Annual report of the Wisconsin Geological Survey for the year 1878. 1879

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ANNUAL REPORT

OF THE

WISCONSIN GEOLOGICAL SURVEY

FOR THE YEAR 1878.

BY T. C. CHAMBERLIN,

Chief Geologist.

MADISON, WIS.:
DAVID ATWOOD, STATE PRINTER.
1879.

ANNUAL REPORT, 1878.

To his excellency, WM. E. SMITH, *Governor of Wisconsin*:

SIR: I have the honor to submit herewith, in accordance with legal requirement, a brief report of the progress and results of the Wisconsin Geological Survey for the year 1878.

Most respectfully, your obedient servant,

T. C. CHAMBERLIN,

Chief Geologist.

BELOIT, December 31, 1878.

REPORT.*

The state of progress of the geological survey at the close of last year was set forth in my annual report for 1877. There was at that time statute provision for the continuance of the survey only until the first of last June. But by enactment of the legislature the work was ordered continued until the 31st of March, 1879, and an appropriation of five thousand dollars granted to meet the necessary expenses. The previous annual appropriation had been thirteen thousand dollars; and this wide difference in the funds placed at the disposal of the corps, must be taken into consideration in judging of the results attained during the year. It would be quite unfair, however, to infer from the smallness of the appropriation that the importance of the survey was not appreciated and endorsed by the last legislature, since their generous action in relation to the publication of the reports and to other matters pertaining to the survey, evinced a cordial and appreciative interest in it.. But the advanced condition of the work, and the large amount of accumulated material ready to be wrought into permanent form and published, and the great labor and large measure of the time of the members of the corps which this would necessarily occupy, rendered it wise, perhaps, to curtail somewhat the prosecution of the field work. There arose also, then as now, the question whether the degree of completeness attained by the survey was, or was not, sufficient to subserve the best interest of the state. A survey of this kind admits of being carried to almost any degree of exhaustiveness. While a survey cannot be stopped, without defeating its objects, until the general geological structure of the state is fully ascertained, the degree of minuteness and thorough-

*The appearance of this report has been delayed somewhat by sickness and death in my family. T. C. C.

ness to which it should be carried beyond that is somewhat more a matter of judgment. It is the opinion of experts that such work becomes increasingly profitable as it is carried to greater and greater degrees of completeness and exactness; because the application of the results to the development of the resources of the state become more certain and evident. At the close of last year the survey had arrived at the stage indicated. The degree of detail to which the work in the southern part of the state had been carried was shown by the volume and atlas issued during the year. A similar measure of completeness had been attained in the other portions of the state that were settled. In the northern regions, the work had been more concentrated on the iron belts, where some very thorough work had been done, and only a general knowledge of the formations underlying the great forest region had been attained. The corps had conscientiously endeavored to place the work in the best attainable condition for closing at the time specified in the organic law of the survey; and they felt that, however far from that entire completeness which they might desire, they had placed the work in such an advanced condition that they might cheerfully accept the judgment of the legislature as to its continuance. It was also felt that, in view of the depressed condition of the industries of the country, which rendered less imperative the immediate development of some of our natural resources, a smaller appropriation, with more time, might be quite as economical and satisfactory in the end, as a larger allowance and more rapid execution. It is therefore in a spirit of entire concurrence in the wisdom of the enactment, that attention is called to the more limited means granted for the prosecution of the work during the past year, and it is only here referred to, because it must be taken into account in forming a just judgment of the work of the year.

GENERAL PLAN OF WORK.

The attitude of the survey being such as has been indicated, it was deemed best to concentrate the field work upon the more important practical subjects of investigation. It hence follows that the results of the year's survey have a more directly practical bearing than it has always been possible to give the work in previous years. The laying of the foundation of any structure, whether material or mental, has little value in itself, but finds its importance in the superstructure built upon it. The working out of the geological foundations of the state, is of value mainly as a basis upon which to found investigations of more direct and specific industrial importance; and this latter class of work, the survey now finds itself competent to enter upon in a larger degree than ever before.

The subjects selected for investigation, were the more thorough examination of the important Oconto iron district, the completion of the observations on Penokee iron range, the continuation of the crevice survey of the lead region, a special study of the method and laws of deposit of the lead and zinc ores, and an examination into the nature and means of utilizing our sandy soils.

Besides these special topics, chemical, microscopical and paleontological examinations have been in progress, and the observations in the various departments of natural history have been continued as heretofore, while the elaboration of the report has occupied a large measure of time. A brief outline of the work in these several districts, is given herewith.

WORK UNDER PROFESSOR IRVING.

Professor R. D. Irving has been occupied, during that portion of his time given to the geological survey, in the completion of his final report on the eastern portion of the Lake Superior district. This comparatively small area has, crowded within it, fully 50,000 feet in thickness of crystaline rocks, with many subdivisions, the accurate defining and mapping of which is of immediate practical importance as well as of scientific interest. In order satisfactorily to attain this result it has been necessary to examine in minute detail some thousand of specimens collected in the field, making use largely of microscopic analysis. In this new method of investigation we have been aided by Professor Pumpelly who has examined a suite of our copper rocks, chiefly with a view to their comparison with the rocks of the Michigan copper series, as to which he is the chief authority. Mr. A. A. Julien has also examined a small collection of eleven specimens, mainly from the Huronian series, with the rocks of which, as developed in Michigan, he is especially familiar. It has, however, been necessary to extend the microscopic work much beyond this, in order that each one of the subdivisions of the copper and Huronian series should be thoroughly investigated, and also that the numerous ledges examined might be thrown into their proper stratigraphical positions. This microscopic work Professor Irving has himself undertaken, and during the past summer he has examined over 200 of these sections in detail. In this way a number of difficulties have been overcome, and some interesting new points developed. Several colored plates, representing the appearances under the microscope of the rocks of each of the great groups of the region, have been prepared and are now in the engraver's hands. These will serve as a guide for the determination of the true stratigraphical position of the ledges to be found in the future, and thus will be of direct practical value.

In order to add to the collections of specimens from this district, especially from those portions poorly represented in the collections already on hand, Mr. A. D. Conover was employed in May last to spend two weeks collecting. Mr. Conover's route was from the crossing of the Montreal river by the Flambeau trail, up the river to the mouth of the Gogogushugun, thence up the latter stream for two miles, thence westward to the Potato in T. 46, R. 1 W., thence down the Potato to the falls in Sec. 17, at which point some time was spent in mapping the large ledges exposed in the bed and sides of the stream, thence southward along the west line T. 46, R. 1 W., and T. 45, R. 1 W., to the southeast corner of the latter town; thence westward to the large gabbro ledges on the south line of T. 45, R. 2 W., thence northward to Tyler's Fork, in the north part of the same township, and thence down that stream to its junction with Bad river, Sec. 17, T. 45, R. 2 W. Mr. Conover's trip was thus planned so that he might both add to the collections from points already known, and collect from ledges, or determine their absence, on lines not previously followed.

Professor Irving's report is nearly ready for the printer, the maps and plates having been for the most part engraved. This report has cost much more labor than was anticipated, but it is hoped that it will afford great assistance and a reliable guide to the iron and copper explorer. The general nature of the report was outlined in the last annual, and, although a number of additions, then unthought of, have been made, it will so soon appear in the final shape, that it is not necessary to give anything further with regard to it here.

RECONNOISSANCE IN POLK AND BURNETT COUNTIES.

The observations of our lamented colaborer, Mr. Strong, in Polk and Burnett counties, were only partially revised and reduced to permanent form at the time of his death, as some of them had been made just previously, and no opportunity had been permitted. For the purpose of becoming, in some measure, familiar with the region to which these relate, preparatory to editing them for the final report, and to make some supplementary observations, the writer visited these counties in June, and made a brief reconnoissance of the region, in company with Mr. D. A. Caneday, who had been Mr. Strong's field assistant. Aside from such observations as were made upon the Copper-bearing series, which it would scarcely be proper to introduce here, in anticipation of those of Mr. Strong, some new facts were gained in relation to the surface geology, and the drift movements. It is often of much assistance to explorers to know definitely in what direction the blocks broken off from prominent ledges have been borne by the drift agencies, or rather the converse, to know from what direction any given bowlder, which may possess interest, has come. It seems to have been the common impression heretofore, that the drift movement of this region was from northeast to southwest, as this is undoubtedly the direction of the general movement about Lake Superior. But in the vicinity of St. Croix Falls, the striation and abrasion of rock prominences show that the line of drift was from northwest to southeast, the average trend of the scratches and grooves being S. 45° E. In the northeastern portion of Polk county, in the townships of West Sweden and Clam Falls, four localities show the direction of drift to have been S. 20° to 25° E., S. 18° to 20° E., S. 10° E., and S. 25° E., respectively. All these, except the third (S. 10° E.), were upon prominences, and there is no reason to suppose they were modified by local topography. The evidence of the striation was corroborated by the forms of rock prominences and the abrasions they had suffered, as well as by the distribution of the drifted material and the linear form of the lakes, marshes and topography of the region. Prof. N. H. Winchell, State Geologist of Minnesota, expresses the conviction that the later drift in the region of St. Paul and Minneapolis was from the northwest. My opinion is, however, that this southeastern movement was characteristic of only the southeastern margin of the later drift area, and that in the Lake Superior trough, and in its extension westward, the direction was southwesterly, which was really the general line of massive ice movement; but on the margin of the great ice stream, the lines of movement diverge toward the border of the glaciated area, in a manner analogous to that which has been demonstrated in eastern Wisconsin. In my view, if the glacial grooves could be continuously traced backwards along their course, they would be found trending more and more to the northward, until the great channel of ice movement was reached, when they would be found coming from the northeast. This view is based upon the analogy of the Green Bay and Lake Michigan glaciers, the proximity of the Kettle moraine, and such facts as are known concerning the nature and distribution of the drift materials.

Considerable additional information was also gathered concerning the great Kettle moraine, which, in this part of its course, passes southwesterly through Burnett, Polk, and St. Croix counties. While its general position in this region is established, many details remain yet to be wrought out, but as they have only subordinate industrial importance, they must await opportunities when they can be studied in connection with other subjects, or until the settlement of the region renders their examination less expensive.

