THIRTY-EIGHTH ANNUAL REPORT OF THE STATE GEOLOGIST

IOWA GEOLOGICAL SURVEY,
DES MOINES, DECEMBER 31, 1929.

To Governor John Hammill and Members of the Geological Board:

GENTLEMEN: Six papers are herewith submitted to the Board with the recommendation that they be published as Volume XXXV—the Thirty-Eighth Annual Report of the Iowa Geological Survey. The titles and authors of the papers are as follows:

Further Studies of the Pleistocene Geology of Northwestern Iowa, by J. Ernest Carman

The Dakota Stage of the Type Locality, by A. C. Tester

The Stratigraphy of the Kinderhook Series of Iowa, by Lowell R. Laudon

The Natural Molding Sands of Iowa, by John E. Smith

On a New Specimen of a Paleoniscid Brain from Iowa, by Roy L. Moodie

Mineral Production in Iowa in 1928 and 1929, by James H. Lees.

A report entitled the Pleistocene geology of Northwestern Iowa by Dr. J. Ernest Carman was published by the Iowa Geological Survey in Volume XXVI (1917), pages 233 to 445. Later work in northwestern Iowa has shown that those parts of the report of 1917 having to do with the Kansan drift region, as there interpreted, should be revised in order to recognize an Iowan drift region in the eastern part of the area there called Kansan. The recognition of this Iowan drift region required many changes of interpretations and much of the data presented in Chapters III, IV and V of the report of 1917 is here presented again in rearranged form and with new interpretations.

In the present report Chapter I summarizes that part of the earlier work in northwestern Iowa which bears directly on the area here called Iowan. Chapter II treats the Iowan drift region including certain associated gravels. Chapter III treats the Kansan drift region. Chapter IV deals with the loess and Chapter V with the gravels in the valleys, chiefly of the Iowan drift region. The report closes with a sum-

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mary of the conclusions reached concerning the various subjects treated in the report.

The Iowan drift region of northwestern Iowa as recognized in this report includes a questionable area which has been variously interpreted by earlier workers in this region as Wisconsin, extra-morainic Wisconsin, Early Wisconsin, Iowan or Kansan. During the progress of the work upon which the report of 1917 was based this area was differentiated and its limits determined, but because of its indefinite characteristics, and also because of differences of opinion as to its correlation, it was finally decided not to recognize it as separate from the Kansan drift region. It is an elongate north-south area lying between the Des Moines lobe of the Wisconsin drift sheet on the east and the more positive Kansan drift region along the west line of the state. Its extent in Iowa is about 2,000 square miles and it continues northwestward across southwestern Minnesota to Watertown, South Dakota. Southward the area terminates at the south line of Sac county.

The characteristics of the Iowan drift topography are faint and rather indefinite. The drainage pattern is roughly dendritic and a general view suggests an erosional topography. However, a closer study shows that the slopes are not long, smooth slopes due to erosion but are somewhat uneven and billowy, and the valleys are more or less obstructed. The interpretation is offered that this region had an erosional topography developed in the Kansan drift and that the thin Iowan drift sheet merely veneered this erosional topography. It thus results that the greater relief features are erosional and the minor features are constructional. It is a masked erosion topography. The characteristics of the Iowan till are so like those of the Kansan till that the two tills cannot in many exposures be definitely separated. The till of the Iowan region has much gravel associated with it. Some of the gravel is in masses in the till, some is in low mounds at the surface, some is interbedded with the till, and some is in bedded deposits in the valleys. These several types of gravel, which appear to have had a common origin, are discussed and interpreted. The till and gravels of the Iowan region are overlain by a thin layer of loess which is interpreted as Peorian in age. This loess is continuous with the Missouri River loess to the west.

