GEOLOGICAL SURVEY OF MISSOURI.

ARTHUR WINSLOW, STATE GEOLOGIST.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BUREAU OF GEOLOGY AND MINES

TO THE

36TH GENERAL ASSEMBLY

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS.
1891.

On motion, 1,000 copies ordered printed, January 22, 1891.

Mr. Davis, of Henry county, offered the following resolution: *Resolved,* That 2,000 copies of the biennial report of the State Geologist be printed in the form prescribed by law—1,000 of said copies for the appendix to the House journal and the remainder for the office of the State Geologist for distribution. Which was read and adopted.

A. S. SMITH, Chief Clerk.

LETTER OF TRANSMITTAL.

January 22, 1891.

To the Thirty-sixth General Assembly of the State of Missouri:

GENTLEMEN—The Board of Managers of the Bureau of Geology and Mines, appointed under an act approved May 23, 1889, was organized August 28, 1889, and, on the following day, Arthur Winslow was elected State Geologist, and entered on the discharge of his duties on the 20th of September, 1889. The progress of the work is set forth in the report of the Geologist, which is forwarded herewith through the House. The Board has endeavored to use the money at its disposal to the best advantage, and is of the opinion that the State is more than amply repaid for the expenditure made by the additional knowledge that has been acquired, and the valuable information that has been disseminated concerning the mineral wealth and resources of Missouri. The monthly reports of the Geologist have been of benefit to the public, and the bulletins issued have presented, in practical form, the results of the Survey, and have added materially to the literature of Missouri geology. In our opinion the Survey should be continued in the line begun, and to enable the accomplishment of that end an appropriation much larger than that of 1889 is desirable, if not necessary. Bulletins Nos. 2 and 3 are now in print and will be ready for distribution in a few days. We desire to call your especial attention to the interesting report of the Geologist, which gives a history of Missouri geology from its beginning, and states, in an impressive manner, the advisability of a continuation of the present survey, besides showing, in detail, the progress that has been made since the organization of this Board.

Respectfully,

DAVID R. FRANCIS,

Governor and ex officio President of the Board of Managers of the Bureau of Geology and Mines: For the Board.

PREFATORY LETTER.

JEFFERSON CITY, Dec. 31, 1890.

To the President, Governor David R. Francis, and the Members of the Board of Managers of the Bureau of Geology and Mines:

GENTLEMEN—I have the honor to submit to you, herewith, my report of the operations of the Geological Survey of the State since the beginning of work in October, 1889, to the present date.

As the present work is practically a continuation of operations begun by earlier Surveys, I have introduced this report by an historical sketch describing the origin, the progress and the results reached by these Surveys, so that the foundation upon which the present work stands may be clearly known, and so that the reasons for the existing plans of work may be appreciated.

Following this I have undertaken to describe the organization of the present Survey, giving an outline of the general plan of work and the reasons for adopting it.

Succeeding this is a statement of the results which have been reached by the Survey during this year's work, after which I have submitted a classified statement of the expenditures to date. The last part of the report is devoted to a consideration of the needs for the future.

That the results of this, the first year's work, may meet with your approval, and that they may prove of true benefit to the State, is my earnest hope. Toward this end I have directed my best efforts. In this work, however, I have been cheerfully sustained by other members of the Survey, and recognition for this is due them here. Such success as may have resulted is due, in large part, to their co-operation. Coming to the Survey variously prepared and with variable appreciation of the character of the work ahead, they have, as a body, applied themselves with zeal to the accomplishment of immediate ends; they have endured the exposures and the hardships without complaint, and have displayed ability and talent in the execution of the work.

Further, the Survey owes a debt of gratitude to those citizens of the State who have advanced the work, either by extension of hospitality, by furnishing information or by guidance in the field. Such assistance not only hastens the progress of the work, but, when accompanied by a cordial exhibition of interest, adds zest and a sense of recognition which is always inspiring.

Finally, Mr. President, I owe to you, with whom I have been in most frequent intercourse, an expression of gratitude for the attention you have given to all affairs of the Survey concerning which I have consulted you, for your valuable advice in relation to matters of administration, and for the confidence you have exhibited in my management.

To other members of the Board I am further indebted for much assistance in advancing the work, and for hospitalities extended to myself and others of the Survey corps.

Very respectfully submitted,

ARTHUR WINSLOW,
State geologist.

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BIENNIAL REPORT OF THE STATE GEOLOGIST

FOR THE YEARS 1889 AND 1890

HISTORICAL SKETCH.

OPERATIONS PRECEDING THE FIRST GEOLOGICAL SURVEY.

The geology of the State of Missouri has been a subject of study for comparatively few years. But, though this is true with reference to the general geology of the State, or so far as any systematic investigation of its mineral deposits is concerned, yet the existence of such mineral deposits has been known for a long time. From early in the eighteenth century the lead deposits of the State (then a part of the colony of Louisiana) attracted attention. The operations of Sieur de Lochon on the Meramec in 1719 were among the earliest. In 1720, the Mine LaMotte was worked under Governor De LaMotte, the first governor under the Crusat patent. The immigration, started through John Law, brought many miners to the State who continued the development of the lead deposits. The precious metals were generally the objects of search in these early mining ventures; but, at the same time, a large amount of lead was produced, though mostly from surface diggings.

About the time of the transfer of Upper Louisiana to the United States, in 1804, we find a communication to Congress on the lead mines of the region, by Capt. Amos Stoddard,* of the United States Army, the officer assigned to take possession of the District. Succeeding this there are a number of communications and reports to Congress, by Lieut.-Col. Bomford, of the United States Army, and others, relating to the lead mines and salt springs. These were, in part, the results of

* See American State Papers, 2nd Session, 8th Congress. No. 103. Vol. 1, pp. 188-191. Also Appendix B., p. 686, Report of the Geological Survey of Missouri for 1873-4.

private or incidental observation, and, in part, the result of special inquiry for the purpose of land classification. They can hardly be classed as products of professional explorations.[1]

About the same, and in the immediately succeeding years, expeditions and explorations of a more pretentious nature were planned and executed, generally under military control. Those including Missouri as part of their territory are the Lewis and Clarke expedition, from 1804 to 1806[2], the Pike expedition, from 1805 to 1807[3]; the Long expedition in 1819.[4] The reports of these expeditions contain matter relating to the geology of Missouri; but it is only such matter as could be gathered from observations along a limited strip of country tributary to the line of travel, and from cursory observations at that.

In 1834, Mr. G. W. Featherstonhaugh made an examination of the elevated country between the Missouri and Red rivers, under the auspices of the war department[5]: His report refers to explorations in the Ozark mountains, and he writes of the iron ores and of the lead mines of Missouri, referring especially to the latter, and deploring the manner in which the latter are worked.

In Owen's report of a Geological Exploration of a part of Iowa, Wisconsin and Illinois in 1839,[6] reference is made to the rocks of Missouri and a classification of them is proposed. Later, in his report of 1851 of a Geological Survey of Wisconsin, Iowa and Minnesota,[7] is in-

1 See reference to "American State Papers, Miscellaneous Documents of the United States Congress," pp. 46 and 48, Bibliography of Missouri, Bulletin No. 2, Geological Survey of Missouri, 1890.

2 Travels to the Source of the Missouri River and across the American Continent to the Pacific Ocean, performed by order of the Government of the United States in the years 1804, 1805 and 1806. By Captains Lewis and Clarke: published from the official report, and illustrated by a map of the route and other maps. London: Printed for Longman, Hurst, Rees, Orme & Brown, Paternoster Row. 1814. Quarto.

3 Exploratory Travels through the Western Territories of North America: Comprising a Voyage from St. Louis, on the Mississippi, to the Source of that river, and a Journey through the Interior of Louisiana, and North-eastern provinces of New Spain. Performed in the years 1805, 1806 and 1807, by order of the Government of the United States. By Zebulon Montgomery Pike, Major 6th Regt., United States Infantry London: Printed for Longman, Hurst, Rees, Orme and Brown. Paternoster Row, 1811. 4, 436 pp.

4 Account of an expedition from Pittsburg to the Rocky Mountains, performed in the years 1819 and 1820, under command of Major S. H. Long. Philadelphia 1823. The Atlas accompanying it was issued in 1822.

5 Geological report of the examination made in 1834 of the Elevated Country between the Missouri and Red Rivers. By G. W. Featherstonhaugh, U. S. Geologist. Washington, 1835. 97 pp.

6 See Message President of the United States concerning the Mineral lands of the United States. 1st Session, 26th Congress, H. R Ex Doc. No. 239, pp. 9-115
Also republication with slight revision in 1884, in Senate Doc. No. 407 of 28th Congress

7 Description of the Carboniferous Rocks of Iowa, including that of a Coal field west of the Mississippi, lying partly in Iowa and partly in Missouri, etc. Report of a Geological Survey of Wisconsin, Iowa and Minnesota; and incidentally of a portion of Nebraska Territory. By David Dale Owen. Phil. 1852. 4to.

cluded a description of northern Missouri, with a special reference to the coal fields.[1]

The explorations and researches thus far referred to have, however, all been made under the auspices of the General Government, or were the results of individual enterprise. About the earliest record which we have of official action on the part of the State in the direction of a geological survey is in the message of Governor Lilburn W. Boggs, to the 10th General Assembly, in 1833. In this he recommends an appropriation for a geological survey as a part of a general system of internal improvement. He refers to the activity of other States in this direction, and he cites the advantages and benefits to be derived from such a survey.

Apparently as a product of the spirit prompting this recommendation, the surveys of the Meramec, the Salt, the North Grande and the Osage rivers were promptly started under a Board of Internal Improvements, and a geological examination of the Osage river was made under Dr. H. King.[2]

This report is referred to by Governor Boggs in his message to the ensuing Legislature, in the year 1840, in which he speaks of the coal, lead and iron of the Osage river country.[3]

After this, the matter of further investigation by the State seems to have fallen into neglect for several years. But, in October, 1846, a convention was held in Springfield in the interest of internal improvements. At this convention a memorial was framed to the General Assembly[4] in which especial stress is laid upon the value of the development of the mineral deposits of the State. In the message of Gov. John C. Edwards to the General Assembly in the same year[5] the subject of a geological survey of the State is again recommended for consideration. The matter was referred to the Committee on Internal Improvement, of which DeWitt C. Ballou was Chairman. In a report of eight pages[6] this committee strongly advises the inauguration of such

1 An interesting fact, historical, in this connection, is Owen's assignment of the Upper Coal Measure Limestones of Northwest Missouri to the Lower Carboniferous formation, a determination disproved early in the progress of the First Geological Survey of the State, under Swallow.

2 See report of the Board of Internal Improvements to the General Assembly of Missouri, pp. 485-525. Report of a Geological Reconnoissance of that part of the State of Missouri adjacent to the Osage river, made to William H. Morell, Chief Engineer of the State, by order of the Board of Internal Improvement, by Henry King, M. D., Geologist, President of the Western Academy of Natural Sciences, etc., etc.; pp. 506-525. Senate Journal, Appendix, 1st Session, 11th General Assembly, 1840; pp. 458 525.

3 See message of Gov. Lilburn W. Boggs, Nov. 17, 1840. 15 pp. Senate Journal, 1st Session, 11th General Assembly, 1840, pp. 15-29. House Journal, same. pp. 12-26.

4 See Appendix House Journal, 1st Session, 14th General Assembly, 1846, pp. 245-249.

5 See Senate Journal, 1st Session, 14th General Assembly, 1846, pp. 25-35. Also House Journal, same year, pp 17-28.

6 See House Journal, 1st Session, 14th General Assembly, 1846, pp. 250-257.

an undertaking, and cites the advantages to be derived in detail. No immediate action seems to have followed this, however, and, at the next session of the General Assemby in 1848, a memorial of 13 pages was presented from the Historical and Philosophical Society of Missouri,[1] again inviting the attention of the Legislature to the matter. This memorial refers to the value of the results of such work in guiding members of the State Government in directing works of internal improvement; it refers to the various mineral deposits of the State, and explains why and how such a survey would result in benefit.

The immediate effect of this memorial was another memorial from this Legislature to Congress,[2] urging that the National Government have a geological survey of the State made. Nothing seems, however, to have resulted from this memorial, and, in the following year [1850], Governor Austin A. King, in his message to the 16th General Assembly, again urges the importance of attending to these matters. He advises thorough work, but is of the opinion that the General Government should contribute to the expense of this work, inasmuch as two-thirds of the land of the State was Government property. He recommends that the memorial of the last Legislature be again pressed upon the attention of Congress. Again nothing immediate seems to have been done, but the interests involved were too important for the work to be much longer neglected. Previous agitation of the subject had educated the people to an appreciation of the need of such work. Papers were published advocating it,[3] and, during the session of the Legislature, an act creating the First Geological Survey of the State was passed and approved Feb. 24, 1853.

