louisiana, Mo. It is devoted largely to the paleontology of the area.

(5) "Geology of the Disseminated Lead District of St. Francois and Madison Counties." Vol. IX, 2nd series.
This report is the result of several years careful study by Dr. E. R. Buckley, former director of the Bureau. It includes a detailed study of the stratigraphy and structure of the region as well as a complete discussion of the genesis of the ore deposits. Four geological maps illustrate the relation of the ore to the geological formations and accurately outline the areas in which productive ore bodies have been found. The report is one of the most valuable yet published by the survey.

Geological Map. A new geological map of the State was published in 1907. It incorporates the results of all field work completed prior to the date of publication, and is of great value in outlining the area underlain by the Coal Measures, in showing the formations in which the lead and zinc ores are found, and in designating the occurrence and distribution of each of the geological formations in the State.

Report in Preparation.—At the time I became Director, there was in preparation a report on "The General Geology of Missouri." The manuscript is about two thirds completed and a number of the necessary illustrations have been collected.

The report is intended primarily as a guide to those interested in Missouri geology. Chapters are devoted to the methods of identification of the common minerals and rocks; to the classification and description of the different geological structures and to a discussion of the geological history of the State. Maps and illustrations will picture the more prominent and important geologic and topographic features. Chapters are also devoted to the economic resources of the state. This volume will be of great

educational value and should serve as a basis for school work in physical geography.

Unfinished Field Work.—Considerable field work, which is not embodied in reports already published, has been carried on in several sections of the State. The greater portion of this work was done during the summer of 1907. The areas under investigation will require additional mapping and study before the results will be available for publication.

This work has been mainly a study of the stratigraphy in those areas where the investigations will have a direct bearing upon the development of our mineral resources.

Geologic Mapping.—Mr. O. W. Wheelwright spent one field season in mapping the geology of Platte, Buchanan and Andrew Counties, the plan being to publish a report upon the Geology of Northwest Missouri. That portion of the State is underlain by the greatest thickness of the Coal Measures strata and therefore is considered the most favorable territory in which to prospect for oil and gas. A knowledge of the structure of this region is particularly important, in order to determine, if possible, the most favorable areas in which to drill for these fuels.

Messrs. O. U. Stromme and C. R. Wood spent one field season mapping the surface geology in the vicinity of the mining camps of Aurora, Wentworth, Stotts City and Sarcoxie. The results of this work are to be embodied in a report upon the Lead and Zinc District of Southwest Missouri.

The bodies of lead and zinc ore of Southwestern Missouri are closely related to the geological structures of the region. Maps showing these structures indicate the probable direction of the future extension of the mining districts and are therefore important in indicating the most favorable territory for prospecting.

The St. Peters sandstone, locally known as the "Pacific" or "Crystal City," was mapped over a considerable area in St. Louis, Franklin and Jefferson Counties by Mr. O. U. Stromme. This formation is the chief source of glass-sand in this State.

The mapping of this formation north of the Missouri river and south of Crystal City, along the Mississippi river, should be continued. The preparation of a map showing in detail the area covered by this formation, will be of value in indicating the region from which our future supply of sand will chiefly come.

Mr. V. H. Hughes spent one field season mapping the area underlain by the LaMotte sandstone, and locating the eastern

boundary of the Bonneterre dolomite on the Farmington quadrangle. The Disseminated lead deposits of Southeastern Missouri occur in the latter formation and this work is of importance in determining the possible limits of these deposits in both St. Francois and Ste. Genevieve Counties.

Drill Records.—During the past year a co-operative arrangement was made with the United States Geological Survey for collecting cuttings and records of well borings throughout the State. In accordance with this agreement the Federal Survey has forwarded to this Bureau all drill cuttings, and copies of all drill records which they have collected in this State. The information obtained by the Bureau from an examination of these records and cuttings is of value in showing the character of the rock formations passed through, and the depth at which water is encountered. At the present time the Bureau has not sufficient data at hand to indicate the depth and character of the water supply throughout a greater part of the State.

Topographic Mapping.—The last General Assembly made an appropriation for topographic mapping to be carried on in co-operation with the United States Geological Survey. While many of the states have, for a number of years, made appropriations to carry on this important branch of the work, this is the first expenditure of funds by Missouri for this purpose. The work completed prior to 1907 was entirely at the expense of the Federal Survey.

Under the terms of the agreement, one-half of the total expense is paid by the Government. The execution of the work is under the charge of the topographic branch of the Federal Survey.

The following sheets were completed under this co-operative agreement during the past biennial period.

Macon quadrangle	229 sq. miles.
Higdon "	236 " "
Weingarten "	236 " "

The Rolla quadrangle is also approximately two-thirds completed; 126 square miles having been mapped during 1908. This quadrangle will be finished during the spring of 1909. The work was temporarily suspended because of a shortage of funds. The early completion of this quadrangle is especially important because of the value of this map to the engineering and geological departments of the School of Mines.

In addition to the co-operative work the United States Geo-

logical Survey mapped 175 square miles in the western half of Platte County. This area was mapped with twenty foot contours on a scale of 2,000 feet to the inch. The work was carried out at the request of the Department of War for use of the garrison stationed at Ft. Leavenworth. The map will be useful to this Bureau as a base upon which to work out the geological structure of Platte County.

The total area mapped, topographically, during the years 1907 and 1908, was 1,002 square miles, including 287 miles of primary levels, 1,850 miles of secondary levels, 248 miles of primary traverse and 2,824 miles of secondary traverse. Sixty-four bench marks were established.

Laboratory Equipment.—During the past biennial period the Bureau has installed a well equipped chemical laboratory, which will greatly facilitate the work of the department.

The value of many of the undeveloped deposits of stone, clay, coal and metallic ores depends largely upon their composition, which can only be accurately determined by careful chemical analyses. While it is not the purpose of the department to undertake commercial work, many of the specimens collected by members of the staff require analyses to determine their value. Hundreds of specimens are also received from citizens who desire to know their probable value. In many cases careful tests are required to answer these inquiries. The equipment recently installed is adequate to serve the department in making both mineral and water analyses.

A Bausch and Lomb petrographic microscope with photographic attachment has been added to the laboratory equipment. This instrument is required for the study of thin sections of lead and zinc ores, and structural materials, including building-stone, cements and mortars. A number of drafting and field instruments were also purchased.

The above equipment places the Survey in a much better position to carry on its research work than it has been heretofore.

Library. During the past year the Survey library was moved to the room formerly occupied by the School of Mines library, on the second floor of the Survey building. Through the exchange of publications with other Geological Surveys and scientific institutions the usual additions have been made to the library during the biennial period. Approximately 350 volumes of geological reports and technical journals have been added in this manner.

Many of the reports of the scientific societies of America and Europe are received unbound, the complete volumes of which often consist of several parts. The technical journals received are also unbound. The Survey has never been provided with a fund to bind these volumes, and in an unbound condition they are almost valueless for reference. They contain much information of value to the department in conducting its researches, and since this is the geological library to which the members of the staff must refer, the volumes should be bound, thereby making the information which they contain easily accessible. It is estimated that the missing files can be completed and the more important of these volumes can be bound at an approximate cost of $800.

Museum.—The Geological Museum has been enlarged, so that it now occupies the entire eastern half of the first floor of the Survey building. New cases have been erected in that part of the room formerly occupied by the library. Many instructive specimens illustrating the economic geology of the State, which were formerly in the store room, have been unpacked and placed where they can be used for reference.

The Survey has a representative collection of fossils, building stone and lead and zinc minerals of the State. During the past biennial period, approximately 500 specimens have been added to this collection.

It is hoped in the near future to supplement this with a series of specimens showing the products of concentrating and smelting lead, zinc, iron, copper, nickel and cobalt ores. In addition to this there will be installed a collection showing the raw materials and manufactured products of clay, stone, baryta, sand, tripoli, etc.

Each series will illustrate, as far as possible, the method of treatment starting with the raw material and ending with the finished product.

Information Bureau.—One of the very important functions of the Geological Survey is in disseminating information regarding the mineral resources of the State. Thousands of letters are received each year requesting information concerning these resources. Many requests for information come from investors and capitalists who reside in distant portions of the United States. These inquiries cover practically every natural resource of the State, and the information given to such parties, through correspondence, must be of great benefit. Requests for information concerning the possibility of finding oil and gas and relative to

the iron ore deposits have been especially numerous during the past two years. All letters have been answered as promptly as possible and no matter how trival the request may have seemed, it has been given full consideration.

Demand for Reports.—The value of the investigations carried on by this Bureau is indicated, in a measure, by the demand for our published reports. Requests are received almost daily for copies of the reports published between 1890 and 1900. The editions of a majority of these reports are exhausted, but copies can be purchased at second-hand book stores in the larger cities. Probably there has never been a greater demand for the reports of the Bureau than during the past biennial period. As shown by the following list, a total of 5,165 volumes have been distributed during the past two years.

Vol. 12, Part 2	20
" 13,	25
" 1, 2nd series	103
" 2, " "	376
" 3, " "	301
" 4, " "	451
" 5, " "	510
" 6, " "	1011
" 7, " "	650
" 8, " "	538
44th Biennial	1180
Geological Map of Missouri	1500

At the present time the department has the following volumes for distribution. They will be forwarded to any citizen upon receipt of transportation charges.

	Postage.
Areal Geology, Vol. XII, Pt. 2, by C. F. Marbut and G. C. Broadhead	25c.
Preliminary report on Structural and Economic Geology, Vol. XIII, 1900, by Jno. A. Gallaher	25c.
New Year's Announcement, Jan. 1, 1901, by Jno. A. Gallaher	10c.
Biennial report of the State Geologist to the 41st General Assembly, by Leo Gallaher,	10c.
Biennial report of the State Geologist to the 39th General Assembly, by Charles R. Keyes,	10c.

Geology of Miller county, Vol. I, 2nd series, E. R. Buckley, A. F. Smith and S. H. Ball, 25c.
The Quarrying Industry of Missouri, Vol. II, 2nd series, 1904, by E. R. Buckley and H. A. Buehler, 40c.
Biennial report of the State Geologist to the 42nd General Assembly, by E. R. Buckley, 10c
The Geology of Moniteau Co., Vol. III, 2nd series, 1905, by F. B. VanHorn, 15c.
Biennial report of the State Geologist to the 43rd General Assembly, by E. R. Buckley, 10c.
Geology of the Granby Area, Vol. IV, 2nd series, 1906, by E. R. Buckley and H. A. Buehler, 20c.
Biennial report of the State Geologist to the 44th General Assembly, by E. R. Buckley, 10c.
Public Roads, Vol. V, 2nd series, by E. R. Buckley, 15c.
Lime and Cement Resources of Missouri, Vol. VI, 2nd series, 1907, by H. A. Buehler, 25c.
Geology of Morgan Co., Vol. VII, 2nd series, 1908, by C. F. Marbut, 15c.
Geology of Pike Co., Vol. VIII, 2nd series, 1908, by R. R. Rowley, 15c.
Geological Map of the State, 10c.