At a few places in the Iowan drift region a till, beneath the Peorian loess, rests upon older loess, silt and sand deposits which are younger

than the erosion of the Kansan till and are interpreted as Loveland. These exposures fix very definitely a post-Loveland, pre-Peorian till in northwestern Iowa. It is assigned to the Iowan age and correlated with the Iowan of eastern Iowa on the bases of similar topography, similar relations to the Kansan below and to the overlying mantle of loess, and similar geographical positions with respect to the later Wisconsin drift region.

The paper by Dr. A. C. Tester entitled The Dakota Stage of the Type Locality is the result of several years study in the field and laboratory. It deals primarily with the exposures of Dakota rocks in Woodbury and Plymouth counties, but it also describes in detail the rocks of the same age in Dakota county, Nebraska, and makes some comparisons with other localities in Iowa, Nebraska and Kansas.

The first chapter contains an analysis of all previous work done in the area or in adjacent areas which have a bearing on the type section.

The literature on the subject dates to the first decade of the nineteenth century when Lewis and Clark, Nuttall and others made their explorations. The last work of significance was done during the closing years of the nineteenth century and the first part of the twentieth century by Calvin, Bain, Gould and others. Since this work many new ideas have developed and the question of the age and stratigraphic relations of the Dakota has become one of considerable interest.

Following the detailed descriptions and interpretation of ten stratigraphic sections the author describes other exposures of the Dakota in southwestern Iowa and in Nebraska and Kansas. The exact stratigraphic position of the marine invertebrate fossils in Iowa and Nebraska is related for the first time in the study of these formations. A comparison is made of the fauna as found in this locality with that of the Mentor-Kiowa of Kansas, and the close relationships of types and age are stressed.

No stratigraphic or erosional break occurs between the Dakota and Graneros of Iowa, and the fauna of the Dakota is of the lower Cretaceous type, which is much older than previously supposed for the Iowa formations. This fact suggests that the lower Cretaceous of the northern interior is a *series* closely related to the upper Cretaceous Series. The Dakota is described as the upper *stage* of the lower *series*. Lower stages of the Cretaceous are not known in Iowa though they do occur farther south.

It is believed that the sea advanced into Iowa from the west and

southwest. Petrographic analyses of the sandstones show appreciable amounts of quartzite, basic feldspars and chert grains. It is believed that a land mass including northwestern Iowa and southwestern Minnesota furnished much of the materials present in the Dakota sandstone beds. The rivers carrying this material had a general west or southwest course, draining from the landmass of Siouxia.

Dr. Lowell R. Laudon in his paper entitled The Stratigraphy of the Kinderhook Series of Iowa states that the Series in Iowa contains three formations, the Maple Mill at the base, followed by the English River, and capped by the Hampton formation. The term Hampton is proposed for the Kinderhook members above the English River formation. It is named after the city of Hampton in Franklin county, around which the beds are best exposed.

The Maple Mill formation consists mainly of shales and fine silts. Its distribution is mainly in southern Iowa. It is correlated with the Chattanooga of the standard Mississippian section.

The English River formation consists mainly of blue to yellow quartz siltstone. It is exposed mainly in southeastern Iowa. The northernmost exposure is at LeGrand, Iowa. It is very fossiliferous throughout and is correlated definitely with the Hannibal formation of Missouri. It is separated from the overlying Hampton formation by a marked angular unconformity. Its relation to the underlying Maple Mill formation is not definitely known.

The Hampton formation consists of a varied group of mainly calcareous sediments. Dolomites predominate by far. It includes also oölitic limestone, lithographic limestone, limestones of various colors, chert, and a little sandstone. The Hampton formation has been divided into members on the basis of both its lithology and its fauna. These members have been traced areally throughout the belt in which the Kinderhook is exposed in Iowa. The Hampton formation is unconformably overlain by the Burlington limestone.

The results of Doctor Laudon's investigation may be summarized as follows:

1. The Sheffield formation has been determined to be Upper Devonian in age and has been correlated with the Chemung of New York.
2. The Kinderhook formations have been found to be separated from the Sheffield formation by a marked angular unconformity and a very sharp faunal break.
3. The shale formation of southeastern Iowa (Maple Mill) and

the shale formation of north-central Iowa (Sheffield) are not of the same age.