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1 See Senate Journal, 1st Session, 10th General Assembly, 1838, pp. 13-28.

2 Memorial of the Legislature of Missouri, relative to a General Survey of that State. Feb. 29, 1849. 30th Congress, 2d Session, House of Reps., Miscellaneous, No. 58, 3 pp.

3 See Western Journal and Civilian. Vol. III, pages 12 and 76, Vol. VIII, page 228, Vol. IX, page 319.

THE FIRST GEOLOGICAL SURVEY OF MISSOURI.

The act creating the first geological survey of Missouri reads as follows:

AN ACT TO PROVIDE FOR A GEOLOGICAL AND MINERALOGICAL SURVEY OF THE STATE.

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

1. The governor of this state is hereby authorized and required, as soon as may be after the passage of this act, to appoint a state geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy; and the said state geologist shall, by and with the consent of the Governor, appoint any number of suitable persons, not exceeding four, to assist him in the discharge of his duties, who shall be skillful analytical and experimental chemists; and may appoint such other subordinate assistants as he may deem necessary.

2. It shall be the duty of the said state geologist and his said principal assistants, as soon as may be practicable after their appointment, to commence and carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of this state, with a view to determine the order, succession, arrangement, relative position, dip or inclination, and comparative magnitude of the several strata, or geological formations, within this state; and to discover and examine all beds or deposits of ore, coal, marls and such other mineral substances and mineral waters as may be useful and valuable, and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the state.

3. It shall be the duty of the said assistants to make full and complete examinations, assays and analyses of all such rocks, ores, soils or other substances as may be submitted to them by the state geologist for the purpose, and to furnish him with a detailed and complete account of the results so obtained.

4. It shall be the duty of the said geologist, on or before the first day of December in each and every year, during the time necessarily occupied by said survey, to make an annual report of the progress of said survey, accompanied with such maps, drawings and specimens as may be necessary and proper to exemplify and elucidate the same, to the secretary of state, who shall lay such report or reports before the legislature.

5. It shall be the duty of the said state geologist to 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 discovered; and, on the completion of the survey, to complete a memoir 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.

6. It shall be the duty of the state geologist to forward to the secretary of state, from time to time during the progress of the survey, such specimens in triplicate of the rocks, ores, coals, soils, fossils and other mineral substances discovered and examined, as may be proper and necessary to form a complete cabinet collection

of specimens of the geology and mineralogy of the state; and the said secretary shall cause one set thereof to be deposited, in proper order, in some convenient room in the state capitol, there to be preserved for public inspection, and another set with the state university, and another with the city of St. Louis, to be deposited by said city in some convenient place, or with some public institution in that city, for public inspection.

7. For the purpose of carrying into effect the provisions of this act, the sum of ten thousand dollars is hereby annually appropriated, for the term of two years, to be expended under the direction of the Governor; provided, however, that the salaries of the said state geologist and his assistants shall not commence until they shall have entered upon the execution of their duties; and upon presentation by the said state geologist of the proper vouchers, the auditor of public accounts is hereby required to draw his warrant on the treasurer for the amount of the cost of any chemical apparatus or other outfit deemed necessary by said state geologist, and also for the amount of the quarterly pay of the said state geologist and his assistants, on presentation of the proper vouchers by said state geologist, and upon the order of the governor, who shall be satisfied that the services for which such pay shall be demanded have been performed: provided, that the amount of such cost and pay shall not in any one year exceed the amount herein appropriated.

8. The said state geologist and his principal assistants, before entering upon the discharge of their duties, shall each take an oath before some judge or justice of the peace faithfully to perform all the services required of them under this act, and to abstain from all pecuniary speculations for themselves or others in the objects of their survey during its progress.

9. The annual salary of said state geologist shall not exceed three thousand dollars; the annual salary of the principal assistants shall not exceed fifteen hundred dollars, and the pay of subordinate assistants or servants shall not exceed one dollar per day for every day of actual service.

10. Before appointing said state geologist, as provided for in the first section of this act, the governor is requested to correspond with men of science on the subject, with the view of procuring the services of a person entirely suitable and competent.

11. This act is to take effect from its passage.

Approved February 24, 1853.

THE ORGANIZATION OF THE FIRST GEOLOGICAL SURVEY.

Pursuant to the instructions of this law, Prof. G. C. Swallow was appointed State geologist, by the Governor in 1853. Prof. Swallow came directly from Maine, where he had been engaged in teaching. This survey continued in active operation until June, 1861, under the direction of Prof. Swallow. With him were associated, at different times, and for various periods, Prof. A. Litton, as chemist, Dr. B. F. Shumard, as paleontologist and assistant geologist, Mr. F. B. Meek, Mr. G. C. Broadhead, Mr. Henry Engleman, Dr. J. G. Norwood, Dr. John Lock and Mr. C. Gilbert Wheeler, as assistant geologists, and

as abroad, have confidence in making investments, and feel that they are not entering into mere speculative fields.

4. The formation, on a scientific basis, of a standard by which the geological features of the region may be compared with those of other districts. There is a wide demand for something of this kind for purposes of instruction in schools and colleges. Text-books commonly used consider only the principles of science; the reports of the Survey supplement this outline by giving detailed information of local application.

5. An advancement of agricultural interests. This is more fully considered elsewhere under the subject of soils.

PREVIOUS WORK.

Owen's geological reconnoissance of the upper Mississippi valley in the later forties, under the auspices of the Federal government, gave to the world the first scientific account of the mineral wealth of the region. A year after the appearance of the report, Missouri instituted a special investigation of her natural resources. This geological survey of the domain was begun under favorable conditions, and the grand results of the first years of its existence in pointing out to the civilized nations of the globe the great mineral wealth of the State are known to all. But before the work had been fairly begun, unforeseen circumstances of national import arose, causing a cessation of operations for more than a decade. Reorganized in 1870, work was commenced anew, but owing to the calls one after another of the directing spirits to other fields of action, investigations were again given up after a few years. Nearly fifteen years elapsed before the geological survey of the State was again renewed in the present organization. Although up to the time of the last revival of official geological work in the State the existence of the survey had been fitful, it was not without invaluable results; how much more valuable might they have been had it been conducted under favorable conditions and without embarrassment can only be conjectured. Yet, owing to so interrupted a career, it is safe to say that not less than three-fourths of the information obtained has been practically lost to the public. Dear experience, then, not only in this State but in other states as well, has taught that a temporary survey is money largely expended in vain; that if it cannot be carried to completion, the investigation should never have been commenced; that being established and so well begun, it should be liberally encouraged to completion, that its results may endure for all time to the advancement of the State.

Chapter IV. *Special Report on Cooper County*, 17 pp. This is similar in character to the report on Marion county, but no map accompanies the Cooper county report.

Chapter V. *Geology of the Southwest*, 5 pp. This is principally descriptive of certain sections constructed through Southwest Missouri.

PART II.

Dr. Litton's Report on Lead Mines and Mining of Southeast Missouri, in the counties of Franklin, Jefferson, Washington, St. Francois and Madison. This report describes the mode of occurrence of the [lead] ores, analyses, product and sketches of some mines. It also includes a preliminary report on copper mines of Franklin county, and of the most important iron mines of Southeast Missouri, with 48 analyses of ores, rocks, etc.[1]

F. B. Meek, Special Report on Moniteau County, pp. 22. County report with map.

F. Hawn, description of the formations along the Han. & St. Joseph railroad, with a catalogue of fossils collected.

Dr. Shumard's Report. Geological Section on the Mississippi River, 17 pp.

Special Report on Franklin County, with map, 12 pp.

Special Report on St. Louis County, with map, 16 pp.

Palæontology, pp. 24, including a description of 48 new species of fossils, with three plates of same.

Appendix, 31 pp., containing a list of publications previously made relating to the Geology of Missouri. A paper on the use of fossils, a catalogue of the fossils of Missouri and of her trees and shrubs, and a glossary of Geological and other scientific terms.

This completes the first report in which any attempt was made to describe systematically and comprehensively, the geology of the State as a unit. It is largely, and necessarily, of a generalized nature; it deals with the general classification of the rocks and other broad questions which had first to be settled before questions of detail could be entered into. Considering the limited time in which it was prepared and the short acquaintance of the director with the special subject, it stands, truly, a monument to Professor Swallow's ability, to his energy in gathering so much material and to his discernment in classifying it.

In marked contrast to this are, however, the succeeding reports of this Survey.

The Third Report of Progress was transmitted in December, 1856, and is of 4 pages. It recites briefly what work has been done during the years 1855 and 1856.

The Fourth Report of Progress was made in December, 1858, and is of 14 pages. This describes, in greater detail, the operations of the survey during the years 1857 and 1858, and gives, in tabular form, a statement of progress to date.

The Fifth Report of Progress of December 30, 1860, is of 13 pages and is a similar statement of operations during the years 1859 and 1860, with a brief reference to

1 See Broadhead Hist. Memoir, p. 619.

the results reached concerning the coal, lead and iron deposits and the soils of the State In this report the product of the Survey to that time is given in tabular form. According to this there were:

1.	Counties in which field-work was finished	80
2.	Counties in which field-work was half done	13
3.	Counties in which field-work was commenced	13
4.	Counties in which little or no work was done	7
5.	Counties of which maps were engraved or printed	19
6.	Counties of which maps were drawn and not engraved	25
7.	Counties of which maps were commenced	62
8.	Counties of which maps were not commenced	7
9.	Counties of which reports had been made	33

THE WORK OF THE FIRST GEOLOGICAL SURVEY.

The Survey continued in active operation until June, 1861; but, during the time which intervened between this and the date of the Fifth Report of Progress, it is not probable that much, if anything, was accomplished. Disregarding, however, what may have been produced during this year, we are led to inquire what became of the results of the six years of work intervening between the date of preparation of the Second Report and the year 1861. The labors of the Survey during this time had evidently been centered upon the systematic county work leading to the production of special county reports and maps, such as are presented by the reports on Marion, Cooper and other counties in the Second Annual Report. The table contained in the Fifth Report of Progress shows that much had been done in this direction. In the Second Annual are contained five of the county reports, with accompanying maps, referred to in the table above. During the life of the First Survey Prof. Swallow also made an official report on the Southwest Branch of the Pacific Railway, of 93 pages; and he, and his assistants, published a number of papers relating to the geology of Missouri in Periodicals, and in the proceedings of Societies. Further, during the progress of the Second Survey, in 1873, a volune of 323 pages was issued, containing reports on twenty counties, of which nine were accompanied by maps, all of which were inherited from the First Survey in a condition ready for publication. It is probable that others of such reports were used in the preparation of the county descriptions contained in the Pumpelly Report of 1873 and the Broadhead Report of 1874, hereinafter to be mentioned. Similarly we have, on file in the office of the present Survey, a mass of notes and rough reports in a more or less fragmentary condition, relating to twenty-one counties, which were among the old Survey material. Much of this is, however, in too rough a condition to be put to direct use, and only the person who collected the notes could so systematize them as to make them available; individuals,

some of whom are now dead, and others of whom are scattered to various parts of the country. But, even were it practicable to put these reports into condition for publication, the information which they contain is now so antiquated as to make them hardly worth the cost of publication. Thus, regarded even in the most favorable light, we must consider the last six years of the Swallow Survey as poor results when compared with the first two years; and we must deplore as lost a great part of the fruits of these six years of labor. It is difficult to assign this loss to any single cause; several reasons are apparent, and of these the most important are probably the catastrophe of the war, mistakes in the administration of the Survey, and the absence of a definite policy governing such work on the part of the State.

THE PERIOD BETWEEN THE FIRST AND SECOND SURVEYS.

Not long, however, were the interests of the mineral deposits of the State allowed to be neglected. Even before the close of the War we have a petition by James McKenzie to the Legislature,[1] the object of which is to secure the publication of information concerning the resources of the State for foreign distribution.

In the report of the Corresponding Secretary of the Board of Agriculture for 1865,[2] the importance of a scientific survey is dwelt on, though no definite conception seems to have existed as to how such a survey could best be made. In the report of the secretary for 1866[3] the need of geological work finds again expression; and at the meeting of the Board of Agriculture in December, 1867, a resolution is passed to memorialize the General Assembly to appoint a State geologist.[4]

The first movement on the part of the Legislature in response to these solicitations was the passage of a bill in 1866 authorizing Professor Swallow and Mr. L. D. Morse to publish the manuscripts of the Geological Survey. The idea was, however, abandoned on account of the expense.[5] In 1867 a memorial was presented to the Legisla-

1 See Senate Journal, Appendix, Adjourned Session, 22d General Assembly, 1863. pp. 31-32.
2 See Appendix Senate Journal, Adjourned Session, 23d General Assembly, 1865-6, pp. 151-276.
3 See Second Report, 1866, pp. 160-164.
4 See Third Report, 1867, pp. 17-18.
5 Historical Memoir of Missouri Geological Surveys, page 614.

ture from the St. Louis Academy of Science, earnestly advocating the re-establishment of the Geological Survey, and calling attention to the loss which will result if no provisions were made for the publication of the results of the work done during the years immediately preceding the war.[1] In the message of Governor Fletcher, January, 1869, we find the recommendation that the means should be provided for the preparation of a report on the geology of the State.[2] It appears that, in 1865, a State Board of Immigration had been created, and it is for the purpose of supplying information for distribution by this Board that the preparation of this report is recommended. In the message of Governor J. W. McClurg,[3] immediately succeeding this, in January, 1868, much space is devoted to a consideration of the resources of the State, and the need of making the existence of these resources widely known is especially emphasized. He pays tribute to the value of the Swallow report, and recommends the further publication of detailed information.

