ADMINISTRATIVE REPORTS.

FIFTH ANNUAL

Report of the State Geologist.

IOWA GEOLOGICAL SURVEY,
DES MOINES, December, 31, 1896.

To Governor F. M. Drake and Members of the Geological Board:

GENTLEMEN—I have the honor to report that during 1896 the work of the Iowa Geological survey has been carried forward in accordance with the plans approved by the board at the beginning of the year. In selecting the counties to be investigated the survey was influenced by two considerations. First, these counties contain geological deposits of great economic importance, and it seemed desirable to have them brought to public attention as early as convenient. Second, the counties were so chosen as to elucidate as large a number of geological problems as possible. With the solution of questions relating to the indurated rocks and the overlying loose or superficial deposits in certain carefully selected typical localities, the work in other localities may be prosecuted more expeditiously and more satisfactorily. With this end in view investigations were made in Johnson county for the purpose of extending the work begun by Professor Norton, on the Devonian system of Iowa, in Linn. The geological formations of Johnson county carry the Devonian section up through more than seventy feet of strata not represented in Linn county, though the lowest Devonian beds in the first named county are the exact equivalents of beds well described

by Norton in his Linn county report. After finishing Johnson county my work was transferred to Cerro Gordo for the reason that in Cerro Gordo the newest or latest Devonian beds are exposed. Beginning with beds that are represented near the top of the Devonian section in Johnson, Cerro Gordo county shows a succession of Devonian strata of remarkable interest, which add more than a hundred feet to the Devonian section at the localities previously studied. By combining the exposures in Linn, Johnson and Cerro Gordo counties, a complete section of the Iowa Devonian may be made; and the several members of the section may be so described that Devonian beds in any of the counties where rocks of this system are exposed, may be at once referred to their proper horizon. Certain horizons furnish brick and tile clays, others building stones, and others lime-burning rocks of desirable qualities, and the intelligent workman may readily know whether or not these are present in his neighborhood.

The Devonian beds of Cerro Gordo are overlain by Kinderhook beds belonging to the Lower Carboniferous. The exposures of Kinderhook, however, in Cerro Gordo are not important. But in Marshall county the Kinderhook reaches its most important development, and extensive quarries, employing large amounts of capital and labor, have for some time been operated in strata of this formation. Marshall county was, therefore, one of the areas selected for investigation, and was assigned to Dr. S. W. Beyer, of Ames. Dr. Beyer's work develops much of importance in connection with the Kinderhook as shown by his report on Marshall county herewith submitted. In addition to the Lower Carboniferous strata so prominently developed in the eastern part of this county, Marshall also contains the attenuated and deeply eroded marginal beds of the coal measure series. The beds of this latter series found in Marshall county belong to the Des Moines stage, or lower coal measures of some authors. This stage, however, so far as Iowa is concerned, is best developed in Polk county, and hence this

A GEOLOGICAL MAP OF IOWA

1897.

Compiled from published sources and from the notes of members of the survey.

SAMUEL CALVIN,
State Geologist.

LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
O'BRIEN
CLAY
PALO ALTO
KOSSUTH
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
SIOUX
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
FAYETTE
CLAYTON
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
WARREN
MADISON
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

LEGEND.

- CRETACEOUS
- MISSOURIAN
- DES MOINES
- MISSISSIPPIAN
- DEVONIAN
- SILURIAN
- ORDOVICIAN
- CAMBRIAN
- ALGONKIAN

Photo-Lith. by A. HOEN & CO., Balto., Md.

county constitutes one of the most important of the areas surveyed during the past season. The work in Polk county was done by Mr. H. F. Bain. It was indeed begun some years ago, but it was carried on only in short intervals spared from pressing duties in the office. Owing to the importance of the area from both a stratigraphic and an economic point of view, it was deemed wise to press the work to completion during the field season of 1896. In connection with his work on Polk county Mr. Bain has also made a complete survey of Guthrie county. Guthrie county carries the Carboniferous section from the Des Moinés stage with which the section ends in Polk, up through a portion of the Missouri stage; and in this county there is furthermore a marginal deposit of special interest belonging to the Upper Cretaceous. The problems in both Polk and Guthrie are very intricate, but they have been worked out with great success, as will be recognized by consulting the reports of Mr. Bain included in the present volume.