CHAPTER II.

FUTURE WORK OF THE BUREAU.

The interest which the general public is manifesting in the State's resources in coal, lead, zinc, clay, baryta, oil and gas demands that a greater portion of the time of this Bureau be devoted to a study of these deposits.

Economic reports upon these subjects should include not only a discussion of the occurrence and value of our mineral deposits, but should also, where possible, point out the dangers of early exhaustion through wasteful methods of mining and milling. An important factor in the future industrial supremacy of this country involves the present conservation of our mineral resources through better methods of exploitation. This is equally true of the several states of the Union.

It is doubtful if more than sixty per cent of the coal in the ground is recovered in many of the coal mining districts of this State. In the lead and zinc district of Southwest Missouri, the methods of mining and milling in conjunction with the present methods of leasing, make the average recovery for the district less than fifty per cent of the mineral in the ground.

It is the province of this Bureau to direct attention to this waste and to make such suggestions as may materially increase the recovery.

Geologic reports covering the following subjects should be prepared as early as possible.

Coal.—Coal is one of the most important mineral resources of the State. In 1907, Missouri produced coal which was valued at $7,306,125. The Coal Measures underlie approximately 25,000 square miles in the western and northwestern parts of the State. With the exception of a few isolated areas, but little detailed study has been made of the Coal Measures and no accurate knowledge is to be had concerning the probable extent of the workable coal seams.

In 1897, this department published a brief preliminary report on the coal deposits being worked at that time. This report is

mainly descriptive, outlining in general the thickness and general nature of the beds occurring in the several areas which were being worked at that time. The information contained in this report was in such great demand that the entire edition was soon exhausted. This volume can now be obtained only by purchase from second-hand book stores.

Many requests are received annually for a comprehensive report dealing with this industry. Such a report should include a complete study of the geologic occurrence of the coal and the results of such laboratory and boiler tests as will determine the relative fuel values of each bed. These tests should be similar to those carried on at the fuel testing plant of the United States Geological Survey at Pittsburg, Pennsylvania.

The importance of such a report is emphasized by the recent discovery in the northern part of the State of valuable coal seams at depths of from 450 to 500 feet. These beds are reported to be from 3 to 5 feet thick and may be a part of one of the important undeveloped areas. The Survey should give special attention to this field at an early date.

Oil and Gas.—Altho Missouri produces practically no oil or gas, there are no other possible natural resources in which the public is taking a greater interest at this time. Citizens in every section of the State and many large producers of oil and gas operating in the productive fields of the eastern and central portions of the United States, are actively interested in this subject. The extensive development of the Kansas-Oklahoma field and the phenomenal growth of the Illinois field, which has been developed during the past three years, has centered the attention of oil and gas men upon Missouri, which lies between these productive areas.

Thousands of acres of land have been leased in different portions of the State. Large tracts, aggregating from 30,000 to 50,000 acres, are being leased by individual companies, the majority of which are substantial producers in other fields and are not promoting stock selling schemes.

During the past year wells have been drilled or started in Phelps, Dent, St. Charles, Harrison, Knox and Johnson Counties. Some of these counties do not give any geological evidence that oil or gas will ever be discovered within their boundaries.

Most of the oil and gas obtained from the Kansas-Oklahoma and the Illinois fields occurs in the sandstones of the Coal Measures, and it is believed that the same series in Missouri is the most favorable to the discovery of these mineral fuels.

The Coal Measures occur mainly in the northwestern portion of this State, being the northern extension of the same series occurring in Kansas and Oklahoma. These series have a maximum thickness in Missouri of approximately 2,000 feet, the lower portion of which consists mainly of sandstone and shale, which are thought to be so related as to afford the proper geologic conditions for the retention of oil and gas.

It is well known that the accumulation and retention of oil and gas in any area are dependent upon certain structural features that have never been worked out in detail for the northern portion of the State. In order to determine the most favorable territory for prospecting, a study of the structure of the region should be made at once. Such an investigation should include the gathering of all data on well drilling throughout the State and should summarize our present information concerning the thickness and structure of the various geological formations underlying the different sections of the State.

Such a report will not only serve to direct prospecting into those portions of the State where oil and gas may be discovered in commercial quantities, but will also serve to discourage drilling in those sections in which there is no possibility of finding these fuels. At the present time thousands of dollars are being wasted drilling in certain areas in Missouri where there is not the remotest possibility of finding either oil or gas.

Lead and Zinc.—Probably no investigations carried on by this Bureau are of greater value than those in the lead and zinc districts of the State. In 1907, Missouri stood first among the States in the production of both metals, the combined value of the lead and zinc ore productions being approximately $19,000,000.

At the present time mines are being operated in twenty-three counties in the State. The workable deposits are largely segregated into mining districts, each of which has distinctive geologic characteristics, a knowledge of which is important in the discovery and development of new ore bodies. There are a number of important areas for which detailed reports have not yet been prepared, and the investigation of these should be taken up at an early date.

At the present time the Bureau has for distribution only two volumes pertaining to lead and zinc: Vol. IV, devoted to the Geology of the Granby Area of Southwest Missouri, and Vol. IX, devoted to the Geology of the Flat River-Bonne Terre area of

Southeast Missouri. Each volume is an important contribution to our knowledge of the occurrence of lead and zinc in this State. However, they include only a very small part of the region requiring investigation. More or less attention should be given to the entire southern half of the State, and at least one geological party should be engaged continually in investigating the areas tributary to the productive fields.

During 1906, small areas tributary to Stotts City, Sarcoxie and Aurora were mapped. During the past season, however, this work was discontinued, due to a shortage of funds. These investigations should be resumed as soon as possible. Other important areas that should be surveyed occur in Franklin, Washington, Iron, Madison, Howell, Lawrence, Newton, Dade and Jasper Counties in the southern portion of the State.

Iron Ore.—Workable deposits of iron ore occur in forty-eight counties in the State. The most valuable of these are located in the Ozark region. While Missouri is not now an important producer of iron, the possibility of a much greater development is apparent when one reflects that a conservative estimate of the iron ore available is approximately 100,000,000 tons.

In 1892, this department published a report upon the iron ores of the State, but the edition has long since been exhausted. The increased interest manifest at present in these deposits makes their investigation an important subject for consideration.

Other Economic Reports.—While the deposits enumerated above should receive early attention, reports should also be published covering the baryta, copper, tripoli and glass sand deposits. Missouri produces more baryta and tripoli than any other state in the Union and has inexhaustible deposits of excellent glass sand. These deposits have never been studied systematically by this Bureau.

County Reports.—During recent years the Survey has published detailed reports on Miller, Moniteau, Morgan and Pike Counties. These reports are important contributions to the geology of the State and should assist materially in giving direction to any effort that may be made to develop the mineral resources.

The economic importance of the brick, stone, tile, cement and sand industries in the vicinity of our larger cities, demands the preparation of reports covering Buchanan, Jackson and St. Louis Counties. Field work should be carried on in at least one of these areas during the coming season.

Water Powers.—The Survey is continually receiving requests for information concerning the water powers of the State. Up to the present time, practically no attention has been given to this branch of our natural resources. The important streams of the Ozark region apparently offer opportunity for the development of sufficient power for heating, lighting and transportation throughout the southern half of the State.

A thorough study of this problem will require gaging stations along all the important rivers in order to determine the volume and variations of flow. As several years are often required to obtain sufficient data upon which to base accurate calculations, this work should be started at once.

Suitable arrangements can no doubt be made with the United States Geological Survey to carry on this work under a co-operative agreement. Such an agreement will greatly lessen the cost to the State and has the additional advantage of commanding the services of a trained corps of engineers now in the employ of the Federal government.

Topographic Maps.—The general importance of accurate topographic maps can hardly be over estimated. These maps show the surface features of the land, locating accurately all hills, valleys, rivers, lakes, springs, etc., as well as all roads, railroads, buildings, bridges and electric lines. Permanent bench marks are also established from which local surveys can be started. The value of these maps to the State and Federal governments may be judged from the following uses quoted from a recent circular published by the United States Geological Survey.

"(1) By the Federal Government.

The State Department—

In connection with questions relating to international boundaries.

The Treasury Department—

The Life Saving Service—

In connection with the location of life-saving stations and boathouses.

The War Department—

The General staff, the War College and the Service Schools—As a basis for military maps, in studies of military operations and problems, in historical studies of military campaigns and in map maneuvers ("war game").

The troops—

In maneuvers of the Army and the National Guard.

The Corps of Engineers—

In connection with work on the improvement of rivers and harbors, as base maps for the representation of information needed for office reference, and as a basis of plans for land defense of seacoast forts.

The Office of the Chief of Artillery—

In the Field Artillery: In the preparation and solution of problems in miner tactics and strategy.

In the Coast Artillery: In the preparation of plans for land defense and seacoast fortifications.

The Signal Corps—

In the establishment of wireless-telegraph systems, in the construction of telegraph land lines, and in ballooning.

