Mississippi
State Geological Survey

E. N. Lowe, Director

Bulletin No. 24

A Series of Papers Presented by the State Geological Survey
at a Meeting of the Institute on Mississippi Affairs,
October 7, 1927.

Issued by the State Geological Survey
March, 1933

M I S S I S S I P P I

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LETTER OF TRANSMITTAL

Geology Building,
University, Mississippi.
March 1, 1933.

To His Excellency,
Governor M. S. Conner, Chairman, and
Members of the State Geological Commission.

Gentlemen:

I herewith present for your approval a series of papers read before the "University Institute on Mississippi Affairs" at the University of Mississippi, on October 7, 1927. This Institute was held under the auspices of the Department of Sociology of the University, directed by Professor N. B. Bond, and embraced a program extending through October 6th and 7th. The State Geologist was made responsible for the program of the second day, on which occasion he felt peculiarly fortunate in being able to present the following speakers, whose papers were timely and informing:

Mr. W. E. Tharp, of the Bureau of Chemistry and Soils, Department of Agriculture, Washington, D.C., on 'Soil Erosion';

Professor W. L. Kennon, Ph.D., Department of Physics and Astronomy, University of Mississippi, on 'The Climate of Mississippi';

Professor George I. Adams, Ph.D., Department of Geology, University of Alabama, on "The Development of Mineral Resources";

Hon. B. E. Eaton, Director of the Mississippi Power Company, Gulfport, Mississippi, on 'Hydro-Electric Power and the Development of Industries";

Dr. E. N. Lowe, State Geologist of Mississippi, on the "Mineral Resources of Mississippi".

It was the purpose to publish the papers and proceedings of this Institute at the time, but funds were not then available; hence the papers sponsored by the Geological Department were later turned over to the State Geologist to incorporate in the publications of his Department, if feasible. We are, therefore, issuing these in mimeographed form, the mimeographing being done in the office of the Geological Survey.

Respectfully submitted,

E. N. LOWE, Director,
State Geological Survey.

C O N T E N T S

SOIL EROSION

W.E. Tharp of the Bureau of
Chemistry and Soils, U. S. Dept. of Agriculture.

The occupation of this country by the white race is making many changes in original conditions. The distructio of wild life, the clearing of forests, the bringing of mill ions of acres under the plow, are changes of great consequence in this our so called conquest of the wilderness. With such rapidity are these transformations being wrought that they have far out run our conception of their magnitude and meaning. Particularly is this true with respect to the effects of cultural operations upon soil erosion. The latter, throughout the humid sections of the United States, has been tremendously accelerated by our tillage practices and engineering operations.

Some conception of this increased rate of removal may be gained by comparing the condition of a freshly plowed hillside field just after a hard rain with a similar slope well set to grass or covered with trees. This is a simple object lesson indeed and one we all have observed many times, but failed, perhaps, to understand in its full significance. Here we see a very serious interference with Nature's way of making and maintaining a productive soil. Her conservative methods have been badly upset. Destructive forces have been released, the ultimate effects of which extend beyond the injury to the particular field observed. Their effects seriously concern flood control in that channel-ways are choked, and the absorptive topsoil is taken off the surface. We are concerned at the moment chiefly with the effects of erosion upon the producing capacity of land.

Let us consider some of the more direct losses for which erosion is responsible. Mr. H. H. Bennett of the U. S. Department of Agriculture, in his capacity as inspector of soil surveys, has had exceptional opportunity for observations on this problem. His estimate on erosional losses in the United States are of especial interest and value. He has calculated the annual loss of plant food material at not less than 126 billions of pounds, while the amount permanently removed by crops is placed at 5 billion 9 millions of pounds. Expressed in another way, this means that for each pound of plant food material, taken permanently from the soil by useful crops 20 pounds were claimed by the rain waters that swept over the fields.

Mr. Bennett estimates the land formerly cultivated but permanently ruined for such purposes by rain wash at not less than 10 millions of acres. In a single county in the Piedmont region it was found by actual survey that 90,000 acres formerly in cultivation had been permanently ruined by erosion. Another county in the Atlantic coastal plain has had 60,000 acres formerly tilled put out of use for tillage purposes.

A s one result of extensive upland erosion, there has been such increased deposition of sand and gravel in the valleys, that much formerly tillable land has been injured. This has been estimated at 3 millions of acres, ruined or seriously impaired by deposition of inert material, or rendered too wet for cultivation by obstruction of stream ways.

These are very impressive figures, and give us some conception of the soil wastage that is accompanying our agricultural operations. While exceedingly conspicuous examples of soil erosion may be seen in the southern part of the United States where the rainfall is heavy and the land does not have the protection of freezing in winter, the evil is by no means confined to that region. In all parts of the northern and eastern states, where rolling to hilly topography prevails, gullies and "bald spots" are becoming common features of the fields. A great deal of severe erosion has occurred on the hilly lands tributary to the Ohio and Missouri rivers. My boyhood home was on the rolling uplands of southwestern Iowa. The changes that have taken place there within 40 years come to me with something of a shock; there are few gullies, but the deep humus-filled prairie soil, which masked the yellow subsoil even of the steeper slopes, has become so thin on hundreds of hillsides, that the clay and stones are much in evidence, where formerly we hardly suspected their existence. The little prairie streams, with their deep, clear pools, have become transient courses for storm waters, and the old swimming holes of the creeks and small rivers have largely disappeared.

These changes are the result chiefly of sheet erosion or of gentle surface washing. This has affected in greater or less degree practically all the cultivated lands in the humid sections of the United States. It is a slow and inconspicuous form of soil wastage compared with deep gullying, but even more serious in its aggregate effects. It removes the lighter and finer soil particles in which so much of the organic matter is held. This constituent, as we all know, is of greatest importance in soil fertility. Mr. Bennett, whom we have previously quoted, reports some investigations on this form of erosion. On a certain soil type in West Virginia, not less than 7 inches of top-soil had been removed in 24 years of tillage. This occurred on gently sloping land devoted to corn under ordinary methods of cultivation. My own observation on an extensive and important type in central Indiana, leads to the conclusion that the original 3 or 4 inches of humus-filled top soil has been almost entirely removed from gentle slopes since these were cleared, a period ranging from 50 to 75 years. On steeper inclines those of from 5 to 10 degrees, the most casual observation shows to what extent the yellowish silty clay subsoil is exposed as a result of the complete removal of the original surface soil. On corresponding topography the same types, if still wooded, have suffered no observable erosion.

The Missouri Experiment Station gives us some very definite figures on soil washing. On a plot having a slope of 3.7 feet to 100 feet, which is not much of an incline, continuous clean cultivation, no growth of any kind being permitted, caused the equivalent of 40 tons of top-soil to be removed each year from an acre. The plot on which corn, wheat and clover were grown in rotation lost about 2 tons annually per acre. The loss from the blue grass plot was almost nothing. Some of this sheet erosion represents merely local transference of material from the higher to the lower ground within the fields, and a part of the loss of humus is due to stimulation of oxidation processes by tillage, and hardly preventable. Also some soils respond so readily to up-building

that sheet erosion is not an irremedial evil, but, making all allowances for these factors, preventable erosion is levying an enormous toll on our soil fertility. It is a sort of skimming process, by which the cream of the soil is being taken away. On many of our finest agricultural types, the extraction of plant fe food by crops has been far less than the tribute taken by storm waters.

In considering the control of soil erosion, let us look at it in a large way. As previously stated, soil conservation, flood control, and forestry, are so closely related they may be considered parts of one problem. For effective results in remedying the situation, there must be correlation of effort in these several departments of conservation work. Years ago, Captain Eads, the great engineer who built the jetties below New Orleans, said "We are tearing the heart out of the continent with our gang plows."

It is becoming more apparent to all of us that the reoccurring disasters in the lower Mississippi valley must be considered in connection with what has been done on the upper reaches of the great river. In the marvelous material development of the territory within the upper Mississippi valley we have been very busy the past 75 to 100 years with things nearest at hand. Without malice aforethought, and not much thought of any kind as to ultimate consequences, we have hastened the departure southward of all surface waters that formerly lingered in the uplands ponds and depression, and were further restrained in their seaward course by the meanders of the local streams. The latter we have made straight and deep and wide the better to receive the fluctuating discharge of thousands of farm and roadside ditches. The chronically wet spots have been cured and the temporary accumulation of surface waters is an evil no longer to be tolerated. Very effectually did we labor as the rapid response of creeks and rivers to seasonal fluctuations in rainfall well indicates.

All this has been a necessary part of our material development. It marks a post-pioneer stage in the history of that region. We have now entered a period in which the more careful use of our sources of wealth is being forced upon us. Public opinions is changing, quite slowly it is true, but there will be found a better response to appeals for the care of the soils, forests, and waters, than would have been made a generation ago. Our attitude toward these various conservation problems is changing, while actual remedial measures the very small compared with what should be done, give us good reason for much encouragement. We are draining no more of our lakes, and are even leaving some of the marshy spots for the wild fowl. There is far less inclination to change picturesque wooded bluffs to corn fields than formerly. In one State (Iowa) County parks are being created for conservational as well as recreational purposes.

The carelessness and indifference to soil erosion, which marks so much of our early development, is gradually giving place to more sane ideas of soil values. The Mangum terrane has got us far north as Missouri, largely in the farm bulletin state to be sure, but we hope to see its broad restraining curves a not unfamiliar feature of the hilly landscapes of northern Missouri and southern Iowa.