Madison county shows more clearly than either Polk or Guthrie, certain interesting phases developed in the southward extension of the Des Moines and Missouri stages of the Carboniferous. The Winterset limestone, the lowest member of the Missouri stage, is important, not only on account of its utility as a building stone, but because it marks a very definite stratigraphic horizon. It seemed desirable to make a careful study of this limestone, together with the beds immediately above and below it in order that the work in Iowa may be properly correlated with that done on the Upper Carboniferous strata by the geologists of Missouri and Kansas. Madison county was therefore selected for investigation, and was assigned to Professor Tilton, of Indianola. Professor Tilton received instructions to note carefully the successive changes in the conditions of sedimentation which the beds of the county record, and to take particular account of the faunal changes in passing from the beds below the Winterset horizon to those above it. The oil and gas horizons of

southeastern Kansas occur in Upper Carboniferous strata and the supply is related to certain well defined beds that may be traced through southwestern Iowa.

In the counties named the superficial deposits present problems of scarcely less interest than the indurated rocks. Johnson and Marshall are traversed by the extreme southern margin of the Iowan drift, and both counties contain heavy beds of loess that are genetically connected with the melting and retreat of the Iowan ice. Cerro Gordo county illustrates the character of the Iowan till at some distance back from its southern margin, while the western part of the county is occupied by morainic hills and ridges and characteristic kettle holes, which in this region mark the eastern margin of the Wisconsin drift. The western part of Marshall county also shows the influence of the Wisconsin drift sheet, and the extreme southern limit of the Wisconsin lobe is found at the south end of Capitol Hill in Des Moines, Polk county. In Polk county the Wisconsin drift overrides loess of Iowan age in the northern part of the city of Des Moines, while to the northwest this drift rests on till of Kansan age. The oldest drift sheet, so far recognized in Iowa, a drift older than the Kansan, is also exposed in Polk county. The southwestern margin of the Wisconsin drift passes through Guthrie county, making this county one of the strategic areas in which to study the superficial deposits.

From an economic standpoint the soils of Iowa constitute the most important geological formations in the state. The first step in the study of soils necessitates a careful investigation of the superficial deposits, and accurate mapping to show their distribution. The composition of soils in any given area, and the purpose to which they are best adapted, depend wholly on the character of the loose surface materials. Soils on drift covered areas vary with the age and origin of the drift itself. Loess soils have their special characteristics and uses. While in the matter of soils Iowa, as in many other respects, has the best, yet the highest rewards of

agriculture will not be realized until the husbandman takes advantage of information furnished by the geologist and, recognizing the fundamental differences in soils, adapts crops and methods of culture to the needs and possibilities of his particular area.

The study of the drift, and of the loose surface materials derived from it, has an economic bearing in another direction. Enormous quantities of vegetable matter have been included between successive sheets of till, and the decomposition of the organic materials thus included in the superficial deposits generates natural gas. In a few known areas this gas has been stored in sufficient amount to make it useful in the heating and lighting of dwellings, and the information at hand justifies the conclusion that the conditions necessary for the generation and storage of gas from this source are best fulfilled near the terminal margin of an overlapping sheet of drift.

The six counties named above, are geologically important therefore, in respect to both indurated rocks and superficial deposits, and reports on these counties accompanied by the necessary maps and drawings are herewith submitted in the confident belief that they will be found of great practical interest to the people of Iowa.

In addition to the counties reported on in the published volumes of the Survey, and the six counties described in this report, the field work is partly or wholly completed in Buchanan, Delaware, Fayette, Howard, Cedar, Scott, Dallas, Story, Plymouth, Union, Lyon and Marion.

