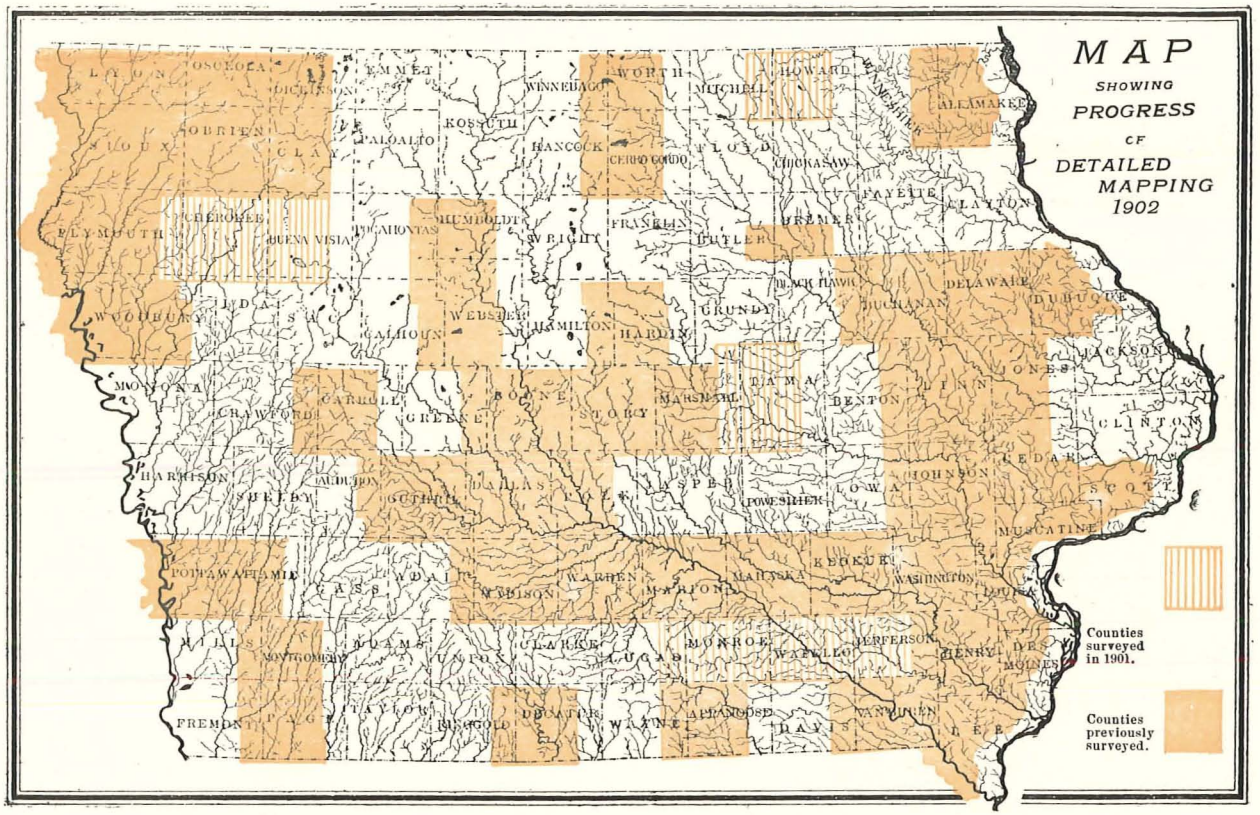
ADMINISTRATIVE REPORTS


MAP
SHOWING
PROGRESS
OF
DETAILED
MAPPING
1902
Counties surveyed in 1901.
Counties previously surveyed.
LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
O'BRIEN
CLAY
PALO ALTO
KOSSUTH
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
TAMA
BENTON
LINN
JONES
JACKSON
CLINTON
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
CEDAR
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE

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faces p. 11 (v. 12)

TENTH ANNUAL

Report of the State Geologist.

IOWA GEOLOGICAL SURVEY,
DES MOINES, DECEMBER 31, 1901.

To Governor Leslie M. Shaw and Members of the Geological Board:

GENTLEMEN:—The work of the Iowa Geological Survey, during the year 1901, has not differed essentially from the work carried on during the years preceding, since the present Survey was organized. Investigations respecting the characteristics and surface distribution of the geological formations of Iowa are not yet complete. The work already done has been purposely scattered so as to gain information concerning each of the important and typical portions of the state; and it may now be claimed that we know in a general and broad way the geological structure at any given point from the surface down to the underlying crystalline rocks; while over more than half the state our knowledge is positive and accurate. Before, however, the study of special subjects for the state as a whole can be taken up with desired thoroughness and success, the geological details for practically every county should be carefully worked out. More than half the work of detailed mapping has been finished. Prior to the year 1901 forty-six counties had been studied with the requisite thoroughness, and reports, accompanied with geological maps, have been published in relation to forty-four. During the year 1901 the geological work was completed in seven counties—namely, Buena Vista, Cherokee, Howard, Jefferson, Monroe, Tama and Wapello; and work has been begun in Adair,

Bremer, Clayton, Fayette, Ida, Sac, Taylor and Winneshiek. Fifty-three counties are now completed, and in eight others the work is more or less advanced.