INVESTIGATION OF THE LEAD AND ZINC DEPOSITS.

As much time as I could spare from office and administrative duties, during the fall, was spent in a special study of the lead and zinc deposits of the southwestern part of the state, with the purpose of determining, as far as possible, the precise method of deposition, and the laws of formation. All the districts where mining operations were in progress, or where mines were known to be accessible, were visited, with one or two unimportant exceptions, and a large mass of data and material was collected. The elaboration of this will require some months labor, and, as I have heretofore persistently declined to prejudge the case by an expression of opinion before the full evidence was collected and carefully considered, I must ask leave to waive all discussion of the subject here. I shall resume the investigation as soon as some pressing duties in relation to publication are performed, and shall endeavor to complete them and present the result at as early a date as possible.

SURVEY OF THE LEAD-AND ZINC- BEARING CREVICES.

In my last annual report, a sketch of the survey of the lead- and zinc-bearing crevices, then partially made, was given. The character and object of the work need not be here repeated. It has been carried on to essential completeness during the past season by Mr. J. Wilson, Jr.

OBSERVATIONS IN EUROPE.

Through the unsought and very generous action of the last legislature, leave of absence for three months was granted the chief geologist to visit the Paris Exposition, and to attend the International Geological Congress which convened there on the 29th of August. Owing to pressure of duties in connection with the survey, it was found impracticable to be absent the full time granted, notwithstanding the proportionately greater advantages of a more protracted visit, when once the long journey is made, especially in view of the great facilities for profitable study which were presented. The period of absence from the state was about two months and a half, nearly one of which was occupied in transit. In this limited time, no very thorough examinations were possible, and such as were made will more appropriately find a place in connection with the discussion of the topics to which they relate.

Observations in Europe.

The Exposition afforded opportunities for studying some of the metalliferous deposits of the several countries represented, and of making instructive comparisons. In respect to the lead and zinc deposits, however, concerning which, particularly, light was sought, little of direct and specific value was to be learned, since the most of the ores of these metals exhibited were formed in quite different manners and associations from our deposits. The same was also largely true of the ores of these metals found in the museums that were visited. The displays of building materials, especially the products of clay, the cements, the slates, the building and ornamental stones were very full and highly instructive. The very much greater extent to which these non-combustible and nearly imperishable materials are used in construction in Europe, is very striking and suggestive. It is doubtless but the practical expression of the lesson which centuries of experience have taught as to the error of building with perishable materials. In our pioneer condition, the large use of wood which has prevailed has doubtless been entirely pardonable, and perhaps it may even be well, that many of our buildings are no more permanent than they are, but as we arrive at that stage, when we should build for the future, this subject assumes much importance. Probably few, if any, states on either continent surpass Wisconsin in the abundance and quality of its brick clays, limes and cements, or its building stone, and these resources must prove of eminent value in the future development of our state. The brick in ordinary use in London and Paris is much inferior in strength and beauty to the white brick so extensively manufactured in many parts of our state. The Portland cement of Europe, mainly an artificial compound, probably still surpasses anything produced on this continent; and, in the less trying climate to which it is there exposed, it proves exceedingly durable, and subserves some purposes to which it could not safely be applied here. But, aside from this foreign article, the Milwaukee cement is taking a leading rank, and increased facilities for its manufacture have been necessitated during the past year.

Without entering at length upon this subject here, it may be proper to urge upon our citizens and civic corporations increased attention to the utilization of our abundant, substantial and enduring building material.

The proceedings of the International Geological Congress have been reported in outline in the various scientific periodicals, and have thus reached those most interested, and the full transactions will presently appear, so that it would be superfluous to give a sketch here.

OBSERVATIONS ON THE RECENT GLACIAL DRIFT OF THE ALPS.

The drift phenomena of our state forms an important feature of its geology, and, owing to some peculiarities of its development, perhaps more than ordinary interest attaches to it. I therefore zealously embraced the opportunity which my leave of absence afforded of observing the drift deposits formed by the glaciers of the Alps.

Observations were made upon the deposits of the Bossons, Bois or Mer de Glace, Findelen, Gorner, Viesch, Aletsch, Rhone, Unter Aar, and the upper and lower Grindelwald glaciers, and, casually, as many more.

It was my endeavor to utilize the limited time at my command to as great an advantage as possible by confining my attention to those features which are most analagous to our drift; the more so, because it is most difficult to gather exact and definite descriptions of this phase of glacial phenomena from most accessible writings on the subject, and, naturally enough so, because the glaciers themselves and their surface moraines present so much more conspicuous and absorbing objects of interest.

My observations will, therefore, have value, if they have value at all, not because of fullness and completeness, for they do not approach to that, but because they were made from this standpoint, and because they have been brought to the standard of the same mental meter with our own deposits; and whether that meter be accurate, or too long or too short, it is hoped that, with some corrections for mental temperature, it has measured alike in both cases.

It is essential, at the outset, to clearly discriminate between the products that arise under those conditions which are peculiar to

Alpine situations and those that are more specifically due to glacial agency without regard to special local circumstances; and hence a few explanatory words, antecedent to the observations themselves, may be appropriate.

In the majority of cases, Alpine glaciers occupy narrow steep valleys which afford them little opportunity to deploy as they undoubtedly would in more open ground, where they might present phenomena analagous to those of continental or arctic glaciers; but in some cases, they terminate, or have recently done so, in broader and less sloping portions of their channels, and thus furnish some very valuable hints as to the probable action of broad glaciers on less sloping floors.

Alpine glaciers derive the material of their deposits from two general sources, and their debris is correspondingly divided into two general classes, 1st, that which falls upon them from above, and 2d, that which they abrade from the rocks over which, or against which, they move. The first class is borne passively *on* the ice stream, while the second is pushed or rolled along *beneath* it. The first is due to the accident of the glacier's position, the second is the direct result of its own action. The first class is only present when the glacier originates among towering peaks or flows along precipitous slopes; the latter presumably is always present. At the edges of the glacier the two classes often mingle, and undoubtedly some of the surface debris, finds its way to the bottom through crevasses and moulins, so that the material carried along beneath the glacier is greater than it would be but for the surface burden; but, for the purposes of our study, this is unimportant. It is imperative, however, that we distinguish between the superficial and basal debris, as the former can have little or no representative in so plane a region as that covered by our drift, and can therefore throw no light upon its origin. This distinction is very easily made, for the most part, in the case of the Alpine glaciers mentioned; for the surface material is almost wholly unworn and angular, while the basal portion is usually abraded and rounded in greater or less measure.

The surface material forms in lines along the sides of the ice stream, where it has fallen from above, constituting lateral moraines; and where two streams unite, two of these lateral moraines are brought together and form a line along the middle of the joint stream, constituting a medial moraine.

To the rock rubbish borne along beneath the glacier, the term ground moraine, or *moraine profonde*, is applied.

So far, all is clear. So long as the glacier itself is present bearing lateral moraines on its sides, medial moraines on its surface and a ground moraine at its base, there is no room for confusion. But this detrital material at length reaches the end of the glacier and is deposited; and here arises something of confusion in the deposit itself, and something of confusion of ideas respecting it, or, at least, a want of accurate and precise use of terms. The phrase terminal moraine is used to designate accumulations formed at the extremity of the glacier. But, setting aside the terminal deposits arising from the dropping of the lateral moraines, which remain somewhat distinct, it is evident that the medial moraines will be dropped upon the ground moraine at the foot of the glacier, and that this will occur under three conditions that ought to be distinguished. First, the foot of the glacier may be retreating, as is the case at present, because the melting is more active than the onward flow of the ice. Under these circumstances, the withdrawal of the ice leaves the medial moraine as a ridge, or line of debris, lying on the sheet-like ground moraine, and their relations remain essentially the same as before, save that the glacier has vanished from between them. In this instance the terms medial and ground moraines may still be used appropriately to designate them.

Secondly, the foot of the glacier may be stationary, in which case the material of the ground moraine, pushed along beneath, will accumulate at the glacier's margin in the form of a ridge, and the medial moraines will pile up in heaps on this. To call this simply a terminal moraine is not to speak very discriminatingly; for, in addition to the complexity of its own formation, it is liable to be confused with that which arises under the third condition, viz.: that in which the foot of the glacier is advancing.

In this case the glacier is not only discharging material from its surface and bearing it along its base, but it is plowing up that previously deposited in its pathway.* The result of this is the formation of a ridge at the foot of the ice plow, as in the previous case, but of more irregular character in respect, at once, to material, structure, and surface configuration. This is a terminal moraine in a more significant sense than the preceding, in that it was not simply accumulated at the foot of the glacier, but was formed by its mechanical agency; and in that it marks the termination of a given glacial advance.

It would appear to be much in the interest of precision of thought and expression to confine the phrase "terminal moraine" to accumulations produced by a glacial advance, and to employ some other term, as peripheral moraine, for ridge-like accumulations due to halts in the retreat of the glacier; while the term "ground moraine" should include the wide-spread, sheet-like deposits of retreating glaciers. Our classification of morainic accumulations would then stand:

I. SUPERFICIAL MORAINES.

(*a*) *Due to local environment and passive glacial agency.*
(*b*) *Characterized by angular material.*
1. Lateral moraines.
2. Medial moraines.

II. BASAL MORAINES.

(*a*) *Independent of local environment and due to active glacial agency.*
(*b*) *Characterized by worn material.*
1. Ground moraines (sheet-like).
2. Peripheral moraines.
3. Terminal moraines.

Besides the glacial accumulations, we have constantly to deal with the associated torrential and other aqueous deposits formed by the abundant glacial waters, but these may usually be distinguished by structural characters.

*A portion is probably also overridden by the glacier.

Observations on the Recent Glacial Drift of the Alps.

The following observations relate to individual features of drift phenomena, and will be found more or less disconnected, and the paragraphs are arranged without much reference to logical sequence of thought:

1. The Rhône glacier surpasses all others visited in its instructiveness in relation to drift deposits. After a course of nearly 15 miles, it descends precipitously, like a gigantic frozen cascade, into the valley of the Rhone, where it finds a broader area and more gentle slope. Here its foot spreads out into a flat semicircular form not altogether unlike an equine hoof.