The Quartermaster-General's Office—
In connection with the development of water supplies for military posts.
The Post Office Department—
In the preparation of post-route maps, and in the administration of the rural delivery service.
The Navy Department—
The United States Marine Corps—
In solving military problems and for use by troops in road marches.
The Department of the Interior—
The Geological Survey—
As base maps for the sheets of the geologic Atlas of the United States in surveys, made to determine the mineral resources of the country, in the classification of the public lands, and in the study of various geologic problems, many of which have an economic bearing. In hydrographic surveys, made for the purpose of determining and classifying the country's water resources, both surface and underground.
The General Land Office—
In the compilation of maps and in connection with the survey and sale of public lands.
The Reclamation Service.
In irrigation projects in the arid regions.
The Office of Indian Affairs.
In connection with allotments to Indians on Indian reservations.
The Department of Agriculture.
The Forest Service.
In the compilation of Forest Atlas folios for use in determining questions of sale, free use of timber, and grazing; in trail construction and other improvements in forest lands and as a base for field investigations.
The Bureau of Soils.
In plotting the character and extent of the various soils of the country.
The Bureaus of Animal and Plant Industry.
In investigations for the improvement of the plant and animal industries of the country.
The Weather Bureau
In connection with the establishment of river gaging station to determine suitable locations and exact elevations.
The office of Public Roads.
In determining routes, mileage, location of road-building materials and topography in country traversed by public highways.
The Office of Experiment Stations.
In drainage and other investigations.
The Biological Survey.
In traveling through little known regions, in laying out field work, in locating and mapping the boundaries of the life and crop zones, and in mapping the geographical distribution of plants and animals.
The Bureau of Entomology.
In plotting the distribution and spread of injurious insects.
The Department of Commerce and Labor.
The Coast and Geodetic Survey.
For obtaining geographical and topographical data outside of the limits of Coast Survey work.
The Light House Board.
In compiling charts for annual reports and for general office reference.
The Bureau of the Census.
In defining the enumeration and supervision districts, in assisting special agents in planning routes of travel, and in preparing maps to illustrate Census reports.
The Bureau of Fisheries.
In physical and biological surveys of lakes and streams in connection with the stocking of interior waters with food fishes and in locating fish-cultural stations.
The Smithsonian Institution.
In planning field trips, including determination of routes of travel and the establishment of camps or bases of supplies.
The Bureau of American Ethnology.
In field work for locating tribes and archeological sites, and in plotting data for file and publication.
The United States Geographic Board.
In the study of questions presented for the Board's decision.

The International Waterways Commission.
In the study of locations and routes of waterways.
(2) By States.
(a) In connection with co-operative agreements with the United States Geological Survey, or with other Government Bureaus.
(b) By State Geological or other surveys.
(c) By State Agricultural colleges.
(d) In good roads investigations.
(e) In connection with legislation involving county or town boundary lines.
(f) In connection with legislation involving the granting of charters, rights, etc., where a physical knowledge of the country is desirable or necessary.
(3) By engineers, for whom the maps serve the general purposes of preliminary surveys.
(a) For location of railroads, canals, highways, trolley lines, etc.
(b) For providing a water supply for municipal use or for power.
(c) In connection with problems involving land drainage or irrigation.
(d) In connection with sewerage systems.
(4) By miners, in prospecting for and locating mineral deposits.
(5) By educational and scientific institutions, in many ways.
(6) As a means of information.
(a) By land investors, through map representation of local conditions.
(b) By travelers or tourists, as guide maps."

Co-operative topographic mapping should be continued during the next biennial period. In order to work out the detailed stratigraphy and structure of northwest Missouri, a number of these quadrangles should be completed as soon as possible. As explained in former biennial reports, where co-operation with the Federal Survey is secured the Government pays one-half of the total cost of making these maps.

Educational.—That the people of the State may be better informed regarding our natural resources and be better able to recognize minerals of economic value the geological survey should devote considerable attention to educational work.

Such work can be done in three ways: 1st, by publishing a series of educational bulletins, describing the general geologic and topographic features of the State; 2nd, by making up a series of mineral specimens for use in the high schools; 3rd, by maintaining a permanent exhibit of minerals and structural materials at the State Fair.

At the present time the Survey has in preparation a volume on the General Geology of Missouri. It is hoped to complete this report during the coming year.

Appropriation Required.—In order to carry on the work as outlined in the preceding pages, it is earnestly recommended that the following appropriation be made:

For maintenance and support	$35,000
For printing and illustrating reports	5,000
For Topographic Mapping in Co-operation with the United States Geological Survey	20,000
Total	$60,000

CHAPTER III.

FINAL REPORT OF DR. E. R. BUCKLEY.

The following is the final report made by former Director Dr. E. R. Buckley to the Board of Managers. It is included in the present biennial report mainly for the purpose of showing changes in the existing laws proposed by one who has done much to bring the Bureau to its present plane of usefulness.

To the President, Gov. Joseph W. Folk, and the other Members of the Board of Managers of the Bureau of Geology and Mines, Jefferson City, Mo.:

Gentlemen—I was elected Director of this Bureau at a meeting held in St. Louis, August the 12th, 1901, and took active charge of the administration of the affairs of the Bureau September the 12th, 1901. My resignation was tendered to the Board at the October meeting, 1907, and took effect April the 30th, 1908. I have served as State Geologist and Director of the Bureau of Geology and Mines for a period of six years, seven months and eighteen days. During this period there has been spent in the neighborhood of $10,000.00 a year, with the exception of the year just past, when the appropriation amounted to $15,000.00.

Upon taking charge of the Bureau I found it not only deficient in equipment, but altogether disorganized and with practically no work in shape for the publication of reports. All of the reports which have been published during the period of my administration, with one exception, are entirely the result of investigations carried on during this period. The report on Pike county, which is Volume VIII., 2nd Series, was in part prepared during a former administration. Including this volume, there have been prepared and made ready for publication during my administration nine volumes of reports, while the manuscript for a tenth volume is practically complete. In addition to these reports, there have been published by the United States Geological Survey, at the request of this Bureau and through co-operation, ten fifteen min-

ute topographic sheets covering an area of, approximately, 1,350 square miles. In addition to this, the United States Geological Survey has mapped one thirty minute sheet which covers an area of over 500 square miles. These maps and reports are in addition to the regular biennial reports submitted to each session of the General Assembly, of which three have been published.

The following is a list of the reports made ready for publication during my administration:

Vol, I, 2nd series, Geology of Miller County, 1903, E. R. Buckley, A. F. Smith and S. H. Ball, Pages 197, Plates 18, Figures 56.

Vol. II, 2nd series, The Quarrying Industry of Missouri, 1904, E. R. Buckley and H. A. Buehler, Pages 347, Plates 59.

Vol. III, 2nd series, The Geology of Moniteau County, 1905, F. B. VanHorn, Pages 100, Figures 25.

Vol. IV, 2nd series, Geology of the Granby Area, 1906, E. R. Buckley and H. A. Buehler, Pages 114, Plates 42, Figures 3.

Vol. V, 2nd series, Public Roads, Their Improvement and Maintenance, E. R. Buckley, Pages 115, Plates 30.

Vol. VI, 2nd series, The Lime and Cement Resources of Missouri, H. A. Buehler, Pages 241, Plates 36.

Vol. VII, 2nd series, The Geology of Morgan County, C. F. Marbut, Pages 94, Plates 19, Figures 19.

Vol. VIII, 2nd series, The Geology of Pike County, R. R. Rowley, Pages 116, Plates 20, Figures 13.

During the last field season, we had parties in the field doing work preliminary to the publication of reports on the fuel resources of Andrew, Buchanan and Platte counties; and on the lead and zinc resources of the areas tributary to Sarcoxie, Wentworth, Stotts City and Aurora. Geological maps were completed covering the areas in the immediate vicinity of these places, and with a little additional work covering an examination of the mines a report could be made ready for publication.

The geology of the Farmington quadrangle has been about two thirds mapped and could be completed with part of a season's field work by one man. The St. Peters sandstone has also been mapped between the Missouri river at Labadie and the Mississippi river at Crystal City.

In addition to the above reports published by the Bureau during this period, we have answered thousands of letters of inquiry relative to the mining resources of Missouri, and have examined hundreds of specimens which have been sent to us yearly

for inspection. There has been no inquiry made by citizens of this State which has not received our careful and conscientious considerations, no matter how trivial that inquiry may have seemed.

We have also visited many parts of the State in answer to requests from Commercial Clubs and citizens who have petitioned us to assist them to determine where to prospect for minerals, fuels, etc.

As a result of our investigations we have been able to establish certain theories to account for the origin of the lead and zinc ores in the southern part of the State. These we believe to be of very great service to those who are engaged in mining these metals. The data upon which our theories are based have not all been published, but it is the hope that they will be printed and ready for distribution before many months.

Since taking charge of the Bureau, some important additions have been made to the equipment, both physical and chemical, and it was expected that during the present year more apparatus would be purchased out of the appropriation made for that purpose by the last Legislature.

The Museum and Library have both been completely overhauled, the specimens and books being systematically catalogued and arranged in the cases and on the shelves in the Library and in the Museum. Several thousand volumes of reports and pamphlets have been added to the Library and several thousand specimens have been added to the Museum collections.

Upon taking charge of the Bureau, I inaugurated a card system of cataloging the information obtained by the Bureau relative to the mineral resources of the State. For the last five years we have been constantly adding to the information contained in this catalog, until at the present time it is very useful in answering inquiries relative to the natural resources of the State. The system of cataloging this information is fully described in the biennial report to the 42nd General Assembly.

As a result of observations made during my administration, I feel that this Bureau is one of the important departments of the State government. I believe, however, that legislation should be enacted whereby its efficiency will be very greatly increased. I believe that the Bureau of Mines and Mine Inspection should be consolidated with this Bureau, and that the Mine Inspectors should be required to report to the Director of this Bureau and that they

should be directly under his supervision, as contemplated by the following bill which was passed by the Senate in the last legislature, but which was not brought to a vote in the House.

"BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF MISSOURI AS FOLLOWS:

That section 8817 of the Revised Statutes of the State of Missouri, 1899, and an act entitled "An act to amend section 8817, Article 2, Chapter 133, of the Revised Statutes of the State of Missouri, 1899, relating to the establishment of the bureau of mines, mining and mine inspection and the appointment of mine inspectors with emergency clause," approved April 13, 1903, and an act entitled "an act to repeal section 8818 of Article 2, Chapter 133 of the Revised Statutes of Missouri of 1899, and to enact a new section in lieu thereof," approved March 27, 1901, and an act entitled "an act providing for the practical and technical qualifications of mine inspectors, mine managers, mine foremen, assistant foremen, mine examiners and hoisting engineers and for the creation of a State mining board, its qualifications, duties and compensation," approved April 4, 1903, be and the same are hereby repealed and the following sections to be known as sections 5817-8818a and 8810a enacted in lieu thereof.

Section 8817—The president of the board of managers of the Bureau of Geology and Mines, shall, by and with the approval of the board, appoint four inspectors of mines who shall, be men of practical mining experience, upon the recommendation of the director of the Bureau, who shall accompany such recommendations with a statement setting forth the fitness and eligibility of all candidates. Each of said inspectors shall hold office until his successor is appointed. The inspectors, in the performance of the duties and exercises of the powers conferred upon them shall be under the control and supervision of the said board of managers, who shall have the power to fix the salaries of said inspectors and to remove them for incompetency, insubordination or other good and sufficient reason. It shall be the duty of the said board of managers to submit to each general assembly a report which shall cover in full the work of mine inspectors for each biennial period, explaining in full the condition of the mines, as regards sanitation, safety, the uses of oil, explosives, fencing of mines, signaling, blasting, ventilation of shafts, traveling ways, boilers, scales, timbering, qualifications of miners, etc., as regulated by law.

