GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN I.

Annual Administrative Report

OF THE

STATE GEOLOGIST

For the Year 1910

TRENTON, N. J.
MacCrellish & Quigley, Printers, Opposite Post Office.

1911.

The Geological Survey of New Jersey.

BOARD OF MANAGERS.

HIS EXCELLENCY J. FRANKLIN FORT, Governor and *ex officio* President of the Board, ... Trenton.

Members at Large.

DAVID E. TITSWORTH,	Plainfield,	1911
GEORGE G. TENNANT,	Jersey City,	1911
HARRISON VAN DUYNE,	Newark,	1912
CHARLES L. PACK,	Lakewood,	1913
JOHN C. SMOCK,	Trenton,	1913
ALFRED A. WOODHULL,	Princeton,	1914
FRANK VANDERPOEL,	Orange,	1914
T. FRANK APPLEBY,	Asbury Park,	1915

Congressional Districts.

I.	FREDERICK R. BRACE,*	Blackwood,	1911
II.	P. KENNEDY REEVES,	Bridgeton,	1912
III.	HENRY S. WASHINGTON,	Locust,	1914
IV.	WASHINGTON A. ROEBLING,	Trenton,	1913
V.	FREDERICK A. CANFIELD,	Dover,	1915
VI.	GEORGE W. WHEELER,	Hackensack,	1911
VII.	HERBERT M. LLOYD,	Montclair,	1912
VIII.	E. H. DUTCHER,	East Orange,	1914
IX.	JOSEPH D. BEADLE,	Jersey City,	1913
X.	CLARENCE G. MEEKS,	Weehawken,	1915

State Geologist,

HENRY B. KÜMMEL.

* Died May 5th, 1910.

Letter of Transmittal.

TRENTON, N. J., January 16, 1911.

Hon. John Franklin Fort, Governor and ex officio President of the Board of Managers of the Geological Survey:

SIR—I have the honor to submit my Administrative Report summarizing the work of the Geological Survey for the year 1910. This report is made in accordance with Chapter 46 of the Laws of 1910, and is not, as in previous years, accompanied by scientific papers. Several reports of the latter class are approaching completion, and, in accordance with the intent of the law cited above, will be submitted for publication in the near future.

Yours respectfully,

HENRY B. KÜMMEL,

State Geologist.

ADMINISTRATIVE REPORT.

HENRY B. KÜMMEL, STATE GEOLOGIST.

CONTENTS:

During the year ending October 31, 1910, the work of the Geological Survey was chiefly along the lines followed in previous years. The regular appropriation available was $16,500, which was supplemented by the sum of $830 carried over under contract from the appropriation of the previous year. The total expenditure aggregated $17,327.53, leaving a lapsed balance of $2.47.

The results of the work are briefly summarized herein. For more detailed results of the various scientific investigations the reader is referred to special reports on those subjects.

ADMINISTRATION.

Expenditures.—A tentative budget covering the expenditures of this money was approved by the Board of Managers early in the year, with authority to the State Geologist to modify it in detail as the exigencies of the work might demand. During the year the initiation of several new lines of work seemed advisable, so that the discretionary power lodged in the State Geologist was largely exercised.

The disbursements were as follows:

Salaries of State Geologist and scientific staff,	$11,284 15
Salaries of clerical assistants,	1,922 21
Traveling and field expenses,	1,150 68
Office furniture,	3 50
Office supplies,	302 30
Laboratory equipment,	65 65
Laboratory supplies,	447 26
Other scientific apparatus,	130 42
Library,	72 20
Museum supplies,	10 00
Postage,	33318
Express,	144 95
Telegraph and telephone,	35 77
Engraving and printing maps,	1,425 26
	$17,327.53

Organization.—The appointment of the State Geologist and the general oversight of the Survey work is vested in the Board of Managers—one from each Congressional District and not more than ten at large, appointed by the Governor for terms of five years. Members of the Board receive no compensation, but are allowed the expenses incurred in discharge of their duties.

In April the following appointments were made by the Governor and confirmed by the Senate for terms expiring April 6, 1915: Frederick A. Canfield, Dover, re-appointment, Fifth Congressional District; Clarence G. Meeks, Weehawken, Tenth Con-

gressional District; T. Frank Appleby, Asbury Park, Member-at-Large.

Rev. Frederic R. Brace, Blackwood, representing the First Congressional District, died May 5, 1910. Mr. Brace had been a member of the Board since April 1, 1903. From the first he had shown a warm interest in work of the Survey and was rarely absent from the meetings of the Board. His wide acquaintance with the southern portion of the State made his counsel of particular value on all problems affecting that section, while his broad-minded interest in all that concerned the whole State pre-vented any trace of sectionalism.

The staff of the Survey shows but few changes from year to year. Six members, including the State Geologist, are continuously employed. The others are on a per diem basis and are engaged upon Survey work as the occasion demands. The following persons were employed during the last fiscal year:

Henry B. Kümmel, State Geologist.
R. B. Gage, Chemist.
Laura Lee, Clerk and Stenographer.
Howard M. Poland, Assistant in charge of collection of well data.
John S. Clark, General Assistant.
W. S. Bayley. Geologist.
J. Volney Lewis, Geologist.
E. W. Berry, Paleobotanist.
S. Percy Jones, Geologist.
W. B. Duryee, Jr., Assistant on Soil Survey.
Tunis Denise, Assistant on Soil Survey.
W. W. Oley, Assistant on Soil Survey.
H. D. Leslie, Assistant on Soil Survey.
W. W. Robbers, Assistant on Soil Survey.

C. C. Vermeule, Topographer and Consulting Engineer.
P. D. Staats, Topographer.
C. C. Stagg, Topographer.
Robert A. Lufburrow, Draughtsman.

John G. Baumann, Janitor at Laboratory.

Publications.—In March the Legislature enacted the following law governing the publication of the Geological Survey Reports:

"BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

"1. The State Geologist shall make to the Governor an annual administrative report of the operations of the Geological Survey. He shall also, from time to time, prepare, or cause to be prepared, such scientific reports as are pertinent' to the work of his department. The State Printing Board shall have authority, on recommendation of the Board of Managers of the Survey, to order printed as submitted any or all such scientific reports. The cost of printing such reports shall be paid from the appropriation for printing public documents.

"2. This act shall take effect immediately."

This law specifically directs the preparation and printing of scientific reports pertinent to the work of the Survey and removes a doubt as to their legality, which had arisen in the mind of one member of the State Printing Board, in spite of existing legislation, the affirmative action of previous printing boards and a precedent extending over nearly fifty years. Promptly upon its passage, the printing of the report on Iron Mining, which had been held up for over six months, was authorized. The law now emphasizes the distinction between the annual administrative report of the State Geologist, which merely recounts the operations of the Survey, and is of only transitory interest, and the scientific papers, which are of permanent value. At a meeting held subsequently, the Board of Managers took cognizance of this separation and voted that the scientific papers which heretofore had appeared as parts of the Annual Report of the State Geologist in the future should be published as bulletins serially numbered, each under its own title, paging and index, the Administrative Report being a separate bulletin of this series. The bulletins will be bound in stiff paper or board covers, and the editions will vary in size as needed. It is expected that they will fall in one of the following classes:

a. Administrative.
b. Economic geology and mineral resources.
c. General and petrographic geology.
d. Paleontologic geology.
e. Water supplies.
f. Soil surveys.
g. Miscellaneous.