There are also certain strong economic factors working in the

right direction. As we all know, there has been a freat deal of hilly land brought into tillage, which should never have felt the plow. The present agricultural and industrial changes are very effectually setting the status of such lands, so far at least as this generation is concerned. They are reverting to pasture and to woods by the thousands of acres every year. And we say, "Let them go". Encourage the change by every legitimate means, for the continued cultivation of these marginal lands not only depresses the price of agricultural products, but lowers the standards of rural life as well. Throughout certain part of the Southern States is this especially true, and the reforestation of these rugged lands is the most practical and profitable way of utilizing them.

In our consideration of constructive measures, we can hardly over emphasize the importance of attention to local conditions. In Mississippi there is a wide range of soils and a great variety of physiographic conditions. The rate and the manner in which erosion takes place are determinated by a number of factors, among which are the texture and structure of the soil material. In the "brown loam" section, our later soil surveys recongize two important soil series developed upon the deep loess. On the Memphis silt loam, which is the younger of these types, the characteristic forms of advanced erosion are deep canyon-like gullies with vertical sides. This material has a very great absorptive capacity and with a soil cover crop much rainfall can be taken care of without surface injury. In methods of tillage and terrace construction, these characteristics should be given due consideration. Incidentally some wonderfully fine examples of the use of grasses to hold very steep slopes may be seen inthe Military Park at Vicksburg. On the Grenada Silt Loam, a closely related type, but with more compact subsoil, erosion, has more tendency toward wide gullies and more severe surfact washing. This latteral extension of deep erosion is very destructive in many places. The Lexington Silt Loam is the soil survey name for the thin eastward margin of the loess as it overlaps the older geologic deposits. Where the deposits consist of sandbeds, we find some extremely difficult problems in soil erosion. A combination of friable silt over loose sand on a hill side, where 50 inches of rainfall must be cared for, presents a hard problem to deal with, if a gully once gets a good start. As a matter of fact, the destruction in many places soon gets beyond possibility of practical control. The time to tackle the problem is in advance of the stage of deep gullying.

The Susquehanna series and all soils having similarly heavy clay subsoils are slow to absorb, as well as reluctant to give up water. The surface becomes saturated quickly, and wide shallow gullying and planing off of the surface soil results. In strong contrast with these clay types but often closely associated with them are the red Orangeburg and Greenville soils which embrace so much of the fine agricultural soils of the uplands. Fortunately these valuable types have textural and structural features, favorable to the maintenance of effective terraces, if built before deep gullying takes place.

Erosion has not generally been considered a serious problem on the Black Belt soils of Mississippi and Alabama, but this assumption is entirely incorrect. The crumbly condition of the surface

layer is dependent in very large measure upon the presence of humus. This organic matter cannot accumulate and reach that stage of decomposition in which it imparts the granular structure to the mineral constitutents, if sheet erosion is permitted to run uncontrolled. This factor has been so frequently overlooked in the management of Black Belt soils that we would call special attention to it. In dealing with erosion on these various soil types, there is need of more exact data relating to their physical properties. What is the capacity of a particular soil to absorb rainfall under various kinds of cover, on different degrees of slope, and under different methods of tillage? How does the soil material resist the loosening effect of saturation? What type of terrace is best suited to this or that kind of soil? True, we can build terraces and plant cover crops, even if we are unable to answer all these questions, but we can do these things more effectively and economically if we have such technical information at our command. In this connection it may be of interest to mention that there are certain types of clay soils in the rainy tropics which do not erode. Surprising as it may seem, gullies are almost unknown on lands where severe erosion should have occurred. It is possible that further studies of these soils would yield results of value in our erosion problem.

Without presuming to advise, it seems that projects for the technical study of this problem as presented by the more valuable soil types of this and other states might well be undertaken. We are informed that a very comprehensive project of this kind has been inaugurated by the Texas Experiment Station. Plots for the study of erosion and related problems have been established on every important type of cotton soil in that great state. The Missouri Station has already given us some very valuable data from the erosion plots laid out about six years ago. Technical investigations in all industrial lines are quite the order of the day. Information thus obtained carries a weight and value that unsupported observations do not usually possess. Field observations have inspired most of our erosion literature, and it is none the less valuable on that account, but data of a more precise nature will be necessary in the future.

Last, but by no means least, let us not forget publicity. We need to let the people know that the problem is important. The public press is very responsive to worth while projects and reforms, provided their sponsers tell the story in a brief and interesting way. All of us who have any ability whatever in writing may contribute something about erosion, or even presume to advise as to remedial measures. In this connection we must admit that as field men of the Bureau of Soils few of us have availed ourselves of our opportunities in this line. Only one member has written very extensively or persistently on soil erosion; but his articles have been widely circulated. The agricultural press can use a good deal of such matter, but it should be quite specific and very adaptable to the territory in which the paper circulates.

The pupils in the County Agricultural High Schools in this state might well be encouraged and assisted in the preparation of short articles on local examples of erosion, terrace building and

the use of cover crops. Such brief communications are acceptable to farm papers, and kodak illustrations are often usable. If we may make the suggestion, why should we not have erosion prevention clubs, just as we have calf and corn clubs? Let us not forget in this conservation work the potency of youth in taking up and carrying on new ideas.

The recent disaster in the Mississippi valley has given such impetus to study of flood control, that we may hope for the ultimate adoption of methods for more comprehensive than those that have here-to-fore been in operations. Eventually there will be a correlation of control measures on the main stream with those on source streams. On the latter emergency dams, catchment basins and other engineering works will play an important part. Combined with these will be recommendations for the expension of forestry on the non-agricultural areas, and greater use on tillable lands of all practicable means of restraining the run-off of the rainfall. The latter is essentially our erosion problem, and inso-far as we contribute to its solution, we are contributing to these other great problems.

THE DEVELOPMENT OF MINERAL RESOURCES

Dr. George I. Adams, Professor of Geology*
University of Alabama

The mineral resources of the state warrant serious consideration at this session of the University Institute on Mississippi affairs. In speaking on their develop ment, I am glad to be able to refer to the summary of them given by Dr. E. N. Lowe, state geologist and professor of geology at the University, and add the comment that the state is more abundantly blessed by nature than the general public is aware. These resources should meet most of the state's needs and supply the raw materials for her industries. I count myself one of those happy mortals who believe that nature has provided sufficiently for us and all that is necessary in order to prosper is to use our energies and ingenuity.

The soils of the state which support the agriculture should receive first consideration. In the early history of the state survey, the work of Dr. Hilgard, one of the first state geologists, attracted the attention of the country to the soils of Mississippi. The character of the soils is directly dependent on the geological conditions. This has been fully recognized. The soil surveys which are being made in connection with the geological work are of great importance and should be continued. As a result of them, the price of farm lands is coming to be governed by the soil types. Since there is to be an address on the soils of Mississippi at this conference, the subject need not be further discussed in this connection, but it may be pertinently remarked that just as agriculture is the basic industry of a nation, so the soil is the most important mineral resource of the state.

Referring again to the summary by Dr. Lowe, it is gratifying to know that so much has been accomplished by the state survey. Nothing is of more value in bringing about the develop ment of the state's resources than accurate, readily available information concerning them. The reports of the Mississippi Geological Survey are very creditable indeed, especially considering the limitations under which they have been made. There is, however, a new economic era dawning and it will be necessary to provide more liberally for work on the geology and mineral resources of the state if Mississippi is to hold her place along with her neighbors. Times have changed. The budget that was deemed adequate when Dr. Hilgard did his work has long since been surpassed, but appropriations have not kept pace with the demands of the times. By way of illustration, reference may be made to the career of Dr. Eugene A. Smith who, when he was a young man was employed on the survey of Mississippi for a brief period.

*Recently deceased

He later was state geologist of Alabama and by arduous work and with limited appropriations succeeded in pu blishing a very creditable five foot shelf of reports on the geology and mineral resources of his state. This last summer, just before he died, the legislature of Alabama appropriated for the next four years a sum of money equal to one third of the total which was available to him for field work during the fifty-five years of his service.

There should be built up in this state an appreciation of the value of geological work. There may be a feeling that since there are no deposits of gold, silver, copper, lead and zinc and no vast deposits of coal and iron, that the geologic condition is not of importance. On the contrary, there is a demand both within the state and from outside the state for more information and it should be supplied. For example: the oil companies are looking to the lands lying east of and adjacent to the Mississippi river, in the gulf region for future development. At Amory a strong flow of gas has been struck and further prospecting in the State may result in the finding of oil. It is true that there has been deep drilling that has resulted in disappointment. The recent flood of oil in the midwestern field has caused a temporary lull in prospecting but there will be renewed demands for information concerning the geologic formations and the structure of the rocks.

Topographic maps of the state are needed. Some excellent ones have been made in cooperation with the United States Geological Survey. It is planned to complete the survey of the whole country. Some states have been entirely surveyed. Mississippi should profit by the cooperative plan and match dollar for dollar, the money which is available for expenditure by the government. The topographic maps are needed not only for geologic mapping and and the investigation of the mineral resources, but they should be available for engineering and industrial projects. The state pays taxes to the government and it is but reasonable that it should secure the return of a portion of the money to the state by cooperating in the making of topographic maps.