Section 8818—The inspectors provided for in this article shall

see that every necessary precaution is taken to secure the health and safety of the workmen employed in any of the mines in the State, and that the provisions and requirements provided for in this article be faithfully observed and obeyed, and the penalties of the law enforced.

Section 8818a—There is hereby transferred to the Bureau of Geology and Mines, all instruments, books, charts, cabinets, records, collections and other property of the State of Missouri heretofore under control of the Bureau of Mines, Mining and Mine Inspection.

Section 8819a—A fee for the inspection of each mine to be made twice each year shall be paid by the person or corporation owning or operating said mine as follows: The fee for the inspection of a mine employing ten men or less, shall be 50c. The fee for the inspection of a mine employing more than ten men, but not more than twenty men shall be $5.00. The fee for the inspection of a mine employing more than twenty men, but not more than fifty men shall be $10.00. The fee for the inspection of a mine employing more than fifty men shall be $10.00 for the first fifty men and $2.00 for each additional fifty men or fraction thereof employed. Such fees shall be paid to and received by the inspector making such inspection at the time such inspection is made and shall be paid into the general revenue fund of the State.

The fact that there is at present no official head to the Bureau of Mines and Mine Inspection, creates an emergency in the meaning of the constitution, therefore this act shall be in force on and after its passage and approval."

The enactment of such a law as that outlined above will increase not only the efficiency of the mine inspection, but will materially lessen its cost. The mine inspector under this Bureau would be able to collect a great deal of information which it is now necessary for each Bureau to obtain independently.

This Bureau should be charged with the investigation of paints and paint pigments, as outlined in the following bill, which might be combined with the bill intended to perfect the organization of the department, which is given on pp.

Be it enacted by the General Assembly of the State of Missouri as follows:

Whereas, the people of the State of Missouri are unacquainted with the suitability of the various ingredients used in the manufacture of mixed and prepared paints, white lead and oils;

Therefore, be it enacted, that the Bureau of Geology and Mines be, and hereby is directed to make tests, as hereinafter provided, of paint pigments, including the sulphate of lead, carbonate of lead, oxide of zinc, lead, lithaphone, barium sulphate, silica, kaolin, magnesium compounds, calcium compounds, and any or all other paint pigments with linseed oil, turpentine, Japan drier, benzine or other oils, either separately or in combination with one another.

Such tests shall be made of said pigments or combination of such pigments ground in any number of said oils and driers or combinations of said oils and driers. The object of said tests being to determine the relative spreading, working and lasting qualities of such combinations and their effects on coloring materials used with said pigments, ground in oil and driers either alone or in combination with other pigments, oils and driers.

To facilitate the carrying out of the provision of this act, manufacturers and producers of paints and paint pigments shall provide the director of said Bureau of Geology and Mines with a complete list of formulas used in the manufacture of said paints and paint pigments; which formulas shall set forth the percentages and physical characteristics of all ingredients used in the manufacture of said paints or paint pigments. Provided that such information shall not be so published or otherwise used as to indicate the source of such formulas.

Said Bureau of Geology and Mines is directed to publish from time to time the results of said tests showing the relative spreading, working and lasting qualities and the effect on coloring of different combinations of said pigments, driers and oils.

There has been a great deal of discussion of late relative to the availability of the water powers of this State. The legislature would be justified in appropriating funds to carry on an investigation of the water powers of this State, such investigation to be under the supervision of the director of this Bureau.

The act establishing this Bureau should be amended in many respects so that there may be continuity in the work from year to year, and from administration to administration. In order to bring this about I would recommend that the following bill be introduced at the next legislature, and that its enactment be pushed with the greatest possible vigor.

Be it enacted by the General Assembly of the State of Missouri, as follows:

Section 1. That Sections 7501, 7502, 7503, 7509, 7512 and 7515, of the Revised Statutes of the State of Missouri, 1899, and an act entitled "An act to amend section 7502, chapter 110 of the Revised Statutes of 1899, relating to geology and mineralogy, and to enact a new section, relating to the same subject, to be known as 7502a, with an emergency clause," approved March 9, 1901, be and the same are hereby repealed and the following sections, to be known as 7501, 7502, 7503, 7503a, 7509, 7509a, 7509b, 7510a, 7512, 7512a, 7512b, 7512c and 7515, enacted in lieu thereof.

Section 7501. There is hereby created and established, a bureau of "Geology and Mines" for the State of Missouri, which shall be under the direction and in charge of a board of managers which shall consist of the governor, who shall be ex-officio president of the board, and four citizens from the State at large, who shall be appointed by the governor, by and with the consent of the senate, and who shall hold their term of office for one, two, three and four years for the first appointees, respectively, under this act, and thereafter for four years. Not more than two shall be appointed from any one political party.

Section 7502. The board of managers are authorized, as soon as they are organized, to appoint a director of the Bureau, who shall be a person of a competent scientific and practical knowledge of the sciences of geology and mineralogy, and whose headquarters shall be located at such place as may be determined by the board of managers, which director of the Bureau shall also be the state geologist, and said director of the Bureau may appoint such assistants and subordinate assistants and laborers as may be deemed necesary in order to make a thorough scentific, geological and mineralogical survey of the State.

Section 7503. It shall be the duty of the director of the Bureau and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the State already begun, with a view to determine the order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the several strata of geological formations within this state, and to discover and examine all beds or deposits of mineral contents and fossils, and to determine the various positions, formations and arrangements of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters and

other mineral substances as may be useful or valuable; also to note carefully the character of the soils and their capacities for agricultural purposes, make examinations of materials suitable for the improvement of highways, and highway construction, make tests of all materials used in building constructions, the growth of timber and other scientific matters that may be of practical importance and interest; and said director of Bureau shall cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances, and on the completion of the survey, to complete memoirs of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

Section 7503a. It shall be lawful for the director of the Bureau, or for any of his assistants, to enter, examine and inspect any and all lands, mines and machinery belonging thereto at all reasonable times by day or night, and the owner, operator or agent is hereby required to furnish all necessary facilities for such examination and inspection; and if the said owner, agent or operator aforesaid, shall refuse to permit such inspection, or to furnish the necessary facilities for such entry, examination and inspection, the director of the survey, or an assistant, shall file his affidavit setting forth such refusal before the judges of the circuit court in said county in which said mine is situated, either during the term of the court or during vacation, and obtain an order on such owner, agent or operator so refusing as aforesaid, commanding him to permit and furnish such facilities for the inspection of such mine, or to be adjudged to stand in contempt of court and punished accordingly.

Section 7509. It shall be the duty of the board of managers to report to each general assembly the progress and condition of the survey, an accurate account of money spent, and such reports of the director of the survey and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

Section 7509a. The Bureau of Geology and Mines is herewith charged with the compilation of complete statistics of the production of all mines, quarries, cement factories, lime kilns, clay-working plants, and such other mineral, stone or clay products as may be exploited or operated in the State of Missouri.

Section 7509b. All special and regular reports, after having been approved by the board of managers, shall be published by the commissioners of public printing, the cost of same being paid for out of the general appropriation for printing State documents. The director shall also obtain, by requisition on the Secretary of State, all necessary stationery, office supplies, postage, etc., which shall be paid for out of the general fund provided for such purposes.

Section 7510a. There shall be maintained by the Bureau of Geology and Mines, a chemical laboratory for assaying and analyzing ores, rocks, clays, and minerals; and a physical laboratory for testing bricks, stone, terra cotta, sewer pipe, cement, concrete, asphalt, and any other materials that may be used in the construction of buildings or the improvement of public highways. Specimens obtained from lands in Missouri shall be examined free of cost to citizens of Missouri, when properly collected from undeveloped mines and prospects. The person furnishing such samples for examination must first present satisfactory evidence to the director that said samples of rock, clay or ore occur in commercial quantity, and he must also furnish, with the sample, a description by quarter section, township and range, or the location of the land from which said specimen or specimens were obtained.

Section 7512. As full compensation for the members of the board of managers, they shall be allowed five dollars per day and their necessary expenses while attending to the duties assigned them: Provided, however, that the aggregate of compensation paid as salary to all of said board shall not in any one year exceed four hundred dollars. The board shall fix the salary of the director of the Bureau. The director of the Bureau, with the approval of the board, may appoint such regular or temporary assistants as may be needed to carry out the requirements of this law. Their compensation shall be fixed by the board of managers, upon recommendation of the director.

Section 7512a. The board of managers may, during the biennial period expend a sum not to exceed one-half of the general appropriation for the maintenance of the Bureau, in the preparation of county reports, including geologic and topographic maps, or both.

Section 7512b. The board is further authorized to enter into agreements with any county in this State to make such reports, provided one-half of the cost of preparing said reports shall be

guaranteed to be paid by said county, either from the treasury thereof, or from private subscription: Provided, that when a county shall have once been completely surveyed it shall not be surveyed a second time under the provisions of this act. The survey of counties shall be made in the order in which petitions are received from the county courts of such counties as shall guarantee one-half of the expense of said survey.

Section 7512c. Every county in the State shall have authority by or through the county court, or an agent appointed by said court, to enter into a contract with the board of managers of the bureau of geology of mines, binding said county to pay one-half the cost of geological and mineralogical surveys of said counties, or parts thereof, made under the supervision of said board, including the cost of preparing and making reports, geological and topographical maps.

Section 7515. The board of managers shall have the general management of the bureau and have full power to remove the director and appoint his successor when deemed necessary for the good of the work entrusted to him; and the director shall have full control over his assistants, and have power to remove and appoint their successors when deemed necessary.

To protect the public from the operations of corporation, joint stock, co-partnership or individual mining enterprises floating fictitious mining stocks, I would recommend the enactment of a law along the lines of the following bill introduced into the last session of the legislature.