The regular corps employed in field work in 1901 was made up of Beyer, Calvin, Leonard, Macbride, Norton, Savage, Udden, Wilder and Young; and in addition there were three volunteer assistants, Gow, Mosnat and Schoonover. The members of the regular corps are men whose familiarity with the problems of Iowa geology enables them to carry on their investigations with a thoroughness which overlooks no significant detail, however minute, while at the same time the work is done with a minimum expenditure of time and money.

As stated in the last Administrative Report, some work on special subjects has already been undertaken. Professor Beyer is still at work on his monograph on Iowa clays. Professor Wilder's report on Webster county, which is offered for publication as part of volume XII, is in effect a monograph in which the extent and possibilities of the gypsum deposits of the state are discussed with exhaustive and scientific fullness. The monograph of Leonard in volume VI and the report on Dubuque county in volume X give the results of careful and laborious investigations relating to the genesis and distribution of the lead and zinc ores of Iowa. It is the purpose soon to begin a special study of the building stones, lime burning rocks and other quarry products of the state; and there is planned, for the near future, a monograph on coal, defining the areas in which prospecting may be prosecuted with reasonable hope of success, accurately marking the limits beyond which no coal is possible, pointing out for the various localities the depth beneath which it is useless to carry the prospect holes, describing the manner in which the workable veins are distributed in the coal bearing area, giving determinations with respect to fuel values, and setting forth all other facts which could be of possible service to the miners and users of Iowa coals.

It is a pleasure in this connection to note the verification of the statements made on pages 453 and 458 of volume XI, to the effect that coal mining in Page county is capable of much greater development than it has yet attained, and that the Nodaway coal

seam is certain to be worked in many neighborhoods where it is not yet prospected. A number of new mines have been reported as opened in the county during the past year, and one at least of these is located on state property, on grounds belonging to the Clarinda Hospital for the Insane. The Nodaway seam is unusually persistent and uniform. The prospector can know beforehand with almost absolute certainty, the thickness and the quality of the coal he is to find. The dip is not uniform, and so the exact depth beneath the surface at which the coal will be found at any given point can not be told to a foot, or even to ten feet; but the coal is present over a very large area, and it is so located with reference to the surface that it will be practicable to mine it over at least half the county. This same coal is present over extensive areas in Adams, Montgomery and Taylor counties and will afford fuel to meet all local needs for many years to come.

In addition to the work done in the field, the large amount of purely clerical and administrative work belonging to the office has been kept up to date. The Des Moines office has been managed by the Assistant State Geologist, Mr. A. G. Leonard, with the assistance of the Secretary, Miss Nellie E. Newman. Two volumes have been isued by the Survey during the year—volume XI of the regular series of reports and volume I of the series of Bulletins. The personal attention necessary to getting out these volumes in acceptable form has occupied a large share of the time of the Assistant State Geologist; but in addition to supervising every detail in connection with the preparation and distribution of the volumes, Mr. Leonard has been able to do practically a full season's field work in Wapello county. For a full account of his work in the office and in the field, you are referred to his Administrative Report, which is herewith submitted.

Bulletin No. 1, which is a report on the Grasses of Iowa, by Professors Pammel and Weems of the State College of Agriculture, has been most cordially received by those qualified to judge of its merits, as a welcome and important contribution to practical science. The favor accorded to volume XI has been equally gratifying. The edition of each volume of the geological series is practically exhausted as soon as it is issued. Were all requests

for copies of the reports granted, the edition would have to be more than twice as large as it is.

Accompanying this report I have the honor of submitting for publication, as volume XII of the Iowa Geological Reports, the Mineral Statistics for the year, by S. W. Beyer; the report on Webster county, with a general discussion of the manufacture and uses of gypsum, by Frank A. Wilder; the report on Henry county, by T. E. Savage; the report on Cherokee and Buena Vista counties, by T. H. Macbride; the report on Jefferson county, by J. A. Udden; the report on Wapello county, by A. G. Leonard; and the report on Monroe county, by S. W. Beyer and L. E. Young. The four counties, Henry, Jefferson, Wapello and Monroe, are among the most important in the state. They are all embraced in the Carboniferous area. In the eastern part of the belt which these counties occupy, we have a record of Carboniferous conditions immediately preceding the deposition of coal; in the western part of the area the record is that of conditions the most favorable known in Iowa for coal accumulation. Cherokee and Buena Vista are prairie counties in which the indurated rocks and all for which they may stand are buried under thick sheets of drift. The drift, however, is the youngest and freshest in the state and is unusually rich in all the constituents which go to make up an ideal soil. Through these counties pass the margin of the Wisconsin drift, and the special effects of the forces operative along the margin of the great ice fields of this particular age, so far as they have been instrumental in modifying the topography of the surface and the quality of the soils, have been carefully studied. Webster county, in addition to its coal and other products, embraces our gypsum field. The gypsum deposit is one of very great economic importance; and the subject, in all its aspects, has been studied with the care and thoroughness which its importance deserves. It is believed that the volume as a whole is fully up to the standard of its predecessors, and that it will meet the just expectations of the people of Iowa in providing, in accessible form, definite information respecting the geological structure and geological resources of some of the most important counties in the state. The extent of the work accom-

plished by the Survey since its organization may be inferred from the following list of publications:

VOLUME I. FIRST ANNUAL REPORT, 1892.

480 Pages, 10 Plates, 26 Figures.
Price, in paper, 70 cents; postage, 26 cents.

Contents:

VOLUME II. COAL DEPOSITS.