The effects of this message were immediate, or, otherwise expressed, the continued neglect of the interests involved had at last aroused public attention, and, on March 24, 1870, an act was passed creating the Second Geological Survey of the State. The provisions of this act are in the main the same as those of the act creating the First Survey; it differs, however, in some particulars, of which, perhaps, the most prominent is that the Bureau is placed under the control of a Board of Managers of nine members, whereas by the provisions of the first act the State geologist is subject to the directions of the Governor alone.

THE SECOND GEOLOGICAL SURVEY OF MISSOURI.

The act creating the Second Geological Survey of the State reads as follows:

AN ACT TO ESTABLISH A MINING, METALLURGICAL AND GEOLOGICAL BUREAU FOR THE STATE OF MISSOURI, AND TO PROVIDE FOR ITS SUPPORT AND MANAGEMENT, AND TO AUTHORIZE A GEOLOGICAL SURVEY.

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

SECTION 1. There is hereby created and established a bureau of mines, metallurgy and geology for the state of Missouri, and the same shall be in the charge and under the control of a board of managers, consisting of the governor (who shall be the president of the board) and one member from each congressional district, who shall be appointed by the governor and hold their offices for the term of four years, and until their successors are appointed and confirmed.

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1 See Appendix House Journal, 24th General Assembly, page 125. Jefferson City, 1867.

2 See House Journal, Regular Session, 28th General Assembly, page 26, Jefferson City, 1869.

3 See Senate Journal, Adjourned Session, 25th General Assembly, pages 13, 14 and 16. Jefferson City, 1870.

SEC. 2. The governor shall, as soon as the board of managers is constituted as provided in the preceding section of this act, by and with the advice and consent of said board, appoint a fit and competent person as state geologist, and said state geologist may appoint, subject to the approval of the board of managers, one assistant state geologist, who shall be a skillful analytical and practical chemist, to assist him in the discharge of his duties; and the said state geologist may employ such other subordinate assistants as may be found necessary.

SEC 3. It shall be the duty of said state geologist and his assistant, as soon as may be practicable after their appointment, to commence and carry on, with as much expedition as may be consistent with minuteness and accuracy, a thorough mineralogical and geological survey of the state, and determine the extent, value, order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the mineral deposits, and the several strata or geological formations within the state, and also determine the extent of the agricultural, horticultural and vine lands, and their adaptability to the varied products of the soil, and also to determine the extent and capacity of the water powers of the various streams, and shall also make full and complete assays and analyses, as they may deem necessary, of all minerals, soils and other substances necessary for a full, complete and satisfactory report of the materials discovered and so treated.

SEC. 4. It shall be the duty of the said state geologist to make a monthly summary of his work, and forward the same to the president of the board of managers for publication, and shall also, on or before the first day of December in each and every year during the time necessarily occupied by said survey, make a full report of the progress of said survey during the preceding year, which shall be accompanied by such maps, drawings and specimens as may be necessary and proper to exemplify and elucidate the same, and deliver the same to the aforesaid president.

SEC. 5. It shall be the duty of the said state geologist, upon completion of the survey, to represent, or cause to be represented, upon proper maps of the state, by distinctive lines, marks and appropriate colors, the area and magnitude of the various beds of different minerals, valuable rocks, marl, agricultural, vine and horticultural lands, and the various interesting or anomalous stratified rocks discovered, and the water powers aforesaid, and shall accompany the same with a complete memoir of all the minerals, rocks, agricultural, vine and farming lands thus delineated, as well as the water-courses required by this act to [be] examined, and shall embrace within such memoir a full, entire and accurate account of the leading discoveries made in the state, and also a glossary of the scientific terms used in the report; and the said report, so made, when (being) completed, shall be deposited with the board of managers.

SEC. 6. It shall be the duty of the state geologist to forward to the president of the board of managers, from time to time during the progress of the survey, such specimens, in triplicate, of the rocks, ores, coals, soils, fossils and other mineral substances examined, properly labeled, giving the names of such specimens and the localities from which they were taken, for the purpose of forming a complete cabinet of specimens of the mineralogy and geology of the state. One set of said specimens shall be placed in the School of Mines and Metallurgy, whenever the same shall be established; one set shall be placed in the State University, and the other shall be preserved in such manner as the board of managers may direct; and the said specimens shall be open to public inspection at all reasonable hours, under such regulations as are necessary for their proper care and preservation.

SEC. 7. The state geologist and his assistant, before entering upon the discharge of their duties, shall each take an oath, before some officer of this state qualified to administer oaths, that they will honestly, faithfully and fairly perform all the duties required of them by this act, to the best of their abilities, and that they will not permit any person to have access to any of their books or papers, or communicate their contents to any person or persons, and that they will not disclose or make public any mine or valuable deposit otherwise than in their official report to the board of managers, and that they will abstain from all speculations in their own behalf, or in behalf of others, during the progress of such survey, and in relation thereto.

SEC. 8. The annual salary of the state geologist shall not exceed three thousand dollars; the annual salary of the assistant shall not exceed two thousand dollars, and the pay of the subordinate assistants shall not exceed, for each of them, the sum of one dollar and fifty cents per day for each day employed.

SEC. 9. The board of mangers of the bureau herein provided for shall have a superintending control over the survey and reports contemplated by this act; shall have power to make yearly agreements with the State geologist and his assistants as to the amount of their salaries; to appoint a committee of their body to examine, audit and allow all necessary expenses of their survey as they occur; and to certify the same to the governor; to remove from office, for cause, the said State geologist or any of his assistants; and so soon as possible after their organization under this act, should they deem the best interests of the State require it, they shall provide for the establishment, at the most accessible point in the State of an office assayer of ores. And when so established, the governor of this State, by and with the consent of said board, shall appoint an assayer for such office, whose duties shall be prescribed by the board of managers, who shall by contract determine the amount of, salary which in no case shall exceed the sum of two thousand dollars per year.

SEC. 10. The said board of managers shall demand and take possession of all the geological reports of this State, published and unpublished, instruments, implements, and all other paraphernalia which were used in connection with the geological surveys of this State, by the former geologist employed by the State. And all persons now in possession of the same, are hereby authorized and required to turn the same over to the president of the board of managers of the bureau herein established, and when received, the said board shall have power to turn the same over to the State geologist, or make such other disposition of them as they may deem the best interest of the State demands.

SEC. 11 The president of the said board of managers of said bureau, shall receive all the reports of the state geologist by this act, shall lay the same before the board of managers for their consideration and approval, at their annual meeting, to be held at any time, at the discretion of the president, before the meeting of the General Assembly, and after the day fixed by this act when the state geologist is required to make his annual report, and at such meeting the president shall lay before said board an accurate account of all expenditures incurred in prosecuting the objects for which this bureau has been created, all of which after the action of the board thereon, shall be laid before the General Assembly, at the first following session, by the president.

SEC. 12. The board of managers herein provided for, shall be allowed as a full compensation their necessary expenses whilst attending to any of the duties required of them by this act, the accounts therefor to be made out under oath and filed with the State Auditor, and the pay of the state geologist and his assistants shall be out of the appropriations applicable to the payment of other civil officers of the State.

SEC. 13. The sum of seven thousand five hundred dollars is hereby appropriated out of any money in the State treasury not otherwise appropriated, to defray the general expenses of the bureau created by this act, and no larger amount shall be expended for such purpose in any one year. The president of the board of managers is hereby authorized to certify to the State Auditor, from time to time, the sums of money required to pay the salaries of the state geologist and his assistants and for the general expenses of the bureau, and on receiving such certificates, the Auditor shall draw his warrant on the Treasurer of the State for the requisite amounts in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

SEC. 14. This act shall take effect and be in force from and after its passage.

Approved March 24, 1870.

THE SURVEY UNDER A. D. HAGER.

Under this law, Albert D. Hager, of Vermont, was appointed State geologist by the board, and the headquarters of the Survey were established in St. Louis. Mr. Hager had been connected with the Vermont Survey and was associated with Professor Hitchcock.[1] Mr. Hager held the position until August, 1871. He published one report[2] of progress of 21 pages, in which he briefly notices the chief building stones and minerals of the State. This report and the work of the Survey is referred to in Governor McClurg's message of January, 1871.[3]

The law was amended March 18, 1871 and the board made to consist of four members besides the Governor, and the limit of the annual expenses was fixed at $10,000 in place of $7,500 previously allowed.[4]

After Mr. Hager's resignation, Dr. J. G. Norwood was in temporary charge of the Survey until November, 1871. Under Dr. Norwood, Mr. G. C. Broadhead was appointed assistant, and Mr. C. M. Litton subassistant.

THE SURVEY UNDER RAPHAEL PUMPELLY.

On November 25, 1871, Mr. Raphael Pumpelly was appointed State geologist. He had studied at Freiburg, had been a professor in Harvard college and was at one time employed by the Governments of China and Japan in geological investigations.[5] He resigned from the position in May, 1872.

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1 Broadhead Historical Memoir, page 615.

2 See Appendix Regular Session Twenty-sixth General Assembly, 1871; pp. 21-43.

3 See Senate Journal, Regular Session, Twenty-sixth General Assembly; page 22, Jefferson City, 1871.

4 A copy of this law is contained in the Preface to the Report of the Geological Survey of Missouri on Iron Ores and Coal Fields of 1872. Raphael Pumpelly, Director.

5 Broadhead Historical Memoir, page 617.

Up to the time of Pumpelly's appointment very little had been made public of the results reached by the Survey, and the changes in management must necessarily have much retarded the work. But in his message of December, 1871, Governor B. Gratz Brown commends the Survey warmly to the Legislature; he dwells upon the importance of the interests which it represents, and points out the need of such work for their development, and further recommends an increase in the appropriation.[1]

Pursuant to this recommendation, the law was amended in March, 1872, and the sum of $20,000 was appropriated annually for the salaries and expenses of the Survey.[2] During Mr. Pumpelly's management of the Survey the Board of Managers consisted of Governor B. Gratz Brown, *ex officio* president, Mr. Edwin Harrison, Professor Sylvester Waterhouse, Mr. Forrest Shepherd and Gen. J. H. Hammond. Governor Brown was succeeded in 1873 by Governor Silas Woodson. Professor Waterhouse and General Hammond resigned in the summer of 1872, and their places were filled by Mr. A. W. Meyers and Mr. L. A. Brown. Mr. A. A. Blair was appointed Secretary of the Board.

The assistants of the Survey under Pumpelly were Mr. G. C. Broadhead, Dr. Adolph Schmidt, Mr. Regis Chauvenet, Chemist, Mr. W. E. Guy, Prof. W. B. Potter, Mr. C. J. Norwood, Mr. J. R. Gage and Mr. Alexander Leonhard. Other sub-assistants employed at different times were Mr. John Pumpelly, Mr. P. N. Moore, Mr. F. Tunica, Mr. C. Gayler, Mr. B. Vitzthun von Eckstadt, Mr. W. Bartlett, Mr. T. J. Caldwell, Mr. T. A. Minor, Mr. A. J. Puls, Mr. A. Hoeber and Mr. M. F. Healy.

The plan of work adopted by Pumpelly recognized two classes of investigation. One was the study of the general stratigraphic geology of the State; the other was the study of the distribution and manner of occurrence of the various important mineral deposits, which latter should be put in charge of specialists, or men whose previous experience should prove them to be specially adapted to this difficult work. In harmony with this plan, the work on the general stratigraphy was divided into five departments: *i. e.*, a survey of the Northwest, a survey of the Southwest, a survey of the Northeast, a survey of the Southeast, a survey of the Porphyry region of the Southeast. The work relating to economic geology was divided into three departments, namely, a Department of the Iron Ores and Metallurgy, a Department of Ores other than Iron, a Department of Fuels and Construction Materials other than iron and wood.

1 See House Journal, Adjourned Session, 26th General Assembly, pp. 26-7. Jefferson City, 1871.
2 See Preface of Report of 1872 on Iron Ores and Coal Fields, p. II.