Speaking more specifically of the mineral resources, it may be pointed out that formerly a young engineer looked forward to being a superintendent of a gold or silver mine, and failing in securing such a position, he might work on deposits of the base metals, and as a last resort, consider coal. With the development of non-metallic deposits and the great demand for the more common minerals, the mining engineer is no longer held by the glamour of gold or the baser metals. Engineering skill is required in the production of such common materials as even sand and gravel. Formerly, the dredging and washing of sand and gravel for the recovery of gold lured engineers into remote regions where a profit was looked for from ground showing values as low as ten cents per cubic yard.

Today the demand for sand and gravel is so great that there are plants capable of loading one hundred cars of washed sand and gravel per day. One of the most successful enterprises which I have seen, considering the cost of equipment and the capacity, was a sand and gravel plant in Mississippi.

One of the state reports which merits special mention is on bauxite. Mississippi has important deposits of this ore of aluminum, but it is not of such a character as to meet the present market demands. The report on bauxite has attracted attention to the deposits and research work is now being carried on which may soon solve the problem of its utilization. The United States Bureau of Mines Experiment Station for this district is engaged on the problem and chemical research is also in progress which may find use for the ore.

There is a vast amount of information which has been gathered and published or is awaiting publication concerning the mineral resources of Mississippi but the unknown is increasing faster than the known. It is the duty of the state to provide adequately for geologic work. A new state geological map is needed. Alabama has just published a map and report which were completed under the deirection of the late Dr. Smith. Tennessee and Kentucky have new maps and Arkansas will probably publish a new map soon. A modern geologic map is a large undertaking, but by cooperative agreement with the United States Geological Survey, just as in the case of the topographic maps already discussed, the most modern methods of reporduction and the best map printing can be secured. Mississippi should make provision for the completion of the detailed survey of the state so that the information now on file and already published may be combined in a map that will meet the modern requirements of the investing public. Such a publication would attract capital to the state, not only for the development of the mineral resources, but along all lines in which modern enterprises are expanding.

This is an industrial age. Mining has been industrialized. It is closely related to manufacturing. The raw materials are now transferred from all parts of the earth to supply local deficiencies. State lines and even national boundaries are forgotten in the attempt to supplement local production.

Mississippi has recently shown great enterprise in obtaining new industries. Those who have labored to bring these industries into the state know full well that before they can interest the general public, they must set forth the local conditions. The fundamental requirements for manufacturing are usually stated to be raw materials, power, labor, market and capital. In the development of the mineral resources, the conditions are much the same. The function

of the Geologic Survey is to make known the raw materials, their location, accessibility, the quantities available, and the conditions which govern their exploitation. Capital is mobile and can be easily induced to come to the state if it finds a natural resource suitable for exploitation, for, there is not more certain basis for wealth than that of robbing nature. It is not infrequent that the citiz ens of the state hesitate to undertake enterprises which will require the investments of considerable sums because they are not conversant with the details of the business undertaking. They prefer to lend their money on first mortgages. But, when once an industry is established, and stock is placed on the market, or an opportunity is afforded for parti - cipation in legitimate expansion, they are willing to venture into the enterprise.

In the case of Mississippi, as in the case of neighboring states, there are so many problems to be solved and so many opportunities for investment, that it is desirable and necessary to attract outside capitalists. I am fully convinced that no more powerful appeal can be made to the financier who is considering expansion in a new field than by unrolling before his eyes a creditable geologic map of the state, and handing him a full report of its natural resources.

This is our earth. We inherit it. We derive our livelihood from it. Competion is increasing, and the conditions under which we live are too simple to serve future generations. We have profited by what our predecessors have done. It is our duty to provide for the future. Just what that future is to be, no one will venture to say. Fortunately, geologic conditions fo not change and geologic information which serves the present will serve the future. In providing for ourselves and our immediate necessities, we are providing for the future and laying a basis which will be s afe and secure no matter what changes there may be in social conditions.

B efore closing this address, I wish to refer to the work of state geologists in general and particularly to the creditable work of your own state geologist. It has been my privilege to know a number of men who like, Dr. Lowe, have unselfishly devoted their lives to the subject of geology and a study of the mineral resources of their states in which they have worked. Occasionally a charlatan or misguided individual appears with a mining proposition which holds the attention of the public for a short time and the state geologist is temporarily criticised or forgotten in the enthusiasm which leads to false hopes and unwise investments. In such times of stress, those who are thoughtful turn to the geologic reports and address their inquiries to the state geologist knowing full well that information which he will give out will be reliable, unb iased and free of charge. His position in the state is that of a faithful public servant. But no matter what the

interest of the public may be, and how earnestly he may wish to further the interests of the state by publishing in adequate form what he has been able to learn concerning it, he is handicapped if he is not given adequate financial support. There should be a sentiment built up in the educational centers of the state and among the political and industrial leaders which will foster the development of the mineral resources.

May the time soon come when Mississippi will take her place along with the other states and make adequate provision for the geologic maps and reports that will meet the requirements of our modern complex civilization.

MINERAL RESOURCES OF MISSISSIPPI

By E.N.Lowe, State Geologist

We sometimes hear the statement made that Mississippi has no mineral resources of value. This is a serious mistake, the error growing out of a misconception of what constitutes mineral wealth. To the average citizen "mineral wealth" means gold, silver, copper, lead, iron, and other metallic minerals; whereas at the present day, with the exception of iron, the non-metallics are far more indispensable to our needs than the metallics above enumerated, and they bring far greater values in the world's markets, though less spectacular.

In 1906 the Legislature of Mississippi created the State Geological Survey, and each year since has appropriated some support for this work, though never very liberally. If, therefore, Mississippi has no minerals, this money has been wasted, and the Geological Survey should never have been created.

At the outset it may be said that Mississippi has no gold, silver, copper, or lead ores. Our metallic minerals are limited to two - Iron and Aluminum.

IRON.* In the production of iron ores we cannot expect to compete with Alabama or Michigan, but in the aggregate our ores will go into the millions of tons. At no one place do we find these ores in beds of great thickness or extent, but comparatively small surficial deposits occur scattered over several counties in both north and south Mississippi. The ore is of two kinds: carbonate or spathic ore, and brown oxide ore, the latter seeming to be derived by weathering from the spathic ores. These ores usually lie at the surface, or under light overburden, permitting of mining by stripping, which is the cheapest method of mining.

Iron ores generally are of two kinds, according to the quality of pig iron made from them - Bessemer and the non-Bessemer ores. The difference being that one is suitable for making Bessemer steel, while the other is not. To be a Bessemer ore it must be low in silica and sulphur and must contain not more than 1/10 of 1% of phosphorus.. Our Mississippi ores are nearly all Bessemer ores. However, our scattered deposits will probably not be mined for steel making until improved transportation facilities make them more accessible than they are now. A few years ago a charcoal furnace in Benton County smelted a small tonnage of excellent pig iron, but the furnace was later abandoned.

It is, however, probable that our Mississippi ores will

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*See Miss.Geological Survey Bull.No.10. E.N.Lowe. 1913

be more useful for the making of mineral paints than for the manufacture of iron. This is particularly true inasmuch as the greater tonnage of these ores is gray carbonate, which on roasting may be made into paints of different shades of red and brown. Within the past few years considerable tonnage of this "paint rock", as it is popularly called, has been shipped out of the state for paint manufacture. While this procedure is better than its total non-use, the returns would be far greater both to the owner of the material and to the state at large if plants were established within the state for its conversion into the finished product.

ALUMINUM.* The ore of aluminum is Bauxite, which is the oxide. Ordinary clays contain aluminum in abundance; but with present processes it cannot be economically extracted from the clay. Hence,for a good many years almost the only commercial source of the metal aluminum has been bauxite, which has, so far, been discovered in only a few states of this country. Fully 95% of the bauxite produced in the United States comes from Arkansas, the output of which is practically all in the hands of the American Bauxite Company. In 1926, 398,546 long tons of bauxite was produced in the United States, and in the same year 281,644 long tons of bauxite was imported from foreign countries, mainly from South America.

The discovery of bauxite in Mississippi a few years ago led to a careful prospecting of the bauxite areas in several northern counties of the state by the Mississippi Bauxite Company, a concern organized at Sheffield, Alabama. The result of several months of detailed investigation disclosed the existence (as shown in our Bulletin No.19, noted below), of large bodies of this ore, of commercial grade. Careful estimate placed the tonnage of high grade ore containing from 50% to 60% of aluminum oxide at 400,000 tons, and of low grade ore, with 40% and lower, of aluminum oxide, at 1,500,000 tons.

At present the chief use of bauxite is in the manufacture of metallic aluminum in the form of plates, sheets, rods, wire and tubes; and the automotive industry and the rapidly developing aircraft industry combine to increase the demand for this grade of aluminum. A wide field of usefulness is also found for the lower grades of this ore in the manufacture of abrasives, and in making refractories, such as fire brick,furnace linings, and similar products, of increasing importance.

CEMENT MATERIALS.** By far the greater part of the cement used in the United States today is Portland Cement, an artificial product, which is made from an admixture of certain proportions of clay and ground limestone of a certain grade of purity. Some limestones have the clay or shale naturally mixed in right proportions to make a cement. This is called Natural Cement, and while it is used to some extent,it is not as reliable as Portland Cement. In the extreme northeast corner of Mississippi enormous deposits of shaly limestone suitable for

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*See Miss.Geol.Survey Bull.No.19,"Bauxite Deposits of Miss." P.F.Morse. 1923.

**See Miss.Geol.Survey Bull.No.1,"Cement Materials of Miss." Crider. 1907.

making natural cement lie within easy reach of the Tennessee River, which furnishes cheap and easy transportation to markets of the Mississippi Valley.

