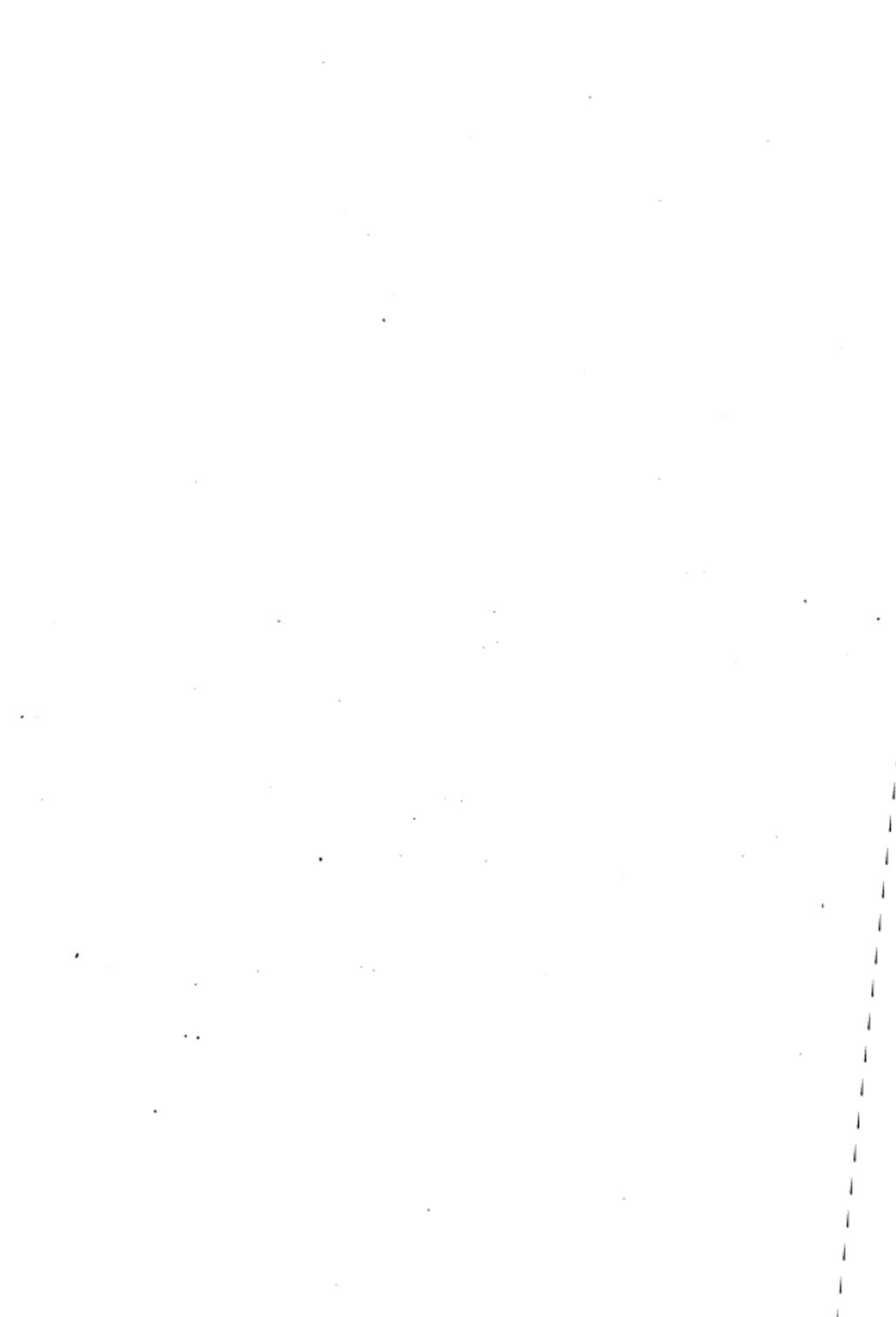

WORK AND SCOPE OF THE GEOLOGI-
CAL SURVEY.

BY

CHARLES ROLLIN KEYES.



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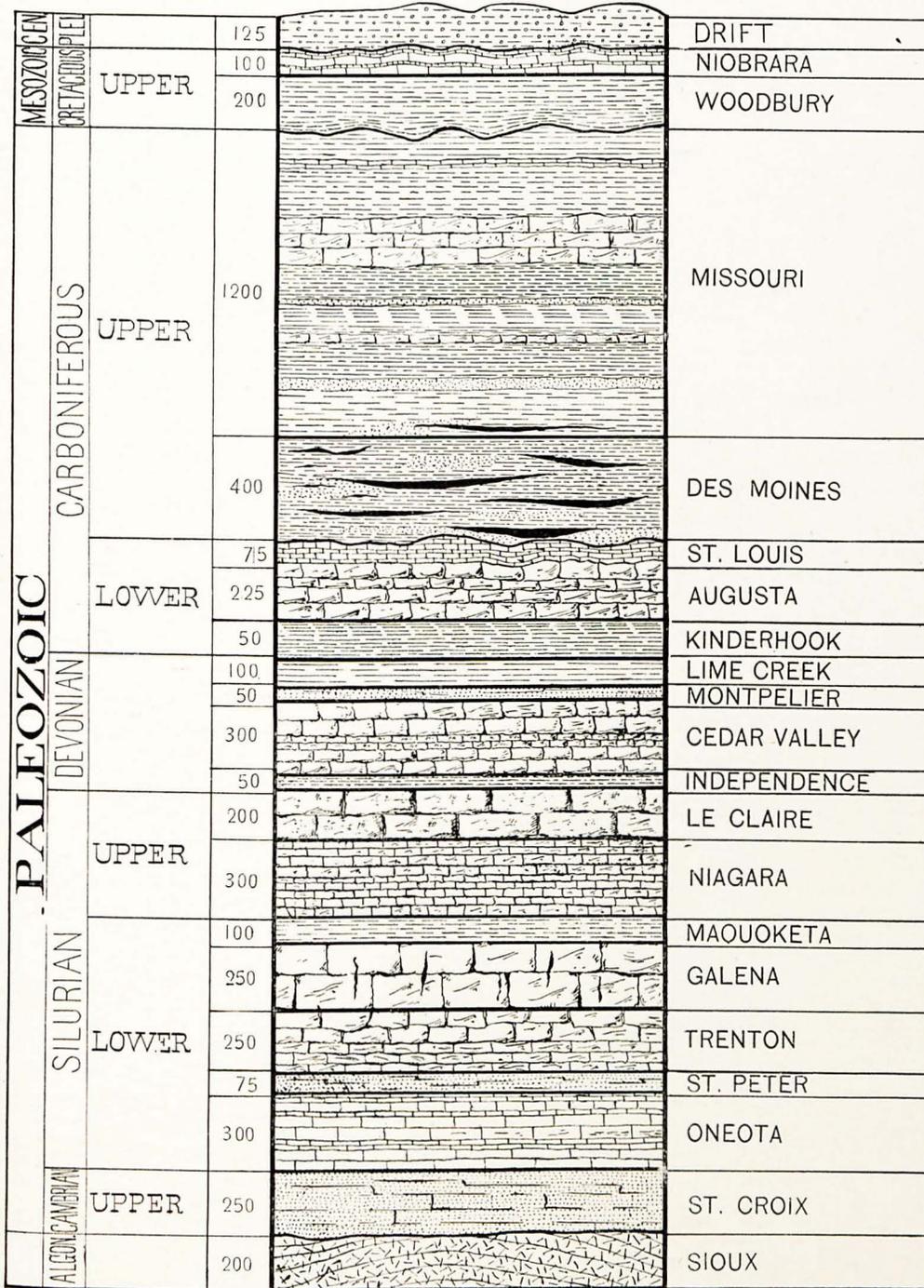
CONTENTS.

Establishment of the Geological Survey of Iowa.....	48
Object of the Geological Survey.....	50
What is to be Expected of the Survey.....	53
General Plan.....	55
Subject Work.....	55
Areal Work.....	58
Publication of Results.....	58
Scheme of Work.....	60
Work in Progress.....	60
Coals.....	60
Clays.....	63
Building Stones.....	66
Artesian Waters.....	68
General Geology.....	71
Mapping.....	73
County Resources.....	74
Chemical Work.....	77
Collections.....	77
Library.....	79
Work Taken Up.....	79
Soils.....	80
Gypsum.....	83
Zinc and Lead.....	84
Minerals (not yet mined).....	85
Road Materials.....	86
Lime.....	87
Cement.....	87
Oil and Gas.....	88
Fossils.....	90
Statistics.....	92
Work Not Yet Begun.....	92
Publications.....	94
Work of the Future.....	96

ESTABLISHMENT OF THE GEOLOGICAL SURVEY
OF IOWA.

The people of Iowa, through their representatives at the last session of the General Assembly, authorized a geological survey of the State. Probably at no period in Iowa's history had she felt more the need of a thorough economic investigation of her native wealth. The survey contemplated was not an investigation such as was vaguely conceived by many, but one broad in its scope and far-reaching in its workings, one whose primary aim was to bring before the public the State's natural products, to encourage its material development and to invite the investment of outside capital. Indeed, it had long been a matter of general regret that a commonwealth so happily supplied with boundless natural riches should have no official information concerning them to which either her citizens or the public at large could turn.

