THE ANNUAL REPORT
OF
THE DIRECTOR

TWENTY-EIGHTH AND TWENTY-NINTH ANNUAL
Reports of the State Geologist

IOWA GEOLOGICAL SURVEY,
DES MOINES, DECEMBER 31, 1920.

To Governor William L. Harding and Members of the Geological Board:

GENTLEMEN: I beg leave to transmit to you herewith several papers with the recommendation that they be published as Volume XXIX of the Survey. This Volume will constitute the Twenty-eighth and Twenty-ninth Annual Reports of the Iowa Geological Survey. The titles of the papers submitted and the names of the authors of the papers are as follows:

Mineral Production in Iowa for 1919 and 1920, by James H. Lees.

Petroleum and Natural Gas in Iowa, by Jesse V. Howell.

The Origin and History of Extinct Lake Calvin, by Walter H. Schoewe.

The Missouri Series of the Pennsylvanian in Southwestern Iowa, by John L. Tilton.

New Echinoderms from the Maquoketa Beds of Fayette County, Iowa, by Arthur W. Slocom and August F. Foerste.

Echinoderms of the Iowa Devonian, by Abram O. Thomas.

A brief statement with regard to each of these papers will familiarize you with their content and will enable you to appreciate their value to the people of our State and to persons elsewhere who are interested in the geological features of Iowa.

MINERAL PRODUCTION IN IOWA FOR 1919 AND 1920.

During the years 1919 and 1920 the Survey co-operated as in former years with the United States Geological Survey in the preparation of statistics of mineral production in Iowa.

The value of the output in 1919 amounted at the places of production to $37,882,183, which was $859,826 less than that of the previous year. The decrease was due largely to the smaller output of coal in 1919. On the other hand, in 1920 the mineral production rose to $57,062,317, an increase caused by rises in the output and especially in the values of the chief minerals produced. Coal was the leading product and clay wares, cement, gypsum, and sand and gravel were the other important materials.

In 1919 there was mined 5,624,692 tons of coal which had a value of $17,352,620. The strike of miners lowered the output much below normal as was the case in all the unionized states. In 1920, however, the output increased to 7,774,916 tons with a value of $30,605,847. The average value per ton at the mine rose from $3.08 in 1919 to $3.94 in 1920. Iowa held eleventh place among the coal mining states in 1919. The United States is the largest producer of coal in the world and in 1918 mined 46.2 per cent of the world's total output.

The production of clay wares experienced a healthy growth during both years being considered. The output in 1919 was valued at $8,125,324 and in 1920 at $10,489,232, both of which figures are the largest in the history of the industry in Iowa. The most important product during both years was drain tile, in which this state leads all the states of the Union. The next material in order was fireproofing and the third was common brick. The values of these three in 1920 were $4,760,115, $3,048,776 and $1,146,182 respectively. The unit prices of these products as well as other clay wares show noteworthy increases each year. Iowa is hardly to be ranked as one of the great producers of clay wares, except as to drain tile and hollow building tile (fireproofing), in which she was third in 1920, as she produces annually less than 3 per cent of the national output.

The limestone and lime sold in Iowa in 1919 was valued at $567,356, while that sold in 1920 was worth $840,544. Most of the stone is crushed—over 379,000 tons each year. The use of finely ground limestone in agriculture is increasing as shown by a consumption of over 46,000 tons in 1919 and over 67,000 tons in 1920.

Sand and gravel are important natural resources of the state as is shown by a production of 2,093,471 tons, valued at $1,383,764, in 1919 and of 2,467,644 tons, valued at $1,993,441, in 1920. Nearly half a million tons of gravel and over two hundred thousand tons of sand were used for paving in 1920, while over a million tons of sand and a quarter of a million tons of gravel were used in buildings.