At the close of each year a small number of the administrative report and bulletins published during that year will be bound

together, as a "Year-book," but not re-paged and without an index of the entire volume. Owing to the limited editions of some bulletins, it will be impossible to send copies of all publications to everybody upon the mailing list. Those who have been receiving publications in the past are requested therefore to advise the State Geologist without delay what classes of reports are desired. Librarians, geologists and others whose interests may cover the entire field of the Survey publications may, upon request, receive either the separate bulletins as published or the "Year-book."

There are several advantages in this method of publication. Reports can be printed as soon as ready, without waiting until the completion of the fiscal year. It will be possible to reply to requests for information regarding certain topics with a report dealing with that subject alone, whereas, under the present system it is usually necessary to send a volume the major part of which deals with other matters. This will result in economy in printing, distribution and labor. Under this plan it is expected that there will be published during the coming year a report on the cost of a canal from Bay Head to the Shrewsbury River, the result of an investigation ordered by the last Legislature; a paper describing the fossil plants of the Raritan Clay beds, by E. W. Berry, which, while of interest to a comparatively small number of persons, is of great scientific value in the contribution it makes to our knowledge of the vegetation of the State during a far remote period; a summary of the quarrying and mining industry of the State with statistics of the mineral industry during 1910, to be prepared in co-operation with the United States Geological Survey.

During the past year the Survey has published the following reports and maps:

The Annual Report of the State Geologist for 1909. The Administrative Report was printed in January and laid before the Legislature. Advance copies of Part I, a Report upon the Development of the Passaic Watershed by Small Storage Reservoirs, by C. C. Vermeule, was printed early in the year for the Legislature. Later in the year the complete report was published and contained in addition to the papers mentioned

Part II. Record of Wells in New Jersey, 1905-1909, by H. B. Kümmel and H. M. Poland.

Part III. Notes on the Mineral Industry, by H. B. Kümmel.

A Report on Iron Mines and Mining, by Dr. W. S. Bayley, was also published, but not distributed during the year, owing to the necessary delay in completing the large geologic maps which accompany it. The report constitutes Volume VII of the final report series and is similar in size and make-up to the reports on Glacial Geology and the Clay Industry. It contains upwards of 500 pages, XIII plates and 31 text figures, in addition to two large geologic maps of the Highlands of the State showing the location of all known iron mines.

After a brief history of iron mining in New Jersey, there is a summary sketch of the geology of the State and a few words concerning the general character of the iron ores which comprise bog ore, limonite, hematite and magnetite. Each of these is in turn described as to nature of the ore, including appearance, chemical composition and metallurgical value, manner of occurrence, origin, distribution of deposits and detailed descriptions of individual mines. Naturally the chapters relating to the bog ores, limonite and hematite are short, for these deposits are relatively of little extent in the State and have yielded but meagerly in comparison with the great bodies of magnetite. The relative importance of the various ores is roughly indicated by the number of pages devoted to each—thus, bog ores are described in eight pages, limonite in forty-two, hematite in twelve, and magnetite in 410 pages.

In connection with the origin of the magnetites, a subject about which there has been a great diversity of opinion among geologists, Dr. Bayley presents not only the present views as to their genesis, but has also exhaustively reviewed the literature and he gives a summary of the opinions of previous workers in this field as well as the conclusions reached by studies of magnetite deposits in other fields. He shows that the New Jersey magnetite occurs "1) disseminated as individual grains through the prevailing gneisses of the district; 2) as small bunches in these gneisses; 3) as an important component of some of the pegmatites associated with the gneisses; 4) as a prominent con-

stituent of certain zones in the Byram and Losee gneisses; 5) as an important component of certain layers of dark hornblendic rocks resembling the Pochuck gneisses in the direction of their banding; 7) as deposits of mixed magnetite, limonite and pyrolusite in the Franklin limestone; and 8) as irregular aggregates of magnetite, garnet and other silicates, and often some sulphides, associated with basic intrusive rocks in the limestone." The accumulations of magnetite having commercial importance are those in the pegmatite (3), those in the black gneisses (5) and those in the limestone (7 and 8). Most of the ore worked is of the fifth type, a mixture of hornblende, augite, feldspar, quartz and magnetite. In brief "the ores are regarded as being of magmatic origin—that is, the source of their material is thought to have been the deep-seated molten magmas portions of which, upon being intruded into the overlying rocks, solidified as the various gneisses now constituting the principal rocks of the Highland ridges. After the partial cooling of the gneisses these were in turn intruded by ferruginous portions of the same magma that gave them birth, and these intrusions were later enriched by iron-bearing solutions or vapors originating in the same subterranean source. In their transit to the surface these solutions or vapors deposited additional magnetite in the intruded ferruginous rocks and made the ore lenses that now comprise the ore bodies."

In connection with his discussion of the probable amount of ore reserves, Dr. Bayley points out that under this theory of origin there is nothing inherent in the nature of the ore or their method of origin to limit them below. In most cases of closed mines, operations ceased because the price of ore fell below the cost of mining and transportation, not because the ore body was worked out. Furthermore, only those ore bodies have been worked which outcropped or are continuations of those that outcropped. It is entirely reasonable to suppose that there must be ore bodies just below the surface which, because they do not outcrop, have not yet been discovered. The maps which accompany the report show many areas of high magnetic attraction[1] within

[1]Data for these areas were furnished by Mr. T. A. Edison, under whose direction much systematic magnetic exploration was carried on about sixteen years ago.

which there may be large undiscovered deposits of magnetic ore. From an inspection of these maps it would seem that there exists a very considerable reserve of ore which has not yet been touched. The total yield of ore during the past one hundred years or more (to the close of 1907) is estimated at about 22,522,000 tons, and Dr. Bayley declares that a conservative estimate of the quantity of good ore still capable of being mined from known deposits is 35,000,000 tons. These figures do not include a vast amount of lean ores, not now commercially available, which some day may be economically mined and concentrated and sent to market under other conditions.

In the descriptions of individual mines the author has availed himself of all data heretofore published. Practically every mine hole has been visited and every dump carefully examined, in the hope that some information on the occurrence and genesis of the ore might be found. All available analyses, some made for the report, have been collated and published, so that there is full information regarding the chemical composition of the ore.

Applications for the report should be addressed to the State Geologist with remittance of twenty-five cents for postage.

Maps.—During the year three sheets of the topographic atlas have been revised and reissued—No. 22, Eastern Sussex and Western Passaic counties; No. 23, Northern Bergen and Eastern Passaic, with the adjoining portion of New York State, and No. 29, the Monmouth Shore with the interior from Matawan to Lakehurst. In printing these maps an innovation was made in omitting the basal tint of buff which has heretofore been a distinguishing feature of this map series. As a result there has been again in clearness and ease in reading the map, particularly the fine figures showing elevations. Previous to publishing No. 29 it was necessary to re-engrave entirely the base, which was done on copper, as the required alterations were too extensive to be made upon the old stones. This was necessarily an expensive process and added much to the cost of the map, but seemed to be justified by circumstances.