The first point of special interest to be noticed is that the crevasses in this flat portion diverge in curving lines from the axis of the glacier toward the expanded margin. This I believe to be correlated with a divergent motion of the ice by which the expanded foot was formed; and in this I find a close analogy to the divergent motion of the ice of our own ancient Green Bay glacier, as shown in my recent report. The valley of the Rhone just below this is covered with drift, so that the striations, which it might be presumed to have made in its recently more expanded condition, are concealed, but at the foot of the Glacier de Bois, in the Chamouni valley, a divergence in striation amounting to about 75° was observed.

2. The Rhone glacier is now retreating at a somewhat rapid rate. With commendable regard for the interests of science and the profit of transient students, the successive positions occupied by the retreating foot of the glacier, each year since 1874, have been marked by lines of tarred bowlders and cairns. The method and rate of retreat, is thus mapped out on the face of the valley itself. It will be sufficiently near for our purposes to say that the average retreat since 1874, has been about fifty paces per year. It therefore presents a fine opportunity to observe the deposition of a receding glacier, and, as it bears but little detritus on its surface, its abandoned ground moraine is well exposed to study. However, certain portions of the plain have been swept by glacial floods, which have somewhat modified the deposit, and care should be aken not to confuse the two deposits. A little close observation

will show that in the portions recently abandoned by the glacier, and that have not been washed by the issuing waters, the bowlders frequently bear, perched upon their tops and slopes, sand, pebbles, and small fragments of rock. It is hence evident that they have never been swept by even the gentlest stream, and that no assorting or modifying action of any kind has been brought to bear upon them since they were abandoned by the ice. Furthermore, we may go to the foot of the glacier and see them slowly issuing, thus crowned, directly from the ice.

The ground moraine here consists mainly of rounded and scratched bowlders, gravel and sand, with but little clay, and only a small proportion of angular blocks that cannot be traced distinctly to the medial or lateral moraines. The surface contour is slightly, though not conspicuously, ridged. The more abrupt side of these little ridges is toward the glacier and their trend is in the main approximately parallel to the edge of the glacier, though sometimes notably oblique. This relationship suggested that they might be due to annual oscillations of the glacial margin. There is also discernable a feeble tendency of the material to arrange itself in heaps and ridges parallel to the lines of movement of the ice.

2. If we now approach the foot of the glacier, we shall find this morainic sheet of detritus passing without notable change or interruption beneath the ice. The appearance is as though a stationary mass of ice had formed on the surface of a bed of bowlders and gravel and was now quietly melting away. More critical examination would, of course, show that any given particle of ice was advancing. The edge of the glacier is thin and sloping and we may walk directly up on it. This edge seems to rest lightly upon the drift below. This last is not a mass of debris frozen together, or imbedded in the base of the ice — although individual bowlders are — but an independent underlying bed of bowlders, and finer material, with open interspaces. These observations of course relate to the immediate edge of the ice. Some of the crevasses enable us to see a short distance farther in, where the same condition prevails. An artificial tunnel, styled an ice grotto, shows the same through a break in the ice.

The marginal portion of the glacier rests, so far as could be ascertained, not upon the bed rock, but upon its own basal moraine. How thick this bottom accumulation was, I had no means of ascertaining, but from the configuration of the valley, I should judge it was considerable.

4. The surface contour of the ground moraine seems to some extent to take shape beneath the glacier. At one point I observed a diminutive hillock, about six feet high, half enclosed in the edge of the ice, which was here nearly vertical. The appearance was as though the ice, in its withdrawal, had half disclosed a mound lying beneath it. This, though a mere mound, was about equal in hight to the adjacent heaps that had been left by the glacier.

5. At other, points, near the center of the valley, the ice may be seen resting directly upon well assorted, stratified sand and gravel. Level sheets of fine detrital matter extend without disturbance of continuity or surface beneath the edge of the glacier. The assorting and stratification of this material was apparently accomplished by sub-glacial streams, which seem afterwards to have found other avenues, when the ice occupied their place, either by settling down from above, or advancing from behind. The singular fact is that the stratified sands should not have been disturbed. It is very likely true that these fragile formations near the edge of the glacier are heated by conduction from the warm earth surrounding, and by transmission through the comparatively thin ice above, and that they are thus enabled to protect themselves from the forcible action of the ice, by melting it as fast as, in its slow motion, it is pressed upon them.

6. If we now turn to the sides of the valley, we shall see that up to a certain hight they are mainly bare of vegetation, and present a fresher and less weathered surface than the slopes above, as though the glacier had recently stood at that hight. If we glance down the valley, we shall see that the upper margin of this surface descends curvingly, much like the contour of the present foot of the glacier. If we descend the valley to the point where this reaches the plain, we shall find the ground moraine rising into a low, irregular ridge, which stretches in a broken curve across the

valley. The material of this ridge is essentially the same as that of the ground moraine, save that there is noticeably more sand and gravel in proportion to the coarse material, and the whole is more thoroughly rounded. These remarks relate to the surface material The superficial contour, however, assumes quite a different and distinctive aspect. Although but a diminutive ridge itself, not perhaps exceeding twenty feet in height, its surface contour, instead of presenting a simple curving outline, exhibits a complex series of still more diminutive ridges, hills and hummocks, of irregular outline and arrangement, accompanied by correspondingly irregular depressions, some of which are filled with water and form miniature lakelets. The irregular outline and little islands of one of these made it almost a Lilliputian Minnetonka. Bowlders are abundant in all positions on and in the ridge, as shown by the sections exposed by the outflowing streams, which also exhibit the confused unstratified condition of the interior. Locally, there are small patches of stratified material. This ridge is most abrupt on the outside, or that away from the glacier, while on the inside, it graduates, without any distinct line of definition, into the bowlder sheet above described.

This ridge presents a striking similitude to our Wisconsin Kettle moraine, and I think it may be safely said to be a miniature representative of the same phenomena.

This is a true terminal moraine, according to our definition, formed by an advance of the Rhone glacier.

7. A few rods — perhaps 20 — below this there is another moraine of like character, but of older date, as shown by the grass and shrubs that have grown upon it, as well as by its position and less angular contour. It is narrower and more simple in form than the preceding, and like it, is interrupted by level passes, the channels of former streams.

About 30 rods below this is a third, still less continuous, a good good illustration of an interrupted, half destroyed moraine.

8. Between these three moraines are level gravel flats of fluviatile origin, and doubtless stratified.

9. On the south side of the Rhone, the middle moraine breaks up into an area of scattered mounds or "knobby drift."

Observations on the Recent Glacial Drift of the Alps.

10. On that side also, at the foot of the acclivity, where the solar action is less effective than elsewhere, a considerable mass of ice has been left by the retreating glacier, and this is much covered by sand, gravel and coarse detrital matter. As the ice melts, it deposits its burden of rock-rubbish in an irregular, hummocky fashion, somewhat resembling that of the moraine above described, but without the ridgy characteristics of the latter. It is mainly interesting as illustrating the form of deposition of a superficial glacial accumulation where the ice lets it down by melting from beneath, instead of casting it over its extremity in the usual method.

11. The south side of the Rhone also presents a fine exhibit of fluviatile silt, sand and gravel flats, and shows the pre-eminent tendency of glacial streams to wander widely, back and forth, across their valleys, when the slope is moderate, owing to the unusual rapidity with which they fill up their channels by the large burden of glacial mud, sand and gravel that they carry, or roll along their beds. They thus rapidly accumulate broad stratified sheets. I suspect that some deposits formed in this way during the Quaternary age have been mistaken for lacustrine formations, owing to their breadth and extent.

12. None of the other glaciers visited terminate in a manner equally favorable for the observations sought, but some of them present particular features of equal interest. The terminal moraines of the Grindelwald glaciers are even more instructive by way of comparison with our drift moraines, because of the closer proximity cf the successive ridges, and the greater similarity of the material, it being a limestone bowlder clay, with some metamorphic erratics included, and some assorted detritus. Some of the moraine ridges are a prononnced bowlder clay, while others are largely composed of bowlders or gravel. On the inner moraine of the upper Grindelwald glacier, there is much fine gravel and sand in heaps and miniature ridges, presenting a very interesting phenomenon. The outer range is more massive than those of the Rhone glacier, and is very strikingly similar to the Wisconsin Kettle moraine in its superficial expression. The corresponding moraines of the lower Grindelwald glacier show the same features very neatly, and those of the Bois and other glaciers display like characteristics.

13. So far as my observations went, the nature of the rock over which the glaciers passed was more influential in determining the proportion of clay, sand, gravel and bowlders, than I had supposed. Where the rock was mainly granitic, the amount of clay was proportionately small, the detritus being mainly coarse sand, gravel and bowlders. This was doubtless due to the difficulty of reducing the hard constituents of granite to powder. Where the glacial channel lay through schistose rocks, or limestone, there was a notably larger proportion of clay, and some of the moraines were a typical bowlder clay. These observations throw unexpected light on the drift of our state, where there is a very marked difference between the glacial deposits of the limestone and granitic districts in respect to the physical condition of the material.

14. In former times, the Alpine glaciers were greatly expanded and stretched entirely across the lake region to the foot of the Jura mountains, on the French border. In this expanded condition, they most nearly, though still quite inadequately, represent the nature American Quaternary glaciers. The Juras and much of the intermediate region are composed of limestone strata. To the west of Lake Neuchatel the sheet of drift extends up the mountain slope nearly 3,000 feet above the lake surface, when it terminates on the declivity in a rude, imperfect terrace of undulatory surface. This, where I observed it, is composed of bowlder clay, usually quite gravelly, and associated with gravel beds. It was my hope to find the margin of this great *moraine profonde* at some point on a comparatively level tract, where its developement would not be cramped or coerced by encompassing barriers, but both at this point and in the vicinity of Gex, west of Geneva — the only two points where I was able to examine it — I found it pushed high up on the steep side of the mountains, and could, therefore, only conjecture what its form and structure would have been on plains similar to those of the Mississippi valley; indeed we can hardly assume that its material would have remained precisely the same, since in more level regions it might have been influenced in a greater degree by glacial waters. As it was, it may be characterized as a gravelly bowlder clay, with accompanying gravel beds.