For many years Iowa has been one of the important producers of gypsum and its products—wall plaster, fireproofing tile, blocks, boards, etc., plaster of Paris and other materials. The last report of the Survey dealt with this subject in a most thorough manner. The production of gypsum materials in 1919 and 1920 showed the same upward trend as that of other minerals and rose from a value of $1,976,414 in 1918 to $2,634,444 in 1919 and $4,422,965 in 1920. In both years Iowa ranked next to the leader, New York, in value of output. One of the remarkable features of this industry is the great increase in the output and value of gypsum boards and blocks. In 1917 the production of these materials was 36,504 tons, with an average value per ton of $8.80, but in 1920 the production had risen to 88,212 tons, which sold at an average price of $18.56 per ton. The use of raw gypsum as fertilizer is on the increase as shown by sales of 41,404 tons in 1920, the largest amount shown by any state, as compared with 12,923 tons sold in 1916. It is most gratifying to be able to state to the Board that the published report of our Survey on gypsum which was prepared by Dr. Frank Wilder has been received most enthusiastically by persons in various parts of the world who are interested in gypsum. It will be one of the chief sources of information about gypsum for many years to come.

Only a few years ago Iowa entered the field as a producer of Portland cement, yet today she stands eighth among the states in this regard. The shipments in 1919 and 1920 were valued at $7,798,347 and $8,742,854 respectively. The annual consumption in Iowa is about 3,360,000 barrels, or about 1.40 barrels per capita of her population. This puts her in fourth place in per capita amount. Iowa is also one of the leading states in the production of concrete stone and block. In 1919

she ranked fourth and in 1920 first in this industry. The value of the articles produced was $706,146 in 1919 and $1,397,266 in 1920.

Other materials produced in the state were: mineral waters, valued at $5,703 in 1919 and $3,419 in 1920; potash, of which 89 tons, valued at $20,025, was made in 1919 from sugar beet waste; and natural gas, valued at $185 in 1919 and $290 in 1920. Some ferro-alloys were produced in 1919, although the value is not stated.

PETROLEUM AND NATURAL GAS IN IOWA.

The great demand for petroleum and its products, particularly gasoline and lubricating oils, has led to an intensive search for new supplies and a no less intensive search for buyers of stock in oil companies. In both of these lines of endeavor much of the effort has been honest, however intelligent or uninformed, but much has been fraudulent. Iowa in common with most states of the Union has had her full share of both classes of these two lines of effort and doubtless will have an abundance in time to come. In order to offer the best available information to those who have in view either the undertaking of a search for oil or gas or the investment of money in stocks of oil companies the Survey has had prepared a report on oil and gas in Iowa. The writer of this report, Dr. Jesse V. Howell, has not only been a student of the geology of Iowa for several years but has had five years' experience as petroleum geologist for several oil companies in the Mid-Continent oil fields. Therefore he is in position to write authoritatively on the subject in hand.

The first chapter of the report is devoted to a discussion of the physical conditions attending the formation and accumulation of oil and gas, the surface indications of oil and gas, the geologic conditions and structure of Iowa, including particularly the possibilities of the occurrence of oil and gas in the different geological formations present in the state, and a summary of the evidence regarding the presence of these minerals in Iowa and the areas in which drilling should be especially discouraged.

The writer states that the evidence indicates overwhelmingly that petroleum has been formed from the remains of plants and animals entrapped in marine or brackish water sediments and kept from decaying by the salt in the water. This material was later decomposed by the action of bacteria and through metamorphism of the rocks—that is, changes due to heat and pressure caused by movements of the earth's crust or by weight of overlying strata. Later accumulation of the oil or gas is dependent on the presence of a reservoir of suitable character, in other words of favorable structure and sufficient porosity, and with a cover tight enough to prevent the escape of the liquids or gases. A table gives the geologic horizons in which the oils of the different fields of the United States occur.

One of the interesting points brought out is the relation between the percentage of carbon in the coals of a region and the possibility of the occurrence of oil and gas in that region. It has been shown that where coal contains more than sixty-five per cent of fixed carbon, commercial deposits of oil have not been and probably will not be found. Most of the oil fields of America are in regions where the fixed carbon percentage is between forty-five and fifty-five. Examination of eighteen hundred analyses of Iowa coals shows that they contain from forty-five to sixty per cent carbon. Therefore this factor is not of itself decisive either for or against the presence of oil.