536 Pages, 18 Plates, 251 Figures.
Price, in paper, 70 cents; postage, 31 cents.

Contents:

VOLUME III. ANNUAL REPORT, 1893.

501 Pages, 37 Plates, 34 Figures.
Price, in cloth, $1.10; postage, 35 cents.
In paper, $1; postage, 30 cents.

Contents:

VOLUME IV. ANNUAL REPORT, 1894.

467 Pages, 11 Plates, 6 Maps, 54 Figures.
Price, in cloth, $1.25; postage, 34 cents.
In paper, $1; postage, 28 cents.

Contents:

VOLUME V. ANNUAL REPORT, 1895.

452 Pages, 14 Plates, 7 Maps, 72 Figures.
Price, in cloth, $1; postage, 34 cents.
In paper, 85 cents; postage, 28 cents.

Contents:

VOLUME VI. LEAD AND ZINC, ARTESIAN WELLS, ETC.

487 Pages, 28 Plates, 57 Figures.
Price, in cloth, 85 cents; postage, 34 cents.
In paper, 70 cents; postage, 28 cents.

Contents:

VOLUME VII. ANNUAL REPORT, 1896.

550 Pages, 11 Plates, 11 Maps, 81 Figures.
Price, in cloth, $1.30; postage, 34 cents.
In paper, $1.15; postage, 32 cents.

Contents:

VOLUME VIII. ANNUAL REPORT, 1897.

427 Pages, 32 Plates, 6 Maps, 13 Figures.
Price, in cloth, $1.30; postage, 30 cents.
In paper, $1.15; postage, 26 cents.

Contents:

VOLUME IX. ANNUAL REPORT, 1898.

572 Pages, 13 Plates, 7 Maps, 56 Figures.
Price, in cloth, $1.45; postage, 36 cents.
In paper, $1.30; postage, 30 cents.

Contents:

Geology of Humboldt County; by T. H. Macbride.
Geology of Story County; by S. W. Beyer.
Geology of Muscatine County; by J. A. Udden.
Geology of Scott County; by W. H. Norton.
Artesian Wells of the Belle Plaine Area; by H. R. Mosnat.

VOLUME X. ANNUAL REPORT, 1899.

666 Pages, 11 Plates, 11 Maps, 102 Figures.
Price, in cloth, $1.85; postage, 40 cents.
In paper, $1.70; postage, 36 cents.

Contents:

Administrative Reports.
Statistics of Mineral Productions; by S. W. Beyer.
Fossil Fauna of the Kinderhook Beds of Burlington; by Stuart Weller.
Geology of Lyon and Sioux Counties; by F. A. Wilder.
Geology of Osceola and Dickinson Counties; by T. H. Macbride.
Geology of Hardin County; by S. W. Beyer.
Geology of Worth County; by Ira A. Williams.
Geology of Dubuque County; by Samuel Calvin and H. F. Bain.

VOLUME XI. ANNUAL REPORT, 1900.

519 Pages, 12 Plates, 9 Maps, 43 Figures.
Price, in cloth, $1.45; postage, 32 cents.

Contents:

Administrative Reports.
Mineral Production of Iowa in 1900; by S. W. Beyer.
Geology of Louisa County; by J. A. Udden.
Geology of Marion County; by B. L. Miller.
Geology of Pottawattamie County; by J. A. Udden.
Geology of Cedar County; by W. H. Norton.
Geology of Page County; by Samuel Calvin.
Geology of Clay and O'Brien Counties; by T. H. Macbride.

The work of our geologists, in co-operation with members of the U. S. Geological Survey, has made Iowa classic ground for the study of problems relating to the drift. The succession of events which took place during that most interesting and most unique of all the divisions of geological time, the Glacial Epoch, is more clearly recorded in Iowa than anywhere else on this continent. It was formerly supposed that there was a single invasion of glacial ice which transported and spread out the great body of drift that covers so large an area in North America; but instead of the single glacial episode recognized by the earlier

observers, there are clear and detailed records of at last five successive ice invasions separated one from the other by long interglacial intervals. Brief notes on the glacial and interglacial stages, as they have been deciphered in Iowa and adjoining states, were published on pages 18 and 19 of volume VII. The facts remain as there stated, but additional facts which have come to light through more careful and detailed studies, particularly through the work of Leverett of the United States Geological Survey, make some changes in the names used in volume VII desirable. The terms employed in the more recent literature of this subject, for the recognized glacial and interglacial stages of the Great Ice Age are:

First glacial stage, *Pre-Kansan* or *Sub-Aftonian.*
First interglacial stage, *Aftonian.*
Second glacial stage, *Kansan.*
Second interglacial stage, *Yarmouth.*
Third glacial stage, *Illinoian.*
Third interglacial stage, *Sangamon.*
Fourth glacial stage, *Iowan.*
Fourth interglacial stage, *Peorian.*
Fifth glacial stage, *Wisconsin.*

The Wisconsin drift is very much younger than the Kansan or the pre-Kansan. There is an enormous interval between the earliest and the latest of the ice invasions. The earlier glacial and interglacial stages seem to have been longer than those of later date. Some of the interglacial intervals were many times as long as the period which has elapsed since the disappearance from Iowa of the great ice fields which characterized the Wisconsin stage of glaciation. If the time since the Wisconsin is taken as unity, the time since the Kansan is at least twenty; the history of glaciation in Iowa is long, the records are exceedingly complex.