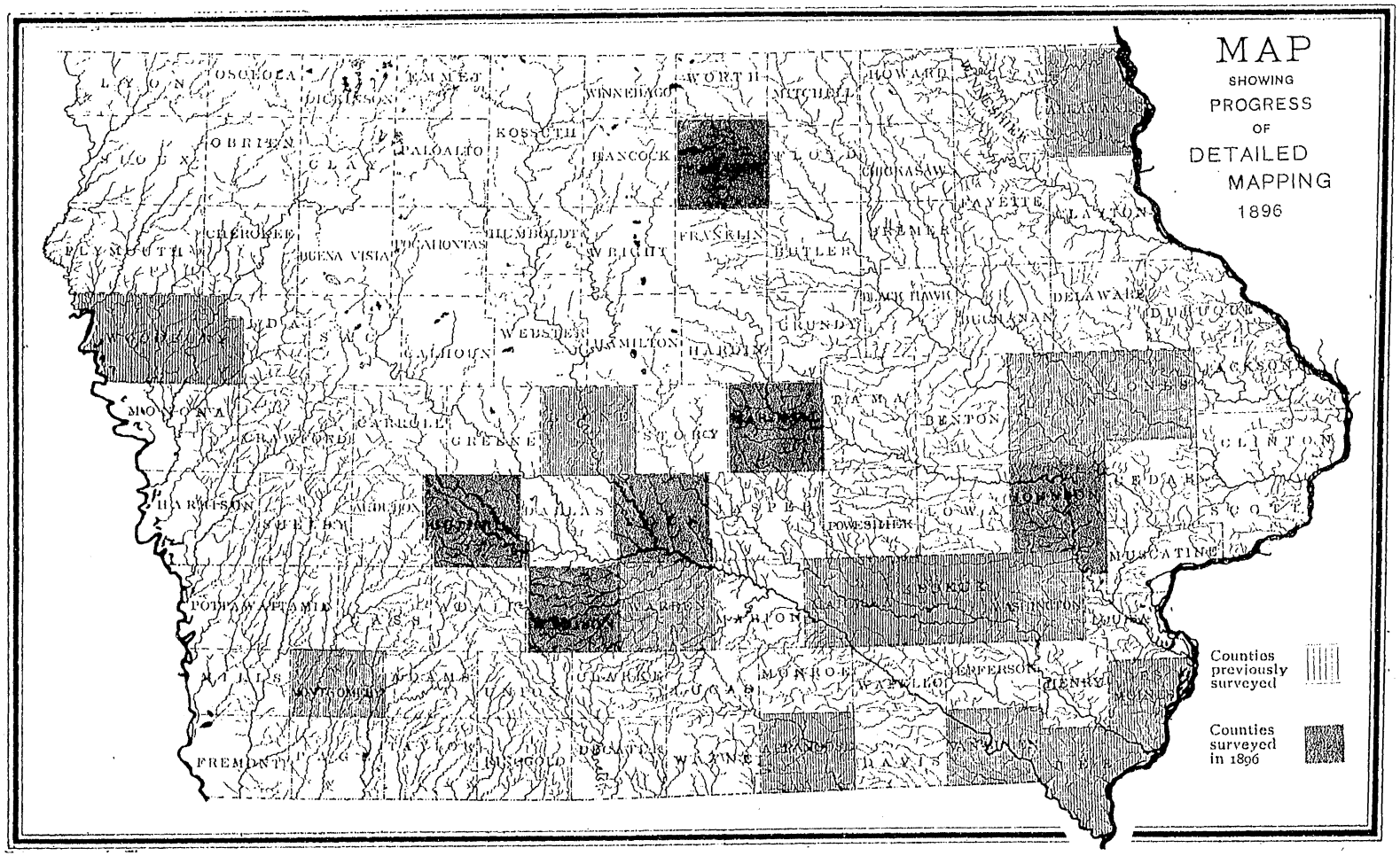
The year's work has also included the publication and distribution of Volume V, of the reports of the Survey, besides the monograph of Mr. A. G. Leonard on the lead and zinc of Iowa, and that of Dr. Beyer on the Sioux quartzite. These last two publications will constitute a part of Volume VI of the reports of the Iowa Geological Survey. The remainder of the volume will be occupied by the elaborate and valuable report of Professor Norton on the Artesian Wells of Iowa,

the manuscript of which, with necessary illustrations, is now ready for the printer.

We have also on hand, ready for publication, a paper by Professor Pammel on the Grasses of Iowa. Intelligent farmers will find this last paper of much practical interest. Its early publication is recommended.