The law establishing the Geological Survey provides for "a complete survey of the natural resources of the State in all their economic and scientific aspects, including the determination of the order, arrangement, dip and comparative magnitude of the various formations; the discovery and examination of all useful deposits, their richness in mineral contents, and their fossils; and the investigation of the position, formation and arrangement of many different ores, coals, clays, building stones, glass sands, marls, peats, mineral oils, natural gas, mineral and artesian waters and such other mineral materials as may be useful, with particular regard to the value of said substances for commercial purposes and their accessibilities; also, the careful noting of the characters of the different soils and their capacities for agricultural purposes; the growth of timber and other scientific or natural history matters that



GENERAL GEOLOGICAL SECTION OF IOWA.

may be of practical importance and interest." The law is liberal in its application, comprehensive in its requirements, practical in its bearings. Not the least valuable of its measures is the provision for the diffusion of useful knowledge among the citizens of the State. The demand for authoritative information of this kind has long been so urgent that it is a matter of much surprise that steps in the proper direction were not taken years ago. To be sure, such a movement has been twice started and twice rendered inactive, first in the fifties and again more than a quarter of a century ago. Both attempts were hurried reconnaissances—one of the eastern half of the State, and the other of the western portion. Being thus merely preliminary, the results were necessarily very incomplete. Moreover, during the past two decades much information concerning the mineral wealth of Iowa has accumulated, and when brought together in a connected way with the results of other investigations it will be of the greatest value. In the same period geology itself has made gigantic strides, not only scientifically but economically.

The great interest now shown in the examination of the natural resources of Iowa is not confined wholly to the people of the State. There are probably as many persons living without the borders of Iowa as there are within them who are keeping themselves informed as to what is being done by the Survey. Indeed, the work has met with as universal favor and appreciation abroad as at home. As was well stated not long ago in one of the leading newspapers, Iowans are, as a rule, too busily occupied with their own affairs to go much out of their way to get information in regard to that which does not connect itself directly with the advancement of their own material interests. The benefits of the Survey appear to some people to be

only indirect; hence, there is often by these persons a lack of proper appreciation of the aims and ends of the work. As the real facts become known and the citizens become more and more acquainted with the doings of the Survey it is extremely rare that a warm interest is not manifested. This solicitude for the carrying out and completion of the investigations begun is not shown in Iowa alone. As the published reports are made accessible they are reviewed and talked about, more or less, in almost every country of the globe.

In connection with the report on the progress of the Iowa Geological Survey, it has been thought desirable to present in some detail the general scheme of operation. As will be readily seen, the entire plan of the Survey is practical in its aim. While thoroughly economic in all its aspects the work is so arranged that it may be carried on in a manner perfectly systematic and scientific. At all times the investigations are conducted in a way which, it is thought, will best serve the interests involved.

OBJECT OF THE GEOLOGICAL SURVEY.

When a merchant wishes to know exactly how his business stands he takes an inventory of his possessions. A state in establishing a geological survey has also in mind an inventory of her possessions; that is, of her natural products, all those mineral substances which may be made to serve the purposes of man. But a geological survey is very much more than a simple inventory—a mere taking account of stock. It not only lists the various minerals, but locates them accurately, investigates their qualities, extent and accessibility, notes their particular uses and value, and suggests improvements in the methods of obtaining and treating them for commercial purposes. In

order that the information may be readily and accurately interpreted the determinations and facts are recorded and explained on suitable maps or in the descriptive notes which accompany them.

In the establishment of the Geological Survey it was manifestly not the purpose of the legislators, as many people suppose, to replace by state work individual testing and investigating, but rather to encourage and supplement personal efforts and greatly lessen the chances of failure.

Among the general objects to be attained for the State through the work of a completed geological survey may be mentioned :

(1) The provision of a suitable foundation for detailed and intelligent search for mineral wealth. One of the chief benefits resulting from this work is the limitation of different mineral bearing areas in which prospecting may be profitably undertaken. The necessity of this course has appeared all the more urgent as the work of the Survey has progressed. It may be a matter of considerable surprise to learn that carefully made estimates show that more money has often been wasted in many counties in a single year in ill-advised and poorly conducted efforts to discover coal and other minerals than would annually support a systematic investigation of the entire State. Numberless abandoned diggings are met with, most of which mark fruitless efforts to obtain minerals in places where success is as utterly hopeless as could be imagined. All this useless expenditure of capital and labor might have been largely avoided had some authoritative information concerning the geological features of the particular localities been accessible.

(2) The assurance of permanency in the development of resources already known. Means will be provided

beforehand by which, without encountering repeated failures and inconveniences, each one may know how to turn his discoveries to best account, how to work the deposits to the best advantage and how to prepare the product in the most suitable manner for market. The properties of the different substances and the uses to which they may be put having been determined practically, the further advancement of the dependent industries is greatly simplified. On the completion of the work on any subject all information possible is brought together, so that when a person engages in any mining enterprise or business connected with the natural resources of the State he can hardly fail to find in the particular report something which will greatly assist him in his efforts and prevent useless waste of time and money.

(3) The establishment of an official guaranty respecting the natural wealth of the State. Information given by disinterested persons concerning the State's possessions is always regarded as more trustworthy than when imparted by private individuals. Citizens at home as well as abroad have confidence in making investments and feel that they are not entering into mere speculative fields.

(4) The formation, on a scientific basis, of a standard by which the geological features of the State may be compared with those of other districts. There is a wide demand for something of this kind for purposes of instruction in schools and colleges. Text books commonly used consider only the principles of science; the reports of the Survey supplement this outline by giving detailed information of local application.

(5) An advancement of the agricultural interests of the State. This is more fully considered elsewhere under the subject of soils.

WHAT IS TO BE EXPECTED OF THE SURVEY.

Popular opinion differs widely as to the proper functions of a geological survey. Just what should be expected of the organization, in accordance with the evident intent and expressed purpose of the law establishing the Survey is manifestly not fully understood by many persons. It, however, has been best stated perhaps by the editor of the Iowa State Register, in an editorial which appeared in the issue of January 31, 1892, when the bill for the Geological Survey of the State was pending before the General Assembly :

“A glance at what other states are doing to encourage the development of their mineral wealth forcibly impresses us that great advantages are to be derived from a thorough investigation of our own natural resources. Nature has given us one of the richest domains in the world. She has done much ; as yet we have done but little. Fortunately, however, our farmers, mechanics, miners and legislators are beginning to see what geological surveys have done for other states and countries, and what a similar organization can do for our own. Geology comprehends all the facts ever known respecting the rocks and minerals of the earth, and all the uses to which they have been applied. It has treasured up the agricultural capacities of every soil and the best means of developing those capacities, yet many persons have doubted whether such a science can aid in developing the great resources of peerless Iowa.

“Now, how will a geological survey help in this matter? If properly conducted, it cannot fail to develop the mineral resources of the State, and place our mining interests on a more permanent basis, by inviting capital and securing systematic and profitable operations.

"It will increase our mechanical and manufacturing interests by pointing out the raw materials and the facilities for converting them into articles for domestic and foreign trade.

"Agriculture will be advanced by the investigation of the structure and the chemical properties of the soils; and the results will enable us to determine the modes of culture necessary to sustain and to increase their productive energies.

"Our artesian waters will be thoroughly understood, so that anyone in the State by simple calculations may determine within a few feet how far he will have to bore to obtain good water, and how much of a flow he will secure.

"The water powers of every stream will be definitely known, and the conversion of this energy into electricity will eventually give us light and heat for the whole State.

"New coal fields cannot fail to be developed, and the limits of the present ones will be definitely made out, so that the great sums of money now annually expended uselessly in vain searches for this mineral in portions of the State where it cannot possibly occur may be saved and turned into other channels.

"Our building stones will be thoroughly tested and carefully located, for without the slightest doubt Iowa has as good building stones as can be found in this country.

"The clay industry will receive a great impetus. Instead of importing large quantities of brick and other clay products from other states, we would be exporting to all the neighboring districts. The aluminum clays would also receive careful attention.

"Commerce will receive a new impulse from the increased products of the farm, the mine, and the workshop.

“Who can estimate the increased value of the land in the State when all the natural wealth has been pointed out. If we can judge at all from our neighboring states there is little doubt that a systematic investigation, such as is suggested, would greatly increase the value of the lands over large tracts, amounting to many times the expenditure.”

It is not, therefore, to be anticipated that the work of the Survey is to be a continuous series of startling discoveries of precious metals, but rather a careful investigation of those things which, as in England, are infinitely more valuable and compel the world to pay tribute in gold and silver.

GENERAL PLAN.

The efforts of the Geological Survey are directed primarily to a consideration of the mineral resources of the State from the standpoint of the utilitarian. In the progress of the work there come to be recognized two classes of operations; the one somewhat general in its character; the other more specific. The first may be called the subject work and the second the areal work. In the former it is designed to take up each particular topic, as coal, clay, building stone, or soil and to consider the deposits as a whole for the entire State. In contradistinction, areal work has for its object the consideration of all useful mineral deposits of limited districts, as a county or other convenient area, particular attention being given to local details. There are, in addition to the two principal classes here mentioned, two other lines of investigation, which together might properly form a third class.

SUBJECT WORK.

Mineral deposits are not limited by modern political boundaries. Each kind of ore, clay or other natural

product dug from the earth belongs to some particular geological formation; that is, it is found at some horizon or level more plentifully than at others. Thus, one formation is abundantly supplied with coal; another with ores of zinc or lead; a third with gypsum, or materials for the manufacture of cements; and others with still different substances of economic value. Each is found in a particular geological zone and rarely or very sparingly elsewhere. Only within certain districts would search for a given substance be successful; outside of these areas no amount of prospecting would ever disclose the material sought.

An investigation of any special mineral substance necessitates a careful consideration of the entire subject. At the outset a clear understanding of the geological structure of the rocks containing it is of prime importance. The localities where it occurs require description. The arrangement, relations and extent of the deposits must be defined; the origin and properties discussed; the accessibility and value determined. The uses of the substances, the nature and status, both present and probable future, of the industries connected should be fully considered. A report on each special subject must, therefore, be comprehensive in character and concise in statement. The work cannot be weighed down with all the details of only local interest, as this would extend the account far beyond the space that could be allotted to it. Information of an entirely local character may be recorded on maps or described in accounts of areas.