In the northeast prairie belt, and in the outcrop of the Vicksburg limestone across the state, unlimited deposits of limestones suitable for the manufacture of Portland Cement lie at the surface in more than twenty counties of the state, and is in thickness suitable to supply all the Portland Cement that the whole South could use for the next 100 years.

In the year 1925 there were 126 active cement plants in the United States, only ten of which were in the South, five being in Alabama and five in Texas. In that year these plants made 157,295,212 barrels of cement, and the demand, especially in the South where rapid development is taking place, is steadily increasing. Texas and Alabama plants can hardly supply home consumption in those states. Mississippi is well located for Cement distribution throughout the middle south, and would probably have had cement plants before now but for the fuel problem, as the greatest single item of expense in in the manufacture of cement is that of fuel, amounting to 30% or 40% of the total cost. Coal is the fuel almost univeraally used; Mississippi has no coal deposits; wood as a fuel is out of the question, and our lignite deposits are not yet developed. It is not difficult then to see why our state has no cement plants. Electricity is now taking the place of coal in so many smelting and other such processes that we may confidently expect at no distant day to see it used in the manufacture of cement.

LIGNITE.*- The coal formations of Alabama stop just short of the eastern boundary of Mississippi. But we have in this state large bodies of lignite of great purity and of high fuel value. Lignite is immature coal. It is not so firm, is of lower fuel value, and contains considerably more water than bituminous coal. Our lignites, which are founs in about 20 counties of the state, contain from 25% to 35% of water when first taken from the mine, and in this condition are unfit to use as fuel.

There are three methods of treatment by which these lignites may be converted into useful fuels. These are: 1st, by briquetting, which consists in grinding, drying, admixing a small proportion of some bituminous substance as a binder, and then compressing the mass under heavy weight into small solid blocks, called briquettes. These blocks are then satisfactorily used as fuel; 2nd, by conversion into gas. This is done by destructive distillation, yielding abundance of gas, which is then used as fuel. By this second it has been proved that, pound for pound, lignite has as high fuel value as bituminous coal when used in the ordinary way; 3rd, by grinding the lignite to a fine powder, and blowing this powder by air blast

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*See Miss.Geol.Survey Bull.No.3,"Lignites of Miss."Brown,C.S. (1933) The recent discovery of gas in this state will probably postpone for a time the use of lignite as a fuel in factories.

directly into the furnace, the heat of which readily ignites it.

CLAYS.* Clay is usually considered of no particular value. In the past most of us have been in the habit of regarding clay as a nuisance rather than as a thing of value. Coal, iron, and oil are usually rated as the indispensable minerals of 20th century civilization. But to these clay should be added as one of the indispensable substances of today. Clay has certain properties which make it of inestimable value, and which no other mineral or combination of minerals has. Whole libraries have been written on the subject of this mineral; whole industries have been built upon it, and numbers of men of science have given their whole lives to its technology. We get some estimate of its importance when we note the statement of the United States Geological Survey, that the clay products of the United States in the year 1920 had a valuation of $374,000,000; and that valuation has risen by leaps and bounds since that date. During any year from 1912 to the present, the clay products of the United States have exceeded in value all the gold, silver and lead combined that was produced in this country (including Alaska) for the same year.

Two general classes of clays may be recognized: first, common red-burning brick and tile clay, and second, higher grade white-burning ball and pottery clays. The first class includes those clays which are chiefly used for the manufacture of common brick and tile, both hollow building tile and roofing and drain tile. Certain of these clays are also used in the manufacture of terra cotta, others for paving brick and other vitrified wares. Practically every county in this state has clays suitable for making brick of excellent quality. Many plants, both large and small in Mississippi are making brick of these clays. Drain tile is made by a few plants, located mostly in the Delta.

In the course of the work of the State Geological Survey it has been discovered that enormous deposits of high grade white clays occur in many counties of our state. In fact, few states in this country are as rich in these clays as is Mississippi. At least six of our counties are known to have these white clays, which are practically as pure as residual kaolin, and in quantity sufficient to furnish the whole country for an indefinite time. In one pit the clay is known to be at least 18 feet thick, and the bottom of the deposit has never been reached, the outcrop extending to a known lateral distance of one half mile. At another pit pure white clay to a depth of 15 feet is exposed, and drillings made in the bottom of the pit revealed a thickness of 40 feet. Below this was a few feet of sand, and this underlain by a deposit of white clay to a depth of 70 feet. Borings have demonstrated the lateral extent of this clay bed to cover at least ten to twelve acres, and probably much more.

These figures can be duplicated in many parts of the state; so there is no question as to the enormous supply of clays within our borders. But it is regrettable that so far these rich clay deposits have received only limited development. Several small potteries operating in a few counties of the state, and some small tonnage of clay shipped out from the state, make up the sum of

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*See Miss.Geol.Survey Bull.No.2,"Brick & Tile Clays of Miss." W.N.Logan, 1907.

this development. In this connection it might be well to note some of the many lines of usefulness to which these white clays have been applied. For example, stoneware of all kinds, such as jugs, jars, churns, crocks, etc.; table ware and all white wares; Rockingham ware; sanatary ware, such as bowls, tubs, sinks, pans and basins; for refractory purposes, as firebrick, crucibles, saggers and glass pots; Faience, or art ware, such as vases, jardiniers, umbrella stands, fern dishes, pedestals, and miscellaneous wares, such as mortars, pestles, emery wheels, retorts, to say nothing of smoking pipes, door knobs, and countless other things in common use. In addition to these uses, white clays are now widely wmployed as fillers for both paint and paper; for electric fixtures and for spark plugs. Certain clays are also used in making soaps, cosmetics, and toothpastes.

With this wide and ever widening field of usefulness for clay we may see why the clay products of the United States - not the crude clay, but the thousand and one things made out of clay - each year bring the almost incredible valuation of $374,000,000. So with our enormous clay deposits we naturally ask ourselves why Mississippi should not realize large financial returns from this almost unlimited resource. But the same general causes have in the past militated against the development of our clays and other resources which have hindered the progress of many other industries in our state. But at the present time industrialism is in the air. and along with other forward movements we may hope for development of our clays. Here, let me say that the one thing that will aid more than any other in that development, is the establishment in the state of a well-equipped Clay Testing Plant and Ceramics Department, such as have recently been established in several of our southern states. Such a plant would enable us to make practical furnace tests of clays to determine their best lines of usefulness; and by exhibiting specimens of wares made from our clays in the markets of the country, would bring them to the attention of the world.

The State Geologist, at the meeting of the Legislature of 1926 asked for the establishment of such a plant, but the necessary appropriation to carry out the plan failed in the Senate. If Mississippi wants her vast clay deposits developed, she must be willing to spend a little money to test and prove their quality.

OTHER CLAYS

For many years Fullers Earth of good grade has been known to exist in several parts of Mississippi. On preliminary test this material has proved as good as the fullers earth from other states or from Europe. Within the past few years other deposits of high grade have become known in Winston and Yalobusha counties. While none of these deposits have been exploited they have attracted the attention of users of this clay in different parts of the country. The State Geological Survey has had many special inquiries about these deposits, with requests for samples of the material. The interest thus shown may lead to development of the material. In 1926 the production of fullers earth in this country was officially stated as 234,152 short tons, in addition to which, about half that

amount was imported. With the development of our own deposits, which are equally good, it is hoped that we may be able to supply the 121,000 tons which are now (1927) being imported from foreign countries.

BENTONITE.*- This is a peculiar clay, supposed to be of volcanic origin, which during the past few years has attracted much attention. It is a rare product, formerly found only in the western part of the United States, but of late discovered in several of the Southern states. In Mississippi it is found in several counties, occupying at least two different geologic horizons. Besides its qualities as a highly plastic clay, bentonite has special qualities, because of which it is now being sought after. It has been found that high grade bentonite when treated with an acid may be used as a fullers earth for clarifying oils, both vegetable and mineral, but having many times greater effectiveness than even the best fullers earth. It is also used in soap making, not as an impurity, but because of its having the qualities of soap. For this reason soap makers are looking for commercial deposits of this clay. Also bentonite has recently been found to have the quality of de-inking old newspapers, books, etc., in which process the pulp can be used over and over again, thereby saving the enormous yearly waste due to destruction of such material, with consequent inroads upon our forests, which now furnish most of the material used in paper making.

From many parts of the country interest is manifested in Mississippi's bentonite deposits, and the State Geological Survey in response to requests has sent out many samples of this material, all of which, when tested, have proved suitable for the various uses, and we may be hopeful of an early exploitation of these deposits.

The great disideratum in the development of our enormously rich clay deposits is the establishment by the State of an adequate plant for the testing of these clays. The Geological Survey receives many inquiries as to the fitness of certain clays of the state for specific purposes; but we are seldom able to give definite answers, for the reason that, while we have chemical analyses of most of our clays, it is only in a few cases that we have been able to give them practical furnace tests. A chemical test cannot supply the information which the furnace test only can give; and in the case of refractory clays only furnaces capable of very high temperature tests will give the necessary information. Hence, such tests as we have been able to give to a few of our clays have been made at northern plants at a cost of from $35 to $50 a sample. Our state could save a great deal of money, and tests of all of Mississippi's clays could be made if a testing plant and a properly equipped Ceramics Department could be established within the state.This would insure the widest possible advertisement of one of our most important sources of wealth.