After discussing in detail the structures which are favorable to oil accumulation and the relation of ground water to accumulation Doctor Howell describes the surface indications of oil and gas. One is oil seepages and springs, which while common in some fields are not so in the Mid-Continent fields. Bituminous rocks are more often unfavorable than favorable as they indicate that any oil which was present in the past has escaped through evaporation. Oil shales are rocks containing organic matter which has not yet proceeded far enough in its decomposition to have petroleum. They are not indicators of oil. Coal beds are often considered as evidence of the presence of oil but there is no relationship in origin or in mode of accumulation of the two materials and the presence

of one usually indicates the absence of the other. There are many misleading indications, among which are: a scum on quiet waters, which is usually iron oxide rather than oil; a film of oil on drillings or water baled from wells which are being drilled, which comes from the oil used on the machinery; and the similarity of the topography of a region to that of other regions where oil is known to be present, which is absolutely valueless. Even the occurrence of fossils is not an indication of the existence of oil.

The geological formations are discussed in detail and the probabilities of oil being found in such well known horizons as the Platteville (Trenton), Silurian, Devonian, and the Cherokee shales, are considered. The prospect is stated to be distinctly discouraging. The only part of the state for which any hope is held out is the southwestern, including most of the three southern tiers of counties as far east as Winterset, Osceola and Leon. There is no use in drilling, either here or elsewhere, below the upper part of the St. Peter sandstone. The chance of failure, even in southwestern Iowa, is very high.

The second chapter of the report deals with stock promotion and outlines the methods in vogue for selling stock, the conduct of business by the best companies and the character and value of geological reports on oil territory. The writer states that in 1920 the people of Iowa lost nearly $100,000,000 in speculations in oil stocks and that in nearly every case the investors had no chance whatever of even securing the return of the principal. Lured on by the almost universal desire to "get rich quick" people have put their money into schemes which they had not investigated and which were promoted by men of whose ability and integrity and qualifications they knew little or nothing.

Oil companies are organized for producing, transporting, refining and marketing petroleum. Some of the larger companies engage in all these functions, but the smaller ones are able to carry on only one or more and it is usually the first, that of producing oil, which occupies their attention. By far the larger number of fraudulent promotions have been among this class.

The oil business is one of the most hazardous of the legitimate enterprises. Statistics show that only 80 per cent of the oil wells drilled in proven fields are productive. Not over 5 per cent of wild cat wells ever produce. An average well in the Mid-Continent field costs $20,000 and unsuccessful tests costing $200,000 are very numerous. Hence it will be seen that a small company with a limited capital stands a large chance of failure in its attempts to find a productive field. This liability emphasizes the need for securing the best geological advice before locating in a field.

With all these facts to guide the public there is only one safe rule in purchasing oil stocks and that is to invest in going concerns, those which are actually making money. Investment in any other company is speculation pure and simple. It is comparatively easy to distinguish the dishonest promoter as his methods are so sensational and extreme. He enlarges on other fields which have been successful and lists other small companies which have paid large dividends. But he forgets to mention the great number of dry holes which are found in every field and the great number of small companies which have absolutely failed. He usually includes a geological report which is written in glowing terms but is so obscure and complex that the average person can not understand it but is only mystified. An honest geological report is conservative, simply written, prepared by a man of known reputation, and should include a structural map of the region concerned. With such a report in hand and with a knowledge of the assets of the company one is in position to act intelligently regarding the purchase of stock.

This chapter is a splendid compendium of facts and ideas which will be of service to prospective investors, just as the first chapter will be of value in guiding the driller or those whom he may wish to interest in prospecting—"wildcatting" as it is called in oil fields. The report is illustrated by several maps and charts showing the geology and structure of Iowa and also by diagrams showing conditions under which oil and gas may accumulate.

The Origin and History of Extinct Lake Calvin

The paper of Doctor Schoewe on the Origin and History of Extinct Lake Calvin will be of special interest to students of Pleistocene geology. Reference to this lake was made first by J. A. Udden in his report on the "Geology of Muscatine County"[1] published in Volume IX of the reports of the Survey. Doctor Schoewe has established beyond a doubt the existence of Lake Calvin. The "fossil" lake is described in detail. Evidence is presented and reasons are given for the belief that Lake Calvin existed for a long time—up to the time of the Iowan ice invasion; for the first time the drainage of the lake is discussed, and the author's view of the origin and history of the lake is presented. The report contains a map showing the extent of Lake Calvin; it covered parts of Muscatine, Cedar, Johnson, Washington, and Louisa counties; its area was about 325 square miles and in places it had a depth of probably 100 feet; the outlet of the lake was at Columbus Junction.