It is highly probable that for some time to come a portion of the annual appropriation will have to be set aside for re-engraving the topographic base which in the case of many stones is becom-

ing so badly worn as to forbid further alteration. It is essential that each new edition of these maps be brought up to date, and this necessitates constant changes, particularly in the case of those maps covering the metropolitan and seashore sections. Up to a certain point these changes can be made upon the original engraved stones, but the limit is soon reached, particularly when the alterations include erasures as well as additions, for the surface of the stone becomes irregular, and it is impossible to obtain good impressions from it. Whatever new work of this nature is undertaken will be on copper rather than stone, as the first cost is not greatly dissimilar and alterations on copper can be more readily made.

Some criticism had been directed against the quality of paper on which the maps were printed on the ground that it lacked toughness. The matter was taken up with the engraver, and after some search a very superior grade of linen paper was obtained on a special order from mills in Germany. The new paper is somewhat lighter than that formerly used, but is much more durable and promises to give better satisfaction. Although its cost is considerably in excess of that formerly used, the increase is fully justified by the better quality.

Distribution.—The demand for the maps and reports of the Survey shows but little change from year to year. Topographic maps are sold at the uniform price of twenty-five cents per sheet, which includes postage, while the geologic folios range in price from twenty-five to fifty cents, postage extra. The reports of the Survey are distributed without charge, except in the case of some volumes for which payment of postage is required. By direction of the Board of Managers the last 200 copies of any reports are sold at cost price. Copies of the following reports, available for free distribution have been exhausted, and they can now be obtained only by purchase:

Annual Report for 1883, ... Price, $0 50
" " " 1892, ..." 1 55
" " " 1903, ..." 40
Paleontology, Vol. I—Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. To residents of New Jersey, by express, charges collect; to non-residents, $1.50, charges prepaid.

" " II—Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey. To residents of New Jersey, by express, charges collect; to non-residents, $1.40, charges prepaid.
" " III—Paleozoic Paleontology, ... Price, $1 00
" " IV—Cretaceous Paleontology, ... " 2 70
Vol. II, Part 1—Mineralogy, Botany. Bound, price $1.50; unbound, postage 25 cents.
" IV—Report on the Physical Geography of New Jersey. Unbound, price $1.00; bound, price, $1.35; photo-relief map, $1.50 extra.

The sale of maps by the Survey during the past three years is as follows:

	Sheets sold		
	1908	*1909*	*1910*
Maps on scale of 1 inch per mile, ...	1637	1435	1485
Maps on scale of 2½ inches per mile, ...	1718	2205	2039
Geologic folios, ...	41	246	150
	3396	3886	3674

During the year 3,248 copies of the report for 1909 and 1,312 other reports, total 4,560, were distributed, as against 4,605 in 1909.

Library.—The Survey library continues to increase chiefly by exchange, but to some extent by purchase. It is becoming a serious matter to know how best to arrange it, as it threatens soon to overflow the limited space available. During the year the accessions were 42 bound volumes; 143 unbound, 54 pamphlets and 54 maps.

TOPOGRAPHIC WORK.

The topographic work, as in former years, has remained in charge of Mr. C. C. Vermeule. It has consisted almost entirely of revision of existing sheets, as no new surveys have been made.

Field work.—Considerable field work was necessary in revision of Sheets 30 and 34, in the southwest part of the State. These maps replace Nos. 10 and 14 of the old series and upon their completion the entire State will be covered by the newer one-inch per mile maps which do not overlap but meet edge to edge.

Office work.—Upon completion of the field work it was neces-

sary to make up copy of these sheets for use of the engraver. Inasmuch as both of these sheets include areas of Pennsylvania or Delaware, it seemed advisable to use for these portions data taken from the United States Geological Survey maps rather than to leave large portions of each sheet blank. It is believed that by so doing they are made more valuable to New Jersey users, as well as to inhabitants of the adjoining States. Considerable time also was spent in reading proof of new sheets Nos. 22, 23 and 29. Early in September, Mr. Vermeule began the preparation of the base for a new State map in two sheets on a scale of 1/250000 or about four miles to an inch. The stones of the old five miles per inch base through repeated use and correction are in poor shape, so that the preparation of a new base is almost a necessity. The old base, moreover, because of multiplicity of detail, is poorly adapted for a geologic map, where colored patterns must be overprinted on the black base. The prospective publication of a new geologic map of the entire State, therefore, rendered the preparation of a new base necessary. The work involved is very laborious and three assistants were continuously employed during the balance of the year on this work, which was only partially completed. The new base will be engraved on copper, so that in the future alterations can be made upon it more readily than if it were on stone.

GEOLOGIC WORK.

Soil Survey.—As stated in my last annual report, the State Survey, in co-operation with the United States Bureau of Soils and the State Agricultural Experiment Station, is making a soil survey of portions of the State. Early in the spring work was carried on in the vicinity of Vineland, Millville and Bridgeton. Later the field party moved to Sussex County and continued the work begun the previous year. Field work was continued until about the first of December, when cold weather and snow caused its suspension. All of Sussex County, except a few square miles, has been covered and soil maps drawn. The field work has been very slow and painstaking and great care has been taken to make it accurate. After the various soil types had been studied and

differentiated over wide areas, they were carefully sampled for both chemical and physical analysis (see p. 26). Co-ordinately with the soil mapping, an agricultural canvass was carried on. Over 1,300 farmers in Sussex County were visited and information covering the following points was obtained.

QUESTIONS ASKED IN AGRICULTURAL CANVASS.

1. Name and address of owner or tenant, and time of occupation?
2. Area of farm, tilled land, untilled pasture, timber, meadow, if any?
3. Kind of soil and rotation of crops?
4. Methods of practices and number of acres in each crop: Corn, potatoes, wheat, rye, hay, oats, forage crops and pastures and truck.
   (a) Time and method of plowing? (b) Method of preparation, *i.e.,* how cultivated? (c) Variety of seed? (d) How and where is seed obtained? (e) Method of planting, distance between rows and in rows, if cultivated crops? (f) Method of seeding? (g) Quantity of seed?
5. Are green manures used? Cost of seed and labor?
6. Manures made and bought, and cost of manures bought?
7. How are home manures cared for, when applied and how much per acre?
8. Cost of fertilizers used? What kinds, how purchased, how applied? How much per acre?
9. Lime: Cost, kind, source. How much and how often applied?
10. Crops sprayed and methods of spraying?
11. Worst weeds and methods of eradication?
12. Cost of crops per acre: Highest, lowest and average yield per acre?
13. How are corn stalks, hay and straw cared for and used?
14. Live stock : Number of each breed of horses, cows, sheep, swine and poultry?
15. What kinds are raised and what bought?
16. Are soiling crops used? Kinds?
17. Silo: Kind, cost, efficiency? Crops used for silage?
18. Production of milk? Size of dairy and cost and method of handling?
19. Kind, character and amount of feeds bought?
20. Average annual yield of milk per cow?
21. Methods of disposal of crops: Transportation, markets, commission?
22. Labor : How much, and how employed? Cost?
23. Estimated values of annual sales?
24. Value of grange and other organizations in purchase of materials and sale of crops?
25. Are yields from the land increasing or decreasing?
26. Number of apple, peach, pear and cherry trees; yield of fruit; method of fertilization; spraying and marketing; income from trees?
27. Is the number of various fruit trees increasing or decreasing?
28. Average value of land per acre? Are values increasing or decreasing? To what extent?