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*See Miss.Geol.Survey Bulletin No.22, Bentonite in Miss.

OTHER MINERALS

Besides those already mentioned, Mississippi has large deposits of several other non-metallic minerals which have undoubted value, and which when developed will prove to be important resources. In fact, some of these may eventually prove to be of greater value than some of the metallic minerals already mentioned.

TRIPOLI. - Great deposits of snow-white pulverulent silica, or tripoli, offer possibilities of value as material for polishing powder, fillers, glass-making, and ornamental wares. Together with adjacent high percentage limestone, tripoli offers possibilities for the making of white cement.

OCHERS, etc. - Ochers and mineral pigments, both yellow and red, form an excellent source of paint. Large deposits of both of these materials, of uniform tints and free from sand and other impurities, lie easily accessible to transportation. Little development of these deposits has so far been undertaken. Ocherous clays and highly colored iron oxides are found in many parts of the state.

BAUKITE. - Lately a highly refractory material under the name of "baukite" has attracted a good deal of attention, and if results of first tests are confirmed by later tests, this takes its place as a resource of real value. Thedeposits are large, and being associated with deposits of bauxite and bauxitic clays, it has the appearance of a highly siliceous bauxite though it grades into almost pure silica. Under the auspices of the Gulf, Mobile and Northern Railroad it is receiving additional tests. This material gives promise of being a good furnace lining.

SANDS. - Sands pure enough for glass making have been discovered in several parts of the state. A good many years ago a development was projected on Horn Island, several miles off the coast of Mississippi, and belonging to the state. But the enterprise proved premature; the sand was abundant and pure enough, but the fuel problem caused abandonment of the plan.

MINERAL WATERS. - These waters, mostly chalybeate, sulphur, and "alum" waters, are distributed largely over the state, being most abundant in the southern half. Some of these wells and springs are well-known resorts, with hotels and other facilities. In some instances the waters are bottled and shipped out of the state, often to distant points. As a valuable resource these waters should be more largely exploited. It seems probable that eventually the warm well waters (which are also highly mineralized) in the Jackson area may prove of value for health resort purposes. Should these waters prove to be radioactive, their great value would be unquestioned.

OIL AND GAS.* - In October,1926, gas was discovered in a well near Amory, Monroe County, but as yet no oil has been found in commercial quantity within the state. It seems quite

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*See Ninth Biennial Rept. of State Geologist, and also Miss.Geol.Survey Bull.No.21,"Oil & Gas Prospecting".

probable, however, that further careful testing will show the presence in the discovery well region, not only of a larger quantity of gas, but of oil as well. Up to the present time (1927), I see no distinct reason for discouragement.*

By the new electro-physical methods of investigation the discovery of hidden domes in the coastal region of Mississippi becomes an interesting possibility.

In conclusion let me say, that in all the above discussions the potential values of Mississippi's mineral resources have been frequently spoken of; but it should be understood that our state's mineral wealth is not all potential. In the year 1920 the mineral output of Mississippi had a valuation of $2,198,013. But this, in view of the abundance of our mineral resources, should have been twenty times as much.

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* (1933) The discovery of commercial quantities of gas in the vicinity of Jackson during the year 1930 has made a notable addition to the state's resources. At the present time the Jackson gas field has about 100 producing gas wells, totaling a capacity of more than one billion cubic feet of gas a day. Only a small fraction of this gas is as yet being used. The city of Jackson is being supplied with gas, and pipe line connections have been established with points in Mississippi, Alabama, and Florida, and more extended connections to a larger market will no doubt soon be made.

The rock pressure in this gas field is more than 1000 pounds, and has not been lowered materially since the opening of the field.

One well at present producing a heavy oil in the same field is estimated to yield approximately 300 to 400 barrels per day.

During the past few years considerable activity in the southern counties of the state has been manifested by a number of development companies in explorations by the several geophysical methods - torsion balance, seismograph, and magnetometer. The results of these investigations have not yet become available; but no drillings seem to have been based upon the findings of these researches, which were probably of negative value.

HYDRO-ELECTRIC POWER AND THE DEVELOPMENT OF INDUSTRIES

By B. E. EATON

The industrial development in the Southwestern States discloses the intimate connection between hydro power and industry, if not their dependence upon each other. Where the greatest power development exists, as in Alabama, Georgia, and the Carolinas, the greatest industrial development also exists. But even in those states industry is found, almost without exception, in the communities that are able to offer hydro power. The present trend of industry is to seek localities that offerpower. In most instances a new industry has difficulty in financing itself, and the cost of an individual power plant is frequently a deterring element against its location. If, in addition to a local power plant, fuel must come from a distance with consequent high freight rates, the cost of operation becomes prohibitive, and the proposed industry either does not materialize or it goes to a more favored location.

That an industrial development is desirable should need no argument. Where industry and agriculture exist side by side, as in Illinois, Ohio, Pennsylvania, and New York, farm products bring better prices, farm values are higher, and wealth produced by manufacturing is enormous.

Mississippi has always been too heavily agricultural. It is proof that a state relying mainly on agriculture accumulates wealth much more slowly than a state with both agriculture and industry. Obviously two sources of revenue are better than one, and if, to the two, mining may be added, the situation is ideal.

Industry usually builds cities, and cities are consumers of farm products. They constantly offer a market for food supplies, and the arms nearest the market are the chief beneficiaries. This is the reason why relatively poor lands near a city are worth more than excellent lands more remote.

The real problem in diversification is not the ability of the farmer to grow other than staple crops. It is in finding a market for diversified crops. The lack of markets for such products is the one great cause for the Mississippi farmer's reliance upon cotton. There would be no more recurring cycles of overproduction and low prices in cotton if there were profitable markets for other agricultural products.

Such markets inevitably result from industry and industrial occupations. Two causes operate in bringing about such result. First, industry tends to draw labor from agriculture and it comes from those localities where agriculture is least profitable. Second, the labor of industry that was

previously a producer now becomes a consumer, thus decreasing the supply and increasing the demand, consequently the price of farm products. When the proper balance is established, a state and its people fare well. (And when not, farewell!)

What is the chance of establishing this balance between industry and agriculture in Mississippi? We know that Mississippi has vast quantities of raw material. Cotton, hardwood, pulp wood, clays, and other minerals will indefinitely supply textile and garment factories, furniture and wood working plants, paper mills, and a varied mining industry. Labor does not have to be imported. It is already here, a native born product, and only needs training for the development of the highest efficiency. The policy of the state toward the investment of capital is now friendly and fair. And for the present we have power--the last needed element.

Today, Mississippi is unique in its power development. Only twenty-six months ago the first hydro current was turned on, in Iuka. There was then no central station service of any extent. Since then, most of the state's potential industrial centers have been connected to high tension transmission lines. These lines are now reaching out to other sections, and soon the entire state will be covered. No other state, in so short a time, has had a comparable growth in power facilities.

There Ts but one cause of anxiety, and that is that the power itself comes from without the state. Economical power sites are found only where deep channels are cut through mountainous or semi-mountainous areas. Mississippi is, unfortunately, without mountains, and its streams run through a flat country. Some small power projects may be feasible, but a major development is prohibitive, and a major development is necessary for large sized industry. Restrictions upon the export of power by neighboring states would therefore be disastrous. For this reason the greatest immediate concern of Mississippians should be to see to it that in the disposition of Muscle Shoals a fair distribution of its surplus power is guaranteed to Mississippi. A persistent fight is being waged to localize the use of this power and build up a great industrial region around the dam. If this effort succeeds, Mississippi will not only be without power for its own industrial development but will suffer a withdrawal of labor and capital to an unfairly favored section.

That Mississippi is capable of sustaining and is responding to the impetus of an industrial awakening is abundantly proved by recent experience. Probably the most outstanding accomplishment of the past two years is the development of the dairying industry in central northeast Mississippi. This is even more than the accomplishment of two years; it is the outstanding accmplishment, so far, of the state's industrial history. Heretofore there has been little market for raw milk.

Large cities were too far away. The small dairyman's product was too limited and his capital too meagre. Cooperative marketing, where tried, had not been successful. Consequently, a useful and essential product had no monetary value because facilities for marketing were lacking. The condensery, the cheese factory, the powdered milk plant, and the creamery have now changed all this, and a market near his door is paying millions to the farmer for what, previously, was an unmarketable product.

In southeastern Mississippi a fruit and vegetable cannery is doing the same thing, though in lesser degree. This industry can and should be greatly extended. The dairy and canning industries strikingly illustrate both the dependence of agriculture upon industry and the wealth produced by their joint efforts.

Two cotton mills, long abandoned, have recently been put in successful operation, and a local market for cotton is being established.

A new industry converting the hitherto burned waste products of saw mills into valuable wood fibre boards is in successful operation at Laurel. This industry is of incalculable potential value.

The list might be enlarged by the inclusion of other activities, but this recital is sufficient to show that Mississippi is recognizing her opportunities and is reaching out to lay hold of them. The one great need is for Mississippians to have confidence in their state and its possibilities and to work and spend their own money in its development. Pessimism has never yet done any worth while thing. Competition is too keen for us to sit down and wait for others to develop our resources. We welcome outside capital, of course, but we must take the initiative in procuring it, and we must express our confidence by combining our capital with that from the outside.

Mr. Chairman, this meeting held under the auspices of the University will be productive of great good. Your program includes the discussion of all subjects that concern the material well-being of the state, and behind these discussions stands out in bold relief the leadership which this great institution ought to assume in the economic life of the state. Thoughtful men welcome your contribution and urge you to continued effort.

