

3. 9. Wash. D. C.

REPORT

Charles Darwin Esq.

Sec Anti-Moses Society

GEOLOGICAL RECONNOISSANCE *by the the the*
from the Importer

MADE IN 1835,

FROM THE SEAT OF GOVERNMENT,

BY THE WAY OF

GREEN BAY AND THE WISCONSIN TERRITORY,

TO THE

COTEAU DE PRAIRIE,

AN ELEVATED RIDGE DIVIDING THE MISSOURI FROM THE ST. PETER'S RIVER.

BY G. W. FEATHERSTONHAUGH,

U. S. GEOLOGIST.

Doc. 333.—Printed by order of the Senate.

WASHINGTON :

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1836.

*Report from the Secretary of War, in compliance with a resolution of the Senate,
with a report from the United States Geologist.*

WAR DEPARTMENT,

April 23, 1836.

Sir: In compliance with the resolution of the Senate of the 1st instant, I have the honor, in the absence, from indisposition, of the Secretary of War, to enclose a report of the Topographical Bureau, transmitting the report of the United States Geologist.

Very respectfully,

Your most obedient servant,

C. A. HARRIS,

Chief Clerk, War Department.

HON. M. VAN BUREN,
President of the Senate.

TOPOGRAPHICAL BUREAU,

Washington, April 23, 1836.

Sir: I have the honor to submit herewith, a copy of the report of G. W. Featherstonhaugh, United States Geologist, called for by a resolution of the Senate of the 1st of April.

I am, very respectfully, sir,

Your obedient servant,

J. J. ABERT,

Lieut. Col. Topographical Engineers.

HON. LEWIS CASS,
Secretary of War.

REPORT.

WASHINGTON, April 22, 1836.

Lieut. Col. J. J. ABERT,
U. S. Topographical Engineers :

SIR: In obedience to your instructions, dated July 7, 1835, directing me to proceed to the vicinity of that elevated ridge which separates the Missouri river from the St. Peter's, the chief northwestern tributary of the Mississippi, hitherto designated on the maps by the appellation of Coteau de Prairie, and indicating Green Bay as a point on my route from whence an opportunity would be afforded of examining the mineral structure of the country on the Wisconsin river, I left this city on the 8th of the same month, and have now the honor to transmit a report of my proceedings.

Before, however, I enter upon that part of my report immediately connected with my instructions, I desire to explain why I have been induced to extend this document, and lend to it a character perhaps not generally expected of it.

Well acquainted with the strong and general desire expressed for the acquirement of geological knowledge in this country, and aware of the importance which would soon be attached to it if proper measures were taken to awaken the public attention, I thought it my duty, when drawing up my report in 1835, concerning the elevated country between the Missouri and Red rivers, to give a somewhat elementary ex-

position of the principles of the science, with a view to draw the public attention still more to the subject, and in order to the more successful illustration of the geology of the United States. The geological works which had hitherto been published, contained, with very few exceptions, references illustrative only of the geological structure of foreign countries, and as I had to treat of what is purely a science of observation, I conceived the great mass of minds to which I felt bound to address myself, would probably have been deterred from, rather than attracted to the subject, had I merely given a technical description of what I had seen, without offering the means of comparative illustration. I therefore adopted, upon that occasion, as I shall do now, that course which promised to be the most extensively useful, confident, that however the task might be imperfectly executed, permanent advantages might be accomplished by it, and that justice would be done to my motives. In this I have not been disappointed: the zeal with which I have attended to my duties has been acknowledged, and I have received, since my return from my late excursion, sufficient evidence of the public approbation of my labors, besides the most gratifying assurances from numerous intelligent members of the present Congress, that the method I had adopted was considered useful, and had been decidedly approved.

But a change had taken place in public opinion since the publication of that report. The authorization of these geological investigations by the General Government, had given great importance to them, much intellect had been at work, and a strong solicitude expressed for an accurate exposition of the general geology of the United States. The most powerful States in the Union were legislating on the subject, and a prospect was thus held out that the general desire for information which the action of the Government had so much contributed to put in motion, would soon receive new vigor from the fostering care of each of the particular States. Looking

at this promising aspect of things since my return from my late excursion, I have become more than ever impressed with the propriety of endeavoring to make my labors as useful, in the popular sense, as my opportunities permit.