Observations on the Recent Glacial Drift of the Alps.

15. In the beautiful valley of Ruz, west of Neuchatel, I found excellent exhibits of the morainic bowlder clay. If an excavation seen on the east side of this valley were placed side by side with any one of a large number that can be found in Wisconsin, no one but a skilled lithologist or paleontolgist could determine to which locality they severally belonged, so striking is the physical similarity of the two formations. Indeed the resemblance of the rock forming the detrital material is so close that, were the Swiss hill transplanted to certain localities in Eastern Wisconsin, probably no geologist would ever detect the imposition, unless fossils, of which I saw none, were found in it.

16. In company with our genial vice consul at Geneva, Dr. Delavan, I had the pleasure of visiting the celebrated Jardin, in the Chamouni region. A four hours walk up the *Mer de Glace* and over the *Glacier de Talèfre* brought us to an island of sub-triangular outline, completely encompassed by a sheet of snow and ice; and around which clustered an amphitheater of mountain pinnacles. It derives its name, "The Garden," from the fact that, although more than nine thousand feet above the sea, and surrounded on all sides by perpetual snow and ice, a handsome flora of grasses and bright, beautiful, little flowers bloom on its southward sloping side. But, putting aside this interesting phenomenon, and restraining the sentiments, which the magnificent surroundings and the grand views of Mount Blanc and the glaciers below, inspire, I can only, in this connection, remark upon the point of chief geological interest to us, viz: the likeness to our driftless area which this glacier-girt island presents. Let me say, however, at the outset, that the Jardin is not a driftless area. It was formerly covered by an ice sheet and contains erratics on its surface. But at present, though the glacier originates much higher up the slope, it divides and passes around the Jardin and again unites below it, leaving it, so far as present action is concerned, a non-glaciated area, surrounded on all sides by active glaciation.

Its likeness to our driftless area, however, ceases here. It is walled in, as is appropriate to a garden, by a steep, sharp moraine, thrust up by the ice in moving around it. On the border of our driftless area, the glacial debris thins out very gradually and disappears in an obscure margin. The Jardin differs also, in that it appears to owe its immunity from present glacial action more to its own prominence than to the effects of adjacent depressions. The driftless area of Wisconsin does not lie, like it, on the summit of a protuberance, but on its lee side. The ice of the glacial period surmounted the Archæan heights, south of Lake Superior, in Wisconsin and Michigan, and descended the southern slope a distance of about one hundred miles, where it terminated on the declivity, and its waters continued on across the driftless area, leaving gravel terraces along their course. We must, therefore, seek elsewhere for an adequate illustration of the essential principles involved.

At the foot of the Viesch glacier, the ice stream divides and the branches pass through valleys on either side of a ridge, though the ice at the point of branching is higher than the ridge. Formerly the branches extended much further, and probably united below the ridge. This would be an approach to an illustration of the phenomena in question, but, unless the ice moved over the ridge and terminated on its slope, it would fail of an essential element.

The right hand branch of this glacier is antagonized by a prominence, and the greater portion of the ice passes through lower channels on either hand; and these subordinate streams approach each other below, leaving an island, or nearly so, on the slope. Above this island the ice terminates on the declivity. On one side, the slope is so steep that the ice breaks away and rolls to the bottom, marring the perfection of the illustration, but not destroying its force. The ice, while not really split in twain, is so far thinned by the combined action of the prominence and the adjacent depressions, as to be unable to maintain itself against the wasting to which it is subjected. If the slope were somewhat less precipious, the illustration would be more complete.

Near the termination of the upper Grindelwald glacier, there has recently been a similar instance of an island in the glacial stream with higher ice on either side and above it. In this case, the slope was so great that a portion of the ice above the island became loosened and rolled down to the ice below. The amount which thus passed over was less than an equivalent of the melting capacity of the area of the island, so that, had not the cohesion of the ice been overcome, it would have been melted on the upper margin of the island.

In all the foregoing instances, the areas have formerly been glaciated, and thus differ from the Wisconsin driftless area. They have force, however, as illustrating, in a miniature and imperfect fashion, the fact that, not only may a glacial stream be parted and an island be formed by a prominence projecting through the ice and wedging it aside, or by valleys leading it around; but also that there may be such a combination of prominence and depression as — while not entirely parting the stream — to so thin the ice passing over the prominence, that it shall be wasted and disappear before it can join the main currents diverted on either side; so that there shall be a non-glaciated area, not on the summit of the prominence, but on its lower slope, and these I conceive to be the esssential phenomena and elucidation of the Wisconsin driftless area.

It was not my original purpose to more than call brief attention to the foregoing Alpine phenomena, as illustrations of the agencies entering into the causation of the driftless area, but it might not seem just to others who have recently written on the subject to pass their views in silence, and a brief review of them will therefore be here given:

Professor N. H. Winchell has attributed the origin of the driftless area to the agency of the Archæan protruberance of northern Wisconsin and Michigan acting, at Kewenaw point, like a wedge, splitting and turning the ice stream to the right and left, through the valleys of lakes Superior, Michigan and Huron.* There seems to me to be a large measure of truth in Prof. Winchell's views; and, as a preliminary theory, looking toward the elucidation of what had previously been entirely without satisfactory published explanation, is worthy of much respect, but he appears to me to emphasize too much the wedge-like action of the Archæan heights; for they did not rise through the ice, and the figure of

* Annual Report Nat. Hist. Survey of Minn., pp. 35, *et seq.*

the wedge does not very accurately portray the topography or its effects on the glacial movements.

His views also fail of adequacy in not accounting for the fact that the nearest margin of the driftless area is more than one hundred miles south of the crest of this Archæan wedge and, that, as already stated, the ice surmounted it, and descended the slope that distance; and this is really *the* point of difficult explanation.

Professor Irving has presented, in the Wisconsin geological report,* a view closely analagous to that of Professor Winchell, but differing from it in emphasizing the diverting influence of the great lake basins, rather than that of the Archæan highlands. To clearly distinguish between the two views, let us imagine the surface of the whole region involved to be brought to an average grade by the removal of the highlands into the depressions. We shall then have an inclined datum plane to which the influence of elevation or depression can be referred. On such a plane, the glacier may be supposed to move as an approximately uniform sheet. If, in thought, we now erect upon this plane the Archæan elevation, the effect it will have in directing the ice stream to the one hand and the other will illustrate the first view, carried to an extreme, and without the qualifications introduced by Professor Winchell. If, on the other hand, without any such elevation above the plane, we excavate the great lake troughs, on either hand, the deflecting effect of these channels upon the ice current will represent the second view, likewise carried to an extreme. It is safe to say that in neither case would there have been any driftless area; for, in the first instance the ice must have passed over the highlands in much greater thickness than it did,for want of the relief afforded by the great lake troughs; and the example of the Jardin and similar cases, as well as theoretical considerations, would compel us to conclude that the ice would wrap around the protruberance, and unite just below it. On the other hand, the lake depressions were not sufficiently capacious to withdraw into themselves all the ice sheet, for it arose at least one thousand feet above our supposed datum

*Professor Irving's report was already printed when that of Professor Winchell was received by him.

plane, and, by estimate, much higher. The removal of the highlands would have given it more freedom of passage and it might not have risen quite so high, but it would still have been so massive as to have resisted wasting influences far beyond what it did, and to have swept on over the driftless area in company with the streams on either side.

The view of Prof. Irving has the merit of appealing largely to established facts in relation to drift movements in Wisconsin, and also the quite important one of showing, in large part, why the main currents were *kept apart* for so great a distance — about 250 miles — south of the highlands.

My own view, entertained some two years previous to the publication of those sketched above, involves a combination of these views, and some supplementary elements that seem essential to anything like adequacy; for when we have combined the above views, and given full emphasis to the agency of the highlands in crowding the ice aside, and to that of the great lake troughs in leading it away, we still have a troublesome residuum to explain; for, as previously stated, the ice, nevertheless, mounted the heights in sufficient massiveness to maintain its onward flow for 100 miles. It cannot be said to have spent its force, for the momentum of a glacier is insignificant, on account of the slowness of its motion.

The disappearance of this stream on the southern slope, I have attributed to the wasting to which it was subjected.* Assuming that the surface over the Lake Superior region was essentially plane, it is evident that this sheet was thinner than those that passed through the lake troughs to the extent of the difference in altitude of the bed of each, which may be stated in round numbers as ranging from 1,000 feet to 2,000 feet. It is manifest that any such difference must greatly affect the progress and endurance of the mass.

In every glacier there are two regions or zones, one of accumulation, and one of waste, with a line of equilibrium between them, where growth and waste are equal, on the average. In Alpine glaciers, the portion undergoing waste forms a very considerable part

* Discussion attending the reading of Prof. Irving's paper before Wisconsin Academy of Science, December, 1877.

of the total length of the stream, and the line of equilibrium is often far up toward the source. In the great glaciers of the Quaternary age, it may be very difficult to locate the neutral line.

Some writers hold that the motion of the glaciers of that period was very slow, because of the slight inclination, and it might be claimed that, if this were true, the waste would be accomplished in less space. But, in offset, it may be urged that the slight slope would bring the ice down the less rapidly into warmer horizons, and hence prolong its endurance. But it may be questioned whether these writers have made sufficient allowance for the accelerating influence of great depth upon the rate of glacial flow. The thick glaciers of Greenland, with moderate slope and low temperature, are said to have a motion of 60 feet per day, in some cases; while that of the glaciers of the Alps, with very much greater slope, and a warmer temperature, is only from one to three feet daily.