During the year 1872 the study of the general stratigraphy of the Northwest and the Northeast was begun and work was done in the Porphyry region of the Southeast in the vicinity of Pilot Knob. In the departments of economic geology the distribution and mode of occurrence of the iron ores was studied and many analyses of these ores and of coals were made. The future work at that time outlined for this department included an extension of the study of the iron ore deposits, a study of the lead, zinc, nickel and other ores, and a study of the building materials of the State, for which a laboratory for experimental tests was needed.

Under the Pumpelly management two reports were issued in 1873. The first was an octavo of 323 pages and consisted entirely of county reports. It represented all of the previously unpublished results of work done before the war which was transmitted in a condition ready for publication.[1]

It contains chapters on Maries, Osage, Warren, Shelby, Macon and Randolph counties, by G. C. Broadhead; on Miller, Morgan and Saline counties, by F. B. Meek; on Ozark, Douglas, Wright, Laclede, Pulaski, Phelps, Crawford, Cape Girardeau, Perry, Ste. Genevieve, Jefferson and Clark counties, by B. F. Shumard. The reports are of about the same length and are similar in character to those published in Swallow's report of 1855; they are illustrated by views, sections and maps. The second report, transmitted in April, 1873, is a large octavo of 655 pages.[2]

It is divided into two parts as follows:

PART I.

Chapter I. Notes on the geology of Pilot Knob and its vicinity, by Mr. Pumpelly.
Chapter II. Analyses of ores, fuels and pig irons.
Chapters III, IV, V and VI, constitute a partial report on the iron ores of Missouri, by Dr. Schmidt. They include a general description of the distribution and character of the ores, special descriptions of the different classes of the ores and a list of the iron ore deposits of the State. This subject is handled systematically, scientifically and ably; but the report bears evidence of having been hurriedly prepared.

1 Reports on the Geological Survey of the State of Missouri, 1855-1871, by G. C. Broadhead, F. B. Meek and B. F. Shumard, Jefferson City, 1873, pp. 324 and IV.

2 Geological Survey of Missouri, Raphael Pumpelly, Director. Preliminary report on the Iron ores and Coal fields from the field-work of 1872. With 190 illustrations in the Text and an Atlas. New York, Julius Bien, 1873, p. XVI, 214 and 441.

PART II.

Chapters I, II, III, IV, V and VI contain general matter relating to the coal fields, by G. C. Broadhead.

Chapters VII and VIII are on the geology of Lincoln county, by Wm. B. Potter.

Chapters IX to XV are reports by G. C. Broadhead on Livingston, Clay, Platte, Buchanan, Holt, Atchison and Nodaway counties. They are of similar character to the county reports contained in the earlier volumes of the survey.

Appendices A, B and C contain respectively the results of some tests of strength of building materials, a note relating to Missouri rocks which admit of a fine polish, and a list of Coal-Measure fossils.

THE SURVEY UNDER GARLAND C. BROADHEAD.

After Mr. Pumpelly's resignation, Mr. G. C. Broadhead was elected State Geologist, and assumed charge July, 1873. Under him there remained Dr. A. Schmidt, as assistant geologist, Mr. Regis Chauvenet and Mr. Charles S. Norwood as chemist, and Mr. Alexander Leonhard, Mr. P. N. Moore, Mr. H. H. West, T. J. Caldwell and C. Heinrich as assistants.

The policy governing the Pumpelly Survey seems to have been continued in the Broadhead work, though more was done in the preparation of county reports than was done previously. During 1873, in the Department of Economic Geology, the examination of the iron ores was continued, and, in addition, the examination of the lead deposits of the Southwest was begun. Surveys for county reports were further made in Jasper, Cedar, Barton, Vernon, Bates, Howard, Linn, Adair and Sullivan counties. In 1874 the lead deposits of Cole, Miller and other central counties were studied, and examinations for county reports were made in Putnam, Schuyler, Chariton, Cole and Madison counties.

One report was issued by the Broadhead Survey.[1] This is a large octavo of over 700 pages, transmitted in August, 1874, and contains the following matter:

Chapters I and II contain an historical introduction and a brief description of the general geology of the State.

Chapters III, IV and V treat in a general way of caves and water supply, and of soils and timber, and the last chapter contains a brief list of the minerals of the State.

Chapter VI contains remarks on the Southwest coal field, and is accompanied by a general section.

1 Report of the Geological Survey of the State of Missouri, including Field Work of 1873-74. With 91 illustrations and an atlas. Garland C. Broadhead, State Geologist. Jefferson City, 1874; pp. 734, L. 4, 56.

Chapters VII to XXI, inclusive, are reports on Cedar, Jasper, Barton, Vernon, Bates, Howard, Sullivan, Adair, Linn, Putnam, Schuyler, Andrew, Daviess, Cole and Madison counties.

Chapters XXII to XXVIII constitute a report on the lead region of Southwest Missouri, in which the general characteristics of the region and its ores are given, together with a description of a number of its deposits.

Chapters XXIX to XXXII treat similarly of the lead deposits of Central Missouri.

Chapter XXXIII contains rules for the development of iron ore deposits.

Chapter XXXIV is on the lead region of Southeast Missouri.

Chapter XXXV is on the iron ore of the same region.

Appendices A, B, C and D are brief papers on the History of Lead Mining in Missouri, on "Lead Mines in Upper Louisiana," on "Metallic Statistics," and on "Mineral Springs of Missouri." Appendix E contains results of analyses of ores, fuels and minerals.

The Survey was discontinued after the year 1874, and most of its working material was transferred to the State School of Mines at Rolla, of which the president, Dr. Chas. P. Williams, was made acting State geologist, with a nominal appropriation. Little field work seems to have been carried on under Dr. Williams, and, after the year 1876, no further support appears to have been extended to the work by the State. One report was prepared under Dr. Williams, which consists of a small octavo of about 200 pages.[1] It contains a chapter on the "Mineralogy and general Metallurgy of Lead," one on the "Zinc Industry of Missouri," one on the "Iron Industry," and one on "Shannon county." In the appendices are given statistics of lead and zinc and a "Note on the Occurrence of Gold in Northwest Missouri."

A SUMMARY OF THE RESULTS OF THE EARLIER SURVEYS.

THE PUBLICATIONS.

Summarizing the results of this early work, we find that we have inherited the following as published matter:

1. 1885. Swallow's report of 240 pp. with plates and small maps.
2. 1855–1861. Swallow's Third, Fourth and Fifth Reports of Progress, together 26 pages; no illustrations.
3. 1859. Swallow's Report on the Southwestern Branch of the Pacific Railroad of 93 pages, with plates and one map.
4. 1871. Hagar's Annual Report of 23 pp., no illustrations.
5. 1855–1871. Broadhead's, Meek's and Shumard's county reports published in 1873 of 324 pp., with plates and small maps.
6. 1872. Pumpelly's report of 655 pp., with illustration and a large atlas.
7. 1873. Broadhead's report of 734 pp., with illustrations and a small atlas.
8. 1876. William's report of 177 pp., with a few illustrations.

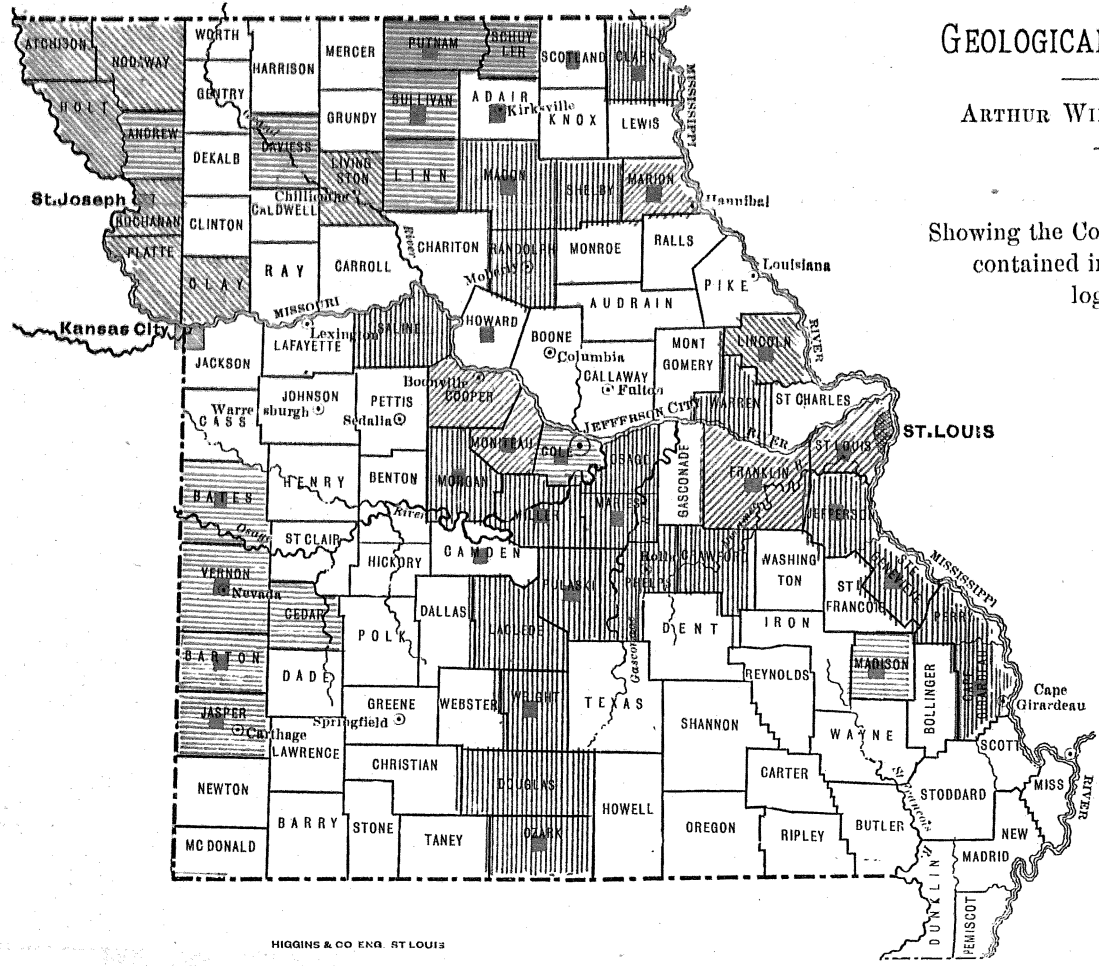
1 Geological Survey of Missouri Industrial Report on Lead, Zinc and Iron, together with Notes on Shannon County and its Copper Deposits. By Chas. P. Williams, Ph. D., Acting State Geologist. Jefferson City, 1877; pp. 177 and XVI.

GEOLOGICAL SURVEY OF MISSOURI.

ARTHUR WINSLOW, STATE GEOLOGIST.

DIAGRAM

Showing the Counties of which Special Reports are contained in the Publications of earlier Geological Surveys of the State.



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LEGEND.

- In Swallow's Report of 1855, 5 counties.
- In Broadhead's et al. Reports of 1871, 21 counties.
- In Pumpelly's Report of 1871, 10 counties.
- In Broadhead's Report of 1873, 15 counties.
- Indicates that maps are printed of the respective counties. 28 counties.

Examining these publications critically, we find that the contained reports may be separated into two classes: First, there are reports relating to special subjects which are the products of what we may call subject work. No such reports are, strictly speaking, contained in the Swallow publications, excepting the report of 23 pages, with plates, on paleontology at the end of the Second Report. Such might properly have been prepared in connection with the examination of the mining districts or the exposition of the "Agricultural and Manufacturing Resources," which he states to be among the objects of his work.[1] In the Pumpelly and Broadhead surveys such reports were produced from what was classed as the Department of Economical Geology, and the special subjects of work were the iron ores and the lead and zinc ores of the State.

The second class of reports are what we may call Area Reports or reports devoted to a general description of special areas In the Swallow, Pumpelly and Broadhead publications, the county reports especially belong to this class. The plan of the county reports was originally framed by Professor Swallow, and five of such reports are contained in his Second Annual Report. They vary in length from 12 to 22 pages, and consist of matter of a general nature relating to the hydrography, forestry, agriculture, general or stratigraphic geology and economic geology. They are sometimes, but not always, accompanied by a small page map of the county described, on a scale of three or four miles to the inch. These maps show, generally, the distribution of the geological formations, and the location of mines and furnaces. The amended law of 1871 required the preparation of county reports, and Swallow's plan for these area reports seems to have been followed in the Pumpelly and Broadhead Survey, and, in the three volumes published between 1873 and 1875, forty-three such county reports are contained. In all, there have been forty-eight such county reports published, distributed as follows:

In Swallow report of 1855	5	county reports.
In Broadhead, Shumard and Meek report 1855–1871	20	" "
In Pumpelly report 1872	8	" "
In Broadhead report 1873	15	" "

On the map of the opposite page is shown what counties were described in these reports, and which in each; further, the counties of which maps accompany the descriptions are indicated.