It is well known that the geological literature of the present day, is not of a sufficiently elementary character for the very great number of persons desirous of possessing a practical guide for their studies, simple and perspicuous enough to keep down the repugnance which technical works, applicable to an advanced state of the science, invariably produce. Many powerful minds are deterred from the pursuit of various branches of natural history, from an inability to take the first step successfully, and he who is properly penetrated with this truth, and obeys its influence, will esteem it no degradation to take upon himself the humbler task of elementary instruction for the benefit of the many, even when he may have reason to suppose his intentions will not always be indulgently appreciated by the least liberal of the scientific few. Independent of the greater chance of doing good, and of the pleasure of looking forward to witness the extraordinary elasticity of minds from which the pressure has been gently removed, the very fact of there being no elementary work applicable to American geology, no geological column showing the succession of the beds and a comparative view of the geological equivalents in both hemispheres, together with a brief abstract of the characteristic organic remains contained in the beds, and the other remarkable phenomena illustrative of the structure of the accessible part of the crust of the earth, would be a sufficient motive for any writer whose experience might be thought to authorize the attempt, not only to endeavor thus to be extensively useful, but indirectly to reflect the greatest degree of intelligence upon the observations which it was his duty to make, that they might be understood, by all who read them, in the most comprehensive sense. In short, perceiving the general desire to acquire systematic in-

formation on this subject, what I would aim to accomplish is, the putting into the hands of all who wish to cultivate geological knowledge, an elementary work which should not be a dry recapitulation of what was familiarly known before, but a brief and intelligent view of the whole subject, explaining the harmony which prevails in the structure of the earth's surface, and how important a knowledge of its details are in an economical point of view, making the whole, at every step, subservient, as much as possible, to the illustration of American geology. I must think that no individual can acquire information of this kind, without experiencing a corresponding enlargement of mind, that makes him a more useful citizen and a happier man. The plainest farmer may thus be made to understand how a knowledge of geology is useful to agriculture. Very extensive districts consist of a recurrence of decomposed shales, sandstones, and superficial soil produced from primary rocks, and are comparatively barren. In such beds siliceous substances predominate, they having but a small proportion of calcareous matter. A single band of limestone sometimes effects a revolution in the value of an extensive district of this character. We hear soils called light, and heavy, and wet; it is the mineral substance of the geological beds which makes them so. Some families of grain and plants fail upon peculiar soils; this is owing to the presence or absence of particular minerals, for even animals do not thrive where their food is not appropriate. Occasionally a district or given area is too wet for crops that would succeed if the land were drier; a little knowledge of geology would teach the farmer that the springy quality of his land is owing to a bed clay that intercepts the rain, prevents its percolating downwards, and forces it out at its surface. Wherever he finds the clay he will find the same inconvenience, and knowing the extent of the cause, his ingenuity will soon teach him to remove it by a proper course of drainage. I remember seeing, several years ago, the most barren

part of the beach at Long Branch, in New Jersey, suddenly bearing a luxuriant crop of clover. This I learned had been produced by carting the common gravel upon it from the adjacent sea-shore. This gravel, which had a very unpromising appearance to the naked eye, upon being examined with a pocket microscope, was found to contain great quantities of comminuted sea-shells and marine animal matter, constituting it a valuable manure. There are those who object to this manner of considering the subject, that it is an attempt to draw farmers off from practical operations to considerations of a more theoretical nature, believing that even an elementary acquaintance with chemistry and geology is not fitted for a class, the majority of which is unstudied. But a long and intimate acquaintance with such men, acquired by a residence amongst them, has convinced me that the objection is not well founded. Divest these sciences of the prejudice which attaches to their names, impart their principles (which after all are the principles which govern nature) to men of good sense, in a plain and regular way, consistent with their own habits of thinking and acting, and they will understand them perfectly well, and put them to the best use. Who can hold a conversation with an intelligent man of this kind, without being affected by his situation, standing upon the threshold of knowledge, whilst to him it is all darkness and confusion. A clear-headed practical farmer may be made, however unlettered, to comprehend enough of these branches to convince him of the unerring truth of the principles which govern his vocation. At every step he takes his condition will become more elevated. Men may ridicule the idea of imbuing the minds of plain farmers with a philosophical turn, yet if it is to be done, it would unquestionably lead to very beneficial results, and the sum of human happiness, in every direction, be thereby greatly increased.