4. The Sheffield formation has been identified as far south as Amana, Iowa.

5. The English river formation seems likely to be a marine overlap from the south and represents only the upper part of the Hannibal formation of Missouri.

6. The English River formation has been traced as far west and north as LeGrand, Iowa.

7. The English River formation is separated from the overlying Hampton beds by a marked unconformity and a marked faunal break. A fish tooth conglomerate marks this contact at one place.

8. The lower part of the Hampton formation is correlated with the Chouteau formation of Missouri.

9. The upper part of the Hampton formation (Maynes Creek, Eagle City, and Iowa Falls members) carries a fauna that has been derived from the Chouteau fauna. The fauna of these members, however, is probably younger than any part of the Chouteau of Missouri.

10. The Wassonville chert horizon has been found to be a very widespread horizon marker in the Hampton formation in Iowa.

11. The Alden limestone formation is separated from the underlying Hampton formation by a marked angular unconformity. The Alden limestone is correlated with the Gilmore City limestone (Humboldt Oölite) of Humboldt and Pocahontas counties. The limestone at Gilmore City carries a fauna which is definitely younger than any Kinderhook fauna but whose stratigraphic position has not been definitely determined as yet. For these reasons the Alden limestone has not been included with the Kinderhook.

The paper by Professor John E. Smith on The Natural Molding Sands of Iowa defines these sands as being "mixtures of sand, silt, and clay in such proportions as to make them adapted for use in various kinds of foundry work." This mixture must allow ready escape for the gases that form when the molten metal is poured into the molds and at the same time it must have sufficient bond strength to allow it to hold its shape in the mold. Professor Smith gives the results of tests on a number of molding sands from Iowa and a few from other states and then proceeds to give descriptions of the deposits that he found in the various counties. Most of these are in eastern Iowa, but

a few are west of Des Moines. They are found, not as a part of the bedrock, but as part of the loose mantle rock and are classified as flood plain deposits, lake deposits, glacio-fluvial and glacio-eolian deposits and eolian and residual deposits. Professor Smith concludes that "There is an abundance of nearly all kinds of molding sand in Iowa and some of each is now being used in the various foundries of the state. Our own sand should be used much more extensively instead of that shipped here from other states."

Dr. Roy L. Moodie in his short paper entitled On a New Specimen of a Paleoniscid Brain from Iowa describes a nodule which contained the fossilized brain of an ancient fish. This nodule was picked up on the Rock Island railroad track at Iowa City and so the exact locality where this fish made its home can not be known. Doctor Moodie first gives a historical review of writings on similar subjects and then discusses the primitive sturgeons with which this Iowa fish was allied. He states that the later relatives of these sturgeons gave rise to land vertebrates, to the air-breathing fishes and to the more modern bony fishes. He then describes the Iowa nodule and discusses the character of the brain and of the type of fishes from which it was derived. Doctor Moodie's paper is a unique and important contribution to the study of fossil life in the upper Mississippi valley.

The mineral production in Iowa during 1928 and 1929 is discussed by Dr. James H. Lees. The mineral industry showed some gains in both of these years although in neither year was the increase a large one. Quantities and values in 1928 were greater in cement, coal and stone produced and values in sand and gravel were somewhat greater, although the quantities produced were somewhat less than in 1927. Clay and gypsum products showed declines, quite marked in the case of gypsum, only slight in the case of clay products. The production of Portland cement was 31 per cent greater in 1928 than in 1927, and shipments were 22 per cent greater. Six plants were working, as the Gilmore City factory, which had been idle for two years, was put into operation. A marked concentration of clay plants is noted, as only 48 plants were at work in 1928 in contrast with over four hundred in earlier years. Only one pottery reported production—that at Bellevue, making red flower pots. The coal industry began to look up after the disastrous strike of 1927, and it increased production by over 700,000 tons. Even then, the production was less than one-half the output of peak years. Marion county now holds the leading place which Mon-

roe held for so long. The results of an extensive series of analyses of Iowa coals are given, both by mines, by districts and by the geologic horizons from which they came.