Be it enacted by the General Assembly of the State of Missouri, as follows:

Section 1. Any person who knowingly makes or publishes, in any way whatever, or permits to be so made or published, any book, prospectus, notice, report, statement, exhibit or other publication of or concerning the affairs, financial condition or property of any corporation, joint stock association, co-partnership or individual, which said book, prospectus, notice, report, statement, exhibit or other publication shall contain any statement which is false or wilfully exaggerated, or which is intended to give, or which shall have a tendency to give, a less or greater apparent value to the shares, bonds or property of said corporation, joint stock association, co-partnership or individual, or any part of said shares, bonds or property than said shares, bonds or property, or any part there-

of, shall really and in fact possess, shall be deemed guilty of a felony, and upon conviction thereof shall be imprisoned for not more than ten years or fined not more than ten thousand dollars, or shall suffer both said fine and imprisonment.

Sec. 2. The director of the bureau of geology and mines or one of his duly accredited assistants under his direction, is hereby charged with the investigation of all supposedly fraudulent corporation, joint stock, co-partnership or individual mining enterprises which may be operating, advertising or circulating literature in this state, which may be duly brought to his attention by the attorney-general, or which he may have reason to believe exists from his own knowledge. The attorney-general is authorized to proceed against any such corporation, joint stock company, co-partnership or individual which, after an investigation by the director of the bureau of geology and mines, may be supposed to be violating the provisions of section one (1) of this act.

Sec. 3. All acts and parts of acts in conflict with this act are hereby repealed.

Sec. 4. In the opinion of the general assembly an emergency exists; therefore this act shall take effect and be in force from and after its passage.

In the matter of future investigations to be carried on by this Bureau, I would suggest that a new edition of Wheeler's report on "Clay Deposits" be prepared and published; that the report on "Iron Ores" by Nason be revised and another edition published; and that the report on "Coal Deposits" should also be revised. The preparation and publication of educational bulletins and the collection of specimens of ores, rocks and fossils for the use of the colleges and public schools in this State would be very valuable in increasing the knowledge of the general public relative to our own mineral resources.

It is further suggested that the "General Geology" which I have about two-thirds completed, be finished and published as Vol. X. In addition to this I had in preparation at the close of my administration, a report on "Well Drilling," which was to contain all available data on well borings; and a report on "Chemical Analyses" which was intended to bring together and classify all chemical analyses of Missouri ores, minerals, coals, rocks and clays, published and unpublished. These volumes would be extremely useful to the public, and would serve to preserve much of the data which is now scattered and therefore useless.

I would further suggest that this Bureau arrange an exhibit annually, for the State Fair, and that to this end the director be instructed to co-operate with the secretary of the Board of Agriculture.

The statistics covering the mineral productions of this State, and collected and compiled by the Labor Commissioner, are not only deficient in the field that they cover, but they are also unreliable. The mining statistics now being gathered by the Bureau of Mines and Mine Inspection are incomplete. If the legislation recommended above be enacted, this Bureau will be given complete charge of the collection of the official statistical data covering the mineral production of this State, a step which is of no little importance.

I would further recommend that an increased appropriation be made for topographic mapping, in co-operation with the United States Geological Survey. The topographic maps are not only a necessity for geological work, but they are also an essential for the proper improvement and maintenance of the highways of the State, also in an investigation of the water power resources, these maps will be of a very great service.

The Director of this Bureau has necessarily spent considerable time in the mines in various parts of this State. His attention has been especially directed to the causes of mine accidents, and I wish at this place to quote from the report of Mr. James T. Sheridan, United States Mine Inspector, who makes the following recommendation relative to the employe's liability in case of accidents in mine. I think that the recommendation here made is one which is worthy of the careful consideration of our legislature.

"A large majority of the accidents in coal mines are due to gross negligence of the miner himself—negligence bred from constant familiarity with dangers incident to his vocation."

"The operator is bound by the law to furnish every reasonable protection to his employee by maintaining proper conditions in and about the mine, and it is the duty of the Mine Inspector to see that these conditions are maintained, and if the law be not complied with, to prosecute the operators and bring suit for injunction to suspend operation of the Mine."

"But the employee enjoys immunity from punishment for violation of the law. He may, by gross carelessness or negligence, endanger his own life or person or that of his fellow-workmen with impunity, the only punishment being the suspension of operation of his working place, and at most his discharge."

"If he were amenable to the law for its violation, it is hardly probable that he would act in such wanton manner as now; when free from such restraint."

During the last few years there has been a concerted movement upon the part of some of our State and national officials looking toward the preservation of our natural resources. This movement has been directed most actively toward the reforesting of our cut-over timber lands and the irrigation of our so-called deserts. In this State the reclamation of the swamp land along the Mississippi river is the only thing that has been brought to the attention of our legislature. However, there are thousands of acres of barren, rock-strewn land in the Ozarks which might be reforested if cared for by the State government.

I desire, also to call the attention of the public to the wasteful methods of mining now in vogue in some parts of our State. A conservative estimate shows that in the southwestern part of the State fully fifty per cent of the lead and zinc in the ore bodies being mined, is lost, by being left in the ground through imperfect methods of mining, by the iniquitous leasing system and through crude methods of concentration. Some mines are being worked on a twenty per cent royalty, and in such the operator never attempts to mine ore which will not pay him a profit plus this twenty per cent royalty. In the richest mines, only that which is most easily concentrated is recovered, the remainder finding its way to the chat pile or the sludge pond.

The lead and zinc ores, for which our State is now famous, do not occur in inexhaustible quantities and the deposits should not be plundered to enrich the present generation at the expense of the future. There is perhaps nothing more desirable than that this Bureau should devote some attention to methods of mining and concentration, whereby the ore deposits within the State may be economically and judiciously exploited.

As concerns national policies, I am of the opinion that our government should not encourage the exportation of raw materials, whether it be the fuels or metals; that our enormous deposits of coal, iron, lead, zinc, etc., should be preserved to meet the needs of future generations. The Bureau of Geology and Mines should exercise such influence as it may possess in seeking to prevent any waste of the State's resources, in order that the fountains from which the wealth and prosperity of the State and Nation are obtained, may survive the careless wastefulness of the present overfed generation.

CHAPTER IV.

MINERAL RESOURCES OF MISSOURI.

Complete statistics covering the mineral industry of Missouri are not collected at the present time by any of the departments maintained by the State. Other than the biennial report of the State Geologist there is no publication in which this important information is brought together and tabulated.

The following short resume includes the value of the ores and structural materials produced in 1907 and a brief mention of the geological formations from which they are obtained.

The State Geological Survey cooperated to some extent with the United States Geological Survey in the collection of statistics covering the production of lime, stone, clay, sand, gravel and cement and the values given below are the result of such cooperation. The Bureau of Mines and Mine Inspection collects the statistics covering the production of lead, zinc, coal, iron, barite, tripoli and copper and the values given for these materials are taken from the annual report of that department.

The following table shows the total value of the mineral output for Missouri during 1907:

Lead ore	$9,823 823
Zinc ore	9,056 965
Coal	7,306 125
Clay products	7,342 421
Stone	2,325 611
Lime	877 970
Portland Cement (est.)	3,000 000
Mineral Water (est.)	100 000
Iron ore	220 176
Sand and Gravel	790 974
Tripoli	48 144
Copper	70 187
Barite	292 540
Total	$41,252 936

This is the largest output in the history of the State. The growth has been steady during the past ten years and will undoubtedly continue to increase as the value of the undeveloped resources become better known.

Missouri has a greater variety of valuable mineral deposits than any state in the Mississippi Valley. This fact is due largely to the diversified geological conditions occurring within her boundaries.

ASPHALT.

Extensive deposits of asphaltic sandstone occur in Barton and Vernon counties in the southwestern part of the State. These deposits have never been exploited for the production of asphalt, altho the stone often contains as high as 15% of bituminous material.

The rock has been quarried in a small way at Liberal where it is used for sidewalks and curbing. It is rather soft and when subjected to heavy traffic wears rapidly.

During the past year the City of Carthage experimented with this material as a road metal. Crushed sandstone, containing a high percentage of Asphalt was used as a surfacing material for a short distance on a macadam road in the northwestern part of the city. When examined the surface was very soft and full of ruts. The material, does not seem to have sufficient binding qualities to make a durable wearing surface and unless a suitable binder is added will not withstand heavy traffic.

Geologically, these deposits occur in the Lower Coal Measures. The asphalt is the residuum from the oxidation and evaporation of petroleum which at one time occurred in these beds. The sandstones vary in thickness and in the percentage of asphalt contained.

In the mining district of Newton and Jasper counties, asphalt is frequently encountered in openings in the Mississippian limestone. This "tar," as it is called locally, has apparently seeped downward from the sandstones to its present position. It does not occur, however, in sufficient quantity in this formation to be of commercial value.

BARITE.

According to the report of the State Mine Inspector for 1907, Missouri produced 60,370 tons of barite valued at $292,540. Approximately three fourths of this was mined in Washington county.

These deposits occur almost exclusively in the Cambrian formations, altho a small quantity has been found associated with galena and sphalerite in the coal pockets of Miller county. The more important deposits occur in the Potosi formation in Wash-

ington county. In the central portion of the State barite occurs in the Gasconade, Roubidoux and Jefferson City formations.

The barite is mined through shallow shafts sunk in the residual clay. This mineral, which is commonly associated with galena, occurs in chunks embedded in the clay and in fissures in the dolomite, the latter deposits usually occur directly underneath the residual ore, which at one time undoubtedly occupied an upward extension of the fissure, the limestone having been removed by solution. These fissures often extend to a depth of several hundred feet. In Franklin county they have been mined to a considerable depth for the galena content, altho the "lode," as the barite is called locally, is constantly associated with the galena.

Barite does not occur in the disseminated lead deposits of St. Francois county nor in the lead and zinc deposits of southwest Missouri.

Brief mention of the occurrence of barite is made in the Miller, Morgan and Moniteau county reports and in the report on "The Geology of the Disseminated Lead District of St. Francois County." The last report contains a map showing the productive and worked out areas in the vicinity of Mineral Point, Mo.

BUILDING STONE.

The value of the stone produced in Missouri for 1907 was $2,325,611. The following table shows, in detail, the value of the limestone, granite and sandstone produced, and the different uses of each.

Uses.	Limestone.	Sandstone.	Granite.	Total.
Building and Monumental	$ 538,114	$25,208	$ 60,097	$ 623,415
Paving	2,218	50	15,966	18,234
Curbing	14,104	150		14,254
Flagging	12,699	325		13,024
Rubble	218,827	2,940		221,767
Riprap	152,090	3,600	8,375	164,065
Crushed: Road making	428,261		16,424	444,685
Crushed: Railroad ballast	284,058		32,100	284,158
Crushed: Concrete	418,990		35,443	454,433
Flux	43,612			43,612
Sugar factories	317			317
Miscellaneous	40,627	3,021		43,648
Total	$2,153,917	$35,289	$136,405	$2,325,611

The total value is $166,317 greater than the production in 1906. While the industrial depression affected certain phases of the industry, notably the dimensional trade, it did not affect the output sufficiently to cause a decrease in value of the total production. The granite industry seems to have been the only branch which suffered a decrease in the total output. Both sandstone and limestone show an increase in production. The use of crushed limestone for concrete shows an increase in value of $102,854. This is an increase of approximately 25% and is the largest advance shown by any of the stone industries.