Entertaining these opinions, I have been greatly encouraged to adopt the course I have pursued, by the advice of gentle-

men in the present Congress, for whose judgment I have great deference, and who, having experienced the difficulties which are inseparable from the study of scientific works, where the higher branches are alone treated of, and where the technicalities are entirely left unexplained, have suggested the usefulness of appending to my report a glossary or explanation of the common terms used in geology. Believing, therefore, that I have not formed an erroneous estimate of what may be deemed both expedient and useful at the present moment, and having for my sole motive the accomplishment of a general good, I have given a brief account of the existing mineral beds both in Europe and America, as far as regards their general structure and order of succession to each other, adding such observations concerning the nomenclature that has been applied to them, as may serve to soften the difficulties to those who are engaging for the first time with geological literature, and to assist in guiding observers in ascertaining the geological position of the rocks which are the subjects of their investigation. This part of the subject will be found further illustrated by a comparative tabular view of the geological column in both hemispheres.

Perhaps the propriety of the extended form which this report takes, may be safely placed upon other considerations. Those who, like myself, have witnessed the rise and progress of civil engineering in this country, are well acquainted with the causes of that frequent misapplication of means in the construction of some of our earliest and most important internal improvements, and the influence of which only ceased in proportion as experience and study had converted good surveyors into expert engineers. The country having become awakened to the value of its mineral resources, the States are now legislating on this important subject, and the same process will have to be repeated in the coming extension of geological surveys. Men of enthusiasm and energy in the acquisition of information connected with natural history,

will have to supply the demand which will soon arise for geological investigations ; but many of them will come forward with attainments variously acquired, and with opinions and prejudices that will be discordant with the views entertained by others. Nomenclatures have been offered for the geological strata of this country, which have little or no affinity for those established by the most experienced geologists, and which, if not discouraged, would throw much confusion into the study of the science ; for geology is the science of nature, and not of any particular country, and apart from the positive advantages derived from the use of simple terms, universally received, it is one of the blessings of science successfully pursued, and often the only reward of those who devote themselves to it, that, establishing a universal harmony of intellect, it inspires mutual benevolence in minds separated by immense distances, and unites them all in the noble object of advancing the best interests of mankind.

In closing these preliminary observations, I must in justice to myself remark that, from the necessity of the case, the reports which it has hitherto been my duty to draw up, could not, however I might have been disposed to comply with the wishes of individuals anxious for minute sections and descriptions of all the particular localities which have come under my notice during my official connexion with the Government, and however desirable, have taken that character. The geological books, it is true, contain great varieties of such sections, and they are eminently valuable, but it is to be remembered that they are the results of labors voluntarily undertaken, limited to particular districts, and accomplished by a leisure independent of all obligations to perform other and indispensable duties. The geological literature we possess, and which is almost exclusively European, has grown out of the brilliant career which this science has had for near thirty years, under the direction of a numerous body of energetic and often wealthy men, assisted by all the facilities of highly-civilized