The Missouri series of the Pennsylvanian in southwestern Iowa

The report of Doctor Tilton deals with the sub-divisions of the Missouri series and their locations in southwestern Iowa. Sections are given from outcrops along the rivers and from well records.

The relations of these Missouri strata in the central part of southwestern Iowa have long been misunderstood. This is in part due to the presence of great beds of Dakota sandstone, and of glacial drift that conceal all but scattered outcrops of strata. When Doctor Tilton was detailed to study the geology of Cass county he discovered that the strata were not like the strata at Winterset but were like strata in southwestern Nebraska. Further study brought to light evidence that a fault, or slip in the strata, that had long ago been reported near Missouri river, really extended from the river clear across southwestern Iowa, and how much further no one as yet knows. This fault divides southwestern Iowa into two distinct areas, and becomes the key to the interpretation of relations found.

He then constructed sections from measurements of outcrops obtained along the rivers, and arranged the records of deep wells so as to connect the eastern outcrops extending from Earlham and Winterset south to the state line with records obtained near the southwest corner of the state. This made it evident where the different subdivisions lay beneath the drift. This study of deep well records was further aided by the presence of some outcrops of the rocks themselves. Gradually it became possible to map the general positions of the beds of Missouri strata so largely concealed beneath Dakota sandstone and glacial drift.

The report while thus solving the major features of this complicated problem gives the data on which the conclusions can be tested and points to new problems, particularly in the study of fossils, which are the markers of the different strata. The report also points out the economic bearing of the location of minor folds, indicates the possibility of the presence of coal seams in the northern portion of the area, and by the fault line marks the northern limit of the Nodaway coal.

NEW ECHINODERMS FROM THE MAQUOKETA BEDS OF FAYETTE COUNTY, IOWA

This paper will be of chief value to persons interested in the past life of the State. Part One of the report was prepared by Arthur W. Slocom and Part Two by August F. Foerste.

Part One contains a glossary of crinoid terminology and the descriptions of five species of crinoids, viz: *Archaeocrinus obconicus, Maquoketocrinus ornatus, Porocrinus fayettensis, Dendrocrinus kayi,* and *Ectenocrinus raymondi.* Four of these are referred to existing genera and a new genus, *Maquoketocrinus,* is proposed for the other species. Two of the genera being members of the Rhodocrinidae, that family is discussed at some length; a complete bibliography of the Ordovician species found in America, a table showing their stratigraphic position and an analysis of their generic characters, are given. Several crinoid bases of attachment, presumably belonging to the Heterocrinidae, are figured and described. Three kinds

of crinoid columns, some of them having the lower row of plates of the calyx attached, are described but their systematic position is in doubt. Some bead-like columnals, which are abundant in this fauna, are referred to *Atactocrinus* Weller.

Part Two includes a description of one genus, two species, and one variety of crinoids, and one genus and five species of cystoids. The crinoids described are: the genus *Carabocrinus* Billings, the species *Carabocrinus slocomi,* the variety *Carabocrinus slocomi costatus,* and the species *Lichenocrinus minutus;* the cystoids described are: the genus *Pleurocystites* Billings, and the species *P. beckeri, P. slocomi, P. clermontensis, P.* sp., *P. multistriatus.* Certain species of *Carabocrinus* occurring in North America are compared with the European species *C. esthonus* Jaekel, suggesting the migration of the species from North America to northern Europe. The data presented indicate that *Lichenocrinus* may possibly occur in northern faunas. The genus *Pleurocystites* Billings is compared with other cystoids of the family Cheirocrinidae. The species *P. multistriatus* is compared with *P. angularis* and *P. anticostiensis.*

ECHINODERMS OF THE IOWA DEVONIAN.

This paper by Dr. A. O. Thomas is a contribution to the paleontology of the rocks of the Iowa Devonian system. These rocks are notable for the great variety and abundance of their fossil content. The remarkable fish remains described by Doctor Eastman in Volume XVIII of the Survey Reports were found in these rocks. Other groups of the Devonian fossils are being studied and illustrated by Doctor Thomas.