THE CLIMATE OF MISSISSIPPI

Dr. W. L. Kennon
University of Mississippi

(Note--The numerical data in this paper has been taken from the monthly publication of the U. S. Weather Bureau, "Climatological Data" (Mississippi Division). The tabulations, arrangement and interpretation of the data are by the author.)

The inclusion of my subject "The Climate of Mississippi" in the "Session on Natural Resources" at once suggests the point of view. I think it important to call attention to this viewpoint since it seems to me to have been too much neglected in evaluating the natural resources of the Southland, and particularly those of our own State. I shall not, therefore, attempt to discuss the subject as a professional meteorologist, which I am not, but rather as an interested student of our natural wealth. The wealth of our forests and soils has for decades been recognized throughout the economic world; the wealth of our pasture lands is just now coming to be appreciated at home and abroad; let us give then honorable mention to the friendly climate that has made possible these and many other sources of wealth, health, and comfort within our State.

As a natural resource, climate has certain peculiar characteristics. It cannot be transported. Our timber, cotton, vegetables, cattle, poultry, and hogs have for the most part, been carried, beyond our borders for manufacture and consumption, and thus have contributed much to the wealth and welfare of the Nation. However, to harvest fully the benefits of our hospitable climate, it is necessary for our distant friends to come within its bounds and thus become our neighbors. Again, climate cannot be manipulated, exhausted or monopolized. Apparently the most fickle of natural resources, it is in the long run the surest and most stable. This characteristic was ably stated by Mark Twain in his famous complaint to the effect that "everyone was talking about the weather but no one was doing anything about it." At least we can guarantee our climate. Climate is a complex thing, the result of many intricately related factors each of which has its own peculiar effect in determining the final outcome. It is impossible to say just what combination of climatic factors would constitute the perfect or ideal climate for all purposes at all times. It is certain that no such perfect climate exists on earth; and yet, we must have some criterion as a basis of discussion.

According to Dr. Robert DeC. Ward of Harvard University, "There is pretty general agreement, among physicians, physiologists and climatologists, that the best climate for most people and most of the time is one which has frequent moderate weather changes; fairly marked annual and diurnal variations in temperature; a reasonable amount of cold during at least part of the year; a refreshing variety in the amount of cloudiness, and sufficient rainfall to provide enough moisture for the growth of grass and crops. Such a climate is an intermediate one. It is neither invariably hot nor persistently warm, neither is it per-

manently cold. It is neither monotonously arid and cloudless nor always dull and rainy. It is between all extremes. A climate, in other words, which encourages people to spend the maximum possible amount of their time outdoors, in the open air, is, other things being equal, the best for the majority of men and women."

Accepting this as a reasonable basis on which to judge the merits of a given climate, we observe that the most valuable charisteristics of a good climate are a distinct variability of its more important elements, such as temperature, humidity, precipitation and sunshine, within moderate limits; it should lack extremes and monotony in these elements. While the above criterion was set up chiefly as a basis of health and physical well being, it serves equally well as a basis for successful agricultural and industrial activity. Examined on this basis, the climate of Mississippi has, I think, an excellent score.

(I must say here, parenthetically, that my audience will understand the time limit by which I am governed in the presentation makes it impossible to attempt an elaborate detailed statistical analysis of this subject. In the general observations which I shall make in support of my thesis, I have been guided by the complete record which I have before me of the climatical data for Mississippi issued by the U. S. Weather Bureau, supplemented by many years of personal experience and observation. This valuable official weather record of our State is easily available to any one desiring fuller details. I wish that I had more time in which to extol the value of this record.)

SUNSHINE AND CLOUDS

Table I shows the number of clear, partly cloudy, and cloudy days for each month during a period of ten years from 1917 to 1926 inclusive, with suitable averages. The average number of clear days per annum over this period is 169.2,partly cloudy 97, cloudy 99.4. The average number of clear days per month varies from approximately 12 for the winter months, to approximately 15 for the summer months; the partly cloudy from 6 for the winter months to 10 for the summer months; cloudy days from 6 to 14. In this classification it is not to be understood that partly cloudy and cloudy days are "rainy days". They include the "rainy days", but a cloudy day does not necessarily imply precipitation. In a general way, then, we may say that from a third to a half of the days of every month in the year are on the average clear, sunshiny days; and that from a half to five-sixths have some sunshine. Of course, individual months vary, as the table shows, from these average values, but not as much as one who had not examined the records might suppose. The number of partly cloudy days implies an important daily variation in the amount of sunshine and cloudiness as well as monthly variation. Certainly, then, we are justified in claiming "a refreshing variety in the amount of cloudiness and of sunshine."

TABLE I.

SUNSHINE AND CLOUDINESS.

(Data for State, not for individual stations.)

Days clear

Month	YEAR 1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Av.
January	9	12	14	8	13	6	14	15	14	11	11.6
February	13	10	11	11	14	9	11	13	11	15	11.7
March	13	14	16	13	11	13	13	13	19	12	13.7
April	16	12	17	12	14	12	12	13	17	15	14.0
May	16	20	9	10	15	10	10	15	19	17	14.4
June	19	16	10	17	13	13	11	15	15	17	14.6
July	13	16	14	10	15	13	14	20	12	16	14.3
A ugust	13	16	10	10	15	16	12	18	20	12	14.2
September	14	17	17	16	14	20	16	17	18	17	16.6
October	23	10	7	19	23	18	19	25	11	16	17.1
November	19	17	14	18	15	15	14	17	15	14	15.8
December	12	13	12	12	13	9	6	11	14	10	11.2
Totals	180	173	151	156	178	153	152	192	185	172	169.2

Max. 192. Min. 151. Av. 169.2

Days partly cloudy

January	5	5	7	5	8	6	6	6	4	7	5.9
February	6	7	7	7	5	8	5	5	9	6	6.5
March	7	9	7	6	11	6	6	8	7	7	7.4
April	7	9	6	8	8	9	9	9	10	7	8.2
May	9	8	10	11	9	12	10	8	8	8	9.3
June	8	10	12	8	12	10	12	10	11	9	10.2
July	10	9	13	13	11	12	11	9	12	10	11.0
August	11	9	14	12	12	10	11	10	8	12	10.9
September	10	6	9	10	12	8	8	7	7	10	8.7
October	4	15	11	6	5	6	5	5	7	9	7.3
November	4	4	6	5	7	7	6	9	4	8	6.0
December	5	5	6	5	6	6	4	6	7	6	5.6
Totals	86	96	108	96	106	100	93	92	94	99	96.4

Max. 108. Min. 86. Av. 96.4

Days Cloudy

January	17	14	10	12	10	19	11	10	13	13	13.5
February	9	11	10	11	9	12	12	11	8	7	10.0
March	11	8	8	12	9	12	12	10	5	12	9.9
April	7	9	7	10	8	9	9	8	3	8	7.8
May	6	3	12	10	4	9	11	8	4	6	7.3
June	3	4	8	5	5	7	7	5	4	4	5.2
July	8	6	4	9	5	6	6	2	7	5	5.8
August	7	6	7	9	4	5	8	3	3	7	5.9
September	6	7	4	4	4	2	6	6	5	4	4.8
October	4	6	13	6	3	7	7	1	13	7	6.7
November	7	9	10	7	8	8	10	4	11	10	8.4
December	14	13	13	14	12	16	21	14	10	15	14.2
Totals	99	96	106	114	81	112	120	82	86	98	99.4

Max. 120. Min. 81. Av. 99.4

The data on "rainy days" for the same period considered above has been tabulated in Table II. The totals for the several years vary from 73 to 112; for the several months of the year on the average from 5.2 to 9.6.

The "rainy day" is generally not regarded with pleasant anticipation, yet it has been an acceptable theme for poets and philosophers. At least, it seems necessary to an extent in the scheme of nature, and the climate of Mississippi does not appear over-burdened with them.

TABLE II.

RAINY DAYS.

(Data for State, not for individual stations.)

Year	Mo. Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1917	10	9	12	7	5	5	10	10	6	5	4	6	89
1918	10	7	4	9	3	8	6	7	6	11	7	6	84
1919	9	10	6	6	14	11	9	10	4	13	8	7	107
1920	11	8	10	9	11	7	11	10	5	3	6	10	101
1921	7	9	8	7	4	8	9	8	7	3	5	8	83
1922	13	10	11	8	12	10	10	7	4	5	6	11	107
1923	8	9	11	12	13	11	10	10	5	5	6	12	102
1924	8	8	8	8	8	7	4	5	5	1	2	9	73
1925	10	7	5	3	5	7	10	5	6	12	8	6	84
1926	10	5	10	8	7	7	7	12	4	6	8	11	95
Totals	96	82	85	77	82	81	86	84	52	64	60	86	935
Averages	9.6	8.2	8.5	7.7	8.2	8.1	8.6	8.4	5.2	6.4	6.0	8.6	93.5

RELATIVE HUMIDITY.

This term refers to the relative amount of water vapor in the air at a given time, more specifically to the amount of water vapor present in the air as compared with the amount required to saturate the air at its prevailing temperature. It is usual to express it as a per cent. To say the air has a "relative humidity" of 100% means that it is holding all the water vapor possible for it. No further evaporation can take place into such air.