and well-settled countries. The great contrast which the remote parts of this country present in this respect, is sometimes not adverted to. My own opportunities are particularly contrasted with those of the European geologists I have alluded to. The Government conceiving itself authorized to cause these geological reconnoissances to be made only in the territories of the United States, my instructions are made out conformably, and it becomes a matter of duty with me strictly to obey them. The vast extent of the United States makes it occasionally difficult to reach particular points, before the season arrives when it is necessary to turn back to escape the rigor of the winter. Such was the case during my excursion last year. To the haste indispensable to the performance of these distant excursions, may be added other serious inconveniences, amongst which may be enumerated the want of accurate maps, and the wild state of the country on the borders of and beyond the white population, where the acquisition of correct topographical knowledge and the cares of self-preservation become a very absorbing occupation. It is true that expeditions of this character compensate to the geologist the advantages he enjoys in other situations. He passes through various countries, and enjoys rare opportunities of comparing their mineral structure, and of tracing the extensive formations of the Western part of this country, but it results from all these circumstances that, being obliged to deal more with general than particular geology, he acquires the habit of considering geology more upon the large than the minute scale. Such is the case with myself, for although I am not altogether debarred the opportunities of availing myself of the details of formations which are new and interesting, and never neglect them, yet I have hitherto, in my reports, thought it more consistent with my instructions generally to suppress for the present, those sections which I have made in localities out of the territories of the United States, reserving them for an occasion when I hope ere long to pro-

duce them, consistent with what is due to every consideration. In one sense, however, these extensive excursions are highly favorable to an object of great importance to the country, the construction of a general geological map of the United States, an undertaking which will probably require a great deal of time to perfect. I have been able to collect materials for the outline of such a map, which we should not have possessed but for the particular nature of my duties and of the journeys I have made, and to supply many others from observations made in passing through the interior of the country. The exertions now making to produce geological information in various States, will increase the number and value of these materials. A geological map of the whole United States, where all the formations would be exhibited on a large scale, and the most important deposits of fuel, metals, and useful minerals be accurately laid down, would be a monument both useful and honorable to the country at home and abroad, and I trust the day is not distant when Congress will direct such a map to be constructed upon a scale commensurate with the importance of the undertaking. I proceed now to the elementary portion of the report of which I have spoken.

Geology, in its most comprehensive sense, means the study of nature and of all natural objects, whether those recent ones belonging to the present order of nature, or those fossil ones belonging to more remote periods, and which are supposed to have preceded the creation of man, because no vestige of the existence of our race has been hitherto found coeval with them. And as all the forms in nature present themselves to us, either in organic or inorganic bodies, meaning bodies which have the faculty of continuing their kinds, and those which have not, it results that geology stands in relation with all the physical sciences, and that every geologist ought to have some knowledge of mineralogy, zoology, and botany, since the first comprehends all inorganic bodies, and the last two all organic forms. In a more limited sense,

geology comprehends only the study of the mineral structure of rocks, their relative position, and the fossils imbedded in them. Restricted to these branches, this study, however useful it might be, could not rise to the dignity of a science. The origin of mountains and valleys, the changes of the bed of the ocean, the action of rivers, and the nature of volcanoes, together with the highly liberal study of comparative anatomy, might be overlooked in this narrow field of observation, and with them all those lofty philosophical views of the harmony of nature, by the aid of which geology may claim to be considered as opening the avenues to all the branches of natural science.

An individual may be supposed whose mind had never before been awakened to this subject, and contemplating for the first time the varied nature of the surface of the earth, the sublime height of the mountains, the profound valleys, the extensive prairies without hills or vales, the oceans, lakes, and rivers, with the thousand irregular beauties which give so much grace to the face of nature. Yet might this superficial aspect awaken no more enlarged idea than that the earth was a confused mass of rocks, and clays, and sands, assembled without order or design. At the sea-shore, however, where the rocks are often worn down to mural escarpments,* and the beach is usually covered with shingles or rounded pebbles, he could not fail to perceive that these last had been brought into that state by mutual trituration from water, and had thus been divested of the angular form they had when first broken off from the parent mass, where they once were, in the language of geologists, *in situ*, or in place. These would at once remind him of the rounded pebbles of a similar character found on the dry land, almost universally, and often at a great elevation above the level of the sea, in many instances thousands of feet above the marine level.

* Perpendicular sections resembling walls.