The wide range of geological formations occurring in the State is reflected in a corresponding variety of excellent building stone. Missouri contains inexhaustible quantities of the finest red granite, limestone and sandstone. The industry is as yet largely undeveloped.

The pre-Cambrian igneous rocks occurring in St. Francois, Iron, Madison and other counties of southeastern Missouri, produce the excellent red granite for which this State is noted. Extensive quarries have been opened at Graniteville and Syenite for the production of monumental and building stone. During recent years several crushing plants have been established at different places in the granite district. The crushed granite is unexcelled for use as a road surfacing material and in granitoid walks.

The granite quarries now in operation produce only rough building and monumental stock. The fact that they do not manufacture finished monuments is undoubtedly largely responsible for the comparatively restricted use of this stone in monumental work.

During the past year the Missouri Red Granite Monument Company of St. Louis, has equipped a modern plant for dressing and polishing Missouri granite. The Graniteville stone is used exclusively by this firm.

The various sedimentary formations produce a variety of limestones capable of being used for practically all constructional purposes.

The Burlington formation furnishes the excellent limestone quarried so extensively at Carthage. This stone excels any produced in the middle west in color, strength and durability. The quarries at Phoenix, Ash Grove and Hannibal are in the same formation.

The limestone of the St. Louis formation furnishes practically all the rubble and crushed stone used in the city of St. Louis.

The Kimmswick limestone exposed at Cape Girardeau has been metamorphosed to a crystalline marble. It furnishes one of the finest building stone in the State.

The Coal Measures underlying the northwestern part of the State, contain a number of heavy ledges of limestone. They are, as a rule, irregularly bedded, poor in color and so badly broken by joints as to be unsuitable for dimensional purposes. They furnish, however, excellent stone for crushing and rubble, being extensively quarried in the vicinity of Kansas City and St. Joseph for these purposes.

The Cambrian formations occupying the south central portion of the State consist almost exclusively of dolomite. The different formations do not contain suitable material for cut stone and the present production, which is comparatively small, consists largely of rubble with some crushed stone. In the southeastern part of the State, certain ledges in these formations have been metamorphosed to a crystalline marble. These beds have been exploited to some extent in the past but are not being worked at present.

The heavy ledges of sandstone occurring in the Coal Measures at Warrensburg and Miami are quarried extensively for dimensional stone. These quarries produce the greater portion of the sandstone quarried in the State for building purposes.

One quarry has been opened in the AuxVasse sandstone south of Ste. Genevieve. This ledge was quarried extensively a number of years ago.

Detailed information concerning the quality of the stone obtained from the various geological formations occurring in the State is given in Vol. 11, 2nd series of the reports of this Bureau.

CLAY PRODUCTS.

Missouri stands seventh among the states in the value of her clay products. The total output in 1907 was valued at $7,242,421 which is approximately equal to the total value of the coal mined in the state. In 1906 the clay products were valued at $6,696,275. There was a total increase in value of $546,146 during 1907 in spite of the depressed condition of the building industries. The following table gives the value of the various clay products for 1907:

Common brick	$1,844,255
Vitrified brick	462,341
Front brick	387,455
Fancy brick	33,638
Fire brick	1,634,204
Drain tile	72,816
Sewer pipe	1,332,080
Hollow building tile	42,673
Terra Cotta, fireproofing, stove lining, etc	835,871
Miscellaneous	175,846
Pottery Products	78,187
Clay mined and sold	443,553
Total	$7,342,421

The manufacture of common building brick is the most important clay industry in the State. Fire brick is second, while sewer pipe ranks third in value. The combined output of the three industries equals 65% of the total value of the clay products. Missouri manufactures approximately one-eighth of the fire brick and one tenth of the sewer pipe produced in the United States.

The clay used in the manufacture of common brick is derived largely from the extensive deposits of loess occurring along the Missouri and Mississippi rivers. These deposits vary from 10 to 150 feet in thickness and extend from the Iowa state line to Cape Girardeau.

The clays and shales used in the manufacture of sewer pipe and fire brick are derived almost exclusively from the Coal Measures which underlie the greater portion of northwest Missouri and the northern half of St. Louis county. This series is composed largely of shales which vary widely in chemical and physical properties. The supply is inexhaustible and many of the beds have never been developed.

The deposits of china clay or kaolin occurring in southeastern Missouri are not being worked extensively at the present time. These deposits are almost free from iron but are quite siliceous. With proper treatment an excellent clay free from injurious constituents can be obtained. There is no apparent reason why this industry should not become of much greater importance.

COAL.

According to the report of the State Mine Inspector for 1907, Missouri produced 4,355,494 tons of coal valued at $7,306,125. The following table shows the production and value by counties:

County.	Tons.	Value.
Adair	584,371	$866,334
Audrain	36,629	65,637
Barton	191,106	288,281
Bates	166,512	272,899
Benton	3,106	6,212
Boone	35,495	65,986
Caldwell	11,656	28,557
Callaway	34,748	66,582
Carroll	4,850	14,067
Cass	3,400	6,800
Chariton	36,474	68,803
Clay	40,590	75,092
Cole	2,401	4,302
Dade	1,912	3,346
Grundy	11,040	27,269
Henry	166,928	303,644
Howard	13,456	25,599
Johnson	66,403	109,706
Lafayette	712,981	1,320,246
Lewis	210	525
Linn	124,068	268,179
Livingston	2,270	4,096
Macon	1,159,233	1,650,055
Moniteau	3,552	8,880
Montgomery	2,990	7,475
Morgan	2,640	6,402
Nodaway	120	450
Platte	259,849	537,873
Putnam	58,999	116,410
Ralls	16,768	30,101
Randolph	97,702	144,685
Ray	349,180	666,371
St. Clair	2,360	5,060
Saline	845	2,112
Schuyler	4,840	9,195
Sullivan	3,000	7,700
Vernon	142,810	221,194
Total	4,355,494	$7,306,125

The Coal Measures occupy approximately 23,000 square miles of the northwestern half of the state. The total thickness of the series which consists largely of shales, limestones and sandstones is approximately 2,000 feet. The formation is separated into the upper and lower Coal Measures by the Bethany Falls limestone. This formation is easily recognized and outcrops along an irregular line extending a little east of north from the western edge of Cass county to the Iowa state line.

The Lower Coal Measures from which practically all the coal is produced has a maximum thickness of 800 feet and underlies an area of approximately 15,000 square miles. The coal beds occurring in this portion of the formation vary from 2 to 5 feet in thickness.

The Upper Coal Measures, which is approximately 1,200 feet in thickness, does not contain known coal beds of importance. Several beds from six inches to one foot thick have been encountered in drilling. A small mine has been opened in Nodaway county on a vein varying from 12 to 18 inches in thickness.

Development work has been actively carried on in several areas north of the Missouri river. During the past year a five foot bed was encountered near the Mercer county line at a depth of 500 feet. A similar bed has been discovered in the eastern part of Harrison county. It is probable that this area will form one of Missouri's most productive coal fields. At present, practically no coal is being produced from the Lower Coal Measures where this series is overlain by the upper coal measures. There is no apparent reason for this lack of production other than the depth to which shafts must be sunk in order to penetrate the coal seams. Drilling in portions of this area has shown workable coal seams in the Lower Coal Measures.

At Leavenworth, Kansas, coal is being hoisted from a depth of 700 feet. This coal which is obtained from the Lower Coal Measures, is mined on the Missouri side of the river. The seam probably underlies a large part of Platte county.

COBALT AND NICKEL.

Missouri is the only state in the union producing nickel and cobalt from native ores. The entire output at the present time comes from the mines near Fredericktown in Madison county. Formerly the mines at Mine LaMotte produced cobalt and nickel sulphides which were smelted to a matte and shipped east to be

refined. Small quantities of these sulphides occur associated with the disseminated lead deposits of the Flat River area. They do not however, occur in sufficient quantity to be of commercial value.

The ore bodies in the vicinity of Fredericktown occur in the upper beds of the LaMotte sandstone and in the lower portion of the Bonneterre dolomite. The ore consists of a mixture of lead, copper, cobalt, nickel and iron sulphides.

During the past biennial period the North American Lead Company has erected a large refining plant for the separation of these metals. The process is largely electrolytic and is being operated successfully on a commercial scale. The company is producing electrolitic copper and nickel, cobalt, oxide and lead concentrates.

The Bureau has never investigated these ore bodies in detail. Similar geological conditions occur over a considerable area between Fredericktown and Mine LaMotte and it is possible that the deposits are more extensive than supposed at present. A complete survey of the area should be made in order, if possible, to outline the relations of the ore bodies to the different geological formations. Such work would serve to point out the favorable areas for prospecting.

COPPER.

Small amounts of copper have been produced in this State intermittently during the past 50 years. During the past two years the North America Lead Company of Fredericktown, Mo., has developed the extensive bodies of copper, cobalt, nickel and lead sulphides occurring in the LaMotte sandstone and is now producing each of these metals. This is the only company producing copper in Missouri at the present time.

Geologically, the deposits of copper found in the state occur in the Cambrian and pre-Cambrian formations of the Ozark region. The only deposit in the pre-Cambrian that has been exploited to any extent occurs near Eminence in Shannon county, where a shaft has been sunk over a hundred feet upon a small fissure vein in the porphyry. The vein contains the carbonates of copper, malachite and asurite, and chalcopyrite. These minerals seem to have been introduced into the fissure by solutions which have leached the overlying Cambrian limestone. Considerable copper carbonate occurs in the latter formation.

Copper frequently occurs associated with the iron ores in the

Ozark region. As these deposits are worked in depth, copper carbonates and sulphides are often encountered. This association of the copper has not been investigated extensively and these deposits are not being worked at the present time.

At the mine of the Copper Mountain Copper Company, four miles southeast of Sullivan, Missouri, copper carbonates and sulphides occur associated with iron ore and clay. This company has completed approximately 800 feet of drifting, most of which is in ore. A small smelter and mill was erected a few years ago and some copper was smelted. The plant has not been in operation during the past year. The property has not been developed in depth to the water level and the extent of the ore is not known.