1 See page 15 of this report.

THE COLLECTIONS OF THE EARLY SURVEYS.

The act creating the Survey in 1853 provided for the collection, in triplicate, of such specimens of rocks, ores, coals, soils, fossils and other mineral substances discovered and examined, as may be proper and necessary to form a complete cabinet collection of specimens of the geology and mineralogy of the State. One set of such collections was to be arranged in a room in the State Capitol for public inspection, another set was to be for the State University, and the third set was to be for the City of St. Louis, to be arranged in some place convenient for public inspection. According to Broadhead,[1] this distribution was never made, on account of the interruption of work by the war, and the whole collection remained packed in boxes at Columbia. The law of 1870 provided similarly for the collection of specimens in triplicate, one set being intended for the School of Mines, another for the State University, the third was left at the disposal of the Board of Managers, and apparently assigned by them to Washington University, in St. Louis. These collections were partly distributed in 1875 according to the law, while those not divided remain in the museum of Washington University arranged in cases. In 1884 the specimens of the Swallow Survey at Columbia were unpacked and partly arranged in the University museum; the greater portion, however, is in trays in a basement room of that institution. From this portion a few hundred specimens were furnished the present Survey for reference.

THE APPROPRIATIONS.

The appropriations for the Geological Surveys preceding the present were, according to Broadhead,[2] as follows:

From 1853 to 1862	$105,000 00	
1870 and 1871	12,500 00	
Under Acts of 1872, 1873 and 1874	60,000 00	
In 1876 and 1877, and by School of Mines	5,000 00	
Printing, 1873	12,000 00	
Printing, 1876	1,500 00	
Total	$196,000 00	
Unexpended appropriations	19,814 45	
Total expended		$176,185 55

1 Hist. Memoir, page 622.
2 Hist. Memoir, page 618.

Of this total, there was expended for printing:		
Swallow's Report, 1854	$5,000 00	
Report 1855–1871	3,000 00	
Pumpelly, etc., 1873	9,000 00	
Broadhead, etc., 1874	7,320 00	
Williams' report, 1876	1,500 00	
Total for printing	$25,820 00	
Leaving a total for salaries and field and other expenses		$150,365 55

THE PRESENT SURVEY.

From the cessation of the work, in 1876, to the inauguration of the present Survey, nothing further was done by the State in the direction of a Geological Survey. It was directly upon the foundations laid by these early Surveys that the present Survey had to build; the results which had been reached nearly twenty years ago furnished the latest available information. To expand from this beginning without duplicating labors became our duty; yet, at the same time, this could not be done arbitrarily; due allowance had to be made for the enlarged requirements which new discoveries, new developments, and the growth of the country had created. This called for careful consideration and nice discrimination.

THE LAW GOVERNING THE PRESENT SURVEY.

The act creating the present Geological Survey was approved May 13, 1889. The law at present governing the Survey is framed upon the same general plan as that of the last Survey, but differs in details. Among the most noticeable differences are the absence of a requirement to collect specimens in triplicate, the diminution of the amount allowed for salaries of assistants, and the absence of the clause requiring county maps and reports to be prepared.

This law is as follows:

AN ACT TO PROVIDE FOR A BUREAU OF GEOLOGY AND MINES TO COMPLETE A GEOLOGICAL AND MINERALOGICAL SURVEY OF THE STATE OF MISSOURI.

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

SECTION 1. 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 shall hold their term of office four years.

SEC. 2. The board of managers are authorized, as soon as they are organized, to appoint one state geologist, who shall be a person of competent, scientific and practical knowledge of the sciences of geology and mineralogy, and who is not connected with any school or college as instructor, who shall be the director of the

survey; and said geologist may appoint such assistants and subordinates, assistants and laborers as may be deemed necessary in order to make a thorough scientific, geological and mineralogical survey of the state.

SEC. 3. It shall be the duty of the state geologist and his assistants, under the instruction and direction 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 or geological formations within the state, and to discover and examine all beds or deposits of mineral contents and fossils, and to determine the various position, formation and arrangement 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, the growth of timber and other scientific matters that may be of practical importance and interest; and said geologist 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 a memoir 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.

SEC. 4. It shall be the duty of the State geologist to make or cause to be made, detailed maps and reports of counties or districts as fast as completed, which maps shall embrace all such geological, mineralogical and scientific details necessary to make complete reports of said districts or counties. The State geologist may also, from time to time, publish or cause to be published any reports of work completed, in the form of pamphlet or bulletins for general distribution.

SEC. 5. It shall be the duty of the State geologist to collect full suits of all minerals, rocks, ores, fossils or other mineral substances of scientific or practical interest or utility as may be discovered, and that may be necessary to form a complete cabinet collection, to illustrate the various resources of the State, as may be necessary to assist in preparing the various reports of the survey.

SEC. 6. It shall be the duty of said assistants to make full and complete examinations, assays and analyses of all such rocks, ores, soils or other substances as may be submitted to them by the State geologist for the purpose, and to furnish him with a detailed and complete account of the results so obtained.

SEC. 7. The State geologist, from time to time, may furnish items of general information or new discoveries for publication in newspapers: Provided, the preparation of the manuscript and publication thereof does not interfere with the progress or add to the expense of the survey; he may also have authority to furnish cabinets for colleges or public museums, located within the State of Missouri, of minerals, rocks or fossils: Provided, said institutions shall pay the expense of preparing, labeling, transporting and putting up said collection; and also, further, that in the selection of said specimens the general State collection is not deprived of duplicates of the same, and that the State collection is not seriously injured.

SEC. 8. The board, with the State geologist, may determine the place for the State cabinet and headquarters of the survey.

SEC. 9. 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 State geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

SEC. 10. The board shall have power to take possession of all property of former surveys, whether reports, maps, collections, instruments or other property belonging to the State, and all persons now in possession of the same shall deliver them up to the order of the president of the board of managers: Provided, that no cabinet or library already arranged shall be removed, but the State geologist and his assistants shall have the power at any time to examine or study such collections in preparing their reports.

SEC. 11. The board may make such by-laws and regulations for the government and control of its meetings and labors of the State geologist and his assistants as may be deemed necessary.

SEC. 12. As full compensation for the members of the board of managers they shall be allowed their necessary expenses while attending to the duties assigned them by this act. The board shall fix the salary of the State geologist, not to exceed three thousand dollars per annum, and his chief assistant, which shall not exceed one thousand eight hundred dollars per annum, for the principal assistant or palæontologist, if one is employed, not over one thousand eight hundred dollars.

SEC. 13. The state geologist may, with approval of the board, appoint other necessary assistants, whose pay shall not exceed five dollars per day, and such other necessary laborers or assistants as may be necessary, who shall receive a fair compensation for their work. He shall also have power to negotiate for such chemical work, chemical apparatus and chemicals as may be necessary, and may, from time to time, with the approval of the board, have such work done. He may also, with the approval of the board, employ special assistants in palæontology, provided it be deemed necessary.

SEC. 14. All accounts of salaries and expenses shall be made under oath, and certified by the board, and filed with the auditor of the state.

SEC. 15. The board of managers shall have the general management of the survey, and have full power to remove the state geologist and appoint his successor, when deemed necessary for the good of the work entrusted to him; and the State geologist shall have full control over his assistants, and have power to remove them when necessary.

SEC. 16. For the purpose of carrying out the provisions of this act, the sum of twenty thousand dollars is hereby appropriated, or so much as may be needed thereof.

SEC. 17. The board of managers, the state geologist and each of his principal assistants shall, before entering upon the discharge of their duties, take the usual oath of office to faithfully perform all the services required of them under this act, and to abstain from all pecuniary speculations for themselves or others in the objects of their survey during its progress.

SEC. 18. The president of the board shall, from to time to time, certify to the state auditor the sum of money required to pay the salaries of the state geologist and his assistants and the incidental expenses of the bureau; and on receiving such certificates, the auditor of the state shall draw his warrant on the treasurer of the state for the requisite amount in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

SEC. 19. All previous acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 20. The importance of the completion of the geological and mineralogical survey of Missouri at an early day, creates an emergency within the intent and meaning of the constitution, which requires this act to take effect at once; therefore, this act shall take effect and be put in force from and after its passage.

Approved May 13, 1889.

THE ORGANIZATION OF THE PRESENT SURVEY.

I was elected State geologist by the present board of managers on August 29, 1889. I assumed the duties of the office September 20, 1889.

The governing ideas in the organization of the present Survey was that the work should be in the line of development of that of previous Surveys, and should be adjusted to the requirements of to-day, so far as was consistent with the instructions of the law. In section 2 of this law provision is made for *"a thorough scientific, geological and mineralogical survey of the State."* In section 3 it is required that this shall be carried on *"with as much expedition and dispatch as may be consistent with minuteness and accuracy;"* and section 4 provides for the preparation of detailed maps and reports, and pending the completion of such the State geologist, is authorized to publish any reports of work completed, in the form of pamphlets or bulletins for general distribution. Section 5 requires the formation of a State cabinet.

In accordance with these ideas, the two classes of work which were recognized as existing during the progress of the earlier surveys, namely: Subject-work and Area-work were recognized here.

SUBJECT-WORK.

Subject-work, we have seen, was first properly begun under the Pumpelly administration, evidently in recognition of the fact that more detailed and authoritative information was required than had heretofore been furnished through the reports of the earlier Surveys. A report containing the results of such subject-work is designed to include general facts of distribution for the whole State concerning a special substance; it is designed to meet the demands from those who wish to know whether a certain substance exists in the State, where it exists, and how, and what its qualities are. Details as to distribution cannot, of course, be given in a report of such comprehensive nature, it must necessarily be somewhat generalized in this respect; it can only indicate

the locality where this special substance exists, without attempting to define the limits of the occurrence. In the discussion of the properties of substance, it can, however, be exhaustive; the breadth of the field of work allows opportunity for the study of a great variety of material, permitting interesting comparative study. Similarly, in the discussion of the origin of the material, of the nature and future of the industries which mry be dependent upon it, such a report can be complete. In short, all which has broad and general bearing can and should receive full treatment here. Details which have local value only cannot be attempted here.

Subject-work is almost a necessity to-day. At the date of the early surveys it was possible for one man to be an authority on a number of subjects pertaining to geology, and, thus, reports could be prepared by one man relating to everything which he might encounter during the progress of his work. In this period of specialists, such is no longer possible. A man to be an authority on any one subject must give his chief attention to that special subject, and must continue to do so for a considerable time. The subjects of work of the Survey are assigned to separate individuals. These individuals are, or become, thus, specialists in their subjects of work, and their final products will be authoritative. This specialization of the work seems to be in accordance with the provision of the law, that *"a thorough scientific"* survey of the State should be made.

AREA WORK.

Area work, however, in distinction to subject work, is designed pre-eminently for the purpose of giving detailed local information. It is calculated to meet the demands for information concerning certain areas. A man, who may or may not be a property-owner, may desire information concerning a special area in which he is interested; he does not want to know so much whether certain things exist in the State, but he wishes to know whether a certain definite locality has something or anything of value. Thus, area work should deal mostly with that which is given a subordinate place under the subject work; and, *vice versa,* the topics of general applicability, which are exhaustively treated under the subject work, should take a subordinate place in the area work. Results obtained in the progress of this area work are, however, to be utilized in the preparation of area reports; some repetition in publication will, of course, occur, but no duplication of field work need arise. In this work the maps will generally constitute the most important part, though their scale and the detail contained on them will vary according to the importance or the intricacy of the area. A

perfect map would be an exact miniature of the surface which it represents, and the nearer it approaches such a miniature the more valuable it becomes. The use of maps is expanding constantly, and the art and skill displayed in their construction and production has grown proportionally. It is designed, in connection with the present work, to construct maps according to modern methods; and, hence, a few remarks will be in place concerning the essentials of such maps, the extent to which they have been adopted, and the information which they furnish.