The gain in output during 1929 was not equal to that made during 1928, but at least it indicated that the mineral industry was progressing. Shipments of cement from Iowa factories were a little less than in 1928, and prices were slightly lower. This was despite the growth of the state's road making program. The value of clay products marketed exceeded that of 1928 by over $700,000 and the value of coal sold was more than a million dollars above the value for the year before. The decrease in building during 1929 seems to be responsible for the fact that gypsum sales fell off by $687,000, and perhaps the same cause may be blamed for the lessened output of limestone and lime and of sand and gravel so far as these materials entered into building construction other than road building. The report includes lists of operators in the state.

The following table summarizes production during 1927, 1928 and 1929.

Product	1927	1928	1929
Cement	$ 9,124,405	$10,734,838	$ 9,781,159
Clay wares	5,194,780	5,048,774	5,791,175
Coal	9,304,000	10,525,000	11,948,000
Gypsum	6,713,497	5,355,214	4,668,856
Stone and lime	1,267,033	1,742,252	1,560,066
Sand and gravel	1,839,176	2,094,955	2,211,752
	$33,442,891	$35,501,033	$35,961,008

In November of 1928 an oil prospect well was begun on the Nodaway river bottoms about four miles south of Clarinda. As this well has attracted much attention among laymen and oil experts, mention of it is added to this report. Interest is attracted to this well by several factors. In the first place its depth of 4,671 feet makes it the deepest in the state by over 1,200 feet. Then too it is located in that part of the state whose underground geology is least known, owing to the fact that the strata lie deeper here than in any other part of the state. This is because of a great basin or trough that bows the rocks far down into the earth, although these same rocks come to the surface farther east and northeast. It has been the hope of oil producers that the western interior oil fields might be shown to extend into southwestern Iowa, but so far this has not been demonstrated. As the promoters of the well sent the Survey a very complete set of samples of

the drillings it was possible to make a careful study of the strata penetrated. The results of this study will be published by the Survey in the near future.

In Volume XXXIV of the reports of the Survey the Director and his research assistant, Doctor Apfel, published a paper entitled "The Pre-Illinoian Pleistocene Geology of Iowa." In the closing paragraph is the following statement: "Although much has been accomplished by the many persons who have contributed to our present knowledge of the Pleistocene geology of Iowa there are yet many unsolved problems pertaining to the tills, gumbotils, gravels, peats, loesses, life, and other features of the glacial and interglacial deposits. In the future new facts and new interpretations of deposits of Pleistocene age will be presented, and as in the past new facts and interpretations will develop renewed interest and stimulate increased effort in unraveling the fascinating history of the Pleistocene deposits of our state and of other states."

More recent papers by the Director have included "Contributions to the Pleistocene Geology of Iowa," which appeared in Volume 36 of the Proceedings of the Iowa Academy of Science; "The Relative Ages of the Iowan and Wisconsin Drift Sheets," published in Volume 21 of the American Journal of Science; and "The Classification and Duration of the Pleistocene Period." The last named paper will appear in the 42d Volume of the Bulletin of the Geological Society of America. In this paper under "Concluding Statements" the most significant features of the paper are summarized as follows:

"Deposits of the Pleistocene or Glacial Period have been subjected to detailed study in America for more than fifty years. In the Mississippi Valley in particular the records of this most fascinating chapter in the earth's history have been remarkably well preserved and thoroughly investigated. In fact, this area has been made a classic one as the result of the researches of T. C. Chamberlin, McGee, N. H. Winchell, Leverett, Calvin, and many other geologists. Here evidence has been found which is conceded to be the most reliable in interpreting the history of the Pleistocene, in classifying the deposits of this geological system, and in estimating the duration of the Period.