So far as climate is directly responsible for the state of health of a community, the factor of "relative humidity" is undoubtedly the most important element. The "pneumonia rate", for example, has been shown by Professor E. Huntington to be especially responsive to extremes in "relative humidity". This is an interesting and important question physically as well as physiologically, and I regret that I have not time to discuss it more fully. We are here concerned with it, however, indirectly.

Not only does "relative humidity" concern the vital question of health but it is foremost in determining personal comfort. It has also economic importance.

The most desirable range in "relative humidity" appears to lie between 60% and 80%. Below 50% or above 85% is not so desirable. Below 40% or above 90% is distinctly undesirable. I make my figures somewhat elastic as there is some difference of opinion as to where the precise danger lies. As to the serious undesirability of decided extremes, when they persist for considerable periods, I think there is little question. (In making such statements as a basis of comparison, of course, it is to be understood that, in referring to undesirable limits, such designation is applicable only when these extreme values persist for some days or weeks at a time. A high relative humidity for a brief period, say, for example, preceding a rainstorm, is, of course, not to be thought of as a menace to health.

The published data for Mississippi shows ten observations for each month, two at ea ch of five stations - Memphis, Tenn., Meridian, Miss., Mobile, Ala., New Orleans, La., and Vicksburg, Miss. One of these observations is made at 7 a. m., the other at 7 p. m. of the same date. Considering the great value of such data, the meagerness of this official record is much to be deplored. For our purpose, however, the stations are favorably located and in the aggregate give a fair idea of conditions. Since the data does not lend itself to the taking of reliable averages and since I cannot exhibit the entire record, I have resorted to a rather unusual method of interpreting this data.

There are 1130 observations for the ten year period under consideration. Of these, 169 are above 85% and 106 are below 60%, leaving 905 within the range of 85% to 60%. Further examination shows only 14 observations above 90% and 14 below 50%. The majority of the figures group themselves around 80% for the morning observations, and around 60% for the evening observations. Because of the restricted data, the speaker hesitates to be too positive in his assertions on this point. However, on the whole, the factor of humidity seems to be satisfactory.

TEMPERATURE.

The yearly normal temperature for the State is 64.3°. The monthly normals are Jan. 46.7°, Feb. 48.3°, Mar. 57.2°, Apr. 64.3°, May 71.5°, June 78.9°, July 80.8°, Aug. 80.5°, Sept. 76°, Oct. 65°, Nov. 55.1°, Dec. 47.3°; such figures, however, give little direct information as to what to expect in the way of actual temperatures. I have, therefore, prepared a temperature table (Table III) assembled from data published by the U. S. Weather Bureau showing the principal elements of variation and the extent of their variation from the mean or average values for the five year period 1922-1926, inclusive. The first column shows the monthly means for the State as a whole, and the second and third columns the highest and lowest monthly means of any stations within the State. The fourth and fifth columns show the extreme values of temperature observed within the State within the month. Inspection of the table brings to the attention many interesting features of the temperature element of our climate, some of which will, I think, be somewhat surprising to those who have not previously studied the record. For example, it is interesting to note at least a few real summer days in each of the midwintermonths, and temperatures in the forties and fifties in June, July and August of nearly every year. High temperatures appear during the summer mon ths, occasionally above the hundred mark, yet reference to the mean values will show that such extreme

temperatures must be relatively infrequent.

Careful study of the whole record given will bear out the statement that, so far as the temperature is concerned, it fully meets the requirements of "fairly marked annual and diurnal variations in temperature, and reasonable amount of cold during at least a part of the year".

Climate, as previously mentioned, is a complex quantity, and so in thinking of the effects of temperature, the effect of prevailing winds and stateof cloudiness must be taken into consideration. Also, the relatively longer nights in southern latitudes offset to a very marked extent the unpleasant experiences of exceptionally hot days. For the State as a whole, the winters are short and the summers long, yet not monotonous. Over the northern division of the State sharp freezes are not uncommon. For agricultural purposes, the growing seasons are long with conditions favoring a variety of crops.

The prevailing mild temperatures are of importance in fuel economy, especially for domestic purposes, and of great monetary value in the maintenance of cattle and dairy stock which may remain unsheltered most of the year.

TABLE III.

TEMPERATURE.

1	2	3	4	5	6	7		9	10	11
Yr.	Mo.	Normal	Mean for State	H. mo. mean	L. mo. mean	H. temp.	L. temp.	Gr. local mo. range	Least local mo. range	Gr. daily range
1922	Jan.	46.7	46.7	55.0	40.7	81	20	58	41	48
	Feb.	48.3	53.7	60.8	48.4	86	19	64	47	50
	Mar.	57.2	56.5	61.9	52.6	87	21	62	48	42
	Apr.	64.3	67.7	71.6	63.9	91	31	52	39	43
	May	71.5	72.7	75.0	70.0	95	47	45	30	37
	June	78.9	79.6	81.5	78.6	104	53	45	29	36
	July	80.8	80.5	82.4	79.0	101	53	48	29	34
	Aug.	80.5	80.1	81.9	78.4	101	54	46	29	39
	Sept.	76.0	78.0	80.6	74.2	105	46	59	29	44
	Oct.	65.0	65.7	70.4	63.4	95	31	64	40	50
	Nov.	55.1	58.3	65.6	54.1	90	25	61	43	46
	Dec.	47.8	54.9	61.8	48.4	85	20	62	39	46
1923	Jan.	46.7	53.3	58.7	47.4	82	23	56	34	50
	Feb.	48.3	47.5	55.4	41.2	83	10	66	55	50
	Mar.	57.2	54.8	60.2	50.6	87	15	66	47	47
	Apr.	64.3	64.1	68.8	58.3	90	23	61	46	40
	May	71.5	70.1	74.1	66.7	97	38	59	43	44
	June	77.9	77.6	79.6	75.7	97	48	48	27	34
	July	80.8	79.4	81.1	77.9	102	54	45	28	37
	Aug.	80.5	80.2	81.9	78.1	100	53	44	34	40
	Sept.	76.0	76.6	80.2	74.0	97	51	44	32	39
	Oct.	65.0	68.9	68.9	60.4	97	26	66	52	49
	Nov.	55.1	53.5	57.4	50.6	90	27	52	40	47
	Dec.	47.8	55.1	60.0	49.8	81	25	54	38	46

TABLE III (Continued)

1	2	3	4	5	6	7	8	9	10	11
1924	Jan.	46.7	42.2	48.4	36.3	78	2	68	56	47
	Feb.	48.3	42.3	53.8	42.8	83	18	64	45	48
	Mar.	57.2	51.9	57.1	46.7	88	20	63	48	43
	Apr.	64.3	64.3	68.4	61.2	90	26	62	45	46
	May	71.5	68.4	72.6	64.0	95	33	54	38	45
	June	78.9	81.3	83.6	78.2	103	56	44	29	34
	July	80.8	81.2	83.8	78.4	108	50	55	39	42
	Aug.	80.5	83.3	86.0	80.6	107	53	50	31	47
	Sept.	76.0	74.0	78.4	69.8	102	37	62	46	50
	Oct.	65.0	66.7	70.2	64.0	97	27	64	44	55
	Nov.	55.1	57.9	63.8	54.0	90	16	70	48	52
	Dec.	47.8	48.3	55.2	42.3	87	7	75	48	49
1925	Jan.	46.7	47.5	55.8	42.0	80	11	63	37	51
	Feb.	48.3	54.6	59.2	49.9	85	19	59	44	45
	Mar.	57.2	59.4	65.5	55.5	88	18	67	50	48
	Apr.	64.3	69.3	72.2	66.6	95	33	58	35	46
	May	71.5	70.6	73.6	67.5	98	32	65	40	48
	June	78.9	81.5	83.2	79.4	104	55	48	34	43
	July	80.8	82.3	83.9	80.4	106	57	49	28	43
	Aug.	80.5	81.1	83/4	79.4	106	53	51	32	45
	Sept.	76.0	83.4	85.2	81.6	111	60	50	25	45
	Oct.	65.0	65.2	72.0	59.2	100	25	68	50	50
	Nov.	55.1	53.8	59.7	49.2	85	22	59	46	49
	Dec.	47.8	45.5	51.0	39.2	83	3	68	56	43
1926	Jan.	46.7	45.3	50.6	40.8	76	12	54	39	43
	Feb.	48.3	52.8	57.4	47.3	84	21	61	45	44
	Mar.	57.2	51.7	56.4	46.7	83	12	69	49	45
	Apr.	64.3	61.3	65.5	58.2	93	20	60	43	48
	May	71.5	71.1	74.6	68.6	102	40	50	36	44
	June	78.9	78.7	81.2	76.4	101	47	52	38	39
	July	80.8	80.5	82.5	78.2	104	48	53	28	45
	Aug.	80.5	81.8	83.7	80.2	103	59	42	23	36
	Sept.	76.0	80.1	82.0	78.2	102	51	51	26	43
	Oct.	65.0	68.7	74.2	64.0	99	37	70	47	47
	Nov.	55.1	50.7	56.1	46.1	82	20	60	42	44
	Dec.	47.8	51.7	60.0	44.5	85	14	64	46	47

PRECIPITATION.

Table IV has been arranged to show the monthly precipitation data for the State over the five-year period 1922-1926, inclusive. This will serve to represent approximately the values to be expected. Column 3 shows the monthly averages; column 4 the departures from normal for the several months; columns 5 and 6 the greatest and least monthly means for particular stations; and column 7 the greatest precipitation in any twenty-four consecutive hours.