The pre-Kansan drift nowhere expresses itself at the surface; it has been exposed in a few places by the erosion of stream valleys; but the most satisfactory sections, showing the characteristics and relations of this oldest of all the known mantles of till, are found in railway cuts and other artificial excavations. In

the report on Page county, volume XI, pages 411 and 447, there are suggestions that the surface drift of southwestern Iowa may possibly be pre-Kansan. The reasons for making these suggestions were found in the enormous changes which the drift of the region has undergone. The surface of the drift has been deeply eroded. Valleys have been cut in it from 100 to 200 feet in depth and two, three or four miles in width. The whole surface of the country, even on the divides, is deeply carved and trenched; while weathering, measured in all its aspects and effects, has wrought profound changes in the deposit to unusual depths. The whole body of the till is completely altered to depths of forty or fifty feet. Taking all the criteria into consideration, the southwestern drift seems very much older than the Kansan till of southeastern Iowa.

Over the greater part of Iowa the Kansan and pre-Kansan drift sheets are definitely separated by soil beds, peat beds, and the remains of luxuriant forests which flourished in the interglacial interval. At Afton Junction, however, there are heavy beds of gravel between the two sheets of till. This gravel was deposited by the strong currents of water which flowed away from the edge of the pre-Kansan ice during the period when it was melting. Gravel was washed out over that part of the pre-Kansan till from which the slowly wasting and retreating glaciers had withdrawn. Later on, the Kansan ice came and deposited drift above it. But in the mean time a thin soil was developed on the surface of the gravel, and forests grew upon this surface during a long interval of mild climate. It is from this typical locality at Afton Junction that science gets the name Aftonian for the interval between the first and second of the recognized ice invasions of Iowa.

During the season of 1901 the "Burlington" road spent vast sums of money in rectifying its alignment and grades in southwestern Iowa; and the great number of deep cuts which were made in the progress of the work afforded an opportunity to determine definitely the relation of the drift sheets in this part of the state. Taking advantage of this unusual opportunity, the region was visited and a number of the cuts were examined. The fresh sections, showing every detail, but emphasized the original impression that the surface drift of this part of the state shows

unusual age as compared with the oldest drift east of the "watershed." The whole body of the till, as noted above, is completely changed by weathering to depths of forty or fifty feet. The iron-bearing bowlders, the diabases, basalts, hornblende-bearing rocks and the like—are more or less decayed; and the iron constituent, completely oxidized, stains the deposit and transforms the original blue to various tones of red or brown or yellow, throughout the whole zone of alteration. From the upper part of the section the limestone pebbles have been removed by solution; and the finer limestone flour, which was originally an important part of the drift, has been leached out by descending waters. The whole lime constituent has now been completely segregated to great depths; and, by reason of secondary deposition from solution, it now appears as concretions resembling the well known loess kindchen. The position of these concretionary lime balls is well down in the sides of the cuts, where they are usually arranged in rather definite rows along the cracks or joints which determined the course of the descending waters.

The fresh cuts west of the "watershed" afford opportunities never before presented to the geologist. In the first place, they have opened up and revealed the true character of the drift in the vicinity of Afton Junction as no excavations or natural exposures had ever done before; and in the second place they have made it possible to trace the surface drift sheet with practical continuity for distances of many miles. It may now be demonstrated that it is the old looking drift of southwestern Iowa that overlies the gravels at Afton Junction. In the first cut west of Afton Junction the Aftonian gravels are exposed beneath fifty feet or more of this old and highly altered drift. Notwithstanding all the unmistakable evidence of age which it presents, the surface drift of southwestern Iowa is supra-Aftonian. For the present at least it will have to be correlated with the Kansan drift of the southeastern part of the state. A sheet of true sub-Aftonian or pre-Kansan till is well exposed beneath the gravels in the bluffs of the river valley, about a mile southwest of Afton Junction. As already stated, the sub-Aftonian or pre-Kansan till is exposed in only a very few sections, and these are limited in size; while,

so far as now known, it does not anywhere control the topographic characters of the surface.

Until the past season nothing was positively known concerning the true location of the respective margins of the Iowan and Kansan drift sheets in the territory lying between the north line of Delaware county and the Iowa-Minnesota boundary. The tracing of drift margins has always, in large measure, been made subordinate to broader studies of the geological structure and resources of the region under consideration. During 1901 the survey of Howard county afforded an opportunity to map the Iowan margin through a part of its course in this unknown territory. The work demonstrated the fact that along the northern state line the Kansan drift extends many miles farther east than does the Iowan, while at the middle of the north line of Delaware county the margins of the two till sheets appear practically to coincide. The correct mapping of the glacial deposits in northeastern Iowa can not be finished, however, until detailed surveys have been made in Clayton, Fayette and Winneshiek counties. In Howard county the Iowan boundary cuts the Minnesota line near the northwest corner of section 11, Forest City township, loops back into section 10 a few rods south of the line, trends almost south toward Foreston, turns southeastward and passes south of the mill at the village named, traverses the north half of section 14 and crosses into Albion township in the southwest quarter of section 18. From this point its course is in the main southeastward, passing a few rods south of the centers of sections 20 and 27, and leaving Albion township near the northeast corner of section 36. Here, as elsewhere, a thick loess ridge marks the limits attained by the Iowan ice. From the summit of this ridge one looks northward and northeastward over a succession of rounded, loess-covered hills which have been developed by long erosion of the older Kansan drift; toward the south and the southwest the Iowan drift plain, dotted with bowlders and free from loess, stretches away to the horizon, as level as a sea. The deeply eroded, weather-stained Kansan drift, with its mantle of loess, continues eastward, extending well across Winneshiek county, but the exact line which divides the drift-covered from the driftless area in this part of Iowa remains to be determined

when work has been extended over the unsurveyed counties through which the border of the old Kansan glaciers passes.