Subject work is thus quite prominent in dealing with all the useful mineral substances found in the State. It necessarily includes two classes: the principal topics, which are the larger subjects, each requiring a very

considerable period to finish, and the subordinate subjects which comprise numerous minor points. The former of course are taken up first. While they are being investigated facts are continually accumulating in regard to the collateral subjects which, with a little special attention later, will ultimately be brought together, forming valuable additions to what is already known concerning the resources of the State.

The advantages of having the work done according to topics are numerous :

(1) Since different mineral substances, as already stated, are rarely confined to single counties, but usually extend over several and sometimes many such districts, it is necessary to investigate each kind of deposit in its entirety. It may then be told with certainty how and to what extent the several locations will be benefited by the development of such minerals.

(2) The general discussion of the properties, uses and magnitude of each deposit may be investigated and the results published long before all of the work in the counties containing the particular substance can be finished.

(3) If lasting results are to be obtained more or less work of general character is always necessary in order to interpret intelligibly the phenomena observed in any one county and to connect them with those seen in neighboring districts.

(4) It enables the investigations to be made by experts or specialists in different lines. The results accomplished are therefore much more satisfactory, more accurate and far more valuable than if obtained in any other way. Furthermore, much less time is required and the cost is consequently less.

(5) As the majority of people are interested in one industry only, the information they most desire is brought together. The miner wishes to be informed about coal, the quarryman, architect or engineer is interested in building stones; the brickmaker desires information regarding clays; each wants to know in regard to his special field and cares little or nothing about the others.

AREA WORK.

Area work has for its object the consideration of the economic resources of particular districts, as already explained. Its direct purpose is to satisfy constant and ever increasing demands for information in regard to given localities. The desire to know about the mineral products of each particular neighborhood is so general throughout the State that full details are required concerning every substance which is or is likely to be of value to the land owner or occupant of the territory. Probably one-half of the people of the State seek this local information.

PUBLICATION OF RESULTS.

One of the cardinal points in the investigation of the natural resources of the State is the placing of practical information in regard to the various deposits before the people as rapidly as possible and at the same time in a measurably complete form. Therefore in making public the results of the geological survey of the State the common practice of transcribing field notes and of making incoherent preliminary reports on different subjects has been discarded. The general plan of field work is of course arranged so as to accord with the ultimate presentation of the results in printed form. Hence, two general divisions are recognized in publication, as in the field

work, though their distinctions may not be so obvious at first glance.

A single series of publications has been adopted. All the numbers of the series will be uniform in general style, in binding and in size. As nearly as possible each volume will contain about 500 pages. There will be, however, one exception, the final State atlas. Although numbered consecutively the separate volumes are in no way dependent upon any which have gone before or any which may follow. Each may therefore be regarded as complete in itself. This plan enables one volume to be devoted to one topic and another to another. It allows all information on one subject to be brought together. It permits the placing of results before the public as rapidly as the investigations are completed, without long and vexatious delays. A particular deposit extending into a number of districts may thus be studied thoroughly and a report made without waiting for the entire work in the several counties to be finished. Similarly, different counties or areas may be reported upon before any special deposit is examined over all the State. In some cases the work requires a very much longer time to complete than in others; and it is often very desirable, especially with the larger subjects, that some information be made accessible before the appearance of the final report. When the work on any particular topic has reached a more or less advanced stage of completion some special phase of the subject may be briefly discussed and emphasized in advance, but the article is always made complete in itself, depending neither upon anything which has been nor which is to be published.

The appearance of the results of investigations concerning different deposits and areas is further hastened

by carefully prepared articles of general interest which are given to leading periodicals and to the newspapers of the State.

SCHEME OF WORK.

As the investigations of the Geological Survey go on the work resolves itself into three general categories: (1) the work in progress, (2) work taken up incidentally, and (3) work not yet begun. To these a fourth class may shortly be added, viz.: work completed.

Work in Progress.

As already explained the general investigations regarding the natural resources of the State run along parallel lines. To these the terms subject and areal work have been given. While covering the same ground in part they do not necessarily occasion duplication in either field work or publication. Of these two divisions the former, from its nature, must in the beginning receive greater attention. All the problems of economic importance and interest cannot be solved at once. Time is required to do the work carefully and thoroughly. Consequently it was necessary to make some selections before entering upon the work as a whole. Those subjects which were thought to most need immediate attention were taken up and the work pushed vigorously. At the same time a number of collateral subjects demanded prompt consideration and these were investigated as far as circumstances permitted.

WORK ON THE COAL DEPOSITS.

Although at the present time coal easily ranks first in importance among the mineral resources of Iowa, less has

been known in regard to its structure and distribution than perhaps any other mineral deposit of economic value in the State. The subject was therefore clearly among the first demanding attention. At the very beginning it was found that in order to make satisfactory progress it was necessary to carry on the investigations in a perfectly systematic way. Consequently localities were visited first which, it was thought, would furnish most readily a key to the structure, character and disposition of the coal beds over large areas. The leading geological features of these districts were carefully made out and the examination extended into neighboring regions. In this way the extent of territory covered and the amount of practical information secured was far greater than could have been obtained otherwise.

The area of the Coal Measures in Iowa embraces over twenty thousand square miles; besides, there are numerous Carboniferous outliers, or isolated areas, along and beyond the borders of the productive measures, which make up many additional square miles. The investigation of the coal deposits of the State is thus seen to be a work of no small magnitude. Detailed attention to the coal industry in all its phases involves labor which cannot be completed in a few months; it will require several years to make satisfactory observations, to accumulate the facts and carry on the proper tests.

In the presentation of the information there are contemplated:

(1) A report on the coal deposits, somewhat general in its character, perhaps, but supplying temporarily a great and ever increasing demand for information on the subject. This desire for authoritative accounts of different portions of the great coal field is shared not only

by the citizens of Iowa but by many persons with means who now reside in distant places, but who are desirous of making safe investments in the State, of starting new industries and possibly of soon becoming residents of the commonwealth.

(2) A detailed account of the geological features of the coal district. This should embrace a full description of the different kinds of beds and their associations, the minute structure of the coal bearing strata, the exact relations of the different seams, the distance from the surface that it is necessary to go in order to reach them, the pointing out of notable and easily recognized strata which may serve as guides in searching for particular veins, and all kindred information of practical import.

(3) A discussion of practical mining in the State, the methods employed and improvements which may be made, the kinds of machinery used and its advantages, the best plans and the most suitable machinery for prospecting.

(4) A description of the uses and properties of Iowa coals, with tables of chemical analyses of all the principal varieties from the different counties, the adaptabilities of the various kinds for steam, domestic and metallurgical purposes and for gas-making. In this connection will be considered all information tending toward a greater development of the industry, including the utilization of coal dust, slack and the lignites of northwestern Iowa.

The first portion of the work is now completed and the report ready for distribution. It forms a volume similar in size and style to the First Annual Report. The information contained, in respect to the arrangement of the coal bearing strata is of the greatest practical value, as well as of scientific interest.

The work on the coal is being continued. Special mapping of certain typical areas has been undertaken. Upon the maps will be based the construction of several relief models which will show clearly the details of structure, arrangement and present accessibility of the coal seams. The models will exhibit graphically all the facts pertaining to the disposition of the veins and will clearly illustrate the nature of coal occurrences over wide areas. A map of the State showing the location of all the mines and the natural outcrops is also in preparation.

EXAMINATION OF CLAYS.

The number, extent and importance of the industries based upon clays has been little appreciated. Still less has the existence, distribution and qualities of the available deposits been comprehended. Yet, to-day manufactured clay products constitute one of the leading features in the material welfare of the commonwealth.

It would be difficult at this time to place an exact valuation on the building materials, pottery and other products made of clay which are used yearly in the State; \$20,000,000 would probably be a very conservative estimate. For many years large sums of money have annually left the State to purchase clay products from other districts. This, evidently, is not due to a lack of raw material, for recent investigations have amply shown that Iowa possesses vast and exhaustless deposits of the very best of clays, and that they are to be found in nearly every geological formation and in every county of the state.

Much information of great value has already accumulated in regard to the clays and the industries connected with them. Another field season will go far toward the completion of a report which will be comprehensive and

practical. The investigations have already gone far enough to indicate the general character and scope of the final report on the subject. It will contain a full discussion of:

(1) The origin, composition and properties of the clays in Iowa.