INFORMATION TO BE SECURED AT CREAMERIES.

1. Name, location? Is it managed as a co-operative or private enterprise?
2. History of. When established? Changes in equipment and methods?
3. How much milk or cream is being handled?
4. What is the average distance through which milk is carried before it reaches the creamery?
5. On what basis are the patrons paid? Average amount of milk delivered by each patron?
6. What is done with skim milk?
7. What have been the fluctuations in the past ten years in the amounts of milk handled and the prices paid?

It is believed that, when this information has been tabulated and studied in reference to the physical and chemical composition of the soil types on each farm, it will be possible to draw most important conclusions regarding the needs and possibilities of the soils studied. A report upon the soils of Sussex County, with a soil map, will be published as soon as the data can be compiled.

As noted above this work is jointly carried on by the State Geological Survey, the State Agricultural Experiment Station, and the United States Bureau of Soils. The State Survey does a portion of the analytical work; defrays the field cost of the agricultural canvass and contributes to the field expenses of the soil survey.

Geologic map.—The last geological map of the entire State was published in 1890, and has been out of print for many years. Numerous large scale geologic maps of portions of the State have been published in connection with the reports of the Survey, and four folios of the final geologic atlas have been issued, and others are in preparation, but since this is a co-operative work with the Federal Survey, it will be a number of years before folios covering the entire State will be issued. Since there is a demand for a geologic map of the whole State on a moderate scale, it has been determined to prepare one on a scale of 1:250,000 or about four miles to an inch. This work will involve the engraving of a new geographic base as well as the preparation of the color stones showing the geology.

During the summer, Prof. J. V. Lewis was employed in compiling the geologic data for the map, while Mr. Vermeule and his assistants were at work on the geographic base. No new field surveys were necessary, but a vast amount of material had to be gone over carefully in order to incorporate all the corrections of the old base. Prof. Lewis's task was chiefly the transfer of the geologic boundaries from the field and office maps of various survey workers. It did not involve any new field work, although a few days were spent in the field with the State Geologist in an endeavor to obtain decisive data in a few regions where the relations are more than ordinarily complex.

Office work.—For many years the field work of the Survey outran the office work. As a result a vast amount of geologic information has been collected, much of which has never been properly compiled and published. More recently a larger part of the effort of the State Geologist and his assistants has been directed towards the compilation of these data and the preparation of reports. The geologic folios heretofore published and those in preparation are an expression of this side of the Survey's work. Until more of this accumulated data has been worked up it is not expected that any new lines of geologic investigation will be undertaken.

HYDROGRAPHIC WORK.

Underground waters.—The collection of data regarding the underground water supplies of the State has been in charge of Mr. H. M. Poland, and the plan of co-operation with the United States Geological Survey outlined in my last report has been continued. Between forty and fifty well drillers co-operate more or less fully with the department in furnishing data. During the year 104 new records and 37 sets of samples have been received.

I am in frequent receipt of requests for information regarding underground waters at various points in the State. Several well drillers often avail themselves of this opportunity to secure definite information regarding geologic conditions in regions where they are about to sink wells, particularly when operating in a region somewhat unfamiliar to them. During the past year,

also, I have received requests for information from two State institutions—the Rahway Reformatory and the Glen Gardner Sanatorium, both of which desired underground supplies. The Glen Gardner Sanatorium is located in the Highlands in the midst of the oldest rocks of the State—dense, crystalline gneisses. At the request of the Superintendent, I made an investigation of the geology of the Sanatorium grounds and vicinity, the results of which were embodied in the following letter:

TRENTON, N. J., April 12th, 1910.

Dr. S. B. English, N. J. Sanatorium for Tuberculous Diseases, Glen Gardner, N. J.:

DEAR SIR—At your request, I made, on April 11th, an inspection of the Sanatorium grounds to determine, so far as could be done by a surface examination, the possibilities of obtaining an adequate supply of artesian water. I beg to submit the following statement:

Geological Structure.—Numerous outcrops of a gray granite-gneiss occur along the ridge back of the Sanatorium. Similar rock was noticed in railroad cuts and a quarry near the railroad station at Glen Gardner. The same type of rock unquestionably underlies the lower fields both north and south of the central wooded ridge along which the ledges show, although on these lower slopes bed rock may be covered by 10 or 20 feet of stony soil.

In many sandstones the pore space is large, so that such rocks will absorb water to the amount of 20 to 40 per cent. of their volume. On the other hand, very few granites or granite-gneisses have a porosity exceeding 1 per cent. and the average is only one-half of one per cent. or lower. Practically all the water to be obtained from these rocks, therefore, is that present in the cracks and joints which traverse them. Observations on the ledges outcropping above the Sanatorium and elsewhere reveal at least two sets of joints at approximately right angles to each other and steeply inclined, and another set, approximately horizontal. In the quarry and railroad cuts the majority, of these joints were dry, but a few carried some water. The only chance of obtaining water from wells in these rocks is by the boring intersecting one or more large cracks which carry considerable water or a sufficient number of small ones, each of which will contribute its share.

Previous Results. —A large part of Connecticut is underlain by rocks of similar character to those at Glen Gardner, and the results of 300 borings are on record. The yield varied from nothing to 200 gallons per minute, the average being about 15 gallons. Only three wells were reported as yielding more than 100 gallons per minute, and eight wells 60 to 100 gallons per minute, although the yield of several others is reported as "good," "large" or "very large." About 10 per cent. yielded less than 2 gallons per minute.

In New Jersey very similar results have been obtained. Of twelve wells drilled in gneiss and granite near Bernardsville, the average yield was only 15 gallons per minute, although one well was reported to give 100 gallons per minute. I therefore conclude that the chances of obtaining a supply sufficient for the Sanatorium from a single well, while not impossible, are very remote,

probably not one in sixty. The probabilities of a sufficient supply from a number of wells is, of course, better, but it must not be forgotten that 10 per cent. of the wells drilled in Connecticut yielded less than 2 gallons per minute.

Flowing Wells—Very rarely indeed is a flowing well obtained in these rocks. In the Connecticut wells, so far as recorded, the water stood at heights varying from a little above the surface in the case of flowing wells to 100 feet below. It is almost certain that pumping would be necessary in any well drilled at Glen Gardner.

Pumping from Wells vs. *Pumping a Surface Supply.*—In a system of rock wells the water might not rise high enough to permit its being carried by gravity to a receiving tank from which it could be pumped to the reservoir. If this should prove to be the case, it would be necessary to pump directly from the wells. If the total capacity of the wells was only slightly in excess of the requirements of the institution, continuous pumping would be necessary, day and night. Under present conditions I understand that it is necessary to pump only at intervals during the day, which is, of course, much more economical.