Maps properly constructed present in a condensed form facts which it would be almost impossible to describe in words; all the details of location and distribution are there seen at a glance. A comprehensive conception of the relation of parts is obtained through the study of a good map, which can be obtained in no other way, and this with none more than with geologic maps. Regarding maps as miniatures of the surface, representation of the topography naturally becomes essential; and, hence, in all advanced systems of mapping, both in this country and in Europe, topographic work has played an important part. It is a trite axiom in geologic work that topography should precede geology. Hence, we find that, with almost all geological surveys in which detailed stratigraphic work has been attempted, topographic maps have been constructed, where such were not already available. "A perfect geological map," says Geikie, Director-General of the Geological Survey of Great Britain, "should represent: 1st, a full and accurate topography, with the form of the surface and heights in contour lines, shading or otherwise; [1] 2d, all geological deposits, from the most recent to the most ancient, with their boundary lines accurately traced and the relation of their distribution to the external form of the ground clearly depicted." Says Lesley, State Geologist of Pennsylvania: "The topography is always our best guide to the geology. In the coal regions this is especially true. Every lineament of the surface indicates a mood in the geology beneath, so that the whole face of the earth, like the countenance of a man, is instinct with living expressions of its past experience." [2] A topographic map "is fundamentally necessary for a geologic map," says Powell, Director of the United States Geological Survey. "A proper geologic map cannot be made without the basis of a topographic map." [3] "It is an impossible thing to make a good geologic map of the country without having as a groundwork a good topographical map of the country," says Alexander Agassiz. [4] Whitney, formerly State geologist of California, when writing of the Mississippi Valley States, remarks that the topography is of a kind "which requires a very minutely detailed study of the geology to be laid down with accuracy." [5] Says Prof. Cook, late State geologist of New Jersey: "At the beginning of the survey no such work as is here given entered into our plans. But as the successive reports appeared, and as the attempts at descriptive geology were made, it became apparent that, for the study and

1 Outlines of Field Geology, by Archibald Geikie, p 38.

2 A Manual of Coal and Its Topography, by J. P. Lesley, p 32.

3 Testimony before a Joint Commission on the Organization of certain Bureaus of the U. S. Government, pp. 8 and 9, 1884

4 Same, p. 1015.

5 Geographical and Geological Surveys, by J. D. Whitney, p. 85. From North American Review, July and October, 1885.

preparation of useful geological reports, it was necessary to have accurate maps—maps which would show the location of all the important geographical points, and also the outlines and elevations of the hills and valleys, and their heights above the sea level." [1]

In this country topographic surveys have been prosecuted in connection with the geological surveys in the States of Pennsylvania, New Hampshire, New Jersey, Virginia, Michigan, Wisconsin, Texas, Arkansas, California, and also with the National surveys under King, Powell and Wheeler. Other States have prosecuted geological work without the aid of topographic maps, but this has been because the nature of their work has been largely such as did not call for accurate maps (2)

In Europe well nigh all geological surveys have been prosecuted upon the basis of topographic maps already constructed, and, where such maps have not existed, topographic work has been done in conjunction with the geologic work. The excellence of the maps constructed by these foreign Surveys, and the amount of money expended on them has hardly anywhere been approximated in this country, and this evidence of their value we cannot afford to overlook here. However much we may disapprove of the foreign form of government, or of foreign social organization, we are obliged to admit that the European nations both more thoroughly appreciate the value of natural resources, and give more thought to their development.

As has already been intimated, topography and geology are not two distinct subjects, but certain aspects of topography are essentially geological. In the character of the topography is expressed, both the nature of the rocks which make up the mountains, the hills, and the valleys, as well as the nature of the forces which have produced these features of relief. A topographic line is very often a geologic line; the outline of a mountain or hill is very often the outline of a geological formation. Topography, combined with other features of geology on a map, furnishes innumerable facts relating to altitude and thickness of formations and deposits, in addition to those of area and distribution which would be shown on an ordinary diagram. With a topographic map in hand one is able to recognize features on the ground, which, with an ordinary map, are only very vaguely defined. A hill or a mountain is a prominent and recognizable feature in the landscape; if such a hill be represented on the map, the position of any mineral deposit, geologic division line or other fact of interest can be shown definitely and clearly on the summit, at the foot, or on the slope, as the case may be, and its position on the ground can be readily found. Without such delineation of the topography the location of the occurrence is necessarily vague; one does not know with certainty whether it is on a hill or in a valley.

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1 Geological Survey of New Jersey. Final Report of the State Geologist, Vol. I, 1888, p. 2.

(2) It is by no means maintained that no geological work can be done without the aid of such maps; valuable results can be reached in the study of the paleontology, of the lithology, of the mineralogy of the State, and elaborate researches can be carried on for the purpose of determining the properties of materials, all without maps of any kind. Further, diagrams or generalized maps showing the distribution of the larger formations, and the general location of the occurrences of minerals and other substances, can be made without the assistance of topography. But, if we wish to enter into detail, if we wish to show with any degree of precision the actual mode of occurrence of individual ore-beds, veins or other deposits of limited dimensions, topographic maps will become indispensible, and the more detailed the investigations which are made in any region, the more practically valuable they are. In fact, says Whitney, "it is only work which is detailed and thoroughly accurate that can be trusted and used where problems of importance, involving a considerable expenditure of money, are to be solved." (Opus cite, p. 85.)

In the case of all bedded deposits, whether they be coal beds, or beds carrying lead or zinc, topography furnishes valuable information concerning the relative vertical positions of different beds, as well as concerning the depths of such beds beneath the surface. On a map without topography, the outcrop lines of the two beds, one above the other, would appear simply as sinuous lines, and no information would be conveyed concerning the interval between these beds, nor as to their depths beneath the surface at any point. In a country which varies locally in altitude two hundred feet or more, these facts are of great importance and very much affect the value of any property. In the instances cited, they determine whether a coal bed may be reached by a shaft twenty feet deep, or by one two hundred feet deep; they determine the dip of the bed and the positions of the anticlines and synclines, which are facts of importance in mining operations; again, if we take the case of a topographic map of the Archaean and Lower Silurian areas of Southeast Missouri, such a map shows whether the granites, the porphyries, the limestones, are in the hills or in the valleys; it shows the maximum altitude reached by the limestones or their residual products, and thence the altitude of the old sea level; it shows whether the ores or the workable stone is located in positions that are easily accessible and from which the materials can be readily worked; it shows the location of favorable sites for the development of water powers; it indicates the amount of overflow which damming at any locality may produce. The topographic map further furnishes the best possible basis for the construction of an agricul-cultural map, which is made part of the work of this Survey; it permits at once of the division of the lands into flat, plateau, or hill-top lands, into slope lands, into bottom lands, and all other agricultural questions dependent upon topography can be readily determined.

The facts contained on the topographic and geologic map are not of two distinct kinds, and are not collected separately and independently in the case of this Survey; in fact, the data for the topography would be almost entirely collected in prosecuting the detailed work for the stratigraphy, and the facts of the topography are of indispensable assistance in solving the geological problems, the results of which are presented in a final map. The outlines of the hills, their altitudes, the positions of the different beds on their slopes all have to be noted whether the topography is accurately plotted or not, in order that we may obtain sufficient facts for delineating details of stratigraphy and distribution; the plotting of the topography along with such notes is, in short, only a systematic method of recording a multitude of observed facts. These facts, when carefully plotted upon such a map, are presented in the best possible form for study and comparison, and it is only through such presentation that many important results can be deduced; thus, the data for such a map must very often be collected, in a large part, whether such map is ultimately prepared for publication or not.

For these reasons topographic maps were deemed necessary in connection with this area work. In the older reports, as already stated, county reports were similarly the results of area work, but the information which they contain is not sufficient to satisfy the requirements of to-day. At the time when these reports were planned, little was known of this country, and a mere statement of the existence of various subtances was valuable information. Not even the existence of the different geological formations of the State was demonstrated, and the first labors of the Survey were necessarily directed towards classifying

these large formations and towards defining their areas. These general facts of existence and distribution are now pretty well established, and what is wanted nowadays, is not alone the information that a certain thing exists in a certain county or district, but exactly where and how it exists in such district is further demanded. In recognition of this, it was thought best, in planning for the area work of the Survey, not to continue with the preparation of county reports similar to those which had been prepared by the earlier Surveys, but to enlarge upon this plan in order to meet the requirements of the day. This seems to be necessary, in order to fulfil the conditions of the law specified in section 4, requiring the preparation of detailed maps and reports. Thus, where, with the old plan, maps of whole counties were made on a scale of three or four miles to the inch, maps for the present work have been constructed on a scale of one mile to the inch, and each sheet represents only a portion of the county. The area of such a map is a quarter of a square degree of latitude and longitude, the size of each sheet being about $13\frac{5}{8}$x$17\frac{3}{8}$ inches, not including the margin. By this means maps are obtained of a uniform size, and the area represented is one permanently defined, it is not subject to change by subdivision or otherwise, as is a county. It is in harmony with a plan of publication which is becoming more and more adopted by Government Surveys.

Similarly, while the older reports deal mostly in generalities concerning the areas described, the new reports will endeavor to be as specific as possible, and will embody a great deal of detail.

THE PLAN OF PUBLICATION.

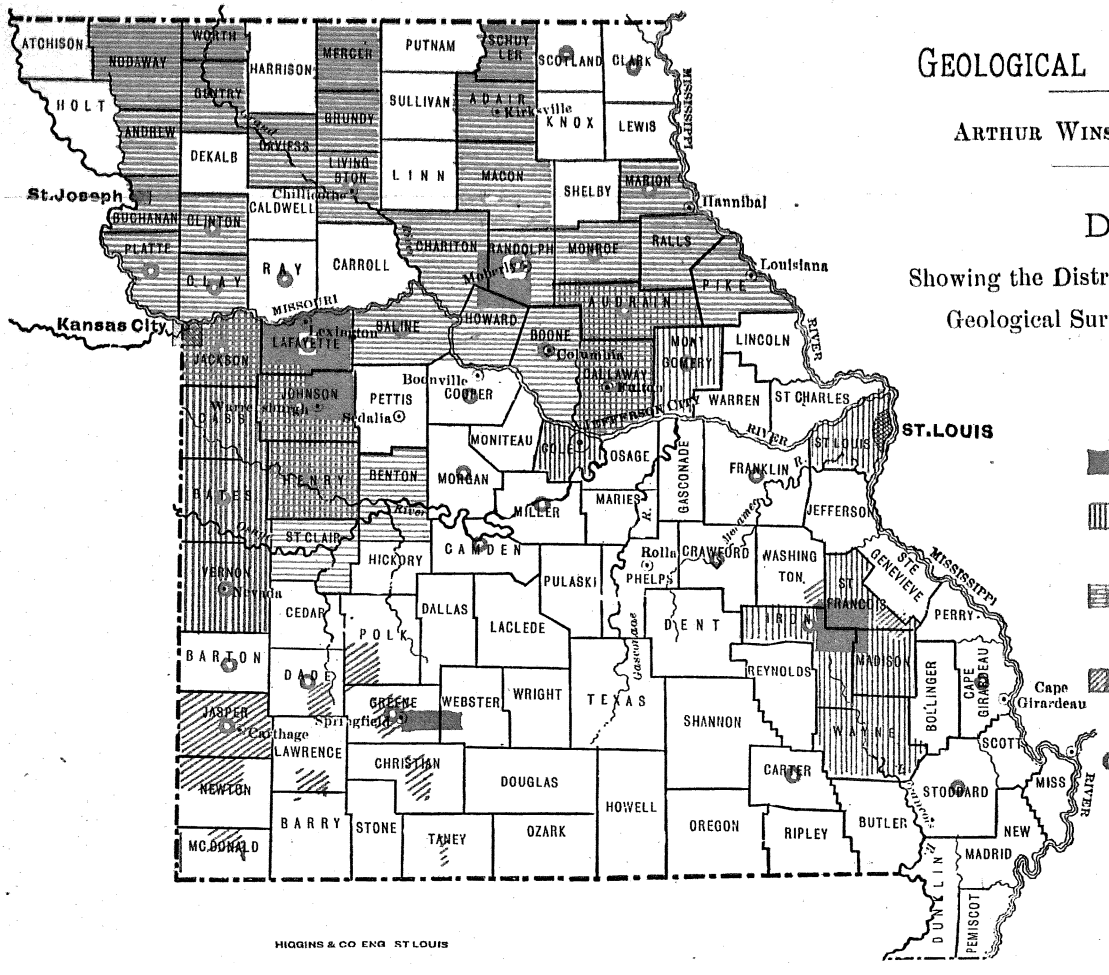
These general plans of work being settled, the next question to be decided was how the results should be prepared and published. To complete the examination of any one important subject in the State calls for one or two years of work, and, similarly, to prepare detailed maps of any considerable area requires a correspondingly long time. The demand is, however, urgent for information concerning many subjects and many localities; further, many facts are collected in the progress of the work which are of temporary value and which ought not to be withheld for the preparation of final reports or monographs. To meet this demand for information, and to supply a means of ready publications, the bulletins of the Survey were designed. The matter which they contain is essentialy provisional and is somewhat hurriedly put together, but they are calculated to become very useful. They partially satisfy the demand for information and avert the danger of publishing what should be a complete report, before sufficient time has been

GEOLOGICAL SURVEY OF MISSOURI.

ARTHUR WINSLOW, STATE GEOLOGIST.

DIAGRAM.

Showing the Distribution of the Work of the Geological Survey, during the year 1890.



HIGGINS & CO ENG ST LOUIS

LEGEND.