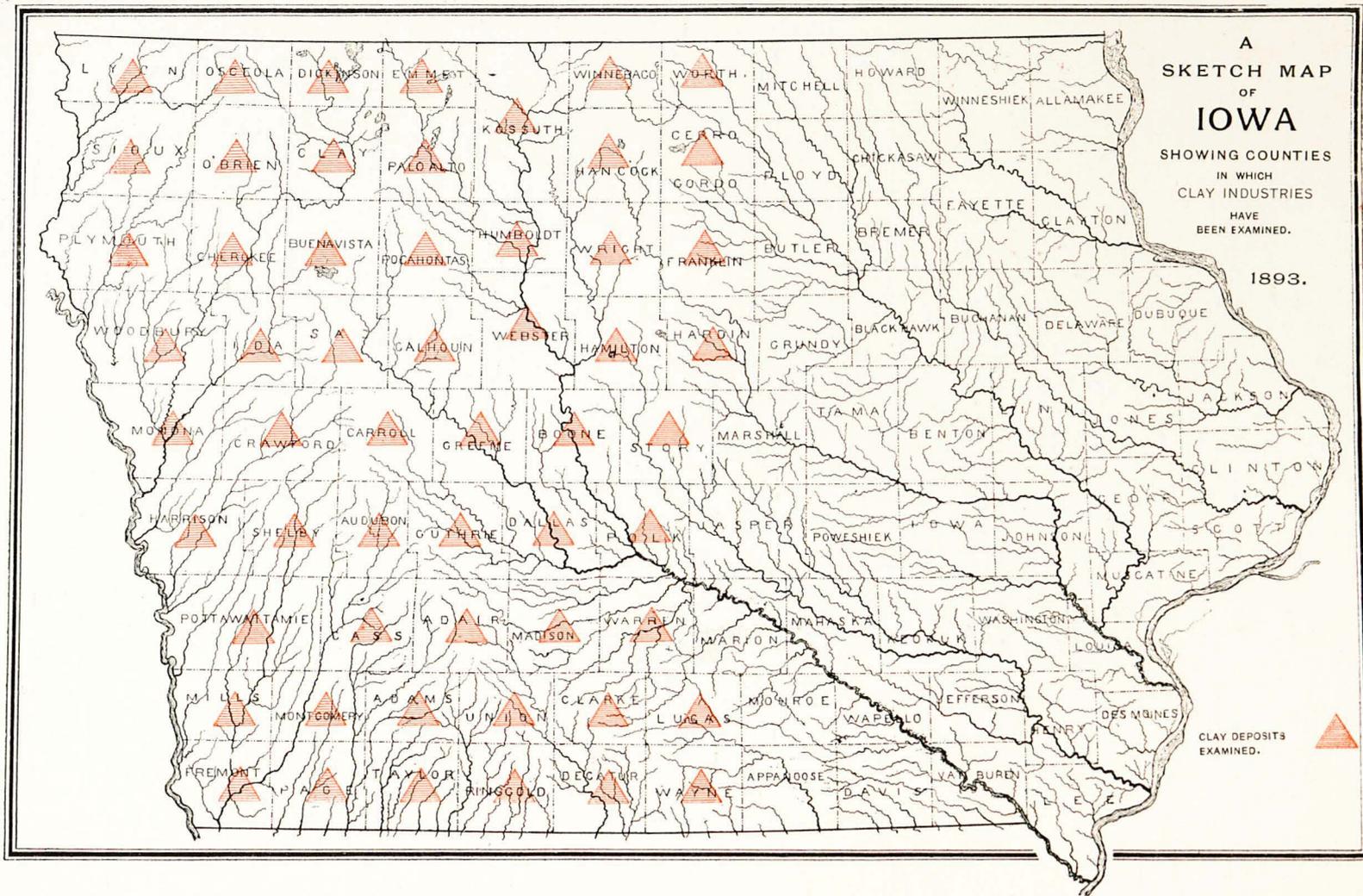
(2) The uses to which the various kinds of clay are, and may be put, and a consideration of the best varieties adapted to each specific purpose.

(3) The general geology of the State with special reference to clay deposits, their distribution and availability.

(4) The brick and draintile clays, the localities yielding the best qualities and the methods followed in rendering the poorer grades workable. There will also be embraced a special consideration of the clays used in making paving brick and sewer pipe. The recent extensive use of brick as a paving material and its superiority over many other substances has rendered the subject of brick for this purpose one of very great importance and one to which sufficient attention has not yet been paid. Paving streets with hard bricks is fast becoming popular in the larger towns and cities. Tests are continually being made which go to prove that the durability of a street paved with good, vitrified brick compares more than favorably with that of streets paved with other material.

(5) Pottery clays of the State, their properties, distribution and location; also the materials used for glazing and in mixtures.

(6) Fire clays and other deposits suitable for the manufacture of refractory products. There will be given in this connection extensive comparisons of the raw materials from the different localities in the State, and references to noted places beyond its limits.



(7) Kaolinic clays. This term applies to all the higher grades of clay which may be used for making the better classes of clay goods for domestic purposes.

(8) The principal industries based upon clay.

(9) Preparation of clay for manufacture into the different products and the methods used.

(10) Recommendations for better methods of manipulation. The importance of raising the standard of excellence of clay goods cannot be overestimated. It not only aids directly the manufacturer of the products but indirectly greatly benefits every citizen by providing him with a superior quality of material at a no higher price than he would otherwise give for the inferior article.

(11) Complete statistics in regard to the production of the various kinds of clay goods.

In this report it is proposed not only to test the chemical but also the physical properties of the clays. Through the latter especially the various comparisons may be more thoroughly appreciated, and the exact character of the different deposits more readily understood. The following outlines the method, taking for example a sample of typical fire clay :

A preliminary examination shows :

Color varying from light ash to drab.

Texture nearly uniform, fine grained, compact.

Taste "lean," gritty.

Slacks slowly into irregular granules with little uniformity of size.

Accessories: pyrite not perceptible; sand as grains from one-tenth to one-thirtieth of an inch in size, freely disseminated.

A physical examination shows :

Specific gravity, 1.950.

Plasticity, as determined by working a clay paste is eminent; as determined by the tensile strength of air dried briquettes it has a maximum of 172, the average of ten samples being 155 pounds per square inch.

Water required to make a plastic, easily worked paste is 15.4 per cent.

66 WORK AND SCOPE OF THE GEOLOGICAL SURVEY.

Air shrinkage, in drying bricklets ranging from four inches by one-fourth inch to eight inches by four inches averaged 5.6 per cent in ten samples. It can be dried rapidly in a warm air bath at 125° to 200° F. without breaking.

Fire shrinkage, in burning air dried samples at a vitrifying heat averaged 2.3 per cent in three samples; requires care and slow heating to avoid cracking.

Total shrinkage, or the sum of the fire and the air contraction, averages 7.9 per cent, which is remarkably low.

Fusion takes place at about 2,400° F., or a white heat; incipient vitrification takes place at 2,100° F., or at a bright cherry red heat.

Color of burned clay is light gray.

Conclusions: This fire clay is a fairly good refractory material, as it may be used for temperatures as high as 2,300° F., or a very bright cherry heat. It admits of rapid air drying without cracking and does not fissure readily in firing. The total shrinkage being very low adds greatly to its value in any practicable application of the clay. Being highly plastic it moulds admirably. The burnt ware is quite strong. The clay when washed may be used successfully by potters. It is even possible that a white ware may be produced if the clay is properly washed and treated.

BUILDING STONES.

The resources of Iowa in building stone are unquestionably great. There is but little doubt that as good rock for structural and architectural purposes is obtainable within the limits of the State as anywhere in the neighboring districts. When, however, Iowa goes to New England, Ohio, and Lake Superior for stone with which to construct the better class of buildings the query at once arises as to the reasons. Furthermore, when inquiry is made concerning the sources of higher grades of stone used in the State, the proportion obtained from Iowa is found to be surprisingly small as compared with the quantity shipped in from other places, and the importance and absolute need of a systematic investigation of the State's domain is immediately made evident.

In order of their importance the chief factors determining the value of a building stone are: Accessibility, Durability, Strength, Structure and Reputation.

No matter how excellent a stone may be it is of course valueless for constructional purposes if it does not have good transportation facilities. Durability is a phase of the subject which cannot be determined readily from hand specimens and is usually brought out through experience. Stones which ordinarily withstand the influences of atmospheric agencies readily waste away when exposed to conditions quite different from those of their native places; and the acid-laden air of great cities is especially deleterious to rock. The resistance to weathering is ascertained best in the field by careful examination of the native ledges. These observations may be supplemented by tests in the laboratory. Strength, however, is usually the only factor tested in determining whether or not a given stone shall be used.

Architects and engineers commonly have neither the apparatus nor the inclination to make extensive tests in regard to local building materials. Consequently they employ stone which already has its reputation established. Thus the lack of authoritative information in regard to local resources causes the rocks of the State to be discarded and building stone to be transported half way across the continent and often placed upon ledges of rock in every way their equal or even their superior. The quarrying industry at home does not receive the support it should, while, foreign markets are entered and purchases made.

The remarks just made indicate the lines along which investigations concerning the Iowa building stones are being made. There is scarcely a county in the eastern half of the State which does not contain stone of good quality for all ordinary building purposes, some of very superior character. Thus Johnson county has a rock of

which the basement of the new Capitol building has been constructed; the same stone was used in erecting the central building of the State University at Iowa City, and although put up more than half a century ago the tool marks are still fresh. Scott and Jones counties have long supplied a very superior stone which has been widely used; while Marshall has shipped a fine grade of ornamental rock to Boston and other large eastern cities. Lyon county has been found to possess exhaustless quantities of the most durable stone in the world, and one which will outlast granite ten times over. These isolated instances show clearly that Iowa does really possess building stone which has all the desirable qualities for becoming a widely known constructional material.

The work of making the observations and requisite tests on the Iowa building stone is already well under way. In collecting this information special attention has been given to the distribution of the ledges and layers best adapted for building purposes, the properties recommending the various kinds and the influences of weathering on the natural outcrops. In the report which will probably be completed next year it is intended to give full descriptions of the localities and of the quarries now opened, statistics as to production and the methods of getting out the stone. Illustrations of some of the finer grades of the ornamental varieties and of the larger buildings and constructions erected from Iowa stone will also be given.

INVESTIGATION OF ARTESIAN WATERS.

The desire for artesian water supplies is widespread among the people of Iowa. The demand for this source of water is not because the State is not well supplied with streams at the surface nor because of the unfavorable

climatic influences, but for reason of the great convenience in the use of flowing wells and on account of the common belief that such water is exceptionally pure. With the desire of securing flowing wells borings have been put down in all parts of the State. In a large number of the cases failure has resulted.

The principles involved in a successful artesian flow are so simple that it comes to be generally believed that the governing conditions are equally simple and all that is necessary is to put down a hole far enough and a flowing well will result. In reality the conditions of a successful flow are quite complex, and the practical determination of artesian areas involves a broad comprehension of the general geological features of the region, not of the State alone, but of the surrounding territory as well.

During the past year the work of collecting facts concerning the artesian probabilities of the State has been carried on vigorously. Records of a large number of borings and wells have been obtained and samples of the drillings secured whenever possible. By careful comparisons of the various data the water bearing strata have been traced over a considerable portion of northeastern Iowa. The investigation is now being extended into other parts of the State as rapidly as circumstances permit. Some of the results of this work are sufficiently complete to be made public, and an account of the investigations will shortly appear. The work also adds largely to a knowledge of the characters of the older and more deeply buried formations in Iowa and discloses much of value in regard to their texture and structural relations.