Number of Wells Necessary.—If only the average amount of water (15 gallons per minute) was obtained from each well, it would be necessary to put down four wells to obtain the 65,000 gallons per day which I understand is needed and to allow 25 per cent. excess for emergencies.

Depth of Wells Necessary.—The Connecticut wells range from 15 to 845 feet in depth. The deepest of those in New Jersey of which I have record are a little over 700 feet. Experience has shown that the most ample supplies are usually (though not exclusively) found within 250 feet of the surface. Below that depth the chances of obtaining water decrease. Since the cost of drilling also increases with depth, it is usually better not to continue a boring in this rock below 250 or 300 feet. If water has not been obtained within that depth it is usually better to try another hole elsewhere than to continue the old one.

Cost of Drilling.—The cost of a well in this rock will probably be between $4.00 and $5.00 per foot.

Location of Borings.—If it be deemed advisable to make tests, I would say that so far as any surface indications go there is very little choice of location, so long as the rocky, wooded ridge back of the Sanatorium be avoided. I would recommend the lower slope well removed from this ridge and not too close to the present springs, if it be desired to avoid interference with them.

Quality of Water.—Water obtained from rocks through which it has passed in open cracks is more readily polluted from surface sources than water obtained from deep sand beds. In this particular case, however, the risk of pollution is probably no greater than to the water now being obtained from the shallow springs. Water from deep rock wells may contain slightly more mineral matter than that now used, but in the absence of limestone in this region I do not believe it will be hard enough to prove objectionable.

In view of the many uncertainties connected with an underground supply in these rocks, my opinion is that if a satisfactory surface supply can be obtained, it would probably be better not to incur the risk of failure in boring.

Yours truly,

HENRY B. KÜMMEL,
State Geologist.

Subsequently the ground was examined by a self-styled "specialist in hydrogeology," who by the aid of a radio-sensitive hydroscope of his own design claimed to be able to locate the occurrence of large streams of underground water. Later a well was drilled at the spot chosen by the "specialist" with the aid of this modern modification of the old witch-hazel divining rod. A twenty-four-hour pumping test was made on the well on November 1, when the boring had a depth of 500 feet. At the beginning of the test the water stood in the well at a depth of 27 feet from the surface. After the first five hours of pumping the water level sank from 27 to 220 feet from the surface, where it remained constant during the remainder of the test (19 hours). After this constant water level was reached the yield was 16 gallons per minute or about 23,000 gallons per day continuous pumping or only one-third of what is needed. Previously a 5-hour test had been made at a depth of 138 feet, the yield then being 20 gallons per minute. A second test, 5-hour pumping, was made at a depth of 195 feet, resulting in a yield of 23 gallons. It appears, therefore, that there was no increase in the amount of water in the latter 250 or 300 feet on the well.[2]

In this connection it cannot be too strongly emphasized that there are no devices, electrical, radio-active, or of any character whatever, which can be used to determine the occurrence of

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[1]Of this "hydroscope" an eminent authority in radio-active phenomena has expressed the opinion that "the witch-hazel rod was probably the more scientific instrument," and that there was no way that he knew of "by which there is any reasonable probability that deep water could be discovered by its radio-active properties."

[2] Since the above paragraphs were written, and while the report is in the hands of the printer, I have been advised that the well was subsequently deepened to 604 feet, the water standing 22 1/2 feet from the surface, and on pumping the well yielded 20 gallons per minute. In order to increase the yield 650 lbs. of powder were exploded at the bottom and 350 lbs. at a depth of 328 feet. The water-level then dropped to 33 1/2 feet from the surface. A 48-hour continuous pumping test was made, the yield for 20 hours being 42 gallons per minute and for 28 hours from 63 to 66 gallons per minute. At the conclusion of the pumping test the water-level stood at 82 feet from the surface. Subsequently two additional shots were fired, 350 lbs. of powder at 450 feet and 150 lbs. at 225 feet. Their effect has not been reported to me, but the supply as shown by the tests already made is a great improvement over that previously had.

underground water. The devotee of the time-honored witch-hazel twig and the pseudo-scientist with his recent invention and jumble of scientific terms designed to impress the non-technical man are alike conscious or unconscious fakers. That in many localities the occurrence of ground water is indicated by surface conditions is a fact known to all; that the manipulator of the witch-hazel and all other water-finding devices consciously or subconsciously notes these signs and "works" the device accordingly is unquestionably the explanation of many apparently successful instances of their use, and the fact that in some regions a well dug at any point will furnish abundant water is explanation of other seemingly successful attempts. Much emphasis is laid upon the cases where water has apparently been located by their use. Nothing is ever said of the numerous instances where they have been absolute failures.

At the Rahway Reformatory a flowing well was obtained in the red shale formation (Triassic) at a depth of 490 feet (total depth 504 feet), the water having a five-foot head above ground and flowing at the surface 35 gallons per minute. On pumping 125 gallons per minute for 15 minutes the water is lowered 150 feet, the yield being maintained at 62 gallons per minute at that depth. Analysis by the State Board of Health showed the water to be extremely hard—2,041 parts of total solids in 1,000,000, and having a total hardness of 310. Sodium sulphate and a compound of magnesium were present in considerable amount.

Surface supplies.—No additional studies of the surface supplies of the State have been made during the year. The drought which prevailed during much of the summer and fall placed a severe strain upon many reservoirs and in some cases drew them down beyond the safety limit. The shortage of water in many communities emphasized the importance of the wise solution of this problem, but it is important that the lessons of the year should be correctly learned and the facts not misinterpreted. There was nothing in the experience of the year to invalidate to the slightest degree the conclusions of the Survey, based upon long and careful study of the streams of the State, that the aggregate amount of potable surface water is far in excess of

the present needs of the State and of all future needs for many, many years to come, even though the population increases in density far beyond any reasonable anticipation.

The lesson, as I interpret it, is the necessity of providing reserve supplies sufficient to meet such droughts as previous experience, evidenced by the records of the Weather Bureau, give us the right to expect. These should be provided in storage reservoirs of sufficient capacity to meet the demands of the severest drought there is any reason to expect, or in case of underground supplies, in the development of new territory by additional wells sufficiently in excess of ordinary demands to meet such emergencies. The fact that several large water companies of the State were hard put to meet the legitimate demands of the communities dependent upon them was due entirely to a failure to provide the necessary reserves which rapidly growing communities and annual variations in rainfall make absolutely necessary. It was not due to a shortage of surface supplies, for there are many streams as yet undeveloped, and even on those watersheds now utilized the storage capacity provided is in most instances far less than necessary to develop the total capacity of the watershed.

Inasmuch as several communities in the northern part of the State are, or will be, in need of additional supplies in the near future, I wish to call attention to the possibility of the further development of the upper Passaic watershed by means of several small reservoirs constructed from time to time as necessity demands. This plan was worked out in much detail in the report by Mr. C. C. Vermeule published in the Annual Report of the State Geologist for 1909. It was accompanied by a map showing the location of existing and proposed reservoirs, and the sources of supply of the various portions of the Metropolitan district. The question of an adequate and economical development of the water resources of the State is so great and contains so many diverse factors, that it needs to be examined from all points of view, and every possible means of solution thoroughly tested. In the final solution of the problem the suggestions set forth in that report should certainly have great weight.