In this paper the classification and the duration of the Pleistocene Period have been discussed. It was pointed out that when the most significant facts of Pleistocene history are analyzed critically in relation to what might be considered as a logical classification it is evi-

dent that from the time of the advance of the first ice-sheet, the Nebraskan, to the retreat of the last ice-sheet, the Wisconsin, there were recurrences of similar geological events with accompanying similar geological results. In other words, there were within the limits of the Pleistocene Period a succession of cycles, the most significant evidences of which are recorded in the deposits which were made during each cycle and in the changes which the deposits underwent before the coming of the succeeding cycle. Reasons were given for the interpretation that Pleistocene history involved four cycles. The judgment was expressed that it would seem to be desirable at the present time to bring together for distinct recognition in Pleistocene classification the sedimentary units which are the chief products of the cycles and to designate these cycles as epochs and the sedimentary units, each of which consists of the intimately associated glacial and interglacial materials formed during an epoch, as series.

A revised classification of the Pleistocene has been presented. It recognizes four epochs (series), each of which is divided into ages (stages) which continue to have the well established names of the present classification. New names have been chosen for the four epochs (series): Grandian, Ottumwan, Centralian, and Eldoran. These names were chosen from localities where the materials of the different stages have been studied in all their relationships and where they have areal distribution.

Estimates of the minimum duration of the Pleistocene in Iowa have been given. The evidence used in reaching judgments as to the durations of the interglacial ages was gained chiefly from extensive field studies in Iowa of relative depths of leaching of calcium carbonate in similar materials which throughout their times of leaching were similarly situated topographically and climatically. Leached gravels of known ages were compared. The differences in depths of leaching are the results of the differences in lengths of time to which the gravels were subjected to weathering agents. The depth of leaching of upland gravels in the Late Wisconsin drift was determined to be about 2 feet 6 inches. This leaching is the result of exposure to weathering since the retreat from Iowa of the Late Wisconsin ice-sheet, that is, through a period estimated to be about 25,000 years. With this rate of leaching of gravels as a unit estimates were made of the lengths of time involved in the leaching of other gravels of known ages. The results for Iowa as given in this paper are as follows: post-Late Wisconsin

time, 25,000 years; post-Iowan time, 55,000 years; Sangamon interglacial time, 120,000 years; Yarmouth interglacial time, 300,000 years; and Aftonian interglacial time, 200,000 years. The combined durations of Aftonian, Yarmouth, and Sangamon interglacial ages, and of post-Iowan, total about 675,000 years.

The durations of the glacial ages in Iowa were estimated from present-day consensus of opinion as to the rates of advance and retreat of ice-sheets. For the retreat of the Late Wisconsin from Iowa the rate of one mile in ten years was adopted. The same rate was assumed for the advance of this ice-sheet into Iowa and also for the advances and retreats of earlier ice-sheets. The minimum duration of glacial time in Iowa was calculated to be about 30,000 years.

In accordance with the methods of evaluation adopted in this paper minimum interglacial time in Iowa was determined to be approximately 675,000 years and minimum glacial time in Iowa about 30,000 years, the combined estimates giving for the whole Pleistocene in Iowa a minimum duration of about 700,000 years. How far this estimate of the minimum duration of the Pleistocene falls short of the actual duration can not be determined from reliable quantitative evidence. However, it would seem safe to state that the Pleistocene involved probably a million years, possibly twice this length of time.

Evidence was presented also for the judgment that the 5 feet of gumbotil on the Illinoian till involved in its development about 70,000 years, the 12 feet of gumbotil on the Kansan till 250,000 years, and the 8 feet of gumbotil on the Nebraskan till 150,000 years. Gumbotil development was preceded in all cases by leaching of calcium carbonate.

As investigations of Pleistocene deposits continue into the future better and better standards of measurements will be established, and hence more and more accurate determinations of Pleistocene time will be made. The classification of the Period will no doubt have to be revised from time to time as further refinements of study of glacial and interglacial deposits enable more definite interpretations of their origin and history."

Respectfully submitted,

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State Geologist.