IRON ORE.

According to the State Mine Inspector's report, iron ore was produced in sixteen counties during 1907. The total output was 120,889 tons valued at $250,556. The following table shows the amount and value of the ore produced in each county:

County.	Tons.	Value.
Butler	9,212	$18,424
Carter	280	700
Christian	2,640	5,480
Cole	714	1,785
Crawford	37,017	74,082
Franklin	18,265	36,580
Greene	5,720	11,440
Howell	11,580	26,055
Lawrence	80	160
Madison	90	216
Miller	840	1,890
Newton	280	560
Phelps	8,125	15,234
Shannon	10,000	22,000
Stoddard	1,800	4,000
Wayne	720	1,620
Total	107,363	$220,176

The above table does not indicate a production for St. Francois county, altho considerable ore was shipped from Iron Mountain. This ore was obtained by washing the old dumps.

Crawford and Franklin counties are the largest producers. Reports received from Mr. J. E. Burton of St. Louis indicate a much larger production than is accredited to Wayne county. Prospecting has been actively carried on in this county during the past two years and the following mines have been opened. A number of these have produced several thousand tons of ore.

Higgins Mine	S. E. ¼ Sec. 5, T. 29, R. 7
Yount & Kelsall	S. E. ¼ Sec. 7, T. 29, R. 7
Christman Mine	S. W. ¼ Sec. 28, T. 28, R. 5
Lundy & Harness	S. W. ¼ Sec. 34, T. 28, R. 5
Inda Mine	N. W. ¼ Sec. 8, T. 28, R. 6
Juda Mine	S. W. ¼ Sec. 35, T. 28, R. 5
Zippi Mine	S. W. ¼ Sec. 27, T. 29, R. 6
Burton Mine	S. W. ¼ Sec. 21, T. 29, R. 6
Myers Mine	N. W. ¼ Sec. 21, T. 29, R. 6
Long Mine	S. W. ¼ Sec. 5, T. 29, R. 6
Van Dolson	
Janase Mine	

The Mississippi Valley Iron and Furnace Company recently incorporated in Missouri has acquired several thousand acres of iron land in the southeastern part of the state. The company contemplate erecting a furnace and opening a number of new ore bodies.

Deposits of iron ores are known to occur in forty-eight counties in the State. The present production is obtained almost exclusively from the deposits occurring in the Cambrian formations of central and southeast Missouri and from the deposits occurring in the residual clay overlying the Burlington limestone of southwest Missouri.

LEAD AND ZINC.

The total value of the lead and zinc ores produced in Missouri in 1907, according to the State Mine Inspector, was $18,880,788. The total production of lead ore was 151,294 tons valued at $9,823,823, while the total production of zinc ore was 225,391 tons valued at $9,056,963.

The following table gives the amount and value of the lead and zinc ores by counties.

COUNTY	LEAD		ZINC	
	Tons	Value	Tons	Value
Benton	2	$ 158.00		
Camden	29	2,384.00		
Christian	1	74.00		
Cole	296	21,312.00	146	$ 6,424
Dade			58	2,465
Franklin	400.75	28,005.00		
Greene	244	17,832.00	800	36,732
Jasper	347.42	2,351,462.00	188,374	7,917,913
Jefferson	113 ¾	7,278.00	1,095	15,330
Lawrence	411 ½	28,877.00	12,935	406,357
Madison	11,188 ½	682,310.00		
Miller	37	2,701.00		
Moniteau	360	26,204.00	61	1,880
Morgan	52	3,744.00	78	3,354
Newton	2,791	207,005.00	21,235	655,330
Polk	4 ½	315.00		
St. Francois	99,324	6,356,368.00		
Taney	120	8,400.00	96	3,744
Washington	11,188	77,400.00	510	7,486
Webster	7	476.00		
Wright	22	1,518.00		
	151,294	$9,823,823.00	225,319	$9,056,965

It is worthy of note that for the first time Missouri leads all other states in the value of the lead ores produced. Idaho formerly surpassed Missouri.

The low price of pig lead resulted in a curtailed production during the latter part of 1907 and the early part of 1908. During this period a number of the important mines of Southeast Missouri were closed or were operated with a much reduced force. During the last half of 1908 the mines were operated at full capacity.

The milling capacity of the Flat River district has been greatly increased during the past two years. In 1907, the Federal Lead Company completed the erection of a large concentrating plant having a capacity of 3,000 tons per day. The Doe Run Lead Company remodeled the plant located on the old Columbia Lead Com-

pany's property and are now erecting a large plant west of Elvins. This mill will have a capacity of 1,500 tons per day.

Very little prospecting in new territory has been carried on during this period. At the present time no new properties are being drilled. Practically no new territory has been discovered, altho the Federal Lead Company has greatly increased its ore reserves by prospecting in the vicinity of its developed mines.

Development in the Joplin district have been largely confined to the sheet ground. Extensive deposits of these low grade ores are being opened and the percentage of the total output derived from these deeper ore bodies is continually increasing.

The low price of ore maintained during the greater part of 1907 and 1908, caused many mines to lie dormant during the greater portion of the period. With the present price of $40 per ton these are again being opened up.

While many important strikes were made in the developed territory, there was a lack of prospecting in the outlying districts. Jasper, Newton and Lawrence counties have hundreds of square miles of very favorable territory that has never been prospected.

The most important development in the western district during the past biennial period was the discovery of rich deposits of ore at Miami, Oklahoma, in 1907. While not in this state, the same general geological conditions apparently occur north of Neck City and Alba and the relation of these ore bodies has an important bearing on the possible extension of the productive area in this State.

Prospecting has been continued intermittently throughout the central Ozark region. Scattered deposits are known to occur in almost every county in the southern portion of the state. A number of these have given evidence of considerable promise.

Northwest of St. Clair in Franklin county, prospecting and development work have been carried on at the Enterprise and Zark properties.

The Enterprise mine has a drift of several hundred feet along a small fault. The fissure which is filled with galena and barite, has been mined to a depth of 75 feet. A small mill will be erected upon the property. The company has approximately 1,500 tons of mill dirt on the dump ready for concentration.

At the Zark mine, a drift approximately 100 feet in length has been driven along a gnarled ledge of flint which carries approximately 3% of galena. The ore occupies small fissures and

openings in the rock. Near the north end of the property, a shaft has been sunk on a breccia carrying lead, zinc and barite. This ore will apparently run 5 or 6%. Very little development work other than sinking the shaft has been done at this point. The property is equipped with a small mill.

According to Hon. J. R. Dalby of Sedalia, a shaft sunk at Otterville, Cooper county, has encountered from 10 to 15 feet of good ore at a depth of 100 feet. South of Sedalia in Pettis county, ore has been encountered at a depth of 85 feet. The ore body is said to have a thickness of from 15 to 20 feet and averages from 8 to 10% zinc. A 75 ton mill has recently been erected on this property.

Prospecting has continued with increased vigor south of Newburg in Phelps county. Some ore has been shipped but the work has been largely devoted to prospecting. The ore occurs in the clay and in a brecciated layer of flint occurring in the Gasconade limestone.

LIME.

During 1907 Missouri produced 190,300 tons of lime valued at $877,970. The value for 1906 was $790,285. The increase of 1907 over 1906 was $87,785 or 11%. The following table shows the increase in value of the lime produced in the State during the past ten years:

1898	$297,401
1899	383,549
1900	398,010
1901	546,549
1902	515,780
1903	641,948
1904	597,258
1905	712,950
1906	790,285
1907	877,970

Missouri stands fourth among the states in the value of lime produced, being surpassed by Maine, Ohio and Pennsylvania.

It is evident from the large increase in production during the past few years that the extensive use of Portland cement in building construction has not injured the lime industry.

Approximately 1-10 of the lime burned in the United States

is used as a fertilizer. Large quantities are also used by sugar factories, steel works, glass plants, smelters, chemical works, soap factories and paper mills. As yet, only a small proportion of the lime manufactured in this state is used in any of the above industries.

During the past biennial period, the Rogers White Lime Company abandoned its kiln at Republic, Mo., and erected a modern plant at Wilson creek in Greene county. Another notable improvement in the industry has been the installation of a hydrating plant by the Hannibal Lime Company of Hannibal. This is the second hydrating plant installed in the state, the first having been erected several years ago by the Ash Grove White Lime Company at Ash Grove.

Missouri produces high calcium limes exclusively. The entire product is manufactured from stone obtained from the Burlington, Kimmswick and Spergen formations. The Burlington produces over one-half of the total output.

This department recently published a volume devoted to the Lime and Cement Resources of the State. It outlines the general character of the various geological formations suitable for the manufacture of high grade limes and describes the character of the different limes being produced in the State.

MANGANESE.

Missouri does not produce ores of manganese at the present time.

A number of deposits of iron ore in the southern part of the State are known to contain relatively high percentages of manganese. During the past year one of these deposits has been developed in Shannon county. The ore shipped, however did not contain sufficient manganese to prove of value and the deposit is not being worked at present.

MINERAL PAINTS.

During 1907, Missouri produced 14,625 short tons of mineral paint, valued at $1,670,052.

This value includes the production of zinc-lead, sublimed white lead, sublimed blue lead, and litharge. The amount of barite, iron ore and ground limestone used for this purpose is not known and is therefore not included in the above.

As the value of the raw material used in the manufacture of these pigments is included under the production of lead and zinc ores, this item is not added to the total value of our mineral resources.

The industry is one of importance to our mining regions as it provides an outlet for approximately one-tenth of the lead ores produced in the State.

MINERAL WATERS.

Missouri is abundantly supplied with a great variety of mineral waters, having excellent medicinal properties. The output is valued at approximately $100,000 annually. This is but a small proportion of the water that could be sold if properly advertised.

At the present time the following springs and wells are marketing waters:

Belcher Artesian Well, St. Louis, Mo.
Blue Lick Spring, Blue Lick, Mo.
Sweet Springs, Sweet Springs, Mo.
McAllister Spring, McAllister, Mo.
Eldorado Springs, Eldorado, Mo.
Lithium Spring, Central Park, Mo.
Lithium and Soda Springs, Excelsior Springs, Mo.
B. B. Springs, Bowling Green, Mo.
American Springs, St. Louis, Mo.
Aqua Vitae Spring, Canton, Mo.
Chalybeate Spring, Mooresville, Mo.
Lithia Spring, Mt. Washington, Mo.