The enormous discharge of icebergs from the glaciers of Greenland and the Antarctic continent, and their great size, would be difficult to understand, if the glaciers of those regions thrust themselves into the sea at no greater rate than that estimated by some writers for the Quaternary glaciers. At the rate of one foot per week, it would take nearly sixty years for a given portion of a glacier to thrust itself forward far enough to give origin to an iceberg 3,000 feet in diameter, making no allowance for melting, or the wear of the waves, and icebergs are said to sometimes considerably exceed this size. With this rate of flow, the great Humboldt glacier, with its vast frontage, would discharge on the average less than two such icebergs per year; and the whole number that could be discharged from the west coast of Greenland would be comparatively small. But hundreds of icebergs of the first magnitude are sometimes visible at one time, and the number annually borne away is very great.

It would appear probable, therefore, in the absence of a sufficient number of positive determinations to make it altogether certain, that the deep, semi-continental glaciers of the present day move at a more rapid rate than the thinner alpine ones; and Mr. Helland's view, that the Quaternary glaciers moved at similar rapid rates, seems the best supported in the present state of evidence. In this view, owing to the comparatively rapid onward flow, and the slow descent into warmer horizons, it would appear that the zone of waste was very broad, and the limit of perpetual snow remote from the margin of the glacier.

It has been a matter of surprise to some geologists that so little evidence of glaciation has been found in the Appalachians, in the near presence of the great glacier; and, on the supposition that the limit of perpetual snow lay near the margin of the glacier, it would, indeed, be difficult of explanation; but, if that limit was remote from the foot of the glacier, to an extent in any measure analogous to that of existing glaciers that terminate simply by subaerial waste, it is not at all remarkable. I believe it is a fact that the Juras escaped general glaciation, even while the foot of the ancient expanded glaciers of the Alps pressed hard against their flanks.

I think, therefore, that I am safe in assuming that, during the glacial period, the line of equilibrium between glacial growth and waste lay entirely to the north of the driftless area. In addition to the reasons above indicated, the general import of the drift phenomena seems to me to harmonize with this view, and to be discordant with any other known to me.

In the zone of waste, the endurance (1) of a glacier is dependent upon its massiveness, when melting and evaporation are uniform. The extent (2) to which it stretches onward is dependent upon its massiveness and the rapidity of its flow. Other things being equal, the greater the volume, (3) the faster the flow. As the waste is almost wholly at the top and bottom, it is evident that the *proportional* rate of waste (4) is greater in thin sheets than in more massive ones. It is manifest, therefore, that, in the trial of endurance and southward progress, to which the glaciers of the region were subjected by a wasting climate, the advantages were vastly in favor of the deep massive currents of the great valleys.

This advantage is manifested in the comparative lengths of the glacial streams at the time of the formation of the Kettle moraine. Taking the Lake Superior watershed as a datum line, the massive Lake Michigan glacier stretched southward, according to my determinations, about 400 miles; the less gigantic Green Bay glacier reached 280 miles; while the shallower stream that passed over the highlands, only reached about 75 miles. The westward current cannot well be compared with these because of the long stretch through the trough of Lake Superior before it passed over the watershed.

There is no room for question that Wisconsin lay below the snow line at the time of the formation of the Kettle moraine; and the immunity of the driftless district at that time must be explained on that basis.

I think it has been successfully shown that the Kettle moraine marks the limit of the ice at a period of secondary glacial advance. There must, then, have been at the time, a zone of waste, north of the line of this moraine, sufficiently wide to cousume the enormous thickness of ice, and stay its progress at this limit. I think that no glacialist will claim that this was a narrow or insignificant belt. Aside from the nature of the case, the distinctness of the Lake Michigan, Green Bay and other glaciers forbid such a supposition. It would be difficult, if not impossible, to imagine any rational means by which their differentiation and divergent internal motions could take place within the region of perpetual snow. It would be still more absurd to suppose that the re-entering angles of the terminal moraine penetrated the region of glacial accumulation. The most extreme supposition that can be admitted, is that these glacial lobes arched up in their central portions so as to be above the line of perpetual snow.

The question toward which we are tending is this: Was the advance at the time of greatest glaciation, beyond that represented by the Kettle moraine, sufficient to bring the line of perpetual snow down to the southern limit of the driftless area?

The Lake Michigan glacier at the time of the formation of the Kettle moraine, extended more than 200 miles (probably about 275) south of the point where it became entirely distinct from the Green Bay glacier, as shown by the striation and intervening moraine. In its most advanced state, it never doubled this length. There is no evidence that it was ever expanded in width westward towards the driftless district more than 30 miles. If there was, at that time, no distinction between it and the Green Bay glacier, then there was essentially no advance westward beyond the area subsequently occupied by the two.

The ice stream that came over the highlands has left no evidence of having ever extended more than about 25 or 30 miles south of the position occupied at the time of the formation of the Kettle moraine, and this is the stream that should have overwhelmed the driftless area, if any.

The Minnesota glacier seems to have been proportionally more extended; but, granting this a most liberal allowance, both in extent and effects, it seems highly improbable that the advance of maximum glaciation over that which obtained at the period of secondary glaciation, represented by the Kettle moraine, could have brought the snow line below the driftless area. And, if not, it must have been an area of higher temperature, warmer atmosphere, and probably clearer and dryer skies than the glaciated regions around it, and it must have thus been assisted in maintaining to itself its immunity from glaciation, by acting as a heated area, melting back the advancing ice, which it consumed by the time it reached its margin. Originally, it may have had a little climatic advantage over adjacent areas, and it had to contend with a thinner, slower stream of advancing ice, which it mastered, while the regions on either hand were overwhelmed.

On any other supposition it is not clear to me how an ice stream sufficiently strong to bear immense blocks of rock from the Lake Superior basin onto, and over the crest of the Archæan heights, and to descend its slope 100 miles could be stayed in its course, while its comrades on either hand pushed on some hundreds of miles farther south.

Professor Dana has recently * attributed the origin of the driftless area in Wisconsin to hygrometric conditions; and, in support of his view, appeals to Mr. Schott's charts showing the present rate of precipitation of rain and snow. He calls attention to the fact that the driftless area, except its southern portion, lies within areas of less abundant precipitation, than adjacent regions, both during the winter and the entire year.

* American Journal of Science, April, 1878, pp. 250 *et seq.*

If I understand Prof. Dana correctly, his argument is based upon the assumption that the driftless area lay within the zone of perpetual snow, but that the accumulation was not sufficient to cause motion. I have already given reasons for thinking that the limit of perpetual snow was never brought below the driftless area; and to those given, others might be added; so that, unless I am in error, whatever explanation is adopted must be one applicable to the zone of glacial waste. Within that zone, it is evident that a slight winter precipitation will be the more readily removed in spring and will the less retard the wasting action brought to bear upon the glacier. It seems also probable that a dry summer would facilitate glacial waste; so that, the present rate of precipitation over the region mentioned, *if it then obtained*, would be favorable to glacial consumption, and would, therefore, assist in protecting the driftless region from the advancing ice sheet.

But I cannot free myself from a grave doubt as to whether the present rate, or even ratio, of precipitation can safely be assumed to correctly represent, *in its details*, that of the glacial period. While it is freely admitted that there is much force and importance in the sagacious suggestion of Prof. Dana in reference to the *general* effect of the great arid region of the west, it seems much less probable that the comparatively slight local variations in precipitation, observed in Wisconsin, remained constant in character, and fixed geographically, through such vicissitudes as the glacial theory presupposes.

Aside from these general and fundamental objections, there are certain special ones, in part admitted, but whose force would doubtless have been much more fully conceded, had a more accurate outlining of the driftless area been at the command of the distinguished author of the article. The area is mapped as extending to the northwest fully 70 miles beyond the limit assigned by Mr. Strong, and includes considerable territory heavily covered with drift; and this elongation quite materially adds to its correspondence to the designated areas of meager precipitation. When correctly outlined, the correspondence is not very obvious, at least, much less so than that between the area of low precipitation and the sandy belt underlain by the Potsdam sandstone, which has been supposed, with some plausibility, to be an influential agency in reducing the precipitation. Of course, it matters not what is the cause, so long as it remains efficient; but the efficiency of a soil would cease, if it became perpetually covered with snow.

When accurately outlined, scarcely more than two-thirds of the driftless district lies within the belt of low precipitation and the trends of the axes of the two areas are mainly transverse to each other, while areas of similar precipitation on either hand were covered to great depths.

In the foregoing discussion, the present relative elevations of the region have been accepted as a basis of explanation, and no support has been asked from any supposed change of topography. There is some evidence, however, that a slight change was an historical fact. This is based upon the present inclined position of the ancient flood plains of some of the rivers adjacent to the driftless district. One of the best illustrations is afforded by the Rock river, which runs parallel to the longer axis of the driftless area. From above Janesville to Rockford, in Illinois, a distance of about 40 miles, there stretches a gravel plain from three to five or more miles wide, having a uniform, plane surface, except as channeled by streams. The underlying drift is stratified gravel of varying coarseness, with intercalated beds of sand. Wells from 50 to 100 feet deep seldom reach its bottom, and, in one case, it is known to have a depth of 350 feet. The coarseness, water worn character, lamination, and position of this deposit is such as to make it quite evident that it was formed by the glacial predecessor of Rock river, acting mainly at the time of the formation of the Kettle moraine, which limits it on the north.

The original surface of this plain, of course, sloped to the south in the direction of the flow of the depositing waters; but profiles *across* the valley should show an essentially level surface, as the flood plains formed by glacial streams of the present day do, and from the nature of the case must. At the present time, however, the drainage is toward the west side of this plain, and throughout the 40 miles of its length, the Rock river hugs its western margin, and even encroaches upon the adjacent territory.

The Sugar river, which runs parallel to the Rock river, on the west, and lies on the immediate border of the driftless district, presents a similar ancient flood plain, apparently formed at the same time and by the same means; and for a somewhat greater distance — as far as the plain continues — the present stream runs on its western border. Similar phenomena may be observed in connection with other streams to the north and westward as far as the Chippewa river.

These facts would seem to justify the belief that in the latter part of the glacial period, at least, the general surface was either lower at the east or higher at the west. In either case, the driftless area must have been *relatively* higher, in a moderate measure, than at present, so far as the region lying east of it is concerned.