Not only the mapping of the different areas but also other considerations are taken into account. These may be noted separately :

(1) The essential conditions of flowing wells are discussed in connection with their special application to the State. The structure of the region, the geographical distribution of the formations, the texture of the rocks, the amount of rainfall and kindred topics require explanation and description.

(2) Under nature of artesian wells there is properly included all studies upon the flow, the force and the factors upon which it is dependent, the height to which the water rises, causes of decrease in flow and methods of increasing it.

(3) In discussing the uses of the waters there are considered the adaptabilities of artesian flows; their values as sources of power, as supplies for city waterworks and as medicinal remedies.

(4) Certain methods of boring and special forms of machinery have been found to be more economical in this work and a description of these are within the scope of the work.

(5) In connection with mapping come those topics which relate more especially to the conditions of individual areas.

Fundamental to this work is the careful collection and study of the records of all wells previously sunk in the State. These records become very largely the basis of subsequent work. In the determination of flow levels certain geological horizons have been found to be water bearing. For example the Dakota sandstone is in South Dakota the source of many wells; in northeastern Iowa the Saint Peter sandstone is the best known stratum performing a similar function. It becomes important to determine which among the many layers are most likely to prove valuable for this purpose. Next to the question

of what horizon may be expected to furnish supplies of water comes that of the depth at which it will be encountered. This may be made out by a careful comparison of the levels of outcrops, surface waters, horizons in neighboring wells and similar data. The areas available for artesian wells can, therefore, only be determined by a detailed study of the structure and texture of the rocks as well as the other conditions mentioned.

GENERAL GEOLOGY.

In all geological work there are certain broad preliminary questions relating to the origin and succession of the formations which must be considered in order that the best results may be secured in regard to the more strictly economic work. Some of these are wide-reaching in their bearing. They are not confined to a single district nor a single county but may extend over a greater part of the State or through several states. Fortunately many of these problems had already been partially or wholly solved before the work of the Survey had begun. A general study of the rocks, their arrangement and relations in this and the adjoining states had been made. The results, to which the Iowa Survey fell heir at the very beginning of its career, greatly facilitated the preliminary investigations which invariably must precede all detailed examinations. With the broad general questions of inter-state importance already tolerably well understood, those which apply more particularly to the State alone are much more easily taken up and more readily solved than they could be otherwise. There is considerable work of this kind yet to be done. A discussion of it, which embraces a somewhat generalized and co-ordinated consideration of

the lithological characters of the different formations, the structure and arrangement of the various beds and a classification of the formations in accordance with the latest criteria of geological science, is necessary. The direct bearing of the general geological problems upon the more strictly economic phases of the several topics is shown more in detail in connection with the remarks on the different subjects of which special mention has been made.

The general scheme of the final report is already foreshadowed. It includes a general description of the geological features and structure of the upper Mississippi valley, particularly as applying to Iowa. It takes up the separate geological formations and describes in detail the characters and distinguishing features of each. It considers the arrangement, succession and thicknesses of the formations, the variability of the different strata, the unconformities and deformations. It notes particularly the useful minerals and substances occurring in the different parts of each formation and points out how most readily to detect the deposits; it considers also other useful materials which are not as yet utilized. It discusses farther the origin, conditions of deposition and the associations of the various beds.

Among some of the problems which are of more particular interest may be mentioned the exact divisions and relations of the upper part of the Silurian, the subdivisions of the Devonian and the transitional beds between it and the overlying and underlying formations, the eastern limits of the Cretaceous and the correlation of these beds, and the age of the Sioux quartzite which is yet to be definitely settled.

MAPPING.

A modern geological map is a graphic summary of a vast mass of useful information. In addition to an accurate representation of the ordinary geographical features, as in the best atlases, a properly constructed geological map records much more. On it is indicated, within a few feet, the elevation above the sea level of every point within the compass of the area; the drainage basins and the water powers are noted; the distribution and limits of the different geological formations are plainly marked; the various kinds of ores, building stones, clays and all minerals of economic value contained in the several beds are located; the best places for obtaining all these substances are indicated. The map also forms a reliable soil index.

The construction of a full set of maps of this character is not the work of a few days or of a few weeks, but the labor of several years. In connection with the investigations of the economic resources of the State there is contemplated a series of maps which shall embrace for every part of the State all the information above mentioned. Some of them will be somewhat general in their nature and will accompany the different special reports. Others will be more detailed in their make-up and will cover given counties or such areas as may be thought desirable. In the construction of maps showing the distribution and occurrences of mineral substances it is of prime importance that the surface relief should be depicted in a readily intelligible manner. One which represents most closely a perfect miniature of the surface of the region is far superior to any ordinary atlas. It is invaluable not only to the trained geologist but it is about the only practical way by which the average citizen is able

to comprehend at a glance the explanations. In proportion as the exactness with which the diminutive representation approaches the actual surface, in the same proportion does the usefulness of the work increase. The modern methods of making maps are so far advanced over those of a quarter of a century ago that there is now no excuse for a community to be without the best.

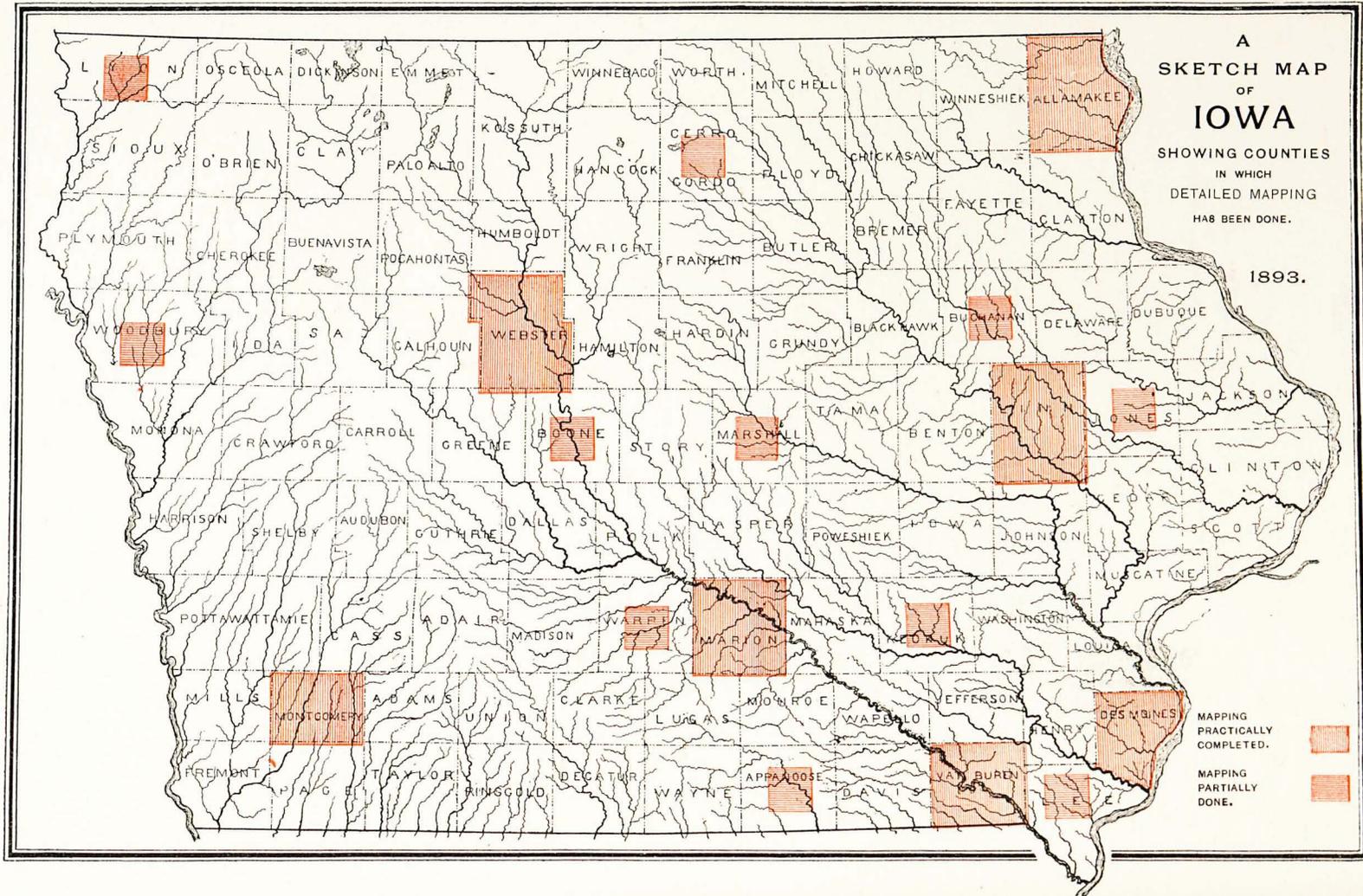
A properly constructed geological map of a district, therefore, not only locates the various mineral deposits but also represents the prominent landscape features by which the locations may be more readily recognized. A relief map also serves other purposes. Upon it is based the models of the more important districts which are to be taken as characteristic of much larger areas and which are to represent in a graphic manner the structure, arrangement and relations of deposits. Eventually a relief model of the entire State will be constructed on a suitable scale.

COUNTY RESOURCES.

As the state is the political unit of the nation, so the county is the political unit of the state. When, therefore, in either the larger or the smaller of the two provinces it is desirable to consider any subject with special reference to its areal distribution the units mentioned become the natural divisions into which a complex topic may be separated. The reasons for making the county the areal unit in the treatment of the natural resources of a region are many:

(1) It is the most widely known and familiar political division of local importance.