The moment such an individual begins to think of the cause which could have produced this agreement betwixt pebbles found in such dissimilar situations, he enters upon the study of geology. This is one of its first and most important lessons, and the solution to the inquiry will be found to be the key to similar phenomena, in situations still more extraordinary. To trace these rounded pebbles to their native rocks, often hundreds of miles distant from them, they must be compared with other pebbles strewed along the whole distance to the original masses from whence they were detached; and then comes the great question of the cause which gave them the pebble form, and which brought them there. Another important question would now suggest itself to him, whether the whole substance of the crust of the earth is one solid mass of materials resembling those which appear on the surface. Although he had observed no mineral differences in the rocks he had examined, yet if the territory upon which he trod furnished several strata or beds superimposed upon each other, he might find some indications of those strata either in the mural escarpments on the sea-coast, in the valleys and ravines inland which had been worn by the action of rivers, or in the fissures which had been caused by any natural agents. In such situations he would often find the mineral structure of the rocks corresponding on the opposite sides of the valleys and of rivers, in consequence of the strata having been divided, and the same beds presenting themselves on each bank. When fully satisfied that there were various mineral beds lying beneath the arable soil on the surface containing the rolled pebbles, he would be still more anxious to learn the nature of all the beds lying beneath those he had examined. At length, extending his investigations, he would find that the same beds, containing the same kinds of fossil shells, were laid upon each other in the same order of succession at very distant points, and that where he could recognise one bed, it would serve as a key to the probable existence of other asso-

ciate strata. And thus, by travelling and practical investigation, and by books and the conversation of experienced men, the geological student at length comes to understand that the earth is not a mass of rocks, clays, and sands, accumulated without order and design, but that a portion of the superficial part of the planet, now called the crust, is composed of a series of strata, differing from each other in very material circumstances; yet observing the same order of superposition to each other at the greatest geographical distances, and having, of course, come into that order at successive periods.

Leaving the geological student to the impressions which these appearances will make upon him, the various strata of this series, as they have been observed both in Europe and in the United States, and which comprehend the whole rocky structure of the crust of the earth, as far as it has been examined, will be briefly considered. It is stated in my report of 1835,* that the whole of these rocks, considered as a geological column, which, in one sense, as will be hereafter shown, form a true geological column, may be subdivided into two divisions; the inferior, in which no animal or vegetable fossils have been observed, and therefore deemed to be inorganic, and the superior, which is organic, because in it those fossils abound. This last division is probably, in contradistinction to the lowest rocks of the preceding division, of aqueous origin, being constituted of the ruins of some of the inferior rocks, brought into a comminuted state by the action of water, which, when in a state of repose, subsequently distributed them into levels. Other rocks are the result of quiet depositions from mineral waters, and some may be the result of copious ejections of mud from ancient volcanoes. There is also another class of rocks, to which the term "intrusive rocks"-has been well applied. It is familiarly known that modern volcanoes eject rocky matter in a mol-

* Pages 12, 13.

ten state in vast quantities; these streams of lava, when indurated, become rock again, of various degrees of mineral composition, and whose constituent parts have a great affinity to the simple elements of the rocks composing the mass of the inorganic rocks before referred to. In examining the strata of the superior part, we often find them penetrated and disturbed by rocks of this character, bearing the general name of trap. It is inferred from them, and from their appearance, even in the inferior rocks, where also granitic veins are found injected, that, in the earliest stages of the crust of the earth, igneous causes were in action of sufficient force to fuse mineral bodies, and to throw them towards the surface, during which progress they penetrated the beds which lay in their way, as is exemplified in diagram No. 1, of a singular exhibition of trap injected into sandstone, at Trotternish, in the Isle of Skye.* It will be observed that the horizontal trap veins represent the handle and triple prongs of a fork, and that if all that part of the section to the left from where the handle is joined to the prongs had been disintegrated and worn away in the lapse of time, leaving the part to the right representing the prongs, or if the same part of the section had been so covered up with other mineral matter as to defy examination, the part exposed would have presented a very puzzling case of horizontal trap veins; but we can here trace the prongs to the handle, and the handle to a huge vertical dike of trap that has its undoubted origin from below.