It is gratifying to note that the publications of the Survey are being more and more appreciated, and are received by the people of the state, as well as by men of science everywhere, with increasing favor. Requests for copies of the reports from persons to whom they would be of great value, but who, under a strict construction of the present law governing the distribution of the volumes, are not entitled to receive them, are very numerous and indicate a widespread interest in the geological resources of the state. High schools in counties already reported on have introduced the separate county reports as works to be read by the pupils studying geology, and so have adopted one of the best possible methods for disseminating the information collected by the survey. Newspapers, with their usual public spirit, have aided in disseminating information by summarizing reports of local interest. Mr. Leonard's paper on lead and zinc was published entire, with illustrations, by some of the papers of Dubuque. Some modification of the law relating to distribution, whereby interested citizens of Iowa may obtain the reports without charge, is greatly to be desired.

Building Stones.—During the year the testing of the collection of building stones mentioned in the last annual report has been completed and the results are now being prepared for publication. The collection included specimens from many of the more important quarries of the state and from some undeveloped ledges. Unfortunately the collection was not as complete as could be desired, though an effort was made to obtain samples from all the principal quarries. Many of the quarrymen failed to respond at all, and others did not send in the required cubes at the specified time. The work


MAP
SHOWING
PROGRESS
OF
DETAILED
MAPPING
1896
Counties previously surveyed
Counties surveyed in 1896
LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
O'BRIEN
CLAY
PALO ALTO
KOSSUTH
HANCOCK
FLOYD
CHICKASAW
FAYETTE
CLAYTON
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
PLYMOUTH
BLACK HAWK
DELAWARE
DUBUQUE
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
BREMER
JACKSON
MONONA
CRAWFORD
CARROLL
GREENE
STORY
TAMA
BENTON
CLINTON
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JONES
CEDAR
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
LINN
JOHNSON
LOUISA
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
MILLS
MONTGOMERY
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
FREMONT
PAGE

must accordingly be regarded as essentially preliminary, though it is complete as far as it was carried on. In all thirty-three specimens were tested, representing thirteen quarries in eight formations.

The specimens were dressed to two-inch cubes and then subjected to compression tests, the work being done at Ames by Prof. A. Marston and Messrs. Murray and Bain. Duplicate specimens were studied at Drake University, chemical analyses being made by Mr. Harry McCormick and absorption tests by Mr. H. B. Murray. The survey is under great obligations to these gentlemen and to Professor Marston for their co-operation. Mr. Bain is summarizing the results, which will be published in some of the future reports of the survey and will probably also be given local publication. The various quarry owners have already been informed by letter of the results of the tests on their stone.

Cement.—The past year has been an unfavorable one for the development of new industries in the state, so that no progress has been made in the direction of opening up the cement beds. The material shipped Mr. S. B. Newberry for examination was found to be too low in lime for use alone. It will be necessary to find in the neighborhood beds of purer chalk to mix with the other material. It is believed that this can be done, and Mr. Bain is to take up the work in Plymouth county for the coming season, with a view, among other things, of clearing up this matter.

Studies pursued with the object of determining the distribution of certain types of soil and their relation to the drift sheets covering the state have incidentally demonstrated that the succession of Pleistocene deposits is more complete and more clearly indicated in Iowa than in any other corresponding area of this continent so far studied. The margin of the Wisconsin drift sheet was traced some years ago by Upham, but until recently this was the only Pleistocene deposit whose boundaries were approximately known. Two sheets of till were differentiated by McGee in northeastern

Iowa, but it remained for the present survey during the past two years to recognize the southern limits of McGee's upper till. Mr. Bain has pointed out a body of drift below McGee's lower till, and sharply differentiated from it, and Mr. Leverett of the U. S. Geological Survey, has demonstrated the existence of drift in southeastern Iowa, intermediate in age between the lower and upper till of McGee. The Pleistocene history of Iowa as now for the first time clearly deciphered includes the following succession of events, each of which has had its influence in determining the present condition and characteristics of Iowa soils.

I. First stage of glaciation, *Albertan.* Invasian of Iowa by glaciers and distribution of lowest sheet of till.

II. First interglacial stage, *Aftonian.* Melting and retreat of glaciers and deposition of gravels, followed by a long period of forest growth, development of soils, and modification of the original drift.

III. Second glacial stage, *Kansan.* Cold more intense and glaciation more general than during the first stage. Distribution of McGee's lower till.