Echinoderms include such forms as the crinoids or sea-lilies, the blastoids, the cystoids, the echinoids or sea urchins, the starfishes, and some others. Each of the above named groups except the starfishes had known representatives in the Devonian of Iowa. While crinoids are not as abundant in the Devonian as in the overlying Mississippian rocks and while there are no famous localities such as at Burlington, Keokuk, or Le Grand, yet the Devonian rocks in places are filled with the comminuted parts of crinoids and a number of highly in-

teresting forms have been found complete enough for study. Blastoids and cystoids belonging to rare and highly specialized genera occur and a number of new sea urchins add much interest to the total assemblage.

In all forty-three species and two varieties are described and illustrated. Twenty-four of these species and the two varieties are new. Two of the genera are new and seven more of the twenty-two genera are reported from the Iowa Devonian for the first time. The other thirteen genera and nineteen species have been described in widely scattered literature. References to these have been brought together and some descriptions by other authors have been quoted verbatim, comments have been added, localities have been fully listed, and bits of history have been given of some of the specimens. Other details touching upon the work of the pioneer geologists, Owen, Hall, Wachsmuth, Barris, Calvin, and others have been interspersed.

A study of the distribution of the Iowa Devonian Echinoderms outside the state shows that only seven of the forty-three species are extralimital but of the twenty-two genera only three are wholly limited to the Devonian of this state. A table brings out the geographic and stratigraphic range of the genera. Some of them are widely distributed in North America and a few are to be found in nearly contemporaneous beds in Europe. The table also shows that the genera are dominantly late Devonian and early Mississippian rather than Silurian and early Devonian, a fact which corroborates the placing of all our Devonian in the upper series of that system as the author has done. A synoptic table of the Iowa Devonian rocks is given. As intimated above a number of rare and interesting genera heretofore remote from Iowa have been recognized for the first time in our Devonian. Such are *Arthracantha,* previously known from New York and Ontario, *Dactylocrinus,* a rare but world wide genus, and *Xenocidaris,* a form only meagerly known from the Devonian of Germany.

The genera *Melocrinus* and *Megistocrinus* are the commonest in our area and their dissociated calyces, arms, and stems make up the greater part of the crinoidal limestone of Devon-

ian age. *Melocrinus is* represented by six species and *Megistocrinus* by eight. *Hexacrinus* is a common genus in the Devonian of Europe. It is rare in America. This paper shows that only four species of *Hexacrinus* have been found in North America, three of these are from the Iowa Devonian, two of them being new. The most striking forms described by the author belong to certain genera of sea urchins found in the Lime Creek beds. Remains of these animals are very rare in early Paleozoic rocks but in the Mississippian system they are relatively abundant. Four species and one variety belonging to three different genera are described in the paper. This practically doubles the number of known echinoids below the Mississippian in North America. One of the new genera, *Nortonechinus*, is remarkable for its large number of interambulacral rows of plates, for the great amount of overlapping of these plates one upon the other, and for the peculiar spines whose outer ends are flattened and polygonal instead of being pointed. These spine apices were in contact and formed a sort of coat-of-mail outside the covering of moveable plates. Ambulacral plates and parts of the lantern are also described. *Devonocidaris*, another new genus, has long slender spines and thin delicate plates. *Xenocidaris*, of which only a few spines have been known from Europe, is represented by abundant spines and some other parts. These sea urchins have European affinities, a fact which some of the crinoids, notably *Dactylocrinus* and *Hexacrinus*, also emphasize.

An analysis of the fauna shows four species of cystoids, four blastoids, nineteen camerate crinoids, six flexible crinoids, five inadunate crinoids, and five echinoids. There is also one new variety of crinoids and one of the echinoids. A large parasitic snail which lived on one of the crinoids has been briefly described.

The fossils have been illustrated in a series of twenty plates on which are five hundred separate illustrations. There are also twenty text figures most of which are devoted to the elucidation of parts of the various species and to the plans of certain crinoid calyces.

OTHER PAPERS SOON TO BE PUBLISHED

Several other papers dealing with important phases of the geology of Iowa will soon be ready for publication. Among these may be mentioned reports by Dr. S. L. Galpin on the Clays of the State; by Dr. F. M. Van Tuyl on the Mississippian System of Iowa; by Dr. James H. Lees on the Geology of Crawford County; and by Dr. A. J. Williams on the Glacial History of Northeastern Iowa.