The subject of petroleum and natural gas continues to occupy a large share of public attention, a fact no doubt due to the phenomenal developments which have taken place at numerous points, particularly in Texas, Colorado and Wyoming. There have been a number of reported discoveries of petroleum in Iowa since the last annual report was written; and in some places the question of putting down prospect holes has been seriously considered. Oil and gas are two phases of the same phenomenon. They are likely to occur together, but occasionally one is found without the other. That they are both of organic origin is no longer seriously questioned; and if their organic origin is clearly apprehended, it will be unnecessary to state that they can occur only in formations that are younger than the introduction of life on the globe. The earliest faunas of any consequence lived during the Cambrian period; but it was not until the Trenton division of the next period that life existed in such profusion as to furnish organic matter in sufficient amount to give rise to gas or oil in quantities worthy of consideration. The Trenton, therefore, is the oldest formation in which oil or gas may be expected to exist in volumes of commercial importance; and as a matter of fact, it is the oldest in which these products have been found in paying quantities. So far as the presence of life is concerned, every formation since the Trenton might have become a source and reservoir of gas and oil; but the conservation and accumulation of these products of organic decay depend on a number of factors which must be coincident at the right time and place. For lack, therefore, of the requisite coincidence of favoring conditions, the formations are not all equally rich; and there is, furthermore, the largest possible variation in the matter of oil or gas content in different parts of the same formation. A very striking illustration of the truth of the last proposition is found in the fact that deposits of the Tertiary age are universally distributed over a large area in southern Texas. The thickness of the beds and their general characteristics are essentially the same everywhere in the region referred to, but oil production at Beaumont is limited to the small eminence known as Spindle Top,

which has an area of less than a square mile. The Trenton limestone is the productive formation in Indiana and western Ohio, but the production is limited to certain favored areas; while other areas in the same territory—in no way different so far as surface indications are concerned—are absolutely barren. The following table shows the geological distribution of gas and oil in the United States and Canada, and the distribution is essentially the same throughout the entire world:

TABLE SHOWING THE GEOLOGICAL DISTRIBUTION OF OIL AND GAS.

GEOLOGICAL PERIODS.	LOCALITIES.
Pleistocene or Quaternary.	No productive oil wells in deposits of this period. Small reservoirs of gas, in the form of sealed in beds of sand or gravel, occur in the glacial deposits at Letts, Herndon and a few other points in Iowa.
Tertiary.....	Los Angeles and other oil-producing localities in California; Beaumont, Texas; Jennings, Louisiana; some oil fields in Wyoming; oil fields in Russia and in Peru.
Cretaceous.....	Florence, Boulder and Pikes Peak, Colorado; San Antonia, Elgin and Corsicana, Texas; some oil horizons in Wyoming and British Columbia.
Jurassic.....	In one field in Wyoming oil occurs in the Jurassic. No productive wells, however, are yet known to be supplied from reservoirs belonging to this formation.
Triassic.....	No known oil-producing horizons in the Triassic.
Carboniferous.....	*Upper Carboniferous.* Popo Agie field, Wyoming; field in northern Indian Territory; Neodesha, Chanute, etc., Kansas. *Lower Carboniferous.* Central Ohio; West Virginia.
Devonian.....	Pennsylvania, western Ontario; some wells in central Ohio.
Silurian.....	No known productive wells, though oil occurs in the Medina sandstone in Canada, and the Niagara limestones about Chicago are, in places, saturated with oil. Some traces of oil at the same horizon in Cedar county, Iowa.
Ordovician....	Oil and gas both abundant in certain localities, in the Trenton limestone, Gaspe, Canada; Lima and many other places in western Ohio; oil and gas fields in Indiana and Kentucky. Some Trenton shales in Iowa are rich in bitumen. In beds of Quebec age, Newfoundland.

GEOLOGICAL PERIODS.	LOCALITIES.
Cambrian.....	No productive wells.
Algonkian.	No probability and little possibility of productive wells.
Erchæan.....	No possibility of productive wells.

An examination of this table shows what has already been said, that the Trenton is the lowest of the geological formations yielding gas or oil in commercial quantities. Now the whole Trenton series crops out so that its several members may be studied as surface rocks in the northeastern counties of Iowa, and the Trenton underlies the surface at no very great depth in nearly all the other portions of the state. The demand for water has led to the boring of numerous deep wells for the purpose of drawing upon the supplies stored in the great water bearing sandstone, the Potsdam or Saint Croix, which lies at the base of the Paleozoic formations in the Mississippi valley. All wells in the interior of the state, which have reached the Cambrian sandstone, have passed through the whole thickness of the Trenton; and each well, so far as concerned the locality in which it was bored, was an effective test for gas or oil in the Trenton and in all the strata which lie above it. A few of the points where decisive tests have been made are Ackley, Amana, Anamosa, Ames, Boone, Burlington, Cedar Rapids, Centerville, Clinton, Davenport, Des Moines, Grinnell, Holstein, Homestead, Jefferson, Keokuk, Manchester, Mason City, Ottumwa, Pella, Sabula, Sigourney, Sioux City, Tipton, Vinton, Washington, Waverly, Webster City and West Liberty.