- Areas which have been mapped in detail.
- Counties in which clays and structural materials have been examined. 16 counties.
- Counties in which mineral waters have been examined. 31 counties.
- Counties in which zinc and lead deposits have been examined. 11 counties.
- Counties in which the coal deposits have been examined, or which have been inspected by the State geologist for other purposes. 35 counties.

allowed for the collection of sufficient data for the preparation of a complete report. These complete or final reports, according to the plan proposed, will be published ultimately in separate volumes, one volume to each subject of importance. The results of the detailed area work will similarly be published in separate form, each sheet or map and accompanying sections being in a separate cover or atlas, and each such atlas being accompanied by a small pamphlet report descriptive of the area.

THE WORK IN PROGRESS.

By referring to the contents of the reports of the earlier Surveys, given in the preceding pages, it will be seen that the subjects of work which have heretofore received most attention are the iron ores of the State and the lead and zinc deposits; the coal deposits have also received some attention, but this has been more in connection with the area or county work than as a part of a general and special work devoted to coal deposits. In organizing the present Survey, the following subjects were selected as worthy of first attention.

1. THE COAL DEPOSITS.
2. THE CLAYS, BUILDING STONES, LIMES, SANDS AND CEMENTS.
3. THE MINERAL WATERS.
4. THE ZINC AND LEAD DEPOSITS.

In Bulletin No. No. 1 there was given a statement of the progress of the work of the Survey up to April, 1890, and it will be unnecessary to repeat here what was there given. On the map opposite this page the distribution of the work, up to the end of 1890, is shown graphically and needs no further explanation. In addition to this, however, we will add a few remarks concerning the character of the work and the progress which has been made since last April.

THE WORK ON THE COAL DEPOSITS.

Work in the coal fields has been prosecuted by the earlier Surveys, but the character of the work done was such as to furnish only general information as to the existence of coal, and very little is given from which one can determine the actual areas underlain by individual beds, or the depth beneath the surface at which these beds occur. Further, so many developments have been made since the operations of the earlier Surveys that much more can be determined concerning these details than would have been at that time possible. These facts

led to the selection of the coal deposits as one of the subjects for detail study, and led, further, to the selection of the coal region as the area in which a large portion of the detail mapping could be most effectively prosecuted.

The work in the coal fields may be divided into two parts: First, that which has been done looking towards the immediate preparation of a preliminary report upon the general distribution and character of the coal in the State. For this purpose inspections have been made in twenty-four counties by myself, as is shown on the accompanying map. Secondly, there has been carried on in the coal region detailed mapping in portions of five counties which has for an object the definition of the area of the individual coal beds. This work has been executed, under the immediate direction of myself, by Mr. Leo Gluck and Mr. C. F. Marbut, assistants of the Survey. During the summer months Mr. C. H. Gordon, a volunteer assistant, was at work with Mr. Marbut in Randolph county. The exact area covered by this detailed mapping is shown on the map above referred to.

THE WORK ON THE CLAYS, BUILDING STONES, LIMES, SANDS AND CEMENTS.

No systematic and critical examination of the clays or of the structural materials of the State has ever been made. A study of the latter was included in the plan of work of the Pumpelly Survey, but seems to have never been started. The only information which we have concerning these materials in the State is contained in the old county reports, or is an incidental part of some other report. The information consists almost entirely of loose and general statements based upon cursory hand examinations; no tests of the materials have been made, and no determinations of their extents instituted. The clays of Missouri rank second to none in the country, and they exist in great quantities. The industries which they have already created give employment to thousands of men, and the value of the products is many millions. They constitute a most important subject of work, which has already been too long neglected. The results of what the Survey has done in this connection already give promise that the report on this subject will be one of the most valuable that could have been prepared.

Since April last the work on the clays and structural materials of the State has been actively pushed, though sickness caused interruption during the latter part of the summer. The work has been extended over fourteen counties by Mr. Ladd, and twenty-three samples of clays

and seventy-seven samples of limestone have been analyzed by Mr. Woodward, including five hundred and sixty determinations. Further, experimental tests of the clays are in progress under Professor Wheeler. Mr. Ladd was assisted in the field work during the spring and early summer by Messrs. J. D. Robertson and E. H. Lonsdale. During the autumn, however, he has continued the work alone.

THE WORK ON THE MINERAL WATERS.

The mineral waters of the State have, similarly, been heretofore almost entirely neglected. Missouri has a large supply of such waters, and many of the localities where they occur have been improved at considerable cost, and some are equipped with handsome hotels and well kept grounds. Some of these waters have already a wide reputation, while others of similar composition are hardly known. It is the object in this work of the Survey to determine, in an authoritative manner, the composition of these various waters; to publish the results, and to accompany this with such illustrations and descriptions of the surroundings as will lead to the wider use of these resorts, both for purposes of cure as well as for recreation.

The work on the mineral waters of the State has been continued by Mr. A. E. Woodward intermittently since last spring (part of his time being given to the analyses of clays, and to other miscellaneous laboratory work). Since November he has been assisted in the laboratory by Mr. James D. Robertson. Up to the end of the year Mr. Woodward had visited fifty-three mineral water localities in the State, distributed over thirty-one counties, as shown on the map. He has sampled forty-nine waters and analyzed forty-seven, which includes six hundred and sixty-eight determinations of constituents.

THE WORK ON THE ZINC AND LEAD DEPOSITS.

The lead and zinc deposits have already received attention, it is true, by the earlier Surveys, but the work was interrupted before its completion. Further, the development of these deposits has been so active during the past few years that much attention is attracted to them; the demand for information concerning them is very urgent, and there is nothing published on hand for distribution. As a result of this, an investigation of the zinc deposits of this and adjoining States has been ordered by the Secretary of the Interior through the United States Geological Survey. In order to make the results of this

National work in Missouri directly and immediately available to the State, and, further, in order to prevent duplication of labors, co-operation between the National and the State Survey was arranged for, so far as this special subject was concerned. Mr. Walter P. Jenney was assigned to this work by the National survey, and the co-operative work was begun in the autumn of 1889, as explained in Bulletin No. 1. Early in the progress of operations the value of these deposits became apparent, and attention was called to the fact by the Survey. At the same time the need of detailed work, in order to properly display this fact, was evident; and, pending the completion of this detailed work, a preliminary report from Mr. Jenney was arranged for. Soon after the issue of the Bulletin, in April last, field work on the zinc and lead deposits of the State was suspended by Mr. Jenney, who was in charge of the work, and he returned to Washington for the purpose of preparing the preliminary report, in recognition of an earnest desire of mine. The expectation was then that he would take up field work again during the following summer. Pending his return to the State, Mr. Robertson, who was assigned to him as assistant from the State Survey, was put to other work. Up to the present writing no further field work has been done on this subject. The preparation of his report has occupied all of Mr. Jenney's time. He will resume field work this winter, however, and the expectation is that his investigations will be completed in a few months.

THE WORK ON GENERAL STRATIGRAPHY AND PALEONTOLOGY.

Since the last report of progress the work on general stratigraphy has been prosecuted chiefly with the assistance of the United States Geological Survey. For this purpose, Prof. Henry S. Williams, of Cornell University, assistant paleontologist of the National Survey, has commenced the study of the fossil faunas of the Missouri rocks, as part of a general study in this and adjoining States, which has for its object the definition of the faunal characteristics of the different rocks and their more exact correlation. For this work Mr. Gilbert Van Ingen was assigned to the State last spring, to collect fossils, under the direction of this Survey, to be sent to Prof. Williams for study. Mr. Van Ingen continued uninterruptedly at work until September last, when he was taken down with typhoid fever, and he has not fully recovered yet.

THE AREA WORK.

A great portion of this work, as already stated, has been done in the coal regions; but, in addition to this, an area represented by one sheet has been covered in the iron and granite regions of the southeast by Messrs. E. H. Lonsdale and C. F. Marbut. Mr. Erasmus Haworth, a volunteer assistant, was also occupied in this area during the past summer, studying and mapping the distribution of the granites, syenites and porphyries. His labors were in continuation of work done by him during past years for the United States Survey, and the State Survey was fortunate in thus securing the benefits of his knowledge. Further, work of this detailed character was done in Greene county, under Prof. E. M. Shepard, a local assistant. Mr. Robertson, of the regular force, was assigned to this work for over a month, and Maj. E. W. Newton, of Bolivar, gave additional assistance. Less than one hundred square miles were covered here, however, by the mapping; but the results of geological examinations over the whole area of one sheet have been written out by Prof. Shepard, and are on file at this office. The following table gives the exact area mapped in each district:

In Lafayette County	540 square miles
In Randolph, Chariton and Howard Counties	324 square miles
In Iron, Madison and St. Francois Counties	350 square miles
In Johnson County	250 square miles
In Greene County	110 square miles
Total	1,574 square miles

THE WORK ON THE CABINET AND COLLECTIONS.

A great deal of time, especially during the past few months, has been given to the collections of the Survey. These collections may be divided into two kinds. One, and by far the bulkier portion, is gathered for purposes of study and for analyses and tests. The other portion is for exhibition. For every specimen which comes to the Survey office, a label is written, giving the name of the specimen, its geological position, its composition, and describing exactly where it was found, and referring to the proper note-book for further information. Each specimen is given a separate number, and this number, with a copy of the label, is recorded in the office catalogue. The specimens are all filed

away in numbered trays so that any one can be found at short notice at any time. Those exhibited in the cabinet have their number written on them, and special cabinet labels are written, giving the name and the composition of the material and the use to which it is put. These specimens are then mounted and arranged under appropriate group labels. This system and routine is necessary with a large collection in order to preserve an accurate record of where each specimen came from, and of how it was obtained. There are now in the collection of the Survey two thousand three hundred specimens, and of these over seven hundred are arranged for exhibition. Over 130 photographs have been taken by members of the Survey during the past year. These include views of mineral water resorts, of quarries, of mines, of clay works, of rock exposures and other objects relating to subjects of work. Some of these are mounted for exhibition and others will be added later. Since September last, Mr. Robertson has given a considerable part of his time to the arranging and labeling of specimens and other material for the cabinet.

THE WORK IN THE OFFICE.

The work in the office may similarly be divided into two parts: First, that necessary for the preparation of the results of field work for publication. Secondly, that necessary for attending properly to such matters as correspondence, accounts, and the multifarious clerical duties which are a part of every public office. In the first class of office work, all members of the Survey have been more or less engaged, and it has consisted of the plotting of maps, the writing of reports and the correcting of proof. The second class of work has been done chiefly by Mr. J. C. Halligan; all of his time has been devoted to it. Few will realize the amount of the correspondence which is necessary in connection with such a work. Since the beginning of the Survey, not much over a year ago, fully eighteen hundred letters have been written and a corresponding number have been received and read. Many of these contain inquiries concerning minerals of the State, or are solicitations of advice from citizens, and require careful consideration and explicit answers, which call for time in their preparation. Further, every month, the accounts of the Survey have to be made out by all members, have to be carefully scrutinized by me, and have to be submitted to the Governor and Auditor. Further, a report of operations has to be written each month, and some fifty copies of it have to be prepared and distributed. All manuscript that is prepared for publication for the Survey is to be read critically by myself, and is often revised by myself or others. Next, all proof of such publications has

to be read and corrected by me, and all other details in connection with engraving, printing and publishing have similarly to receive my attention. Thus, in these administrative matters of the Survey, much time is necessarily spent.

MISCELLANEOUS WORK.

In addition to what has been described, miscellaneous work of various kinds has been done. In the laboratory, analyses have been made of five iron ores, four coals and one sand, including thirty-two determinations over and above the twelve hundred and sixty determinations already spoken of. Further, ninety substances have been determined in the laboratory, about eighty of which were sent in by outside parties who are citizens of the State.

In connection with the detailed mapping, the Survey has received assistance from the United States Coast and Geodetic Survey, in the southeastern portion of the State, where two determinations of latitude and longitude were made, one at Ironton, the other at Potosi. Meridian points were at the same time established at both of these places, which will be of value to the County surveyors in determining the variations of their needles.

THE PUBLICATIONS.

Owing to the short time the Survey has been in existence, we could not expect to have ready for publication, by this time, any final report or monograph. We have practically had only one season of field work, and most of the time, so far, has been spent in the field. Much material has, however, been collected which will make part of such monograph, and, in addition, we have published or have prepared for publication the following preliminary reports:

Bulletin No. 1—85 pp.

Bulletin No. 2—158 pp.

Bulletin No. 3—100 pp.

The Biennial Report of the State Geologist.

During the present winter it is anticipated that there will be prepared for publication the following:

Bulletin No. 4.

Bulletin No. 5.

Bulletin No. 6.

Report on the Higginsville Sheet, Lafayette county.

In addition to this, the areas tabulated on page 43, which have been surveyed in detail, will be plotted this winter. A description of these areas can be written out soon after they are plotted, and can be published, together with the maps, if advisable, during the present year.

THE EXPENDITURES OF THE SURVEY.