(2) It is the district concerning which nearly every person in the State who is interested in the natural products of his neighborhood inquires.



(3) It forms a convenient district for working out geological details.

(4) It is an area whose size is perhaps best suited to the purposes of instruction in the schools.

(5) It is especially suited to the encouragement of detailed work by local observers.

(6) It is the district most commonly inquired about by investigators living in other parts of the state or in different places beyond its limits.

(7) In Iowa it is an area well suited to the preparation of maps.

(8) It in no way interferes, with the adoption of other units of uniform size for a state atlas, should occasion demand.

As has been said, subject work must necessarily be pushed somewhat more vigorously than areal work in the beginning of the survey. Nevertheless, detailed investigation of a number of counties has already been undertaken where the conditions are especially favorable. Although every county in the State must be thoroughly studied before the completion of the survey, it is readily understood that all these districts cannot be taken up at once. Some must of necessity be studied before others. In making a beginning in this direction the work has been governed to a great extent by the investigation as a whole, those regions being taken up first which best furnish an index to the surrounding counties, thus enabling the work to be done over larger areas and in a much shorter time than would otherwise be possible. Another important factor in determining the priority of certain counties in which operations have been begun has been the presence of volunteer and local assistants. In this way some counties containing educational institutions have afforded

special facilities. The instructors of geological classes in the several colleges have given, to a greater or less extent, attention to the natural features of the surrounding country and have often accumulated considerable information. By utilizing the facts previously obtained and by extending the observations so as to accord with the general plan of the survey the State comes into possession of material of great practical value at a small cost. The reports of these counties will thus serve not only for purposes of class instruction but will reach the public much sooner than they would under less favorable circumstances. In this way work has been undertaken in a number of counties and considerable progress has been made.

A volume of the regular size devoted to the description of the geological and economic resources of several of the counties is expected to be issued early during the coming summer. The general scheme followed in the discussion of each county includes a brief general account of the surface relief and drainage, a description of the lithological characters of the different rocks and the geological structure of the strata. The principal geological subdivisions are considered separately and the means of recognizing each pointed out. All the mineral deposits of a useful nature are described, the various localities taken up in detail, the extent and distribution defined and the present and future value noted. The soils and minerals are also discussed and the discriminations to be made are pointed out. Chemical analyses and practical tests of the various substances are also given. Illustrations are incorporated wherever required. A map on a suitable scale accompanies the report of each county.

CHEMICAL WORK.

In all geological investigations chemical work forms an important part. It is often desirable to know, aside from the occurrence of a particular deposit, its composition more specifically than can be judged from its general appearance. The methods followed are not the same in all cases. While some substances require a complete analysis, many samples need only a partial chemical examination, and with a still larger number it is only necessary to make special tests.

The chemical analyses made by the Survey, like the work in other branches, are not to be regarded as supplanting work of a similar nature which should be done by individuals. All the examinations undertaken are broad in their bearings and of special import as explanatory of work which is being systematically carried on. Every analysis made is, therefore, of much more than local importance. In order that any analysis may be of the widest significance and value the samples must be collected personally by the parties having the investigations of the particular district in charge, since in no other way can satisfactory and accurate conclusions be drawn.

COLLECTIONS.

In the course of the various investigations there accumulates a large quantity of material which illustrates the natural products of the State. The best of these specimens are brought together, carefully labeled and deposited in the rooms set aside for this purpose. As yet, of course, the collection is quite incomplete, but for the short time spent upon it the progress has been very satisfactory. It is expected ultimately that all the mineral materials found in each county will be fully represented

and the collection will form a complete index of what may be obtained in the State. Being attractively displayed and conveniently placed, architects, engineers and others may readily and easily examine and compare the various samples, and learn what is best adapted for their respective purposes. As they are deposited in the Capitol, a place persons from all parts of the State and from every state in the Union are continually visiting, the cabinet serves to show in the best manner possible what Iowa possesses. There are represented the various ores, clays, building stones, soils, limes, coals, minerals, fuels and innumerable other things of interest, as well as the products made from various materials. A series of photographs is also being secured to illustrate the various geological phenomena and, incidentally, Iowa scenery. A set of charts is in preparation showing the distribution and structure of the various useful deposits. The models already referred to in connection with mapping are also designed to be made useful in this connection.

The material for the cabinet which has been obtained by different members of the Survey is added to by the co-operation of many individuals. Owners of various quarries have thus offered to furnish, suitably dressed, different samples of building and ornamental stones. Proprietors of clay industries have been liberal in supplying suites of their wares and the raw materials. Operators have endeavored to send in representative sets of their mine products. Others have likewise aided. Although this work has only been fairly started, the ensuing years will show great gains.

In connection with the material for the cabinet there necessarily accumulates many duplicates which are not needed by the Survey after they have been studied and

reported upon. Most of this material is very valuable for class instruction at the various colleges and high schools throughout the State, and may be made available for this purpose with little or no additional expense. A number of educational institutions have already expressed their desire to obtain suites illustrative of the geology and economic resources of the State. A selected set of photographs pertaining to Iowa geology is also contemplated for class use and may probably be disposed of at the nominal cost of making the prints.

LIBRARY.

Through exchanges and gifts from scientific organizations and institutions a nucleus of a geological library has been established. It is essentially a working collection of books and is designed to serve as a reference library for those directly interested in the geology of the State. During the past year about one hundred and fifty books bearing directly upon geology have been received, besides many others incidentally referring to geological themes. In addition, a considerable number of pamphlets and unbound volumes have been acquired. At the present time these are in the geological rooms but eventually they will probably be deposited in the State library. Efforts are being made to make the collection as complete as possible in the literature pertaining directly to the local geology of the State and in the publications which, though relating to the geology of other states, throw light on the geological structure and resources of Iowa.

Work Taken Up.

In addition to the subjects which have been taken up as principal lines of investigation there have been a number of topics which have been regarded as collateral subjects,

concerning which, though little independent work has yet been done, considerable valuable information has been obtained. In time some of the subjects which now hold a place of only subordinate importance will receive special attention and be elevated to the position of leading topics of investigation.

THE SOILS.

There is probably no phase of economic geology which at present attracts more attention than the study of soils. Owing to the great fertility of the virgin prairies of Iowa, artificial fertilizers have not as yet come into use as in the older states of the Union and in the densely populated countries of Europe. Nevertheless, it has begun to dawn upon many communities, as it must necessarily sooner or later everywhere, that the soils may not yield so abundantly as years go by. In different parts of the country the real conditions are rapidly being comprehended and efforts are being made to rejuvenate the failing soils. The awakening is now occurring in many places, particularly in the eastern and southern states. But the subject is not receiving attention only in those districts where the soils are partly or wholly "worn out." It is beginning to be found out that in many places, even where the soil is surpassingly fertile, proper treatment may greatly increase the yield.

During the past two decades there has occurred in Iowa and the neighboring states in successive years violent fluctuations in the yields of various crops and at least two or three times within the period the crops have narrowly escaped almost total failure owing to prolonged droughts. Human efforts are of little avail in attempting to change these varying climatic conditions, but it is quite

possible for them to effect the same results by manipulating the soil so that it will retain sufficient moisture to carry all vegetation safely through the most protracted dry spells. The accomplishment of this is possible through the proper chemical and physical investigation of the different soils.

It is commonly considered that geology is merely the adjunct of mining, but it is equally the helpmate of agriculture. The interdependence of the science of geology and the science of agriculture is daily becoming more and more intimate. The relations between the primitive rock ledges and the soils resulting from their disintegration are ever becoming better understood. The principle lying at the base of the more recent soil investigations is that each geological formation gives rise to a more or less well marked soil type which is especially adapted to particular crops. The latest work in regard to this subject has been on the physical rather than on the chemical side and the results have been eminently satisfactory.

The results of the application of mechanical analysis to the study of soils may be here summarized.

Starting from the fact that the farmer, simply from the character and appearance of the soil, is better able than the chemist, with his most refined analyses, to tell what kind of grain it will produce, there is reason to believe that the differences in the value of the soils is due rather to their texture and the arrangement of grains than to their chemical composition; that all soils contain sufficient food material to support crops for years; and that their value is measured, not by chemical composition, but by their relations to moisture.

The matter of moisture in a soil, or the circulation of water in it, is very important and is believed to be one of

the leading determining factors in the local distribution of plants. The circulation of water in the soil is brought about by two forces, gravity and surface tension. The first is constant and acts always in the one direction, so that it may be practically neglected. The second acts in any direction, either pulling the water up to the plant or away from it, according to circumstances.

It has been found that, upon an average, fifty per cent of the volume of the soil contains no solids, but is made up of only water and air, and may be regarded as empty space. If a soil is slightly moist the water will form films around the component grains. If there is an increase of water these films will thicken and, the amount of surface exposed being smaller in proportion to the weight of water, the surface tension will become low. If, however, the amount of water be decreased the surface tension increases, as the surface exposed is much greater in proportion to the less weight of water.

The total surface exposure of the particles in a cubic foot of soil is usually in the neighborhood of 50,000 square feet, or a little more than an acre; in some kinds of soil it is over two acres. This amount of space may be divided in different ways and the manner in which it is broken up controls largely the surface tension of the soil moisture. In turn, this determines the relation of the soil to the amount of water it will hold. Experiments have shown that different chemicals have two distinct effects upon the soils. One is to directly modify the surface tension of the soil moisture; and the other is to indirectly accomplish the same result by inducing changes in the texture. Since upon the surface tension existing in the soil depends its ability to absorb and to retain moisture, important changes in

the capacities of land may be brought about through the application of proper chemicals and the power of a given soil to resist drought may be very greatly increased.

GYPSUM DEPOSITS.