Another of the geological horizons of our state, in which organic matter is present in sufficient amount to make it a possible source of gas or oil, in the Upper Carboniferous. The gas and oil of southeastern Kansas are found in associated sandstones and shales of the same age as the Coal Measure deposits of Polk

county, Iowa. This possibly productive geological formation underlies the whole southwestern part of the state. In the southwestern counties, indeed, the geological conditions resemble very closely those at Neodesha and Iola, Kansas. The requisite conditions which have not yet been proven to exist are the porous reservoir and the proper cover; and these conditions might easily be met, even in such an undisturbed region as ours, by a large body of sandstone completely sealed in with shale. In general, productive fields are found in regions of disturbance where the sedimentary strata has been thrown into a series of folds. This is the situation in the productive belts of West Virginia, Pennsylvania, Ohio, Indiana, Colorado, Wyoming and in practically all other areas that could be mentioned. The oil bearing areas of Texas and Kansas may be exceptions, for here the reservoirs may be porous sands or sandstone, not folded, but thinning out at the edges so as to be completely shut in by impervious shales or clays. It is in such sealed-in reservoirs that gas occurs in the glacial deposits of Iowa and a few other localities in the drift-covered portions of North America.

The gas and oil belt of Indian Territory and Kansas is of especial interest to Iowans, for it has suggested to men of enterprise in certain localities the possibility of some as yet untapped reservoirs within the limits of our own state. This belt has a trend slightly east of north, and its extension would pass through northwestern Missouri into southwestern Iowa. Within the territory last named, however, the productive horizons of Kansas have been explored by the drill at such points as Atlantic, Centerville, Clarinda, Glenwood and Osceola, and in each case the results, so far as relate to oil and gas, have been negative. There is another thing to be kept in mind, and that is the fact that the Kansas belt becomes less productive toward the north. It seems as if the porous sandstones which constitute the reservoir thin out in this direction. Heavy bodies of sandstone in the lower Coal Measures, extending over areas of any considerable extent, have not been found in our state. These facts, it should be said, do not positively prove that there is no oil or gas in southwestern Iowa, but their bearing and significance will be readily appreciated by thoughtful and prudent investors. Every boring,

for whatever purpose made, which goes through the productive oil and gas horizons, simply limits by so much the area in which it is worth while even to think of spending money in prospecting.

In the report on Buchanan county, volume VIII, page 220, there is reference to a well defined fold which begins in Delaware county and, extending across Buchanan, passes into Bremer. This is one of the most marked and extensive folds affecting the geological strata of Iowa, and it might reasonably be expected that here, if anywhere, should be found conditions favorable to the accumulation and preservation of stores of gas and oil. So far this fold has not been fully explored by the drill; but the deep well at Waverly is not very far from its axis, and the Waverly well has gone down through all the possibly productive formations and deep into the Cambrian sandstones without bringing to light anything which could suggest even the presence of economic products other than a bountiful supply of pure, wholesome, artesian waters.

Letters received at this office, asking for information and advice relative to boring for oil or gas, have been more numerous during the past year than ever before. In every case the writers have been informed as to the exact facts and left to exercise their own judgment concerning the propriety of proceeding with the contemplated enterprise. In the matter of developing our natural resources the people of Iowa are entitled to the best information that geological science can give; and the present knowledge of the geological structure of the state makes it possible over the greater part of our area, to predict the outcome of drilling for water or for other products, with a high degree of accuracy. It is difficult, however, to get men—even the most intelligent of men—to appreciate the significance of some of the simplest of geological facts, when it happens that the men are not themselves geologists. Nevertheless the world is moving toward a brighter, higher and grander intelligence; and those whose mission it is to teach can afford to exercise patience, to labor and wait.

I have the honor to remain, gentlemen,

Yours very sincerely,

SAMUEL CALVIN.

REPORT OF ASSISTANT STATE GEOLOGIST.

STATE GEOLOGICAL SURVEY,
DES MOINES, December 31, 1901.

DEAR SIR:—I have the honor to submit the following report upon the work of the past year. During the winter and spring months a large share of my time was taken up with the duties connected with the publication of volume XI. These included the editing of the manuscripts, preparation of the maps and illustrations and reading the proof. The regular work of the office also included the answering of the numerous letters of inquiry which are constantly coming to the Survey. Information has been sought concerning the presence or absence in different portions of the state of coal, building stone, clay, artesian water and other mineral products. Not a few of these inquiries come from other states.

During the year the printing of Bulletin No. 1, on the Grasses of Iowa was also finished and the greater part of the edition has already been distributed. The demand has been large and the Bulletin has received wide and favorable mention.