IV. Second interglacial stage, *Buchanan.* Introduced by deposition of gravels in Buchanan, Black Hawk, Floyd, Cerro Gordo and other counties. This stage was very long and the surface of the second drift sheet was profoundly modified by erosion, oxidation and leaching before it came to a close.

V. Third stage of glaciation, *Illinois.* During this stage only a small part of Iowa, embracing portions of Louisa, Des Moines and Lee counties, was invaded by glaciers. The ice came from the northeast, bringing boulders from the eastern shores of Lake Huron.

VI. Third interglacial stage (unnamed), during which the modification of the second drift sheet proceeded over the greater portion of Iowa. The small area occupied by the third deposit of drift also suffered more or less of modification.

VII. Fourth glacial stage, *Iowan.* During this stage the northern half of Iowa was overrun by glaciers. The southern

limit of this incursion may be traced a few miles north of a line drawn from Iowa City to Des Moines, and then deflected northwestwardly to Plymouth county. It was during this stage that the enormous granite boulders so conspicuous in Bremer, Black Hawk, Buchanan and other counties in northeastern Iowa were transported and deposited where they now lie.

VIII. Fourth interglacial stage, *Toronto (?)* This fourth interglacial stage was short as compared with the second, and probably with the third. The amount of erosion, oxidation and leaching that during this interval took place in the surface of the fourth sheet of drift is altogether inconsiderable. The amount of change that has taken place since the beginning of the interval up to the present time is comparatively small.

IX. Fifth glacial stage, *Wisconsin.* The last invasion of Iowa by glacial ice occurred in times so recent, geologically speaking, that the youngest sheet of till exists practically in the condition in which the glaciers left it. The area in Iowa affected by this last invasion is nearly triangular in shape, the base of the triangle coinciding with the north line of the state from Worth to Osceola counties, with the apex located at Des Moines. In the northern part of this area there are numerous stretches of ill-drained lands, the surface is only very gently undulating and the stream channels, where defined at all, have cut only a foot or two into the prairie sod.

X. The recent stage, since the retreat of the Wisconsin ice, brings Pleistocene history down to the present. The recent stage, while long as measured in years, has been too short to produce any appreciable effect in the surface of the Wisconsin drift.

The work of the Iowa geologists in differentiating the Pleistocene deposits and incidentally deciphering Pleistocene history has received the recognition and indorsement of the highest authorities on Pleistocene geology in the United States. Prof. T. C. Chamberlin, chief of the Pleistocene

division of the United States Geological Survey, at various times during the past year, made visits to a number of the typical localities in Iowa and verified the interpretations of the local geologists.

Prof. R. D. Salisbury, also connected with the United States Survey, and in charge of the Pleistocene work of the Geological Survey of New Jersey, accompanied Mr. Bain upon a short trip across the northern portion of the state, going as far west as Sioux City and Rock Rapids. The topographic characteristics of the Iowan and the Wisconsin were studied and the probable equivalence of the drift sheets east and west of the Des Moines lobe was tentatively decided upon. The correlation forms a good basis for the next season's work, and is of particular value because of Professor Salisbury's wide experience in geographic work.

Mr. Leverett spent a considerable portion of the field season in Iowa tracing out the Illinois drift and studying the effect of that invasion upon the drainage of southeastern Iowa. While the work was done for the national Survey the very interesting results have been from time to time communicated to us. This courteous co-operation has been of great value and will greatly lessen the cost of the survey of the Pleistocene deposts of that region when it shall be undertaken. The result of all this combined work on the part of the state and the national Surveys, has been to make Iowa classic ground for the study of Pleistocene deposits.

The Pleistocene deposits not only determine the nature of our soil, but the water supplies for more than half the inhabitants of Iowa are derived from them, and in them the only known permanent gas wells within the state occur. The saving that may be effected by a thorough knowledge of these deposits is sometimes very great. For example the gas that is found in Pleistocene sand and gravel under conditions easily understood, has led persons unacquainted with its origin to infer that a deep well would tap a larger reservoir of this desirable material. Accordingly wells have been

bored at great expense in utter disregard of all the known conditions affecting the generation and storage of natural gas, and the end was loss and disappointment. A very slight acquaintance with the thickness, structure and contents of the Pleistocene would have saved all the expense and disappointment. Lumps and masses of coal occur also as constituents of the drift series and, in not a few instances, these "indications" have led to large expenditure in sinking prospect shafts under conditions that made failure a foregone conclusion.