The figures show that, on the average, rainfall is pretty well distributed, with a distinct tendency to higher values in the winter months, and to lower in the summer. An

examination of the specific values will reveal other desirable elements, as well as some not so desirable. The rainfall, at times especially, may appear in excess of the agricultural requirement. However, the topography of the State is such that natural drainage greatly facilitates the removal of excess precipitation. It chances that both the least and greatest rainfalls of annual record since 1889 occur within the five-year period given in our table, and happen in consecutive years; that of 1923 being 71.03 inches, and of 1924 being 40.06 inches, as compared with the normal of 54.8 inches. As previously stated, such extreme variation from normal has occurred but once in the entire record since 1889, the average variation of the annual mean from normal being about 7 inches. This exceptional occurrence affords a good opportunity to compare the effect of excessive with scant rainfall on the agricultural operations within the state. A study of conditions seems to indicate that farming interests in general "weathered" the wet year better than the dry. In the case of the cotton crop the situation was complicated by the presence of the boll weevil. While the extremely wet season also favored the weevil, and this reversed the situation.

It is difficult to isolate and compare the effect of any one element of climate upon farming operations which are influenced by so many other climatic elements. For example, in 1924 unseasonable "cold periods late in March, during the first half of May, and throughout most of July", probably had as much to do with the lower yields as the excessive precipitation, and this notwithstanding the fact that the mean temperature of the State for the year was less than one-half degree from normal.

One other consideration should be mentioned in connection with the element of precipitation in climate. Although it is subject to wider and more irregular variation, not only in the monthly means, but also in the annual means, than any other element, yet of all climatic elements it is the one the effects of which are under partial artificial control. Irrigation and drainage have proved to a large extent successful in coping with the situation. Of the two, drainage is more generally applicable; that is, it is usually easier to get rid of surplus water than to supply a deficiency. Often well-developed natural drainage simplifies the former problem; and such is the case in Mississippi. It also appears that greater precipitation is required for maximum plant growth where higher annual temperatures prevail than in cooler climates.

On the whole, it seems to the speaker, that considering the uncertain timeliness and local variation of this climatic element almost everywhere, that Mississippi is well favored. Anything like complete crop failures due to excessive or to deficient precipitation is unknown in Mississippi.

TABLE IV.

PRECIPITATION.

1 Yr.	2 Mo.	3 Av. for State	4 Av. departure from normal	5 Greatest mo. total at any one station	6 Least mo. total at any one station	7 Greatest amt. in any 24 consecutive hrs.
1922	Jan.	6.52	+1.49	11.03	2.15	3.00
	Feb.	6.48	+1.56	10.18	3.23	4.15
	Mar.	9.91	+4.46	15.01	6.20	6.50
	Apr.	5.23	-0.23	10.60	1.60	5.28
	May	5.88	+1.34	12.36	3.70	7.40
	June	3,73	-0.59	8.51	1.12	3.10
	July	4.64	-0.42	10.31	1.32	4.84
	Aug.	3.19	-1.17	9.43	0.10	3.45
	Sept.	1.38	-1.95	5.33	0.00	2.80
	Oct.	1.63	-0.95	4.44	0.38	2.56
	Nov.	3.77	+0.35	7.55	1.58	4.43
	Dec.	7.07	+1.80	11.93	3.19	6.60
1923	Jan.	4.47	-0.47	6.53	1.73	3.47
	Feb.	6.43	+1.51	11.71	3.42	3.85
	Mar.	7.44	+1.73	15.72	3.67	5.65
	Apr.	8.54	+3.12	16.16	3.26	7.58
	May	9.09	+4.63	15.45	4.33	5.00
	June	5.24	+0.99	11.39	1.53	3.16
	July	5.80	+0.55	12.08	2.25	5.45
	Aug.	5.52	+1.07	11.53	0.57	5.00
	Sept.	2.15	-1.19	5.17	0.30	2.03
	Oct.	3.71	+1.02	7.35	0.60	6.70
	Nov.	5.12	+1.60	8.87	3.20	3.50
	Dec.	7.52	+2.03	13.80	3.01	5.05
1924	Jan.	6.56	+1.59	10.98	3.84	3.30
	Feb.	4.51	-0.43	7.49	1.53	4.33
	Mar.	4.16	-1.59	7.39	1.13	3.50
	Apr.	5.04	-0.37	8.38	1.42	3.28
	May	4.52	-0.12	10.93	0.82	4.10
	June	3.48	-0.73	9.49	0.30	3.60
	July	1.71	-3.46	6.20	0.00	3.18
	Aug.	1.80	-2.56	6.22	0.26	2.88
	Sept.	1.92	-1.35	4.98	0.13	2.76
	Oct.	0.22	-2.44	2.00	0.00	2.00
	Nov.	0.45	-3.03	2.72	0.00	1.96
	Dec.	5.69	+0.22	10.38	1.55	3.38
1925	Jan.	8.58	+3.48	15.02	2.48	6.09
	Feb.	3.81	-1.16	9.52	1.22	3.00
	Mar.	2.89	+2.78	6.77	0.15	4.43
	Aprl	1.15	-4.26	4.33	0.00	3.45
	May	3.76	-1.43	14.26	0.34	8.50
	June	2.48	-1.78	5.89	0.32	2.95
	July	4.97	-0.51	11.56	1.35	5.76
	Aug.	2.27	+2.02	8.37	0.85	4.05
	Sept.	2.99	-0.24	7.39	0.97	2.25
	Oct.	7.71	+5.22	13.29	3.73	4.02
	Nov.	5.62	+2.26	13.17	1.91	8.02
	Dec.	3.11	+2.38	5.59	1.55	3.23

TABLE IV (Continued)

1	2	3	4	5	6	7
1926	Jan.	6.46	+1.25	12.86	2.30	3.70
	Feb.	3.06	-1.87	7.40	0.59	2.98
	Mar.	7.60	+1.91	15.13	2.55	4.25
	Apr.	3.37	-1.96	6.81	0.61	2.98
	May	3.81	-0.84	8.17	0.65	4.56
	June	3.30	-0.88	9.44	0.23	3.60
	July	4.04	-1.11	10.04	0.71	6.40
	Aug.	6.42	+2.20	16.42	1.29	6.00
	Sept.	1.50	-1.70	5.78	0.00	3.43
	Oct.	2.87	+0.10	7.01	0.92	2.42
	Nov.	4.26	+0.79	6.12	1.99	2.33
	Dec.	9.47	+4.16	19.35	2.20	6.00

FLOODS.

With the exception of the Yazoo-Mississippi Delta, practically the entire area of the State is naturally well drained and not subject to overflow except in the immediate flood plains of the larger streams. The elevation of the surface is from 500 to 600 feet at the northern boundary, dropping to 300 for the central section, and from 300 to sea level for the southern division. During the period under consideration only one instance of loss of life and property damage is recorded. This occurred Dec. 8, 1919, when eight lives were lost and the property damage was estimated at $800,000, affecting mostly the lumber industry.

The unprecedented disaster occasioned by the recent flooding of the Yazoo-Mississippi Delta, with its toll of human life, suffering, and property loss, was, by the character of the topography, necessarily confined to an area less than one-sixth of the State. Those at all familiar with the topography of the State understand that the Yazoo-Mississippi flood plain is bordered by highlands hundreds of feet above its surface.

WINDS.

Moderate winds are normal over the State. The prevailing directions being south and southwest. The monthly maximum velocities range in the neighborhood of thirty miles per hour. Winds of destructive violence occur at infrequent intervals and usually have limited areas of destruction. Sixteen such local disturbances are reported in the ten-year period, of which less than half were probably true tornadoes. The loss of life and property damage was relatively small except in one instance, this being the remarkable occurrence of four tornadoes which swept the eastern half of the State simultaneously on April 20, 1920, affecting some fifteen counties. In all, 130 lives were lost and the property damage was estimated at one and one-half million dollars.

FROSTS.

Table V shows the dates of the last "killing" frosts in spring, and of the first in the autumn. Where the date is different for different localities a mean date has been selected. For the purpose of this comparison, the State is divided into the Northern and Southern Divisions. The phrase "number of crop days" refers to the interval between the last "killing" frost in spring and the first in the autumn. The table shows the average value for the Northern Division to be 186 days, and for the Southern Division 210 days. Heavy snowfalls are infrequent in the State but not unknown. Light snowfalls occur almost every winter over the Northern Division.

TABLE V.

FROSTS.

Year	Last in spring	First in autumn	"crop" days
		Northern Division.	
1923	Apr. 1	Nov. 1	185
1924	Apr. 2	Oct. 23	183
1925	Mar. 6	Oct. 21	189
1926	Apr. 1	Oct. 25	187
	Average number of "crop" days		186
		Southern Division.	
1923	Mar. 20	Nov. 15	210
1924	Mar. 23	Nov. 1	201
1925	Mar. 8	Nov. 3	223
1926	Apr. 1	Nov. 5	198
	Average number of "crop" days		210

SHADE.

Shade trees are not technically an element of climate, yet in reality the magnificent oaks of Mississippi constitute one of the crowning glories of our summer season. Only a Wordsworth could do justice to such a theme.

CONCLUSION.

In conclusion, the climate described is one to encourage people to remain out of doors a large part of the time; one that provides out-of-door occupations under pleasant and healthful environment. Little wonder it is, then, that the State holds a happy, contented, and healthy people, and a people destined to accumulate economic wealth as they continue to develop more fully their rich natural resources.