Although this has not been regarded as a principal subject considerable progress has been made in the investigation of the deposits and the work will probably be finished shortly. Gypsum is widely distributed and occurs more or less abundantly in nearly every geological formation exposed within the limits of Iowa. The only deposits, however, of commercial value are in Webster county in the neighborhood of Fort Dodge. These beds may be regarded as among the most important deposits of the kind in the United States, while their geographical position makes them the most valuable known in the Mississippi valley.

In the manufacture of plaster of Paris and in general production of gypsum Iowa may now be considered as ranking second among the states of the Union. The productive area of the state approximates twenty-eight square miles. The deposits vary in thickness from two to thirty feet or more, with an average measurement of about sixteen feet. The great depth of the drift in many places throughout the gypsum area often makes it extremely difficult and quite expensive to quarry readily, and the cost of removing the soft covering with the means usually employed renders it impossible to utilize the thinner portions of the deposit. With the introduction of proper apparatus the stripping might readily be accomplished by hydraulic means, thus greatly reducing the cost and at the same time enabling all the material to be utilized at a very small expense. The production of gypsum in

Iowa has greatly increased during the past few years and now amounts to more than fifty thousand tons annually. Three or four mills are in operation, employing about one hundred and twenty-five men and a number of teams.

In considering the gypsum there are described the surface relief, the geological formations associated with the deposits, the relations of the beds to the various strata, the character, quality, extent and origin of the gypsum itself, the geological age of the deposits, and the availability. Suggestions are also made in regard to the general development of the industry.

LEAD AND ZINC.

The lead and zinc deposits of northeastern Iowa and states adjacent are well known the country over. Worked for over one hundred years they have continued to yield ore in greater or less amounts up to the present time and yet the industry has not reached its full development. The supply of zinc ore now in sight at the mines is sufficient to keep them in operation for many years.

Considerable work has already been done on the ore deposits of the state. They will receive further attention during the coming season. It is proposed to publish soon an extended account of the deposits. The report on the subject will consider:

(1) The history of the development of the mines, treating especially of the beginning and rapid growth of zinc mining in recent years, its present importance and future prospects.

(2) An account of the geology of the lead and zinc region, the formations in which the ores occur, and the beds to which the deposits are confined.

(3) A detailed description of the mode of occurrence of the Iowa ores, their location in crevices, their association and relation to each other and other facts important to a complete understanding of the subject.

(4) A description of the mines at present in operation. Many of these have already been visited and much valuable information concerning them gathered. The location of the mines will be shown on a map of convenient size.

(5) A detailed review of the different opinions which are held as to the origin of the ores. This subject has recently come into renewed prominence and the discussions of those best informed have thrown new light on the genesis of these deposits.

MINERALS OF THE STATE (NOT MINED).

The mineral deposits which are at the present time of direct commercial importance are taken up as special problems. There are, however, many minerals of different kinds which are not mined and which are not as yet used commercially. Facts in regard to these are continually accumulating in all parts of the state. Some of these minerals are known to have a very considerable economic value and will necessarily soon be the subject of special inquiry. Others will be found to have only a scientific interest. Many having little or no value from an economic standpoint are now attracting popular attention and are causing a considerable expenditure of money, time and labor every year, with absolutely no possibility of any adequate returns. On the other hand a number of those having a great economic value are not being worked to the extent that they deserve or they have received no notice whatever. Even though many of the minerals in

the state should prove to be of no commercial importance negative results are by no means without value. Proof that certain deposits are not extensive enough or are not of a sufficiently high grade for profitable working will be the means of preventing annually a great waste of money and energy.

In the consideration of these minerals there will be given a complete list of the various kinds, full descriptions of their different occurrences, a catalogue of the known localities of each and the possibilities of their extent and utilization.

ROAD MATERIALS.

The subject of good highways is attracting much attention at the present time. The value and desirability of good roads in the state need not, however, be considered here, for it is not the province of the survey to take up the subject in all its various bearings. There are, nevertheless, certain phases of the question which properly come within the range of the investigations for which the Survey was organized. Among the things which may be regarded as demanding attention are the localities and character of any superior stone suitable for improving the roads, the facilities for transportation and the approximate cost of quarrying and preparation. In addition, the qualities and properties of these rocks are to be considered. The location of good gravels, their areal extent and their quality will also receive attention. The subject of the utilization of burnt clays as a road material will be fully discussed. Some of the railroads are already using burnt clay for ballast in preference to rock, sand or gravel, with good results, so that the extension of the use of this

material to highways is in reality beyond the experimental stage.

LIMES.

Iowa is well supplied with limestone suitable for the manufacture of a high grade of quicklime. Some localities are supplying a quality of lime which may be regarded as having no superior in the world. Recent inquiry has shown that the lime industry is not developed nearly to the extent that it might be, and that rocks well adapted to the manufacture of lime are more generally distributed than was supposed. In many places where lime was formerly burned the industry could now be readily and profitably revived, as the circumstances which interfered with its continuance are now largely removed. The subject of lime is one of the first which was taken up by the Survey for investigation, but owing to circumstances which could not be foreseen the examination was delayed after the work had fairly begun. Among the topics to be considered in this connection are the properties and qualities of the various limes made in the different localities, the superiority of certain grades, and the chemical and physical characters of the rocks especially adapted to lime manufacture. The components which give value to lime and those which have a deleterious effect are much better understood at the present time than they were formerly; and the grade of lime that can be produced from given limerocks may now be predicted with considerable accuracy. The methods adopted and the improvements which may be made in the lime industry will receive full consideration.

CEMENTS.

This subject yearly becomes more and more important. The term itself has recently come to be used in a much

broader sense than formerly and now applies to all those calcined lime products which will set or harden under water. Those grades which are capable of a more or less complete hardening are commonly called hydraulic limes and are generally considered better than the ordinary varieties. Their hydraulic properties are said to be enhanced by the presence of magnesia, and consequently certain dolomites are well adapted to their manufacture. Aside from certain so-called hydraulic limestones which occur in various parts of the state there are other materials which are capable of being made into a high grade of Portland or hydraulic cement. The recent investigations in the northwestern part of the state have shown that there are vast deposits of an excellent quality of chalk and clay especially adapted to the production of a very excellent quality of Portland cement. Experiments on these deposits are now being carried on in a practical way and something in regard to their success will be ready to be made public soon. The extent of the deposits, their composition and the methods of preparation will be taken up in detail.

NATURAL GAS AND OIL.

During the past decade no geological question has awakened more popular interest than that of the possibility of finding natural gas and petroleum within the limits of Iowa. In a number of places shallow borings have yielded from time to time sufficient quantities of natural gas for local use. The success of these small wells has led to the putting down of much deeper ones and the expenditure of considerable amounts of money in all parts of the state. The excitement awakened by the discovery of oil and gas in Pennsylvania, Ohio and Indiana has stimulated still farther the efforts to secure

them in Iowa. The general opinion has been, not only in this state, but others as well, that the only prerequisite necessary to the securing of a successful flow of natural gas and oil is the sinking of a deep well. In reality the subject is much more complex than is commonly supposed. There are certain natural conditions all of which must be fully considered before a successful flow of either substance can be obtained. The absence of any one of these can only result in failure. These conditions may be reduced to four categories. There must be, (1) a suitable receptacle or reservoir in which the oil and gas may accumulate; (2) a non-porous cover to retain them; (3) a particular geological structure or arrangement of strata; (4) a pressure sufficient to push the oil and gas to the surface.

The presence in the Iowa rocks of considerable quantities of petroleum is well known. The occurrence of extensive coarse sandstones, conglomerates and porous limestones which act as reservoirs is also known. The existence of compact, impervious shales which serve as covers for the more porous beds is well understood. Artesian or hydraulic pressure sufficient to bring to the surface oil or gas, should either exist, is present throughout most of the state. The remaining condition — that of geological structure — is the chief one which requires investigation in Iowa. Considerable effort has been made towards solving the problem during the past year. The work cannot be finished in a single season, and until more information is acquired on the subject it is not advisable to sink wells for this purpose in the haphazard way which has been followed in the past. The particular phase of geological structure in question is that the rocks must be tilted. This causes in the porous rocks a movement

of the water, oil and gas particles, a simple mechanical rearrangement. They accumulate in order of their specific gravities, the water at the bottom, then the oil, and finally the gas at the top. The special structure of the strata which will accomplish the desired effect is ordinarily known as the arch, fold or anticline. When the top of a fold is pierced gas escapes, when the arch is penetrated a little farther down oil flows out, and when the base of the bow is drilled into only water appears. The most essential line of investigation that is connected with the inquiry into the probabilities of the occurrence of oil and gas in the state is the determination of the location, extent and trend of the folds. Towards this end much valuable information has been obtained.

FOSSILS.

For many years there has been a widespread desire among certain classes of citizens for a more accurate account of the organic remains found in the rocks of the state. This demand is becoming more and more urgent in the light of the fact that fossils have such a distinct economic importance in the determination of the age of useful mineral deposits and hence serve as the most trustworthy guides known in the further development of the natural wealth of a region. In the attempt to satisfy properly the demands arising in connection with the work of this character it is at present contemplated to present as briefly as possible, (1) an index to the fossils of the state, through means of which forms now known to occur within the limits of the region under consideration may be recognized readily without recourse to great libraries; (2) a list of the works pertaining to Iowa fossils, in which is brought together all that has been written

on the subject and which is now widely scattered and practically inaccessible ; (3) a concise summary of all that has been done up to the present time in this branch of science so far as it pertains to the state of Iowa ; and (4) an index to a more comprehensive study in the solution of problems now more or less obscure concerning the arrangement and relations of the various strata.