As already noted in determining the counties to be investigated during the past season, the great importance of the coal beds of the state was recognized and a large share of the survey work has been devoted to their study. In Polk county Mr. Bain has carefully examined the coal horizons already known, with a view of determining the probability of the existence of deeper horizons. In connection with the problem of the influence of the settling of one coal seam upon the formation of the overlying bed, a visit was made by him to the Keb mine of the Whitebreast Fuel Co. near Ottumwa, where a hitherto unsuspected lower coal has been found. The line of investigation seems likely to yield important economic results. In Madison county Professor Tilton, in Dallas Mr. Leonard, and in Guthrie county Mr. Bain, have been tracing in detail the eastern outcrop of the Winterset limestone. The tracing of this limestone is of direct economic interest, since east of it the Des Moines or productive coal measures outcrop. West of it the barren beds of the Missouri stage are the surface formation, and the coal-bearing beds can only be reached by deeper working. Professor Norton's work upon the deep wells indicates that the current estimates upon the thickness of the coal measures of southwestern Iowa are seriously in error, and it is proposed to take up field work in the region within the coming year for the purpose of determining this and other questions. It is a pleasure to recall at this point the accuracy of much of the early geological work in

the state and the way in which predictions made when the geology of the region was so imperfectly understood have since been verified. Thus Worthen*, as a result of work done at Des Moines in 1856, said: "A good supply of a much better quality [of coal] may undoubtedly be obtained by sinking a shaft to the lower seams, which are probably not more than two or three hundred feet below those in the above section." Some years after deeper shafts were sunk, and now there is a large amount of coal mined from these lower horizons. In Guthrie county Mr. St. John†, in speaking of a sandstone found in sinking a shaft at Panora, said: "Beneath the sandstone the horizon of the Lacona coal would be reached probably at a depth of ten to twenty feet, but since the continuity of this bed is known to be interrupted, so that it has the character of a local deposit, we can not with certainty say whether the coal will be found at this locality or not." This is of particular interest, not only from the fact that coal has since been found and is now mined at the level indicated, but from the recognition of the difference between a coal bed and a coal horizon. The location of the coal horizons is properly the work of the geologist, while the finding of the coal bed along that horizon is the work of the prospector. Other instances of predictions which have been verified might readily be cited, but that is aside from present purposes. It is sufficient to state that the continued study of the coal measures is showing that despite their great irregularity there is a certain amount of order in them, and as their study is contined new criteria for structural work are being formulated.

Museum.—The collections of the Survey have continued to grow both by donation and by the efforts of the various members of the force. The museum has been visited by a large number of people, many of whom were strangers and unacquainted with the resources of the state. The displays of

*Hall: Geol. Iowa, Vol. I, p. 171. 1858.

†White: Geol. Iowa, Vol. II, p. 109. 1870.

building stones, brick, clay goods, and minerals form an effective advertisement for the state and it is proposed to enlarge them from time to time. The formation of a collection and the building up of a museum is believed, however, to be an incidental rather than a primary function of the Survey, and until the funds appropriated for the survey are enlarged, but little can be spent on museum work.

The office work of the Survey has been carried on as heretofore, except that Mr. Leonard has been in charge the latter half of the year. The drawing has been mainly done by Mr. F. C. Tate, though the map of Johnson county, submitted herewith was prepared by Mr. M. F. Clements, and the Cerro Gordo map by Mr. C. G. Meier. The Marshall map was drawn and engraved by Messrs. A. Hoen & Co., who have previously done work for the Survey. The remainder of the county maps submitted were engraved and printed by the Iowa Printing Co., of Des Moines.

The correspondence of the Survey has been heavy, including as it does numerous requests for identification, estimates and opinions. The exchanging of the Survey reports for those of other surveys or scientific societies, with the acknowledging of the incoming literature, is alone a matter of some considerable labor. This division of the work has been in charge of the secretary, Miss Newman.