To make the evidence complete, the facts with reference to the rivers on the west side of the driftless region are necessary, but I am not aware that they have been carefully observed with the discriminations necessary to make them completely applicable to this subject.

There seems no reason to suppose, however, from the partial evidence at hand, that the amount of change in topography was large, certainly not sufficient to constitute it more than a minor, auxilliary element in the explanation of the phenomena under consideration.

OBSERVATIONS ON SANDY SOILS.

In certain districts of the state, chiefly those underlaid by the Potsdam sandstone, a portion of the soil is sandy. A considerable percentage of this is good soil, and will give excellent returns to culture under the usual system of farming, but some of it is quite poor, and will require special methods of cultivation and judicious selection of crops to be productive. The question as to how best to utilize these arenaceous lands is one of much importance. It is scarcely to be hoped that an immediate satisfactory answer to this problem can be given, as it can probably only be solved by investigation and experience running through a considerable period of years.

There remained at the beginning of the year a small area lying between the Black and Chippewa rivers, and adjacent to the line of the Chicago, St. Paul & Minneapolis Railway, that had not been included in the districts definitely examined by the members of the survey, though its general geological structure was quite well known. This area includes some of the sandy land in question, and it was thought best to shape the investigation of the region with express reference to the question above stated. Dr. J. A. Renggley, of La Crosse, formerly for nine years Professor in the Agricultural College of Zurich, and familiar with the results of European experience, was engaged to investigate the subject, and a synopsis of his report is here given.

He commenced work on the 30th day of September, and continued it until November 22d, as late a date as it is practicable to carry on this class of field work. To give more completeness to the special subject of investigation, the sandy tracts in the valleys of the Chippewa, Trempealeau and Black rivers were examined as far south as the Mississippi, and also the sand flats formed by the latter and the La Crosse river.

As far as possible, the underlying strata, the rock foundation of the soil, was examined with reference to the origin, extent and quality of the soil. In general, the Potsdam sandstone extends, in unbroken connection, beneath the whole region explored. Below this is found the granitic rocks, which come to the surface to the northward, but do not reach it, in the district under consideration, except in the river valleys, as at and above Chippewa Falls and Black River Falls, where it forms the river beds and banks. The limy sandstones and magnesian limestones are not found until we reach the elevated bluffs of Buffalo, Trempealeau and La Crosse counties, where they lie upon the Potsdam sandstone. As having an important relation to agriculture, there was observed a thin (mostly only a few feet thick) layer of white, or light colored, silicate sand (Kaolin) which was thought to have a very general extension beneath the layer of Potsdam sandstone.

To these rocks, belonging mainly to the Lower Magnesian and Potsdam formations, and including magnesian and sandy limestone, limy and quartz sandstones, and the layer containing intermixed kaolin, the origin of the mineral parts of the sandy soil is attributed.

Without doubt, these formations formerly extended much farther north, and have been carried away by erosion. However this may be, it is sure that where the Potsdam sandstone approaches its northern boundary, especially in Chippewa and Clark counties, the material, so far as it has been found under the soil in flat layers, becomes softer and the layers thinner, and in its further extension is mixed with clay, and, finally, is replaced by a clayish marl, in more or less thick layers, which contain kaolin frequently.

The extent of the sandy soil in the region examined is considerable in proportion to the fertile soil that is not sandy. This proportion is determined by the size of the river basins, and the approach and recession of the bluffs from the river. Since the bluffs on the west side of the river are generally found nearer to the river banks, and, generally, the banks themselves are higher than those on the eastern side (especially those of the Black river), we find that the diluvial depositions, in the form of sandy soil, have a comparatively greater extension in an easterly direction, and rise higher upon the hills and terraces, than on the western side, where the bluffs break down more abruptly to the river. But there, also, we find sandy drifts in places farther back.

We find sand tracts, caused by the Black river, extending in considerable width from Hatfield and Merillan in a northwesterly direction to Humbird; and in a southwesterly direction, they spread through the Trempealeau valley down to Arcadia. We likewise see similar formations in the Chippewa and Eau Claire basins, stretching eastward from Eau Claire to Augusta, while from there to Humbird, the "Garden valley" shows a very fertile tract of land, embracing several townships, and is surrounded by a chain of mostly low wooded bluffs.

At most points where the sandy tracts approach the rocky bluffs, the soil becomes gradually more fertile; and in the immediate vicinity changes to a fertile clay soil. The same is true in the tributary valleys lying between the bluffs. To this change in the mineral constitution of the soil, the annually decaying local vegetation adds greater fertility, and this is enhanced by what is derived from the more or less rich deposits of the forests, which cover the bluffs. Indeed, we find a striking variation in regard to the degree of fertility in the vicinity of the bluffs, according to the size and density of the woods that crown them. It is much to be regretted that, through the destructive agencies of fire and the ax, these heights have been, and are still being, to so large an extent cleared away, as it is greatly to the detriment of the agriculture of the adjacent regions.

A change in respect to fertility, similar to that noticed on approaching the bluffs, is also to be found as we approach the river beds, especially where the banks are low, or rise but little above the highest water mark. There is here, however, this remarkable difference: that the presence of clay is either very rare, or entirely wanting. The increase of fertility of the low lands along the rivers becomes the greater where the adjacent sandy tracts rise back from the river, or form terraces or hills, and are covered with woods.

Those sandy tracts along the rivers that are spread out flat, and are overflowed by the rising of the waters, generally possess a greater fertility, provided that the action of the water is gentle. Rapid overflowing currents usually cause new drifts of sand, which are apt to be infertile. On the other hand, we find that the more the sandy tracts, lying back from the rivers, rise into rolling plains, terraces or hills, the less fertile the soil becomes. While the *humus* in the sandy soil near the bluffs is five or six per cent., and sometimes more, and in the low lands, along the rivers, seven to eight per cent.; we find it gradually decreasing with the rising of the surface, so that the humus in the soil of the higher elevations can be estimated at scarcely more than one-half per cent.

It may also be considered as a general law, that the organic matter in the sandy soil, if it is only a few feet thick, gradually decreases downward. Exceptions to this law are found when the sandy soil at a slight depth has a clayish or rocky foundation.

In regard to the fitness of these sandy soils for agriculture, or forest growth, the presence of water is a condition of great importance.

Sandy soil lying above the highest water mark, and having a porous subsoil, receives its moisture principally from the precipitation from the atmosphere, but a portion rises from below by capillary action. Where the water level lies near the surface, this results in that amount of moisture which, in a sandy soil, is best adapted to a thriving vegetation. The *humus* substances — *humin* and *humic acid*, *ulmin and ulmic acid*, *geic*, *crenic*, and *apocrenic acids* — find under these circumstances, favorable conditions for their chemical combination with the atmospheric elements — *oxygen*, *carbonic dioxide*, *ammonia*, *nitric acid*, etc., and, at the same time, for the absorption by the vegetation of the resulting compounds, dissolved in the proper quantity of water. This action is much facilitated by the great porosity of the soil, This porosity, however, causes a rapid change in the relative amount of moisture. When the deposit of moisture from the atmosphere is copious, the soil absorbs freely and becomes fully saturated, while in dry weather, especially when attended by a high temperature, rapid evaporation takes place and dryness of soil results. Still, in this respect, a remarkable difference is to be found, corresponding to the quantity of humus in the soil. The greater the amount of this, the slower the process of absorption and evaporation, and conversely.

If the sand fields in the low lands are level, and rise but little above the surface of the adjacent bodies of water, they are then, of course, saturated and wet; in which case, even if the humus contained is abundant, its availability for the nutrition of plants will be found to be very small. This will be manifested in the production of a comparatively few kinds of plants, which are mainly *cyperaceæ* and the hardy kinds of *gramineæ*. This striking phenomenon is due mainly to the fact that, of the different forms of humus which are found in marshy lands, some are but feebly soluble in water, while others will practically not dissolve at all, and therefore they have little fitness for the nutrition of vegetation. In these moist lands, the atmospheric agents have but little access to the humus, and are therefore unable to enter into combination with it to produce those soluble compounds that are nutritious to plants.

If sand plains, containing humus, are overflowed periodically, or occasionally, for short periods, and afterward attain a certain degree of dryness, they become well fitted for the production of a manifold and luxurious growth of grass, or arboreous vegetation, and we find such on the bottom lands along the rivers.

The depth of the sandy accumulations above the rock or clayish subsoil, varies greatly. In some cases, it measures only a very few feet, in others, it is ten, fifty, or even one hundred or more. The maximum depth can probably be found in the Mississippi valley, and in the vicinity of the junction of the Black river with it. The average depth of the sand beds, constituting the La Crosse prairie, is above one hundred feet. The depth of the sand deposits generally declines as the valley is ascended, but. in going back from the rivers, it increases in different degrees.

Concerning the adaptability of these sand fields for agriculture, it is to be remembered that what is said applies, not only to the sandy lands of the country examined, but to such lands in general. For the sake of clearness, we have made the following divisions:

I. *Wet sandy soils.*

1st class — swamp lands.

2d class — bottom lands.

II. *Dry sandy soils.*

1st class — very rich in humus.

2nd class — moderately rich in humus.

3d class — poor in humus.

I. 1. *Swamp land.* The soil of this class may be said to be constantly saturated. It is usually very rich in brown, or black, soft humus to the depth of from one to several feet. When dry, it contains about 10 or 12 per cent. of organic, and from 88 to 90 per cent. of inorganic substance.* The rich annual fall of the vegetation growing on it, and the decay of animals of the lower orders that live in it, constantly increase its richness in humus. Nevertheless, it produces only a very simple vegetable growth, with little variety of form, and but few species, the grasses predominating, and constituting the so called marsh meadows. The younger growth only, of these grasses, is filled with nutritious elements.

* Based on analyses of Louis Runkel.

When fully grown, the nutritious portions are greatly reduced, and the plants then consist mostly of hard, woody cellulose.