In July, as soon as the completion of the printing allowed, I began field work in Wapello county and continued it with slight interruption until late in September. The area surveyed and mapped forms one of the important coal counties of the state, and its production of building stone and clay products is also large. Particular attention was given to the coal deposits of the region and to mapping the area covered by the Lower Carboniferous limestone, quarried so extensively as a building stone. Early in November a trip was made to Clarinda for the purpose of examining the core of a diamond drill hole sunk at that place several years ago. The record of this boring is an interesting and valuable one, since it is one of the few from the southwestern

part of the state and furnishes a knowledge of the character and thickness of the deeper strata. Much credit is due to the citizens of Clarinda, who have had the core carefully boxed and preserved. At the time the hole was sunk a record of it was kept by Mr. C. W. Stewart. This was kindly furnished the writer and was used for comparison with one made by the writer. For information respecting the existence of this drill core, as well as for many other similar favors, the Survey is indebted to Dr. Geo. L. Smith, of Shenandoah.

The following record was made from the examination and measurement of the core:

RECORD OF THE CLARINDA DIAMOND DRILL HOLE IN THE NORTHEAST PART OF TOWN. (Se. ¼ OF SEC. 29, TWP. 69 N., R. XXXVI W.)

		Thickness.	Depth.
109.	Drift	43	43
108.	Shale, blue	5	48
107.	Limestone	4	52
106.	Shale, black	1	53
105.	Coal	1¾	54¾
104.	Fire clay	2¼	57
103.	Shale, gray, calcareous and fossiliferous	17	74
102.	Shale, dark	2	76
101.	Limestone	2¾	78¾
100.	Shale, calcareous	1¼	80
99.	Limestone	6	86
98.	Shale, calcareous	1⅔	87⅔
97.	Limestone	3	90⅔
96.	Shale	6	96⅔
95.	Coal	⅓	97
94.	Limestone	18	115
93.	Shale	2	117
92.	Limestone	2	119
91.	Shale, dark, calcareous	2	121
90.	Limestone	2	123
89.	Shale, calcareous	15	138
88.	Limestone	4	142
87.	Shale, dark blue	36	178
86.	Limestone	7	185
85.	Shale, black	1	186
84.	Limestone	3	189
83.	Shale, black	12	201
82.	Limestone	7	208
81.	Shale, blue	1	209

		Thickness.	Depth.
80.	Limestone	2	211
79.	Shale, dark blue	8	219
78.	Limestone, carrying fusulinas	22	241
77.	Shale, dark blue	4	245
76.	Shale, calcareous	16	261
75.	Limestone	6	267
74.	Shale, calcareous	11	278
73.	Shale, red, green and blue	22	300
72.	Limestone	1	301
71.	Shale, dark blue	93	394
70.	Limestone	4	398
69.	Shale, dark blue, calcareous in part	15	413
68.	Limestone	16	429
67.	Shale, black and green	13	442
66.	Limestone	2	444
65.	Shale, black	16	460
64.	Limestone	1	461
63.	Shale, black	1	462
62.	Limestone	1	463
61.	Shale, green and black	6	469
60.	Coal	½	469½
59.	Shale, green and black	6½	476
58.	Limestone, impure, argillaceous	6	482
57.	Shale, black	13	495
56.	Limestone	1	496
55.	Shale, black	4	500
54.	Limestone	2	502
53.	Shale	3	505
52.	Limestone	19	524
51.	Shale, gray and black	4	528
50.	Limestone	1	529
49.	Shale	8	537
48.	Limestone, argillaceous	4	451
47.	Shale, green and black	5	546
46.	Limestone	10	556
45.	Shale, dark blue	16	572
44.	Limestone	4	576
43.	Shale, dark blue	2	578
42.	Limestone	22	600
41.	Shale, black and green	10	610
40.	Limestone	31	641
39.	Shale, black	8	649
38.	Limestone	2	651
37.	Shale	2	653
36.	Limestone	13	666
35.	Shale, black	3	669
34.	Coal	5-6	669 5-6

		Thickness.	Depth.
33.	Fire clay	2 1-6	672
32.	Limestone	9	681
31.	Shale	4	685
30.	Limestone	5	690
29.	Shale	13	703
28.	Limestone	6	709
27.	Shale	1	710
26.	Limestone	1	711
25.	Shale, gray	4	715
24,	Sandstone, micaceous	7	722
23.	Shale, sandy	25	747
22,	Sandstone	1	748
21.	Shale	5	753
20.	Coal	1	754
19.	Shale	1	755
18.	Limestone, argillaceous	3	758
17.	Shale	1	759
16.	Sandstone	4	763
15.	Shale, black	1	764
14,	Sandstone, sandy shale, fine, micaceous	19	783
13.	Shale	9	792
12.	Limestone	1	793
11.	Shale	4	797
10.	Limestone	6	803
9.	Shale	5	808
8.	Limestone	2	810
7.	Shale, black	3	813
6.	Coal	⅓	813⅓
5.	Sandstone	7	820⅓
4.	Limestone	5⅔	826
3.	Shale	3	829
2.	Limestone	2	831
1.	Shale	9	840

The above differs materially from the record of the boring made southwest of Clarinda, in the southwest quarter of section 36, and given in Professor Calvin's report on Page county. But the latter hole was made with a churn drill and the samples of the drillings were never examined by a member of the Survey. The limestones and shales alternate so rapidly and graduate the one into the other in such a way as to make their discrimination difficult, especially in the drillings. Entire confidence cannot therefore be placed in the record already published and it is believed that the one given above is much more accurate. When

the core can be examined the character and thickness of the different strata can be determined with greater reliability. This one resembles the Glenwood section in the rapid alternation of shales and limestones and in the large number of limestone layers. At Glenwood there are sixteen limestone horizons in that portion of the section referred to the Missourian and at Clarinda there are thirteen.