ADDITIONAL INVESTIGATIONS OF THE SURVEY

The Director of the Survey has been interested for several years in some of the problems involved in the interpretation of the glacial history of our State. Recently field studies have been carried forward in western Iowa. The chief purpose of the investigation here has been to determine whether or not a re-study of the tills, gravels and related deposits of the area would permit, in the light of our most recent knowledge of the Pleistocene of southern, southwestern and northwestern Iowa, a more satisfactory interpretation of the relationships and origins of these glacial materials than was possible when previous studies were made. Considerable additional field work will be necessary before final conclusions can be reached, but thus far the evidence warrants the following tentative statements:

1. The two oldest known tills, the Nebraskan till and the Kansan till, separated in many places by Nebraskan gumbotil of Aftonian age and in other places by peat, lignite and soil zones of Aftonian age, have been traced as far west as the western parts of Crawford and Shelby counties, a distance of less than 25 miles from the Missouri river, the western boundary of Iowa. Moreover, in the southeastern part of the town of Council Bluffs, in Pottawattamie county, there is a distinctive zone of leached Nebraskan till separating unleached Nebraskan till below this zone from unleached, oxidized Kansan till above the zone. The evidence in hand seems to indicate that both these two old tills extend to the Missouri river and probably also beyond into the State of Nebraska. If it were not for the thick deposits of loess overlying the tills in this

region no doubt many additional good sections of these two tills could be seen.

2. In western Iowa it has not been possible to distinguish the Nebraskan till from the Kansan till by differences in color, texture, lithological composition, or degree of weathering. Only when it is possible to establish the relationship of an outcrop of till and associated gravel to gumbotil or other interglacial material the age of which is known can the definite age of the till and gravels be determined. When the till is overlain by Nebraskan gumbotil or can be shown to lie lower topographically than nearby remnants of the eroded Nebraskan gumbotil plain, then the till may generally be interpreted as being Nebraskan till. If, however, an outcrop of till is overlain by Kansan gumbotil, or if the till has the proper relation topographically to remnants of the eroded Kansan gumbotil plain, the till may be interpreted as being Kansan till.

3. The sands and gravels of western Iowa which have been described by Shimek and Calvin as being Aftonian interglacial gravels separating the Nebraskan till from the Kansan till and not related in origin to deposits made either during the closing stages of the Nebraskan glacial epoch or during the Kansan glacial epoch are thought by the writer to represent not a distinctive stratigraphic horizon separating the Nebraskan till from the Kansan till. But instead they are interpreted as being lenses and irregularly shaped masses of gravels and sands within a single till, or, if in two tills, the Nebraskan and the Kansan, it is not possible to use the gravels and sands as evidence for differentiating these two tills. The gravels and sands are unleached and appear to be contemporaneous in age with the tills with which they are associated. This view is in accord with the author's interpretation, recently published, of the relationships to till of the well known gravels near Afton Junction and Thayer in Union county.

4. Many mammalian fossils have been found in the sands and gravels associated with the tills of western Iowa. Calvin and Shimek believed that these remains were of animals which were living during the time of deposition of the gravels, which they interpreted as Aftonian and interglacial. But

if the sands and gravels are lenses and irregularly shaped pockets related in age to the till with which they are associated, then a somewhat different interpretation of the age of the mammals becomes necessary. At the present time it is impossible to state whether the gravels in which the mammalian remains have been found are associated with Nebraskan till or with Kansan till since, as stated previously, it has not been possible thus far to differentiate Nebraskan till from Kansan till except where the relationships of the till to gumbotil the age of which is known have been established. If the gravels in which the mammalian remains have been found should prove to be lenses and pockets in Nebraskan till then the evidence would suggest that the animals are Nebraskan in age. It would be reasonable to assume that the animals were living in front of the advancing Nebraskan ice sheet, out from which sands and gravels were being carried. Remains of mammals became imbedded in the sands and gravels, which themselves later became incorporated in the onward moving Nebraskan till. If, on the other hand, the sands and gravels containing the mammalian remains should prove to be lenses and pockets in Kansan till then the suggested interpretation would be that the mammals were living on the Aftonian surface during the advance of the Kansan ice sheet out from which sands and gravels were being carried. After remains of mammals became imbedded in these sands and gravels the Kansan ice sheet advanced and incorporated in Kansan till these masses of sands and gravel in which the remains are found.