CHEMICAL WORK.

Mr. R. B. Gage has continued in charge of the chemical laboratory, with F. H. Baumann and J. Clifford Wilkes as assistants, the latter being employed during the busy season from June 10 to Sept. 10. The major part of the work undertaken has been the analyses of soils, road oil and asphalt, although some work on minerals has been done.

Soil Analyses.—The chemical analyses of soils collected in progress of the soil survey is a part of the contribution of the Survey to the co-operative work which is being carried on in conjunction with the United States Bureau of Soils and the State Agricultural Experiment Station. During the year about seventy-five complete soil analyses have been made, many of them in duplicate and each consisting of at least sixteen separate determinations, so that about 1,200 determinations have been made and reported and probably 800 others made as checks or duplicates. This work has been very carefully done, and much time and attention given to small quantities of certain compounds or ingredients which may or may not be present. Owing to the fact that the work has to be done in a building not designed for a laboratory and under conditions which are far from favorable to accurate results, much time is consumed in precautions to guard the work from error—precautions which would be unnecessary in a properly constructed laboratory.

As the work progressed it seemed advisable to modify some of the commonly accepted methods of soil analysis to secure a greater degree of accuracy and save time, while in some cases new methods for this line of work have been devised. Some new forms of apparatus have been designed and found to be very efficient and accurate. It was necessary, however, to subject all these methods and apparatus to thorough tests on all the various types of soil before they could be adopted. This demanded much work, which will not have to be repeated, but the time spent will be more than saved before the entire work is completed.

Minerals.—A few analyses of miscellaneous substances have been made for private persons upon payment of a fee equivalent

to that charged by commercial laboratories. The Survey does not solicit work of this character, but it is frequently called upon to make analyses of water, ore, etc., by persons who either assume that the gratuitous analysis of any ore for a citizen of the State is one of the regular functions of the Survey, or, expecting to pay a fee, have more confidence in an analysis made in an official laboratory, or who do not know a reliable chemist or assayer to whom to apply. Generally the applicant is referred to a private laboratory. Occasionally when the analysis can be made without interfering with the regular work it is done and a fee charged. In rare instances it is made without charge, when the results seem to be of value to investigations of the Survey already undertaken. In all such cases the right to use the results as may seem desirable in Survey work is reserved.

Mr. Gage has also been called upon to make a number of analyses of rare or obscure minerals to determine their identity, material for this purpose being received from the mineral collections of Harvard and Princeton Universities, Rutgers College, the American Museum of Natural History and from the large collection of Col. Washington A. Roebling of Trenton, as well as from other mineralogists. This work has resulted in the discovery of at least one new mineral and probably two others. Justification for work of this semi-private character is found in the possibility that new minerals may thereby be discovered. It does not involve the analysis of every mineral which may be presented at the laboratory, but is restricted to those rare, peculiar or unknown forms which may be new to science. The Survey reserves the right of publication of these results if it seems advisable.

The new mineral[1], the existence of which has been demonstrated, occurs on leucophoenicite from Franklin Furnace, associated with the typical minerals of that region, crystalline zincite, green willemite and calcite. Owing to the extremely

[1] A preliminary note of this mineral was published by Alexander H. Phillips, of Princeton University, in the American Journal of Science for October, 1910, Series 4, Vol. XXX, p. 283, and the name *gageite* proposed. It is hoped that later Prof. Phillips will be able to measure its crystal faces and angles.

minute size of the crystals and their scarcity, it was a matter of much difficulty for Mr. Gage to obtain enough for a chemical analysis. Finally, through the co-operation of Col. W. A. Roebling, about .04 of a gram were obtained and analyzed by him with the following results:

				Ratio.
SiO_2,.....	24.71	.412	\	1.49
MnO, ...	50.19	.707	|	
ZnO, ...	8.76	.107	├ 1.109	4.00
MgO, ...	11.91	.295	|	
H_2O, ...	(4.43)	.224	/	0.9

This yields the formula $(RO)_8\ (SIO_2)_3\ .2H_2O$. "The crystals are clear and colorless, with a high vitreous luster, delicate, acicular and hair-like, often radiated and grouped in bundles extending out from the wall of small cavities, not unlike the habit of millerite."

It is anticipated that these mineralogical studies will yield enough material to justify the publication during the coming year of a bulletin relating solely to them.

Oils and asphalts.—Co-operation with the State Road Commissioner in the examination and testing of oils and asphalts used in road construction has continued. Upwards of 325 samples of these materials were analyzed during the year, in the course of which 1,200 separate determinations were made. The importance of having these oils and asphalts thoroughly tested and their value for road building established before they are used on the road has been very plainly demonstrated during the past year. Not all oils or asphalts will make good roads. The cheaper ones are naturally of the lowest grades and least desirable, but are the ones the contractors would naturally use, if the selection of these materials was left to their discretion, since it would mean an additional profit. It is next to impossible to distinguish between these various bitumens unless they are analyzed. If the cost of construction and maintenance of the improved roads of New Jersey per year be considered, the amount of money required to test the oils and asphalts used in their construction is so small that it is almost negligible. If the life of a single mile of road

has been doubled by these tests, the total cost of testing the oils and asphalts used during the entire year on all the roads of the State will be far more than repaid. A rough idea can thus be secured of the saving to the State by being sure in advance of the quality of the material which is used in the construction of this type of road.

The expense of this work is defrayed in large part by the State Road Commissioner, from whose appropriation there are paid the salaries of the assistants making the analyses, but in so far as Mr. Gage has given his personal attention to this work, there has been a charge upon the Geological Survey appropriation. This charge has in part been compensated for by the help in soil analyses received from the assistants when the demands of the oil work were not pressing.

The purchase and testing of coal.—A large part of the coal now used by the United States Government is purchased on specifications involving the number of heat units contained therein, and is paid for on a sliding scale based upon the heat units, per cent. of ash, sulphur, etc. Many of the commodities of life have long been purchased according to specifications requiring chemical or physical tests or both to determine whether the material delivered meets the requirements, but until recent years coal has been purchased merely on the statement of the dealer as to its quality. Reliance has been placed on his integrity and on the reputation of the mine or district from which the coal was obtained. This practice still prevails among all small purchasers, but many large corporations and the National Government have adopted specifications providing for scientific tests of the coal purchased and its payment on a sliding scale according to quality. The advantages of this method are manifest, the purchaser pays for what he gets and gets what he pays for. The dealer receives a higher price for superior grades of coal and is penalized for inferior grades. The poorer coals find a market by competing with the better grades, not as to price per ton, but as to the cost of an equal number of heat units.

The most valuable coal is one which gives up the most heat for a given weight burned. Some of the factors determining its value are moisture, ash, sulphur and clinker, volatile gases and

fixed carbon. These vary within considerable limits even in commercial coals of recognized standing, and the variations all have their bearing on the heating power of the coal.