The rules regulating the expenditures of the Survey are given in sections 12, 13, 14, 16 and 18 of the law. These fix the limits of the salary of the State geologist and his assistants, and provide under what conditions the funds appropriated for the Survey shall be disbursed. Subordinate to these requirements of the law, the following instructions are issued by the State geologist, in General Circular No. 1:

Expense accounts are to be made out at the end of each month and sent to the Jefferson City office to the State geologist. They should reach the office not later than the second business day of the month succeeding the one which the account covers. These accounts must be itemized and the items arranged according to date, and must be countersigned by the geologist in charge and handed in with his general account to the State geologist.

The accounts should be made out in the ordinary form of a bill against the State geologist, *i. e.*

JEFFERSON CITY, January 1, 1891.

ARTHUR WINSLOW, *State Geologist*,

To [full name]....., assistant.....Dr.

date.....item.....amount.

Received payment,

[Signature.]

Materials purchased for the use of the Survey must not be entered under the head of Sundries, but the item must be specified.

Railway fare items must state the points from and to which the journey was made. No personal expenses, such as fees, wash bills, medicine, repairs, or purchase of wearing apparel, will be allowed.

It is expected that the members of the Survey will use the strictest economy in regard to the expenses which have to be paid by the Survey. For sums over two dollars, vouchers should be taken, numbered, and handed in with the accounts. In the case of railway fares, however, vouchers are not required.

No allowance will be made for living expenses of salaried assistants while the assistants are at permanent headquarters, or at any branch office or temporary headquarters. While away from permanent or temporary headquarters, expense accounts will be allowed as follows, unless otherwise arranged for:

With occasional and temporary absence any reduction, which can be secured, of expenses at headquarters during the time of such absence must be placed, in the expense account, to the credit of the Survey. Thus, if one's expenses during a week's absence from headquarters amount to $9.00, and the reduction of expenses at headquarters during the same time amounts to $5.00, then the net expense account will be $4.00.

With frequent and prolonged absence, and when no expenses at headquarters have to be carried, only such portion of expenses incurred will be allowed as is over and above what would be a reasonable cost of subsistence at headquarters.

The rate of such cost of subsistence is, until further notice, fixed at $20.00 per month. Thus, if one's expenses during a month's absence amount to $35.00, the net expense account will be $15.00

The expense accounts are to be made out in full in all cases, and the account credited the Survey is to be subtracted from the total, thus:

Total expense account	$35 00
Allowance on expenses to credit of Survey	20 00
Net amount due	$15 00

All accounts, after being scrutinized, criticised and corrected, if necessary, by the State geologist, are then entered upon one general voucher in the following form:

.....18....

STATE OF MISSOURI, To.....Dr.

On account of Bureau of Geology and Mines.

18.... Month	Day.	Salaries and incidental expenses.	Voucher.	No.	
.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....
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.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....
.....	.....	.....	.....	....	.....

I solemnly swear the above account is correct and the amount claimed is justly due me.

.....

Sworn to and subscribed before me this.....day of..... 18....

.....

.....

The above account is approved by the Board of Managers of the Bureau Geology and Mines, and I hereby certify that the amount (.....Doll .....cents) is required to pay expenses of carrying out the provisions the act of the General Assembly, approved May 13, 1889, and the State Auditor requested to draw his warrant in favor of .....for said s of money.

.....

President of the Board of Managers of Bureau of Geology and Mines.

.....18....

The two columns in this voucher are, one for the total amount of the expenditure, the other for the number of the sub-voucher containing the items which go to make up this total. These sub-vouchers are retained in the Survey office for purposes of future reference. After the general voucher for the expenses of the month is made out, it is submitted to the Governor, who examines both the items of the sub-voucher, as well as those of the general voucher, and stamps each one of the former with his office stamp, in evidence that it has been inspected by him on the date stamped. The general voucher, if approved by the Governor, is then signed by him, sworn to by the State geologist, and a warrant is given for the amount called for, to the latter, by the Auditor. The State geologist thus becomes disbursing agent for the Survey of the amount thus transferred to him. The following table gives, in classified form, the expenditures of the Survey, from its beginning to the end of the year 1890:

Salaries	$10,494 58
Railway fares	763 26
Subsistence	1,123 71
Postage and telegrams	197 11
Freight and expressage	269 76
Printing	675 20
Office and cabinet furniture	361 20
Office and cabinet supplies	334 42
Field supplies	632 39
Laboratory supplies	624 79
Horse and wagon hire, car fares, etc., etc	609 44
Library	17 00
Engravings and photographs	45 24
Total	$16,148 10

THE WORK OF THE FUTURE.

The calls upon the Survey from many portions of the State would seem to indicate a general interest in, and an appreciation of its work. In order that these demands may be met in a satisfactory way, a larger appropriation must be made for the continuance of the work. The last appropriation of $20,000 has been made to apply for eighteen months; the next appropriation will have to last twenty-four months. If the Survey be continued with the same force, and in the same manner, for the next two years, an appropriation of $26,200 will be necessary.

It is, however, important that the operations of the Survey should be extended. The investigation of the iron ore deposits, especially of the central portions of the State, was never completed by the earlier surveys, and should be resumed and made a special subject of study by a competent man. The zinc and lead deposits of the State call for immediate attention, and this should be provided for in a more liberal manner than heretofore. The work on this subject which is in progress by the National Survey, should, of course, be considered in planning any work on the same subject by the State; but the experience has been that this National work is not sufficiently responsive to the needs of the State, and that if the State wishes to obtain immediately those results specially desired by the State, the work must be under State control. Further, agriculture and forestry are made by law subjects of work of the Survey, and provisions should be made for a thorough investigation of the character and capacities of the soils and for a determination of their distribution. It is desirable that a report should be prepared on the paleontology of the State, and that additional paleontological work be done for the purpose of settling certaintquestions of general stratigraphy, and for the preparation of a geological map of the State. Finally, an addition should be made to the force for the purpose of extending the detailed mapping more rapidly over those portions of the State which are considered worthy of such work. The amount estimated to be necessary for such extensions of the work for two years is $22,200. The total necessary to maintain the present force of the Survey and to provide for the recommended extensions would, therefore, be, in round numbers, about $50,000.

In addition to the special reasons given for an enlargement of appropriations, there is the general one that the work can be accom-

plished more economically, and the results can be made available sooner through the expenditure of a large sum during a few years than by the expenditure successively of small sums during many years. But further, the proximity of the Columbian Expositon at Chicago creates an additional justification of this demand. This exhibition promises to be the largest ever held in this country, and its importance should certainly be in proportion to the event which it commemorates. Located at Chicago, in the midst of the Central States, the exhibits made by these States must be second to none. Everything will be expected of them, and as they there appear so will they be judged. Thus liberal provisions should be made, not only for a display of the mineral resources of this section, but of all its capabilities and products. But such display should consist not merely of an exhibition of mammoth or unique specimens. To attain the best results, to attract the attention and to command the consideration of the intelligence and culture of the world which will be there assembled, the display must have a deeper significance, must be gathered and arranged with art. In connection with the mineral deposits it is not sufficient that specimens of this and that ore, or clay, or coal be gathered and labeled and piled indiscriminately on shelves; but they should be so arranged as to illustrate how they occur, as to illustrate what products are made from these materials and the processes they pass through. Such an exhibit should be accompanied by diagrams, maps, photographs and publications giving reliable information as to how and where these materials exist. Such a collection once prepared would be, and should be made, of more than temporary value, it would be a valuable foundation for a permanent State exhibit. Hence, for this further reason, it is urgent that means should be provided whereby the Geological Survey can collect and put in shape for publication all of the necessary information.

Few people who have not been engaged in such work, or who have not tried to carry it over a great State like this, so as to produce results which shall be as authoritative as such official work ought to be, realize how small an appropriation of $10,000 per year is, when the magnitude of the interests involved is considered.

Ten thousand dollars represents:

Between $\frac{1}{2}$ and $\frac{1}{3}$ of a cent per individual;

One cent per every forty acre tract;

One-fortieth of a cent per acre;

One eight-hundredth of one per cent of the total assessed valuation of property.

One two-hundredth part of the State revenue;

One one hundred and fiftieth part of the total expenses of the State.

One-twentieth of one per cent of the annual value of the mineral products of the State.

The sum represented by an increase in the land value through the work of the Survey, of only five dollars per acre, and of only twenty square miles, would pay for the operations of the Survey, as at present run, for about six years, and this small amount is now in places paid for mining rights in the State upon lands known to be underlain by coal.

An increase of the same amount over two thousand square miles would raise the amount received by the State from taxes by about $20,000 per year.

Ten thousand dollars per year cannot be more than one-twentieth of one per cent of the annual value of the mineral products of the State.

The portions of this ten thousand dollars per year, derived from different sources, is as follows:

From taxes on real property	$5,500 00
From taxes on personal property	1,600 00
From taxes on R. R., Bridge and Telegraph companies	550 00
From license from dramshops, etc	900 00
From taxes on Merchandise and Manufacturing plants	450 00
From Fees and Special taxes, about	1,000 00
Total	$10,000 00

Data are not at hand from which I can state the appropriations made for the geological work in a number of the States which now have Geological Surveys, but a few figures can be given, and they are as follows:

California	$100,000 a year, printing not included
Texas	35,000 a year, printing not included
Arkansas	18,000 a year, printing not included
New Jersey	8,000 a year, printing not included
Georgia (?)	8,000 a year, printing not included

Some idea of the sums necessary for the prosecution of such work may be gathered from the table of the amounts expended for geological surveys by different States. This includes expenses up to the year 1886:

Pennsylvania (second survey), 1874 to 1855	$1,042,040 00
New York, 1838 to 1880	712,000 00
Ohio, 1869 to 1880	355,786 00
Illinois, 1851 to 1875	190,330 00
Missouri, 1853 to 1877	176,185 00
Wisconsin, 1873 to 1879	149,000 00
Michigan, 1871 to 1875	132,000 00
New Hampshire, 1869 to 1878	59,839 00

These amounts include cost of publications as well as of operations in the field. The amounts vary widely, but the results attained are not always proportional to the cost; the reasons for this lie in details of history and of management, which need not be entered into here. All of these sums are, however, very considerable, and they impress one with the fact that, in order to carry on a great work like this, sums which appear large to an individual must necessarily be provided; though, when compared to the wealth of the area and the magnitude of the interests involved, the sums are very small. These facts, it seems to me, ought to be clearly understood before the inception of such work, and then provisions should be made for carrying on the survey according to a definite policy. The people, or the Legislature through its committees, should thoroughly investigate the subject, so as to obtain a clear appreciation of the necessities of the case and of the means required to obtain certain results; they should be perfectly satisfied of the value of those results, and should have a clear conception of the cost of obtaining them, and should then provide, not only for the maintenance of the Survey from year to year, but for its continuation in a proper manner until the work outlined shall have been completed.

Reviewing the history of the Geological Survey of the State given in the preceding pages, we see that its life has been very fitful. It has existed for a few years only to be discontinued before any plan of work was completed and at the sacrifice of much of the result reached. It has been weakened by successive changes of management with accompanying changes of policy. Its trained corps of employes and its equipments for work have been lost during the interim between two

periods of activity; its collections designed to illustrate the resources of the State have been scattered, and with it all a considerable sum of money has been expended. Yet the interests which this work is especially devoted to have continued to exist and have continued to demand recognition and will always continue to do so, whether it be through a Bureau of Geology and Mines, through a Board of Internal Improvements, through a Bureau of Statistics, or through a Special Commission. And these facts, true as regards Missouri, are based upon the experience of other States and Nations. Just so surely as it is true that it is conducive to the welfare of the State that the existence, the extent and the nature of its mineral resources should be determined and made known, just so surely will such work be prosecuted. History would teach us that the question is, not whether these facts shall be determined or not, but whether they shall be determined now or later. If determined now, the results will be available at once and the benefits will be felt immediately; if determined later, the beneficial effects will be deferred in proportion. The work is not to be regarded as a luxury which a rich State may afford, but which a poor State may dispense with; it is an investment which will yield good returns to the poor as well as to the rich; it is a work of improvement which will enhance the value of property; a work in harmony with the peace-loving spirit of the age, in accordance with which the energies of the State are being directed more and more toward industrial development.

It would be a difficult thing to express by figures just how much time and money should be charged to the account of organization of the present Survey; but it would represent a very considerable portion of what has been expended. Assistants had to be drilled, methods of work had to be adjusted to local conditions and requirements, general inspections had to be made before work was actually begun, equipment had to be provided. The general plan of work is now well outlined and the members of the Survey are familiar with the details, and all moves smoothly. There is no doubt but that, thus organized, much more could be produced in an equal time in the future than has been possible in the past. The policy of the survey contemplates the completion of certain fundamental work which has not been executed in the past. The largest cost lies in this fundamental work, and, for it, the recommended increase of appropriation is intended. This fundamental work once completed, the work of the future will be only such as is necessary to adjust the results to future developments, in order that they may be kept abreast of the times, and such as is necessary for the proper care of the collections.