2. *Bottom lands.* These are very similar to the last, except in their hydrographical relations, and that which results from it. They contain about the same per cent. of organic and inorganic ingredients as the preceding. They differ in that, whereas the swamp lands are continuously wet, the bottom lands are only occasionally covered by floods. These, on retiring, usually leave behind a new deposit of organic matter. During most of the year, the soil is dry, or only fairly damp, so that the atmospheric agencies are admitted, by the porosity of the soil, into contact with its contained humus, and chemical reaction results, rendering the organic matter more available for plant growth. In consequence of this, we see on the bottom lands, a great variety and luxuriant growth of arboreous vegetation. Various species of the oak, elm, maple, beech, birch, poplar, willow and alder there find a congenial home.

II. *Dry sandy soils.* We class a soil as dry, if it does not contain more water than falls directly upon it from the atmosphere, or is derived by capillarity. Its content of water is therefore a changing one, dependent on the phases of the weather. The soil is always very light, and extraordinarily porous, and is, therefore, very easily worked, and freely admits the chemcial agencies of the atmosphere, into combination with the organic matter it contains. The depth to which the humus penetrates is quite varying, but decreases downwards.

An example tested, gave the following results:

	Organic matter.	*Inorganic matter.*
At 1 foot depth	3.77	96.23
At 2 feet depth	3.025	96.975
At 3 feet depth	2.03	97.97

1. The soil of the first class under this group carries humus to a depth of from two to four feet, and is grayish black and blackish gray; and, when thoroughly wet, black. At from 1 to 2 feet depth it is composed of about 6 or 8 per cent. of organic matter, and 92 to 94 per cent. inorganic.

2. In the medium class, the humus soil extends to about 1½ or 2

feet in depth, and is composed of about 4 or 5 per cent. of organic matter, and 95 to 96 per cent. of mineral ingredients.

3. The soil of the third class is poor in humus, the organic element ranging from a fraction of one per cent. to two per cent. It therefore appears to the physical examination very sandy.

In respect to the herbaceous vegetation which grows natively on these sandy soils, we observe that, on the soils of the first and second classes, there grow a great variety of herbs and grasses that are, for the greater part, juicy and nutritious, and furnish the herbivorous domestic animals a food of easy digestion.

On the other hand, we find these very scarce on the sandy soil of the third class, on which the burr grass (cenchus tribuloides) is more abundant, and is known as the characteristic plant.

Of the arboreous vegetation, the red and black oaks are the predominant species. On soils of the first and second quality, they grow well. This can also be said of most of the deciduous trees of our region. On sandy soils of the third quality, the arboreous vegetation arrives at nothing more than crippled trees and shrubs.

In general, the agricultural capabilities of these sandy soils is greatly undervalued. Preconceived ideas that they are not remunerative are generally accepted without due regard to positive evidence.

The following general opinions may be briefly expressed:

1. The humus soils of the swamp lands contain the chemical elements of all kinds in great abundance, and to make this available for agricultural purposes little more is necessary than drainage and cultivation.

2. The drying of the swampy wood-growing lands by drainage would in a short time bring about a mingling of the humus with the almost clean sandy or sandy-marl subsoil; and, through this, a deep rooting of the trees, which would give them a more healthy and natural growth, instead of the feeble one they now manifest.

3. That part of the bottom land which is overgrown with trees, gives, in the condition in which it now stands, a most valuable product of timber and fuel. From the great extent and density of these woods, the bottom lands find much protection from wash by

the annual and occasional floods. They also subdue the climate, partly by breaking the force of stormy winds, and partly through the evaporation of water from their foliage, when the air is hot and dry.

The idea of using the wet bottom lands for any other purpose would undoubtedly be found foreign to the purposes to which they are best adapted. To drain and protect them from floods would be found very difficult on account of their flatness and slight elevation above the adjacent rivers.

4. The dry, sandy soils to which our subject chiefly relates, are, beyond question, easy of cultivation. If they belong to the first or second class, with a small amount of labor they can be made to give a plentiful reward for the labor bestowed. The fertility of the sandy soil of the first quality is similar to that of drained swamp-lands. The extraordinary ease with which the humus soil parts with its nutrition, and the resulting luxurious growth of vegetation, would soon draw from the soil its stock of nourishment, unless its fertility be maintained by regular manuring.

5. The sandy soil of the third quality cannot be cultivated to any advantage unless first well manured. As a manure, Dr. Renggley expresses his opinion that stable manure is the most practically available, and also buckwheat plowed under while in bloom.

"A diligent cultivation, a plentiful manuring, a proper selection of plants, and their timely planting, would be remunerative to the farmer, as well as horticulturalist, on dry, sandy soil."

WORK IN THE MENOMINEE IRON REGION UNDER MAJ. T. B. BROOKS.

NEWBURG, N. Y., Jan. 13, 1879.

Prof. T. C. CHAMBERLIN, *Chief Geologist:*

DEAR SIR: I have only need to report in brief that when I had nearly closed my report on the Menominee Iron Region — about a year ago — and after I had formally resigned all connection with the survey, you informed me that a part of the last appropriation was available for the further prosecution of field work in that region, with the view of settling some questions which previous work had not solved, and which would have left my report in a less complete state than was desirable. I spent nearly two months in the field the past summer, and had parties at work for a longer time, and have pleasure in stating that our fund of facts has been largely increased through more thorough work on the same ground than had been possible before, with the means available. So far as the main objects of my survey of this region are concerned (which have been fully discussed heretofore), I do not regard any further field work as now necessary.

Frank H. Brotherton and Robert McKinlay, of Escanaba, and Geo. A. Fay, of Menasha, were engaged on the work. The latter gentleman, through his full local knowledge of the country, and interest in rocks, rendered much assistance, and continued the survey until the snow stopped it.

Fred. J. Knight, who has been connected with the survey from the beginning, is now engaged in correcting proofs of maps and arranging the material collected the past season.

My assistant, Chas. E. Wright, of Marquette, will determine the rocks collected last summer, and, according to the arrangement some time ago submitted to you, will write the economic chapter on the iron deposits, and make all necessary analyses for the same.

The very complete paper by Dr. Arthur Wichman, of Leipsic, giving the results of his microscopic study of thin sections of the Iron-bearing (Huronian) rocks, south of Lake Superior, has, as you are aware, been in my hands, ready for the printer, for over two years.*

Since my completed report will soon be in your hands, it does not seem worth while to anticipate any of its results.

It is but repeating what has been stated in former reports, and in numerous periodicals, that the explorations of the Commonwealth Iron Co., and of other land owners to the west and north, have proved, beyond all question, the existence of iron deposits of great value, in the Menominee region, which only require transportation facilities to inaugurate a settlement and development of the coun-

* This, of course, could not properly be printed apart from the other reports upon the region to which it relates. T. C. C.

try, parallel to that which is now taking place on the Michigan side of the river.

Respectfully and obediently yours,

T. B. BROOKS.

CHEMICAL WORK.

The arrangements for the analytical work of the survey have continued, as heretofore, with Prof. W. W. Daniells of the state university, and Mr. Gustavus Bode, of Milwaukee. Their analyses will appear in the reports of the parties for whom they were made, and will there be duly accredited.

DRAFTING.

Professor W. J. L. Nicodemus,* topographical assistant to the survey, and Mr. A. D. Conover, of the state university, who have previously done the larger part of the drafting of the geological maps, have completed those assigned them for the atlas that is to accompany volume III of the final report, and have made progress with other work placed in their hands.

PALEONTOLOGICAL WORK.

Prof. R. P. Whitfield has completed the descriptions and drawings of the fossils selected for representation, and this portion of the report is now stereotyped.

The ticketing and cataloguing of the paleontological and a portion of the lithological collection, a labor of several months, has been performed by Mr. I. M. Buell, and the distribution will be made at an early day. It will be necessary to retain till a later date most of the lithological specimens for further study in connection with the preparation of the reports yet to be completed.

ZOOLOGICAL AND BOTANICAL WORK.

For the character of this work reference is made to my two preceding reports. The observations there indicated have been con-

* Since this was written, we have been called upon to mourn the sudden death of Professor Nicodemus. This painful loss will be further referred to in another portion of the report.

tinued; those on the fishes, reptiles and insects of the state by Dr. P. R. Hoy; those on the food of our native birds by Prof. F. H. King; those on the crustaceans and the fungi by Prof. W. F. Bundy; and those on the phenogamous plants by Prof. G. D. Swezey.

PUBLICATION.

The final report will consist, when completed according to the present plan, of four volumes, with accompanying maps. As heretofore explained, Volume I, in obedience to the specifications of the law of publication, will include the general geology of the state and certain special reports that can only be properly prepared after all the detailed reports are elaborated, and it will therefore be published last.

Volume II was issued during last year. The appreciative manner in which it was received by the people of the state and the scientific public has been very gratifying. A second edition, to be placed on sale exclusively, was ordered by the last legislature, and has been prepared during the year. Owing to some delays in publishing and to my absence in the field, it was not placed before the public until late in November, and the extent to which there will be a demand for it is not yet evident.

Work in the preparation of volume III has been in progress during the entire year in connection with other duties, and it was hoped that it would have been essentially completed at this date, but it has involved more labor than was anticipated. This volume relates to the northwestern portion of the state, and will include: (1) a report on the upper Mississippi region, by the late Moses Strong; (2) on the lower St. Croix district, by L. C. Wooster; (3) on the fossils of the state, by R. P. Whitfield; (4) on the general geology on the Lake Superior district; and (5) on the detailed geology of Ashland county, by R. D. Irving; (6) on the Penokee Iron Range west of the Gap, by C. E. Wright; (7) on the west Lake Superior district, by E. T. Sweet; (8) on the upper St. Croix district, based mainly on the notes of M. Strong; and (9) on the microscopical characters of the copper-bearing rocks, by R. Pumpelly. It will be accompanied by an atlas of ten large maps, uniform with those accompanying Vol. II. The first three parts are composed and stereotyped, and most of the remaining manuscript ready.

Some progress has also been made in the preparation of Vol. IV, but a large amount of labor will yet be requisite to bring it to completion.

ACCOUNTS.

Full accounts of all expenditures connected with the survey, accompanied by vouchers, may be found on file in the Executive Office.

ACKNOWLEDGEMENTS.