If these conclusions are justified, then this mammalian fauna may not be a strictly interglacial fauna of Aftonian age. It is important to note, however, that the fauna is certainly early Pleistocene—that is, it was closely associated either with the advance of the Nebraskan ice or with the advance of the Kansan ice sheet, or it was associated with both as a result of having persisted on the adjacent plains from Nebraskan through Aftonian to Kansan time.

5. The name Loveland formation was given by Shimek to a deposit in western Iowa which is a "heavy, compact, red-

dish (especially on exposure to the air) or sometimes yellowish silt, which when dry is hard with a tendency to break into blocks like a joint clay, and when wet becomes very tough and sticky and hence is sometimes called a gumbo." The type section of this formation is at Loveland, Harrison county. By early workers this formation was thought to be related to the widespread buff loess of the region, but Shimek believes that it is a fluvio-glacial deposit "formed during the melting of the Kansan ice." In many places it is calcareous and contains calcium carbonate concretions, many of which are from 3 to 6 inches in diameter; a few were seen with greatest diameter more than 12 inches. The Loveland does not show the laminations of water-laid clay, but in places sands and silts of distinct aqueous origin are interstratified with the Loveland clay; and in a few places volcanic ash is interbedded with the formation. Moreover, it has the vertical cleavage of loess and stands with similar vertical faces. Although in places fossil shells are present in the Loveland they are extremely rare in comparison with the numbers of shells which are in the buff loess. The writer believes that the Loveland is not a fluvio-glacial deposit but a loess distinctly older than the widespread buff loess which overlies the Loveland and which is thought to be chiefly of Peorian age; the Loveland is younger than the Kansan glacial epoch, since it lies upon the maturely eroded surface of Kansan till.

6. Northeast of the village of Little Sioux, in Harrison county, there are along the east slope of the Little Sioux river tills, gravels and related materials which were described by Shimek as the County-line exposures. Here are fine, whitish silts which were thought by Shimek to be part of a section of sands and gravels which he interpreted as being Aftonian in age. Recently these silts were studied by Doctor Alden, who proved that they are volcanic ash. The writer is convinced that this volcanic ash is not of Aftonian age but is of the same age as the Loveland loess with which in some of the County-line exposures it is interstratified.

The Assistant State Geologist, Dr. James H. Lees, is studying the geology of several of the counties of the State. More-

over, he is rendering valuable service in editing reports of the Survey. He is by correspondence and by personal visits furnishing information to persons interested in the development of one or more phases of the geology of the State.

The Survey is co-operating with the United States Geological Survey in the work of stream gaging and discharge measurements of the State, in the collecting of mineral statistics, and in the preparation of topographic maps. In connection with the stream gaging the Survey co-operates also with the Iowa State Highway Commission and the Mississippi River Power Company.

Dr. W. H. Norton continues to furnish to the municipalities of the State useful information with regard to the underground waters of Iowa.

WORK OF THE SURVEY OFFICE

The work of the office has been in charge of Dr. James H. Lees, Assistant State Geologist, and Miss Nellie E. Newman, Secretary. Among the many kinds of service being rendered by officers of the Survey, permit me to refer again to those which have been emphasized frequently in reports to the Board:

1. Replying to scores of letters in which information is asked with reference to the geology and mineral resources of the State. In much of this correspondence questions are asked with reference to local geology.

2. Furnishing information in regard to state reports and other publications dealing with the geology and mineral resources of the various sections of the state.

3. Itemizing and reporting on numerous specimens of minerals and fossils which are submitted by the citizens of the state. Advice is given as to whether or not the minerals are of value or are likely to be found in sufficient quantity to be of commercial importance.

4. Giving advice with regard to reliable firms where analyses and other tests may be made to establish the commercial value of any mineral deposit.

5. Trying to prevent an unfounded rumor from gaining ac-

ceptance in the public mind with regard to the reputed discovery of gold, oil, or other product before it leads to large losses and unnecessary excitement.

6. Giving the geological facts to city officials, railway companies, and private citizens with regard to water supplies, availability of road materials, etc.

7. Informing citizens regarding the advisability or inadvisability of investing time and money in the development of particular deposits of mineral within the state.

Respectfully submitted,

GEORGE F. KAY,
State Geologist