The above are only a few of the springs occurring in the State. The waters sold include Chalybeate, Litha, Muriatic, Sulpho Saline and Alkaline. Probably no state in the middle west has a greater variety of waters which possess medical properties. As the value of the different springs become better known, the output will rapidly increase.

The Ozark region has abundant large springs of pure water. These are not extensively utilized at present for domestic purposes.

NICKEL (See Cobalt).

PORTLAND CEMENT.

Missouri produced approximately 3,000,000 barrels of Portland cement during 1907. The development of the industry in the State has been very rapid, and the output will be greatly increased during the next few years. Two new plants have been erected during the past biennial period. The Kansas City Portland Cement Company completed its plant north of Independence during 1907. The Continental Portland Cement Company of St. Louis has recently completed a plant southwest of the city. The maximum capacity of the four plants operated in the State at present is approximately 20,000 bbls. per day.

The Missouri Portland Cement Company of Kansas City, Mo., contemplated building a 2,500 bbl. plant at Iatan during the coming year. The Cape Girardeau Portland Cement Company of Cape Girardeau has also completed plans for the erection of a plant south of that city.

Missouri is supplied with inexhaustible quantities of the raw materials necessary for the manufacture of Portland cement. As shown in the recent report published by this department covering the Lime and Cement Resources of Missouri, suitable limestone occurs in the Trenton, Burlington, St. Louis and Coal Measure formations.

The eastern and northern portions of the State are underlain by these formations. At present the Burlington and St. Louis limestones of the Mississippian and the Iola limestone of the Pennsylvanian are being used. The Cape Girardeau plant will use the lower Trenton limestone.

The shales which are being used belong to the Devonian and Coal Measures. The Atlas Cement Plant at Hannibal is using the Hamilton shales, while the St. Louis Portland Cement Company and the Kansas City Portland Cement Company are using the Coal Measure shales. Both formations contain inexhaustible quantities of good shale. The Continental Portland Cement Company of St. Louis is using loess clay.

Within a few years Missouri will undoubtedly lead the states of the Mississippi Valley in the production of Portland cement.

OIL AND GAS.

The recent extensive development of the oil fields of Illinois, as well as the enormous production of oil and gas in Oklahoma and Kansas have combined to direct the attention of producers to the territory lying between these fields.

During the past biennial period, thousands of acres of land have been leased throughout the State and wells have been drilled in St. Louis, St. Charles, Dent, Phelps, Knox, Johnson and Mercer counties. A number of these are located in territory that does not possess the geological conditions necessary for the accumulation of commercial pools of either fuel.

The major portion of the oil and gas produced in Illinois, Oklahoma and Kansas is obtained from the Coal Measures. Similar beds underlie the northwestern part of this State and it is this area which offers the greatest promise of finding oil and gas. The Coal Measures have a thickness of approximately 2,000 feet.

While this region has not been prospected extensively, gas has been encountered in a number of wells drilled at several places. Shallow wells north of Warrensburg in Johnson county, have encountered gas at a depth of from 90 to 300 feet, and when the water is pumped out of these wells, they burn continuously. The gas, however, is not under sufficient pressure to cause a flow when the water is allowed to rise in the well.

A flow of gas is also reported at Lathrop in Clinton county. The well has a depth of 200 feet. Recently a small flow was encountered while drilling near Cameron. At Holt, in Clay county, there is also a shallow well showing gas.

At Belton in Cass county, a number of wells have encountered some oil in the sandstone of the Coal Measures. A production of several bbls. per day was reported from this area for a short time but at present they are not producing.

A number of wells drilled in St. Louis have encountered gas at various depths. The following paragraphs quoted from the biennial report of this Bureau to the 43rd General Assembly, describes the most important flow yet encountered in that area.

"In 1903, the Welle Boettles Bakery Company of St. Louis struck natural gas in a well which they drilled at their plant on Vandeventer avenue and Forest Park boulevard. The gas was struck at a depth of 670 feet and is reported to have furnished a pressure of 250 pounds. Since then two additional wells have been

sunk to a depth of 1,000 feet without encountering anything but salt water. In the third well traces of oil were found at a depth of 280, feet and gas at 675 feet."

"The gas from the first well has been used to heat three furnaces, or six ovens day and night."

There is very little probability of encountering either gas or petroleum in large amounts in the small basin of Carboniferous rocks, upon which St. Louis is located. Other wells of small pressure may be found, but the structure of the region combined with the restricted nature of the basin argues against finding either petroleum or gas in large quantities."

This Bureau has not completed a detailed geological survey of the area underlain by the Coal Measures and until this work is done it will not be possible to outline the most favorable area for prospecting.

SAND AND GRAVEL.

The value of the sand and gravel produced in 1907 was $790,974. The following table shows the output and value of the sand and gravel used for different purposes.

	Quantity (Short Tons)	Value
Glass Sand	138,483	$ 92,898
Moulding Sand	48,314	32,668
Building Sand	1,899,822	435,441
Fire Sand	15,788	8,979
Engine Sand	34,500	6,803
Furnace Sand	15,000	7,500
Sand (Misc. uses)	48,760	27,051
Gravel	874,663	179,634
	3,075,280	$790,974

The above table is incomplete in that it does not include the sand and gravel used for concrete and road metal in many of the smaller towns and villages of the State. The total production of the State will easily exceed one million dollars in value.

The glass sand is produced exclusively from the St. Peter's sandstone which occupies a narrow belt in the eastern part of the State. The sandstone is quarried extensively at Klondike, Pacific and Crystal City. The deposits are easily worked and produce an excellent grade of white sand which is used in the manu-

facture of plate glass. Care must be taken in quarrying not to include those portions of the sandstone containing iron.

The greater portion of the common building sand and gravel is obtained by dredging from the Mississippi and Missouri rivers and their larger tributaries.

In the northern portion of the State small deposits of sand and gravel of glacial origin are worked for local use. In Bates and Vernon counties sand is obtained from the weathered portions of ledges of sandstone belonging to the Lower Coal Measures.

TRIPOLI.

According to the report of the State Mine Inspector, Missouri produced $70,144 worth of tripoli in 1907. The value is the largest yet reported for any single year.

The main deposits, which are controlled by one company, occur within a radius of ten miles of Seneca, Newton county. They consist of partially decomposed flint which has become very porous through the abstraction of the soluble silica. The value of the deposit depends upon the extent to which decomposition has taken place. Where the tripoli is soft and easily pulverized, it is ground and used for polishing powder. Where decomposition has not gone so far and the material is not easily broken, the tripoli is used exclusively for the manufacture of filters.

The deposits occur near the surface of the ground and are generally overlain with red clay. They vary from small boulders embedded in the clay to solid ledges 20 feet in thickness. In the thicker beds the upper and lower portions can ordinarily only be used for ground tripoli.

Decomposed boulders of chert having the same characteristics as the tripoli at Seneca occur in other portions of south Missouri. These are not being exploited at the present time and have but little value. Ordinarily they do not have the unform texture shown by the Seneca tripoli.

ZINC (See Lead.)

FINANCIAL STATEMENT—1907-08.

(From State Auditor.)

SUPPORT APPROPRIATION—1907.

Buckley, E. R.	$3,449 81
Boyd, J.	24 50
Buehler, H. A.	975 24
Barnes Crosby Co.	239 66
Crane, G. W.	808 70
Cottey, L. F.	64 04
Cooke, G. T.	16 25
Ellis, J. R.	54 45
Gahrtz, Frank	613 40
Grover, H.	25 00
Gatch, E. S.	30 20
Gast, Aug. Bank Note & Lith. Co.	116 96
Hughes, V. H.	344 28
Gottschalk, V. H.	468 13
Long, Edw. (postage)	175 00
Moore, Ellis	14 00
Mining News Co.	93 00
Mix, W. B.	67 50
Morse, Edw.	187 64
Mound City Eng. Co.	139 08
McLean, Chas.	28 50
Rowley, R. R.	268 30
Reiss, E. F.	32 50
Snyder, B. J.	50 00
Snyder, W. H.	36 50
Shepard, E. M.	204 48
Strobach, (Miss) L. J.	440 00
Stephens, Hugh, Printing Co.	729 69
Stromme, O. U.	474 89
Spaulding Sta. Co.	99 35
Wood, C. R.	172 84
Wheelright, O. W.	355 97
Total	$10,799 86

SUPPORT APPROPRIATION—1908.

Buckley, E. R.	$1,884 91
Buehler, H. A.	2,270 50
Cornwall, Mrs. E. (postage)	200 00
Cottey, L. F.	18 70
Gahrtz, Frank	520 75
Gatch, Elias S.	47 82
Graham Paper Co.	392 48
McCaw (Mrs.), W. J.	212 00
Marbut, C. F.	102 90
Morse, Edw.	175 00
Mound City Eng. Co.	160 83
Small (Mrs.), J. C.	61 00
Stephens, Hugh	18 55
Stromme, O. U.	255 07
Shepard, E. M.	142 32
Seltzer, A. J.	40 00
Strobach (Miss), L. J.	40 00
Stephens, Hugh, Printing Co.	2,090 26
Jones & Cleino.	30 00
Whitner, C. L.	55 73
Total	$8,768 82

LABORATORIES, TOPOGRAPHY, ETC., 1907.

Anderson, C. G.	$2,509 71
Buckley, E. R.	1,053 45
Cunningham, E.	8 25
Ellis, J. R.	185 48
Hawkins, R. H.	9 25
Harris, A.	10 00
Henry Heil Chem. Co.	170 37
Lilly, Ira	23 00
Reese, E. F.	57 09
Roberty, J. N.	119 15
Snyder, W. H.	12 25
Smith, A. A.	82 40
Wilson, Elber	16 83
Total	$4,268 35

LABORATORIES, TOPOGRAPHY, ETC., 1908.

Anderson, C. G.	$1,449 26
Baker, H. W.	575 58
Buehler, H. A.	59 47
Baker, J. T., Chem. Co.	40 44
Buxton & Skinner Sta. Co.	1,058 00
Eimer & Amend	292 27
Gast, Aug., Bank Note & Lith. Co.	550 00
Gale, Thos.	161 90
Heil, Henry	92 76
Lilly, Ira	22 25
Mound City Eng. Co.	408 33
Roberty, J. N.	28 50
Scruggs, Vandervoort & Barney	38 00
Spilman, J. A.	185 61
Scott, J. W.	38 40
Illnski, A. X.	17 50
Mathews Northrup Works	350 00
Total	$5,368 27

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