The survey has been greatly indebted during the past year, as heretofore, to numerous citizens, who, by their kind assistance through personal services or valuable information have greatly aided in its prosecution. To all these, the members of the corps desire to return their warmest thanks. While the number of these favors is far too great to admit of enumeration here, some have been so conspicuous as to merit special mention, particularly the generous assistance of W. T. Henry, Esq., of Mineral Point, and also of Mr. J. J. Ross and Mr. John Hutchinson, of the same place; of Senator O. C. Hathaway, of Muscallonge; of Hon. H. Robbins, Hon. J. H. Evans and Mr. Leonard Coats, of Platteville; of Mr. John Cover, of Lancaster; of Hon. Gabriel Mills, of Hazel Green; of Mr. Frank Craig, of New Diggings; of Mr. Phillips, of British Hollow; of Capt. Poad, of Linden; of Mr. Geo. Weatherby, of Shullsburg, and of Dr. Geo. W. Seymour, of Taylor's Falls.

The survey has also been placed under renewed obligations to the officers of the Chicago, Milwaukee & St. Paul railroad, the Chicago & Northwestern railroad, the Chicago, St. Paul & Minneapolis railroad, the Wisconsin Central railroad, the Western Union railroad and the Mineral Point railroad, for free transportation, which has much facilitated the work and reduced its expense.

The survey is also particulary indebted to Mrs. G. P. Mavine, for a suite of specimens of the Michigan copper bearing rocks collected by her late husband. My cordial thanks are also due Governor William E. Smith, for documents that proved of much service in my European trip, and to General Lucius Fairchild, consul at Paris, Governor Packard, consul at Liverpool, and Mr. Montgomery and Dr. Delavan, consul and vice consul at Geneva, for much kind assistance.

APPENDIX.

IN MEMORIAM *—WILLIAM J. L. NICODEMUS.

August 1, 1834 — January 6, 1879.

William J. L. Nicodemus was born August 1, 1834, at Cold Springs, Va. Soon after his birth, his parents moved to Maryland, settling near Hagerstown. In his early childhood, he gave evidence of unusual mental activity, developing a remarkable memory. His precocity was, however, unduly encouraged, and while still a small boy he was the victim of a severe attack of brain fever, which very nearly proved fatal. He recovered from this with almost wonderful rapidity, and soon regained a condition of sturdy health.

At quite an early age, his parents commenced sending him to the country school, and here he very quickly outstripped the other scholars, exhausted the meagre course of study of the district schools of the day, and fitted himself to teach, by the time he had reached the age of fifteen.

Teaching during the winter and working on the farm during the summer, occupied his energies during the next three years. Meantime, his unusual abilities and pleasant address had attracted toward him no little attention, and in his eighteenth year he received from the representative of his district an appointment as cadet in the West Point Military Academy, whither he went in the fall of 1854.

His life at West Point was, with all its rigors, an exceedingly pleasant and profitable one. He graduated from the academy in June, 1858, and the following month received his commission as second lieutenant in the Fifth Infantry. His first post was Newport Barracks, Ky., just opposite Cincinnati. Here his handsome face, genial and gentlemanly ways, and thorough enjoyment of the comparative freedom from rigorous discipline, soon made him a great favorite among his brother officers and in social circles.

* Prepared by Professor Allan D. Conover.

In May, 1851, he was promoted to first lieutenant of the Eleventh Infantry, and transferred to the Department of New Mexico, where he remained until June, 1862, acting, during that time, as assistant adjutant general of the department.

Meanwhile the confederate forces had entered the Department, and on February 21, 1862, came to an engagement with the Union troops in the battle of Valverde. In this action Lieut. Nicodemus showed great gallantry, and was recommended by Maj.-Gen. E. R. S. Canby, commanding the United States forces, for a brevet majority. After this battle the federal forces, divided into two commands, one at Fort Craig, the other a Fort Union, two hundred miles apart, the intervening county in the hands the enemy, and of hostile Indians, were in great danger of being forced to surrender. Every means of communication had been tried, and had failed. Lieut. Nicodemus volunteered to open communication and succeeded, though at great risk of his life. A union of the federal forces resulted.

The campaign which followed was short but stirring, and in it Lieut. Nicodemus took active part, and was present at every engagement. The enemy were driven from the Department. Lieut. Nicodemus was now made the bearer of important dispatches to Washington, whence he returned, and was, at his request, relieved, that he might join his regiment in the east.

He was now in the real theater of the war, and in October, 1862, after acting for a while on recruiting duty at Cincinnati, he was tendered, and accepted from the governor of Maryland, a commission as colonel of the 4th Md. Volunteers. He immediately joined his regiment in the field, but was soon afterward ordered with his regiment to Baltimore, to guard conscripts. It was a post of trust, and Col. Nicodemus, his regiment largely in sympathy with the men they guarded, passed two months of intense activity, on duty day and night, cathing only short snaches of sleep in his clothes, but never a full nights rest. The strain proved too great, and ended in his complete nervous prostration. He resigned his commission, and, after a short rest, rejoined his regiment.

While in New Mexico, he had shown great efficiency on signal duty, and February, 1863, was selected to take charge of the "Signal Camp of Instruction for officers and men." He was at the same time given command of the signal detachment of the department of West Virginia, and personally superintended a signal line of communication from Harpers Ferry to Washington, after the battle of Gettysburg until Lee had been driven south of the Potomac.

His valuable services in this Department were promptly recognized, and, in July, 1863, he was promoted Major of the Signal Corps of the army; in October following, was placed in charge of the Signal Bureau; was promoted Lieut. Colonel of Signal Corps in September, 1864, and was soon after made Inspector of Signal Corps. In this position, he acted until August, 1865, when he was mustered out as Lieut. Colonel, and then rejoined his regiment, the 12th Infantry, as captain, to rank from October, 1861. In March, 1865, he was brevetted Major in the regular army, "for faithful and meritorious services during the war."

Captain Nicodemus was stationed, during his service on the Signal Corps, very largely at Georgetown, and here he became acquainted with Miss Fannie E. Pettit, to whom he was married December 27, 1864.

From 1865 to 1868, Captain Nicodemus was stationed at Washington. In 1868, he was detailed to give instruction in Military Science and Tactics at the Western University, at Pittsburg, Pa., and remained there two years.

In 1870, the Regents of the University of Wisconsin elected Captain Nicodemus to the chair of Military Science and Civil and Mechanical Engineering, a position which he accepted, at the same time resigning his commission as captain in the regular army.

In thus breaking away from the associations which his early education and long and active military career had so well fitted him to enjoy, in time of peace, and where his position promised him speedy promotion at least one step, and a life of comparative ease and freedom from anxiety, Captain Nicodemus was actuated by a desire to secure for his wife and young family the benefits and advantages of a permanent home. This sacrifice for those he loved typifies the man.

In February, 1870, he moved to Madison, bringing his family with him, and immediately entered upon the duties of his new position.

Ambitious and energetic, he soon gave life to the department to which he had been called. He thoroughly remodeled the course in Civil Engineering, and soon drew around him a number of students of that specialty, winning from them, by his thorough but kindly manliness, his enthusiastic devotion to their wants, and his efforts for their subsequent welfare, a warm and lasting regard. Equal success crowned his efforts in the Department of Military Science, where he succeeded in making both popular and useful the drill, which before had always been extremely irksome to the students.

His genial manner and varied experience made him a very pleasant companion, and he soon won the regard of his fellow workers at the University, and of a large circle of acquaintance among those in public and private life around him. With some of these he was associated in business enterprise, and they know, and have felt, as others cannot fully, the thorough honest manfulness of his character, his wholesome integrity in small as well as great affairs, his manly way of meeting any draft on his time and energies they had a right to call for.

With the State Geological Commission, whose surviving members now mourn his loss, he has been associated in sympathy from the commencement of their labors, as a sharer in their work, since 1875, when he was commissioned Topographical Assistant of the Survey. Of his work for the survey, those atlas maps to which his name is signed, speak sufficiently.

Since his settling in Madison, Professor Nicodemus had more than once been tempted to leave, and among other proffers, he received one from Gen. Sherman, with whom he was personally well acquainted, asking him to accept a position as Professor of Mathematics at $2,500 per annum, in gold, in a college just being started by the Khedive of Egypt.

Of modest, retiring disposition, Professor Nicodemus rarely spoke of himself or of his many experiences. Possessed of large store of nervous force, he rapidly and efficiently accomplished whatever he took in hand. Ambitious to provide for the wants of his family, should they ever be left without his care, he felt pressed to engage in business enterprise outside of the duties of his professorship, and never slack in his duty to the university, he must have drawn very largely on his vitality, to accomplish the work he undertook. This is more especially true of the past collegiate year, when, burdened more than usually with the needs for instruction in his growing department, and with his work for the Geological Survey, he shared largely in the labor, the risks and anxieties consequent on publishing his large state map. The draft on his nervous system proved great, and brought on *insomnia*, which finally developed alarmingly.

Shortly after the beginning of the fall term, his condition became so precarious as to necessitate absolute rest, and he obtained leave of absence. With country air and complete rest he was rapidly regaining his normal state of health, when he was suddenly called to his home, to watch and care for one of his little children, who, attacked with a malignant type of diphtheria, hovered for a long time between life and death, but finally recovered. This care and anxiety probably lost him all he had gained, and though he again attempted his duties, he was soon compelled to give them up and again seek rest. He returned once more at the beginning of the winter term, and though at first apparently well, soon became subject to the same trouble. He struggled against it, but all in vain. His trouble grew on him, till finally he was unable to sleep at all. He resorted to the use of opiates, and it is probable that on the night of January 5th, he unwittingly took an overdose of laudanum. Discovered toward morning in an utterly unconscious state, he once or twice rallied, never becoming fully conscious, but finally, after a terrible struggle, gave up his life at 2:30 P. M., January 6th. His widow and four small children, the oldest thirteen, are left to mourn his loss.

Prof. Nicodemus was a devout, consistent member of the Roman Catholic church, and dying, received its last offices. His was a truly liberal Catholic spirit, and his life and bearing bespoke the real goodness of the man.

MADISON, WIS., February 1, 1879.

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