The economic value of fossils is commonly overlooked. Ordinarily these remains of ancient life are regarded merely as curious ; to the specialist the interest in the old organisms is wholly scientific ; but by him who is fairly well acquainted with their character the rocks are read as a printed page. One of the best established facts of modern geological science is that there is an intimate relation between all mineral deposits and the surrounding rocks ; hence the age of particular beds becomes an important factor in the early attempts to develop new mineral districts. These inferences rest upon one of the cardinal principles of geology, that the geological sequence of strata is determined most readily by the remains of life contained. Thus in reality fossils are labels on the rocks, telling one at a glance the age of the beds being worked and providing the most reliable guides that could possibly be secured in directing the miner and prospector to the layers most likely to contain the mineral sought.

In connection with the work recently done and which is being continued, a typical series of the most characteristic fossils of each geological formation will be collected and arranged in the cabinet for ready reference. Eventually a report on the subject will be prepared in accordance with the lines already marked out.

STATISTICS.

In order to compare the yearly progress of the different industries dependent on the geological resources of the state, it is desirable to collect annual statistics in regard to the work and output. The information obtained is regarded as strictly confidential in every way, and the tables of comparison are arranged by counties in such a manner as not to disclose the details of any individual business.

Work Yet to be Taken Up.

It perhaps is hardly necessary to state that it is a physical impossibility with the present resources of the Survey to consider all subjects in the beginning. Some must wait until others have been disposed of. With the means at command at present the different topics must be taken up and investigated in the order of their importance. Among the subjects which have not as yet been taken up in connection with the other work are a number of very considerable import.

The *lignites*, or brown coals, of the Cretaceous deposits of northwestern Iowa are now known to be of considerable importance; and their extent is much greater than heretofore suspected. Different localities are reported in which the veins of brown coal are upwards of four feet in thickness. By comparatively inexpensive methods of cleaning and grinding it may be made into briquettes which have the properties and qualities approaching the harder coals. Should the deposits be found as extensive as they now seem, the whole northwestern part of the state and the adjoining portions of Nebraska, South Dakota and Minnesota could be supplied with a very desirable fuel, which would compete with the eastern coals now largely used in these districts.

The *peats* of the state are known to be quite extensive, and with proper treatment can doubtless be utilized to advantage as fuel in those localities where other kinds are difficult to obtain. In this connection their distribution and availability become important subjects for future consideration.

The *iron ores* of the state have never received any attention, and their occurrences should probably form a theme for early investigation. The various kinds which occur throughout the Coal Measures and in the different regions of northeastern Iowa as well as elsewhere require careful consideration. The extent, distribution and utilization of the several kinds of ore and the methods best suited to their development should receive the attention they deserve.

The deposits suitable for the manufacture of *mineral pigments* is an important subject. In Jasper county an industry has been started for manufacturing metallic paint. Though only recently begun the output is already over 2,000,000 pounds a year. There are many other localities which doubtless furnish materials which are equally well adapted to such uses. There are, besides, ocher and other substances which might also be utilized to a great advantage.

Many *sands* of the state might be readily used not only for building but for other purposes. At numerous points these sands are sufficiently pure to admit of the manufacture of a good grade of glass. In the northeastern part of Iowa, in Clayton county, siliceous materials of this description have been shipped for a number of years to Chicago and Milwaukee for glassmaking purposes. There is no reason, however, why these industries should not be started up within the limits of the state.

The *crystalline rocks* of Iowa, though small in extent, demand investigation. The principal area is in the north-western part of the state and the stone occurring there forms the most durable building rock known. The origin, relations and accessibility of this rock require attention. Large boulders of granite and other crystalline rocks, forty to fifty feet in diameter, occur widely scattered over the northern part of the state. Many of these have been quarried for building purposes and the extent to which they are utilized should be understood.

The so-called *marls* of Iowa, though not yet used for fertilizing purposes, may give rise before many years to a new industry. It is desirable to know the localities and extent of these deposits.

The *mineral waters* of the state are many. A description of the different kinds, their origin, composition and medicinal properties, as well as the extent to which they are at present used, should be considered.

The *water powers* deserve more attention than they now receive. The recent great development in the use of electricity furnishes a ready means for utilizing the waste power of streams by converting it into a form of energy of the highest practical utility. The amount of power that may be developed in the streams of Iowa is a question of great importance to every community.

PUBLICATIONS OF THE SURVEY.

The general plan of publication of the reports of the Survey has already been explained. It remains to state in this place what has been done toward placing the results of the work before the public. Two volumes of about 500 pages each have been made ready and a third is now in press. The contents of the three are appended.

VOLUME I. FIRST ANNUAL REPORT, FOR 1892.

480 Pages, 10 Plates, 26 Figures.

CONTENTS :

- Administrative Report of the State Geologist.
- Administrative Report of the Assistant State Geologist.
- Geological Formations of Iowa ; by Charles Rollin Keyes.
- Cretaceous Deposits of Woodbury and Plymouth Counties, with Observations on their Economic Uses ; by Samuel Calvin.
- Ancient Lava Flows in Northwestern Iowa ; by Samuel W. Beyer.
- Distribution and Relations of the Saint Louis Limestone in Mahaska County, Iowa ; by Harry Foster Bain.
- Annotated Catalogue of Minerals ; by Charles Rollin Keyes.
- Some Niagara Lime Burning Dolomites and Dolomitic Building Stones of Iowa ; by Gilbert L. Houser.
- Bibliography of Iowa Geology ; by Charles Rollin Keyes.

Price, in cloth, 85 cents ; postage, 31 cents.

In paper, 70 cents ; postage, 26 cents.

VOLUME II. COAL DEPOSITS.

536 Pages, 18 Plates, 221 Figures.

CONTENTS :

- Chapter I. Introduction.
- Chapter II. Origin of Coal.
- Chapter III. Carboniferous Basin of the Mississippi Valley.
- Chapter IV. General Geology of the Coal Region.
- Chapter V. Lithology of the Coal Measures.
- Chapter VI. Stratigraphy of the Coal Measures.
- Chapter VII. The Coal Beds.
- Chapter VIII. Description of the Coal Beds now operated in Northcentral Iowa.
- Chapter IX. Description of the Coal Beds in Central Iowa.
- Chapter X. Description of the Coal Beds of Southeastern Iowa.
- Chapter XI. Description of the Coal Beds of Southwestern Iowa.
- Chapter XII. Description of the Coal Beds of the Outliers in Eastern Iowa.
- Chapter XIII. Composition of Iowa Coals.
- Chapter XIV. Waste in Coal Mining.
- Chapter XV. The Coal Industry.

VOLUME III. ANNUAL REPORT (IN PRESS).

CONTENTS :

- Administrative Report of the State Geologist.
- Administrative Report of the Assistant State Geologist.
- Administrative Report of the Chemist.
- Work and Scope of the Geological Survey.

96 WORK AND SCOPE OF THE GEOLOGICAL SURVEY.

- Gypsum Deposits of Iowa ; by Charles Rollin Keyes.
Clay Industries of Western (half of) Iowa ; by E. H. Lonsdale.
Certain Building Stones ; by S. W. Beyer.
Thickness of the Paleozoic Formations in Northeastern Iowa ; by W. H. Norton.
Carboniferous and Devonian Outliers in Northeastern Iowa ; by W. H. Norton.
Glacial Markings in Southeastern Iowa ; by F. M. Fultz.
Cretaceous Rocks of the Sioux River ; by H. F. Bain.
Zinc Industry ; by A. G. Leonard.

In addition to the reports mentioned a number of papers announcing results worthy of special notice have appeared in some of the principal scientific journals. During the year articles of a popular character have been given to leading newspapers of the state. Besides bringing out facts of both permanent and temporary value and supplying in a measure an ever increasing demand for information in advance of the completed lines of investigation, these articles keep the public in close touch with the progress of the work in the different parts of the state. The usefulness of this feature and the deep and widespread popular interest taken in it has been very much greater than was at first anticipated. During the past year upwards of fifty articles of this kind have been sent to various newspapers. The urgent demands for information concerning the different lines of work have been so numerous that even greater efforts in the same direction will be made during the coming season.

FUTURE OF THE GEOLOGICAL SURVEY.

The foregoing is a brief statement showing the scope of the survey and the methods followed in investigating the natural resources of the state. A summary is also given of what has already been accomplished during a period of but a little over one year, of the work which is in progress and of the work which is yet to be

taken up. It may be readily inferred that a geological survey of a region, a thorough investigation of the useful deposits of a given district, is not a luxury which a state may well be without; but it is one of the fundamental factors of all industrial activities. In the words of one who has been, and is yet, prominent in the affairs of State, a properly conducted geological survey "is an investment which will yield good returns to the poor as well as to the rich; it is a work of improvement which will enhance the value of property; a work in harmony with the peace-loving spirit of the age, in accordance with which the energies of the state are being directed more and more toward industrial development."

The demands which are continually being made upon the survey from nearly every part of the state show clearly the widespread interest taken in the different lines of investigation with which it has to deal. As the work continues the fact is coming to be more and more appreciated by the people in general that the class of investigations now being done is what should have been undertaken a generation ago.

The work of the geological survey is now fairly begun. The plans of operation along different lines are fully laid out. The investigations undertaken are progressing systematically. The results are rapidly accumulating. In order that the work may be carried on to completion time is required. A fitful existence can only give rise to a depreciation, in a great measure, of the results already attained. That the attainments may last for all time to the benefit of the state liberal provision is necessary to carry the work to completion.

For reasons fully stated elsewhere practically only one field season has been allowed for work. The first

appropriation has thus been made to cover a little more than a year and a half. In order that the work may be continued with the same vigor during the next two years the annual appropriation should not be less than that in the past. There is, however, a desire to have the investigations go on more rapidly, the reasons for which have already been stated. If the work is to be extended in the manner expected an enlargement of the means for the next one, two or more biennial periods, as the case may be, is necessary, after which a diminished amount would suffice until the completion of the survey. The advantages recommending this plan rather than that of smaller expenditures extending over a long period of years, are greater economy, more definite limitation to the completion of the work, quicker attainment of results, and earlier presentation of the information to the public.