The upper coal seam, No. 105, is mined in several places near town, two mines having been opened in it during the past year (1901). This seam is the Nodaway coal, which is mined at several points in Page and surrounding counties.

In the above section the base of the Missourian is believed to be at about 715 feet, there being but little limestone below that depth. This would give the Missourian here a thickness of 670 feet, which is the thickness given for that formation at Glenwood.

During the past year the following publications have been added to the library of the Survey:

Annual Report of Smithsonian Institution, 1900.
Annals of the New York Academy of Sciences, Vol. XII, Parts II and III, Vol. XIII, Part I.
Proceedings of the United States National Museum, Vols 22 and 23.
Geological Survey of Alabama. Plant Life of Alabama.
25th Annual Report of Indiana Geological Survey.
Maryland Geological Survey. Eocene.
Geological and Natural History Survey of Minnesota, Vol. 6 Atlas.
Transactions of the Kansas Academy of Science, Vol XVII.
Bulletin of the Buffalo Society of Natural Sciences, Vol. VII, No. 1.
Proceedings and Collections of the Wyoming Historical and Geological Society for 1900.
Geological Survey of New South Wales. The Mineral Resources of New South Wales.
Proceedings of the Philosophical Society of Glasgow, Vol. XXXII.
Report of the Ontario Bureau of Mines.
Eclogæ Geologicæ, Helvetæ, Vol. V.

Very Respectfully,

A. G. LEONARD,
Assistant State Geologist.

TO PROF. SAMUEL CALVIN,
State Geologist.

REPORT OF PROF. W. H. NORTON, IN CHARGE OF ARTESIAN WELLS.

Dr. Samuel Calvin, Director, Iowa Geological Survey:

SIR:—I have the honor to make the following report of the work done during the year 1901 in reference to the artesian wells of the state.

During the past year a smaller number of wells was being drilled within the limits of the state than in several previous years, and the opportunities of this office have been correspondingly diminished.

We have advised with the State Board of Control as to a number of wells now drilling or in contemplation at state institutions. Of the well at Mitchellville, we were kept informed as the drilling progressed, and were thus able to state the formations in which the drill was working, and the probabilities as to their water supply.

The unfinished well at the Hospital for the Insane at Cherokee has also been placed under our advisory supervision. A complete set of samples of the drillings has been sent to the office of the 1,000 feet already drilled, and others will be forwarded as the work goes on. While at present advising the further prosecution of the boring, we shall be able to advise against its continuance, whenever we find that it has passed below the water bearing strata, or aquifers of the region, thus making it possible to avoid the waste of thousands of dollars which in a number of cases in Iowa as well as in other states, has resulted from drilling wells to needless depths for want of expert advice. The drillings from the Cherokee well will give us for the first time a reliable lithological section of the deeper rocks in this region of the state, and data of great value in regard to its water resources.

We were also consulted by the Board of Control as to the advisability of sinking new wells at the state institutions at Glenwood and Mt. Pleasant, in proximity to the deep wells there, whose

capacity is not equal to the needs of the hospitals; and in each case were able to give favorable reply, after taking into account the various factors in the cases.

To the chief engineer of the Minneapolis and St. Louis Railway, we were able to supply a large amount of data as to the extent and depth of the leading water horizons of those portions of the state traversed by that railway.

The deep well at Sumner, over which we had some supervision, has been brought to a satisfactory completion, after a series of delays owing to accidents of the usual kinds in the progress of the work. Through the intelligent care of the council, a complete set of drillings was preserved, most of which have already been sent to this office.

The Board of Control has also directed that the sample drillings from the artesian well recently drilled at the Hospital at Mt. Pleasant be sent here for determination. This will give a reliable geographical section for this area, where our data had before this been incomplete.

We have collected data of considerable value from a number of wells recently sunk, from the second and third wells of the waterworks at Boone, from the well at the state institution at Glenwood, and from the Davenport artesian field relating to interference of wells.

I have the honor to remain your obedient servant,

WILLIAM HARMON NORTON.

Cornell College, Mt. Vernon, Iowa, Jan. 17, 1902.

REPORT OF DR. J. B. WEEMS.

AMES, IOWA, December 31, 1901.

SIR:—I have the honor of presenting the following report for the Chemical Work of the Geological Survey.

The laboratory work has been limited to the analysis of clays in connection with the investigation of the clays of the state.

During the year twenty-five samples of clay have been analyzed. The analytical work included complete chemical and rational analyses for each sample. The Chemical Section of the Experiment Station is continuing its work upon the soils furnished by the Survey.

The lack of space for the chemical work of the department and the Chemical Section of the Station has made the work for the Survey a difficult matter, and has caused long delays in the chemical work.

The Grass Bulletin prepared by the Departments of Botany and Agricultural Chemistry of the College has been completed and published during the year. The work has been well received by those interested in the advancement of agriculture.

Respectfully submitted,

J. B. WEEMS,
Chemist.

TO PROF. SAMUEL CALVIN,
State Geologist.