Moisture.—Coal as mined contains more or less moisture, and in shipment it may be either dried out or drenched by rain. If in a ton of coal the moisture equals 5 per cent (a not unusual amount for some grades), the purchaser buys 100 lbs. of water with every ton, which not only cannot burn, but which consumes in its evaporation a very considerable part of the heat produced when the coal is burned, and on which freight and cartage has been paid.

Ash.—Earthy matter and other impurities which will not burn are classed as ash. In commercial coals the proportion of ash may range from *4 to 25 per cent.* It is manifest that coals containing small amounts of ash have higher heating capacity than those high in ash. They also offer less resistance to the free distribution of air through the fire, and the added expense of handling large amounts of ash must not be overlooked. With an ordinary furnace equipment there is a considerable loss of efficiency and capacity with a large percentage of ash. In some experiments coal containing as high as 40 per cent of ash would generate no steam. Under the conditions of the experiment such coal would be not only worthless, but its use would involve a direct expense due to the cost of handling it.

Sulphur in coal with other impurities often forms a clinker which clogs the grates, shuts out the air and increases the labor of handling the furnace. Hence coals low in sulphur are regarded as the more desirable.

The coal bill of the various State Institutions of New Jersey is upwards of $125,000 per annum. In the past none of this coal has been purchased under specifications providing for a test of its heating properties. In view of the advantage which it is believed would result in the application of a more exact method of purchase the Board of Managers of the Survey has directed the State Geologist to co-operate with any State Institution desiring to purchase coal under a more exact plan. The Survey will, when requested, assist in drawing up the necessary specifications and will make the required tests of the coal as it is

delivered. This will be done without cost to the institutions, except that the sampling must be done by an officer of the institution and the reduced sample forwarded to the Survey laboratory. In beginning this work, it will be restricted at first to anthracite coal, since facilities at present available at the Survey laboratory for this work are rather limited. and the testing of anthracite is more readily done than bituminous.

INLAND WATERWAY SURVEY.

On April 6, 1910, the Legislature passed the following concurrent resolution:

"WHEREAS, The construction of the inland waterway along the New Jersey coast has already shown in a marked degree the advisability of such an improvement; and

"WHEREAS, There is a general demand that the same be continued by means of a canal from Bay Head in Ocean county to the Shrewsbury River in Monmouth county; therefore be it

"*Resolved* by the House of Assembly (the Senate concurring), That the State Geologist be directed from such data as may be in his possession to ascertain the approximate cost of the construction of a sea-level canal, with minimum depth of six feet and minimum width at the water level of sixty feet between Bay Head and the Shrewsbury River, and to report thereon at the next session of the Legislature.

"*Resolved,* That the Governor be authorized to appoint two competent residents of the State, who, shall estimate the value of the real estate necessary to be taken for the line of such canal, their estimate thereon to be incorporated in the report of the State Geologist."

It will be noted that the resolution did not carry with it any appropriation of money, nor did it direct or authorize any survey of a canal route. It directed only the preparation of an estimate made up from data already in the possession of the survey. This data consisted of published topographic maps on a scale of 2,000 feet per inch, with contour intervals of 10 feet, manuscript geological maps of the rock formations and well borings showing strata. There was also a detailed report of the cost of a canal for a part of the route, namely from Bay Head to Manasquan Inlet, made in 1903.

Although no funds were appropriated specifically for this work, a small part of the regular Survey appropriation was avail-

able for incidental expenses in this connection. The most available route was located upon the topographic maps, and afterwards checked by field inspection. A profile of the route was then taken from the topographic map and the amount of excavation calculated.

Full details of the route, cost, etc., so far as they can be determined in a preliminary estimate of this character, are given in a separate report which is accompanied by maps and sections. It is sufficient to state here that the estimated excavation amounts to over 7,000,000 cubic yards; the cost of excavating and disposal of material from $970,000 to $1,758,000, according to plan adopted; drawbridges about $380,000 and right-of-way, including land for dumping, $200,000 to $400,000, administration, engineering, legal and contingent expenses 10 per cent., making a total of $2,152,000 to $2,784,000. Reference is made to the special report for fuller details. It must be understood that this line of inquiry was not initiated by the Survey, but was undertaken in response to the direction of the Legislature.

CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

The State Survey co-operates with the United States Geological Survey in the publication of geologic folios, which are parts of the geologic atlas of the State, in the collection and recording of well data and in the collection of mineral statistics. During the past year, however, the co-operative work in statistics was by mutual agreement suspended owing to taking the National census, which made it incumbent upon the United States Survey to work in harmony with the Census Bureau. Under the circumstances, it did not seem best for the State Survey to duplicate the statistical work in all lines, but data regarding the production of iron-ore, zinc-ore, cement and limestone for 1909 were obtained and the results published in the report for 1909, which was somewhat delayed in printing.

The statistics for 1910 will be collected in co-operation with the United States Geological Survey and made public in a special bulletin to be printed as soon as the full returns can be collected. The results of co-operation in collecting the well records have

already been mentioned (see p. 20). The method pursued is fairly effective, provided it is constantly followed up by personal visits to the drillers and by inspection of the work to insure correct records and the saving of samples. This Mr. Poland has been able to do in large measure.

NEEDS OF THE SURVEY.

The greatest need of the Survey is better accommodations for carrying on its work. The offices provided in the State House are as large as the crowded condition of that building will permit, but they are entirely inadequate for the proper conduct of this department. The general office is shared with the Forest Commission. The office of the State Geologist, a small room, is also the library and is crowded with book shelves and filing cases. The vault, containing valuable records to which more or less frequent reference has to be made, is on another floor of the State House, off a room belonging to the Supreme Court Clerk's suite. Two assistants occupy a small room in the basement so dark that artificial light must always be used. Still another assistant has a desk in an obscure corner of the basement surrounded by discarded voting machines and junk of various kinds. The reports and collections of the Survey are stored in three different sections of the basement. In the aggregate, the storage room is fairly adequate, but its diffusion adds greatly to its inconvenience. Year by year the chemical laboratory has become of increasing importance. For several years it has occupied and still occupies, through the courtesy of Col. Washington A. Roebling, one of the Board of Managers of the Survey, the second story of a building several blocks removed from the State House. The building is but poorly adapted for a chemical laboratory, but is the best obtainable at present and has been made to serve our purpose. However, as the Survey is a tenant only by courtesy of the owner, its occupancy of these quarters can be regarded at best as only a temporary expedient until something better can be provided, It seems hardly consonant with the dignity of the State that it should have to depend upon the generosity of a private citizen for accommodations for one of its departments.

The work of a scientific bureau for investigation and research cannot be successfully carried on under conditions which may be satisfactory for business and administration. Those engaged in research must have adequate laboratory and office room where experiments can be conducted under conditions favorable to accurate results, and where reports can be prepared free from interruption. The writer knows of no State Survey so poorly provided with suitable quarters for its work as is the New Jersey Survey. The support afforded the Survey both in annual appropriations and provision for printing its results has always been generous and hearty. No state has ever done so much for so many years in proportion to its size. The next step is an appreciation of the needs of the Survey in the way of larger quarters, better adapted to our work, and designed to bring closer together the widely separated branches of the department.

PUBLICATIONS.