During the year the Iowa Survey has profited by numerous courtesies from geologists and organizations in no way directly connected with it. The visits of Chamberlin and Salisbury, and the season's field work of Leverett, in connection with the study of the Pleistocene, have already been noted. A number of strategic points in the state were also visited by Prof. G. F. Wright for the purpose of studying these same deposits. The Survey receives freely the results of the observations of these specialists and the benefit of their judgment.

Within the past few months the old State quarry in Johnson county has yielded remains of a remarkable fish fauna.

The beds in which the remains occur are of Devonian age, but no such assemblage of Devonian fishes has hitherto been found in North America or, for that matter, in the world. The material has been placed in the hands of Dr. C. R. Eastman, of the Museum of Comparative Zoology, at Cambridge, Mass., and he generously proposes to study the collection and prepare the material for publication without cost to the Survey. Concerning the matter of publication, some joint arrangement whereby a part of the edition may bear the imprint of the Museum of Comparative Zoology, and part that of the Survey can probably be effected to mutual advantage.

The most important work by outside organizations in Iowa is that of the Topographic Division of the United States Geological Survey. Early in the season a party of topographers began work in northeastern Iowa, the object being to complete the topographic map of that portion of the state. Some years ago topographic mapping was begun in eastern Iowan and carried northward from the parallel of 41° 30′. It is now proposed to extend the work to the north line of the state. The importance of this work to the Iowa Survey is difficult to estimate. The district to be covered embraces the part of the driftless area that extends into Iowa. The peculiarities of the area are such that geological work can scarcely be done with any acceptable degree of exactitude without the aid of a topographic base map, and without such a base map geological mapping is practically out of the question. With the completion of the topographic work and the publication of the maps by the United States Survey, the geological work in that interesting region may be prosecuted with success, and with less than half the labor and expense that would otherwise be involved.

General Supervision.—During the past year considerable time has been spent both by Mr. Bain and myself, in general studies, particularly upon the drift, and in field trips with other members of the Survey. It is believed that the best

preparation for making a satisfactory report upon any small area in the state is a preliminary study of regions where the different formations are most typically developed. This has been particularly necessary in taking up the study of the drift since the criteria used in the discrimination of the drift formations are different from those used in other geological work. With this in view the various members of the Survey have, from time to time, made visits to those points in the state where the different formations are best developed.

Individual Work.—My own work, apart from the supervision above noted, has embraced a general direction of survey work, the reading and editing of manuscripts submitted by different members of the force, the answering of endless inquiries by correspondents, the identification of fossils collected in the several counties investigated, and the examination of various materials submitted by citizens of the state with a view of determining their economic value. All this was merely incidental. During the year I have completed the field work in Johnson and Cerro Gordo counties, and have prepared the manuscript reports on these counties, with maps and illustrations. These reports are now submitted as a part of the accompanying volume. The field work was extended into Floyd county. Reports on Buchanan and Delaware counties will soon be ready for submission. A paper has been prepared on Pleistocene Iowa, and another on the state quarry beds in Johnson county. Early in the year some anomalous conditions encountered in boring the Postville well were investigated, and a special paper has been prepared and published on the great stone quarries at Cedar Valley in Cedar county.

During the early months of the year Mr. Bain was mainly employed in the office, his time being principally taken up with supervising the printing of Volume V, which was then going through the press. The field work in Polk county was carried on at the same time and short excursions into various portions of the state were taken for the purpose of making

general correlations. In the spring the determination of the relations of the drift deposit south of Des Moines occupied some time, and in May the Guthrie county work was taken up.

July 1st Mr. Bain was given partial leave of absence, since which time a portion only of his time has been devoted to survey work, Mr. Leonard taking his place in the office. During the remaining months of the year most of Mr. Bain's time, so far as it was devoted to survey work, was spent in Polk and Guthrie counties, the reports upon these areas being submitted herewith. He has spent some time, however, in more general studies of the drift problems of the state in company with Messrs. Chamberlin, Leverett, Salisbury, Tilton, Beyer and Leonard. During the season he made some studies of the soil value of the loess, presenting a paper upon the subject to the State Horticultural Society in November.