The appended list makes brief mention of all the publications of the present Survey since its inception in 1864, with a statement of the editions now out of print. The reports of the Survey are distributed without further expense than that of transportation. Single reports can usually be sent more cheaply by *mail* than otherwise, and requests should be accompanied by the proper postage as indicated in the list. Otherwise they are sent *express collect. When the stock on hand of any report is reduced to 200 copies, the remaining volumes are withdrawn from free distribution and are sold at cost price.*

The maps are distributed only by sale, at a price, 25 cents per sheet, to cover cost of paper, printing and transportation. In order to secure prompt attention, requests for both reports and maps should be addressed simply "State Geologist," Trenton, N. J.

CATALOGUE OF PUBLICATIONS.

GEOLOGY OF NEW JERSEY. Newark, 1868, 8vo., xxiv+899 pp. Out of print.

PORTFOLIO or MAPS accompanying the same, as follows:

1. Azoic and paleozoic formations, including the iron-ore and limestone districts; colored. Scale, 2 miles to an inch.
2. Triassic formation, including the red sandstone and trap-rocks of Central New Jersey; colored. Scale, 2 miles to an inch.
3. Cretaceous formation, including the greensand-marl beds; colored. Scale, 2 miles to an inch.
4. Tertiary and recent formations of Southern New Jersey; colored. Scale, 2 miles to an inch.
5. Map of a group of iron mines in Morris County; printed in two colors. Scale, 3 inches to 1 mile.
6. Map of the Ringwood iron mines; printed in two colors. Scale, 8 inches to 1 mile.
7. Map of Oxford Furnace iron-ore veins; colored. Scale, 8 inches to 1 mile.
8. Map of the zinc mines, Sussex County; colored. Scale, 8 inches to 1 mile.

A few copies can be distributed at $2.00 per set.

REPORT ON THE CLAY DEPOSITS of Woodbridge, South Amboy and other places in New Jersey, together with their uses for firebrick, pottery, &c. Trenton, 1878, 8vo., viii+381 pp., with map. Out of print.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi+233 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. I. Topography. Magnetism. Climate. Trenton, 1888, 8vo., xi+439 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8vo., x+642 pp. Unbound copies, postage, 25 cents. Bound copies, $1.50.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 8vo., x+824 pp. (Postage, 30 cents.)

REPORT ON WATER-SUPPLY. Vol. III. of the Final Reports of the State Geologist. Trenton, 1894, 8vo., xvi+352 and 96 pp. (Postage, 21 cents.)

REPORT ON THE PHYSICAL GEOGRAPHY of New Jersey. Vol. IV. of the Final Reports of the State Geologist. Trenton, 1898, 8vo., xvi+170+200 pp. Unbound copies, $1.00 cloth bound, $1.35, with photo-relief map of State, $2.85. Map separate, $I.50.

REPORT ON THE GLACIAL GEOLOGY of New Jersey. Vol. V. of the Final Reports of the State Geologist. Trenton, 1902, 8vo., xxvii+802 pp. (Sent by express, 35 cents if prepaid, or charges collect.)

REPORTS ON CLAYS AND CLAY INDUSTRY of New Jersey. Vol. VI. of the Final Reports of the State Geologist. Trenton, 1904, 8vo., xxviii+548 pp. (Sent by express, 30 cents if prepaid, or charges collect.)

BRACHIOPODA AND LAMELLIBANCHIATA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1886, quarto, pp. 338, plates XXXV. and Map. (Paleontology, Vol. I.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.5o, charges prepaid.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, Plates L. (Paleontology, Vol. II.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.40, charges prepaid.)

PALEOZOIC PALEONTOLOGY. Trenton, 1903, 8vo., xii+462 pp., Plates LIII. (Paleontology, Vol. III.) (Price, $1.00.)

CRETACEOUS PALEONTOLOGY. Trenton, 1907, 8vo., ix+1106 pp., Plates CXI. (Paleontology, Vol. IV.) (Price, $2.70.)

ATLAS of NEW JERSEY. The complete work is made up of twenty sheets, each about 27 by 37 inches, including margin. Seventeen sheets are on a scale of 1 inch per mile and three on a scale of 5 miles per inch. It is the purpose of the Survey gradually to replace Sheets 1-17 by a new series of maps, upon the same scale, but somewhat differently arranged so as not to overlap. The new sheets will be numbered from 21-37, and will be subject to extensive revision before publication. These sheets will each cover the same territory as eight of the large maps, on a scale of 2,000 feet per inch. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 15, 16 and 17 have already been replaced as explained below. *No. 10. Vicinity of Salem* from Swedesboro and Bridgeton westward to the Delaware.

No. 14. Vicinity of Bridgeton, from Alloway stown and Vineland southward to the Delaware Bay shore.

No. 19. New Jersey Relief Map. Scale, 5 miles to the inch. Hypsometric.
No. 20. New Jersey Geological Map. Scale, 5 miles to the inch. (Out of print.)
No. 21. Northern Warren and Western Sussex counties. Replaces Sheet 1.
No. 22. *Eastern Sussex and Western Passaic counties.* Replaces Sheet 4.
No. 23. Northern Bergen and Eastern Passaic counties, to West Point, New York. Replaces northern part of Sheet 7.
No. 24. Southern Warren, Northern Hunterdon and Western Morris counties. Replaces Sheet 2.
No. 25. Morris and Somerset counties, from Lake Hopatcong to Somerville and New Brunswick. Replaces Sheet 6.
No. 26. Vicinity of Newark and Jersey City—Paterson to Perth Amboy. Replaces in part Sheet 7.
No. 27. Vicinity of Trenton—Raven Rock to Palmyra, with inset, Trenton to Princeton. Replaces Sheet 5.
No. 28. Trenton and Eastward—Trenton to Sayreville. Replaces Sheet 8.
No. 29. Monmouth Shore, with the interior from Ernston to Lakehurst. Replaces Sheet 9.
No. 31. Vicinity of Camden, to Mount Holly, Hammonton and Elmer. Replaces Sheet 11.
No. 32. Part of Burlington and Ocean counties, from Pemberton and Whitings to Egg Harbor City and Tuckerton. Replaces Sheet 12.
No. 33. Southern Ocean County—Tuckerton to Tom's River and Chadwicks. Replaces Sheet 13.
No. 35. Vicinity of Millville, from Newfield to Port Norris and Cape May Court House.
No. 36. Parts of Atlantic and Cape May counties—Egg Harbor City to Townsend's Inlet, with inset of New Inlet and Great Bay.
No. 37. Cape May—Cape May City to Ocean City and Mauricetown.
No. 38. New Jersey State Map. Scale, 5 miles to the inch. Shows all municipalities.

Other sheets of the new series, Nos. 21-37, will be printed from time to time, as the older sheets become out of print. All the maps are sold at the uniform price of twenty-five cents per sheet, either singly or in lots. Since the Survey cannot open small accounts, and the charge is merely nominal, remittance should be made with the order. Order by *number* of the State Geologist, Trenton, N. J.

TOPOGRAPHIC MAPS, NEW SERIES.

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THE ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1864. Trenton, 1865, 8vo., 24 pp. Out of print.

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