Mr. A. G. Leonard began work in June, taking the place of Mr. Bain, in the office. Whenever the conditions in the office have made it possible, Mr. Leonard has spent the time in field work, devoting special attention to Dallas county.

Prof. W. H. Norton has devoted the time that could be spared for work in connection with the survey to completing his report on Artesian Wells. This work proved to be one of much greater magnitude than was at first supposed. The interpretation of the well records is a task requiring a vast amount of conscientious labor, and the correspondence involved in procuring records and giving directions for keeping them, consumed a great deal of time. The report as now presented brings the records to date, but the work of collecting information as new wells are bored in the future should be continued. The expense will be trifling compared with the value of the definite information which well records properly interpreted are capable of affording. Short supplementary reports, bringing the records up to date of publication, may be issued from time to time as occasion seems to warrant.

Dr. S. W. Beyer has devoted such time as he could spare chiefly to work in Marshall county. The work in this county is now complete and the report, suitably illustrated, is submitted as a part of the accompanying volume. Dr. Beyer spent a few days with me in Cerro Gordo county, and in my company he made a visit to the typical outcrop of the Buchanan gravels, the object being to get data for definite comparisons with Pleistocene deposits in Marshall county. He has also the field work in Story county well advanced toward completion.

The work in Madison county was assigned to Prof. J. L. Tilton and has been completed with very great care. The directions for careful studies of the different members of the Madison county section of indurated rocks and included faunas, with a view to using the information in correlating certain coal measure horizons in Iowa with those of other states, were faithfully carried out. Professor Tilton made some trips to typical localities elsewhere for the purpose of collecting data that would aid in the work in Madison. His report on the county, with necessary maps and illustrations, accompanies this report.

Miss Newman has continued to fill the position of secretary and general office assistant; and has performed the exacting duties of the place with such satisfaction and success as to merit special commendation.

I have the honor to remain, gentlemen, with great respect,

Your obedient servant,

SAMUEL CALVIN,
State Geologist.

REPORT OF MR. A. G. LEONARD.

IOWA GEOLOGICAL SURVEY,
DES MOINES, December 31, 1896.

SIR—I have the honor to submit herewith a report of the work done since entering upon my present duties last June. Much of my time during the summer was given to field work. Several weeks were spent in Guthrie county, part of the time in company with Mr. Bain, in studying the drift and Cretaceous rocks of that region. In July field work was commenced in Dallas county and was continued at intervals until the end of the season. Considerable material was collected for a report on the geology and economic resources of the county.

During the last of August and early part of September several trips were taken into Decatur and Clarke counties for the purpose of studying the Missouri or upper coal measure limestone, and also to establish more definitely the eastern limits of the formation. The limestone was studied at Osceola and Davis City in Iowa, and Cainsville, Missouri, and its border located at several points. The limits of the formation had already been determined farther north in Guthrie, Dallas and Madison counties. The value of this stone as a quarry rock makes the determination of its distribution and extent a matter of no little economic importance.

As a preliminary to the study of the drift deposits numerous points of interest in Polk county were visited during the summer. Trips were made to Polk City, Berwick, Mitchellville and the vicinity of High Bridge. A day was spent along

the Skunk river in determining the width and extent of its broad alluvial bottoms. Since the completion of the field season, as well as previously, a portion of my time has necessarily been taken up with the routine work of the office. Considerable progress has also been made in the preparation for publication of the results of investigations in the field.

Very respectfully,

A. G. LEONARD,
Assistant State Geologist.

To PROF. SAMUEL CALVIN,
State Geologist.

REPORT OF MR. W. H. NORTON.

MOUNT VERNON, Iowa, December 1, 1896.

SIR—I have the honor to transmit herewith the report just completed on the Artesian Wells of Iowa. The scope of the work has already been indicated in my report for the year 1895. During the present year, several months have been given without reservation to this investigation—a much longer time than was considered necessary at the opening of the year. The delay thus caused in the completion of the volume is only in a measure to be regretted; since the report now includes a much fuller treatment of several important topics than otherwise would have been possible, and collates a large amount of most valuable data from wells recently sunk in different parts of the state.

Your obedient servant,

WILLIAM HARMON NORTON.

TO PROF. SAMUEL CALVIN, PH. D.,
Director Iowa Geological Survey.