Before the geological column spoken of is described, a few remarks may be offered on the current nomenclatures which have been applied to its various members. It was necessary in the infancy of the science, to give names to the strata as they were recognised; these were, of course, either theoretical or local, as a natural and philosophical classification and

* McCulloch's Western Islands.

nomenclature can only be the result of much experience. How many of the modern designations will be eventually retained we know not ; but for the present, independent of their own merits, it appears important that we should adhere as closely as circumstances will admit of it, to the arrangements of British geologists. It is acknowledged, even on the continent of Europe, that their great exertions and learning have raised the science to the consequence it now enjoys ; and as the most valuable records of geological literature are contained in our common overspreading language, there seems to be every motive for our present deference to British authorities on this subject, and for establishing such harmony of views between the geologists of both hemispheres as will accelerate the period of a permanent classification. For the present all geologists appear to be agreed upon the fact that we have sufficiently advanced in the examination of the structure of various parts of the earth, to perceive that the numerous strata which constitute the accessible part of its crust have come into their places in succession to each other, according to an order which may be said to be invariable, since the exceptions to invariability which occasionally occur can be satisfactorily referred to causes necessary to the constancy of succession of the strata ; for the deposition of the sedimentary rocks, or those deposited from water, is referable to the indirect action of those subterranean causes which have either dislocated or broken down the older rocks, from the ruins of which most of them are composed, or have sent to the surface such wide-spread mineral solutions, that we are able to conceive of them only by the extent of their deposites, which could never have been produced by mineral springs upon so contracted a scale as those which exhibit themselves under the present order of things. In other words, the causes which have directly or indirectly produced the deposition of all sedimentary rocks have continued to act at successive periods, sometimes disturbing the older beds, and forming

new ones from their ruins, at other times producing new strata from mineral solutions.

Accordingly one of the most interesting problems in geology is to separate those periods from each other, and to ascertain, by the mineral structure of such rocks, by the organic remains imbedded in them, and by the measure of conformability of strata to a horizontal line, the positive affinities and differences between them all. By this process, an estimate may eventually be formed of the exact amount of those affinities and differences in the most distant parts of the earth, and a consentaneous judgment be pronounced upon the nature of those causes, from the universality or locality of their effects, whether they are constitutional to the planet or not.

It is then, only, that a nomenclature founded upon those unerring principles by which nature is constituted, can be established and applied to all the strata and phenomena which have preceded the present order of things, being those which are peculiarly the objects of geological inquiry. It will probably also be found that the judgment which will ultimately be formed will be confirmed by what is passing in the present order of nature, where the sum of affinities and differences is still further extended, and where the partial production of rocky matter, whether of a sedimentary or intrusive nature, is obviously caused by the action of the same universal principles.

In accordance with the intention to treat this subject in an elementary manner, a brief account will be given of the principal strata composing the geological column, as it has been observed in Europe, noticing, at the same time, the American beds, which, from their general agreement and position in the series, have been thought to be equivalents; premising, however, that where a group of beds occurs, the members of which have a strong affinity for each other in mineral structure and organic remains, and which differ materially from the adjacent beds lying above or below, it is sometimes called a formation,

and its members are deemed to have been deposited at an epoch peculiar to themselves, and separated from any other epoch by a period of time of some duration. If the existing surface of the earth should at any future era be entombed, with the zoological and botanical bodies constituting the present order of nature, by new sedimentary deposits brought there, as the existing ones apparently have been, and a new order of things were to commence consequent to the repose after such an event, having some affinities for the preceding one, yet possessing organic bodies not belonging to it, such sedimentary deposits would, according to the received language in geology, be called a new formation. This hypothetical state of things is thought to have been often repeated in the ancient state of the planet. It is proper also to remark, that, although the members of this column preserve an invariable succession to each other, yet it frequently happens that, in various parts of the world, many of them are wanting. These deficiencies in the localities, where they are observed, are to be attributed either to the inaction of the causes to which the beds owe their origin, or to other causes, through the agency of which they have disappeared. Sometimes, indeed, the deficiency is only apparent, the strata being so much altered in appearance from the contiguity of intrusive rocks, as to assume another character. Wherever any of the strata are found, however, the order of their succession is constant, like the alphabetic order of letters, B in America being never found above A, whilst A in China, or in any other part of the world, is always found above all the other letters, and never under any of them. The intrusive rocks are of course excluded from this statement. Where A (and the same may be said of any other letter) is found contiguously overlying G, or any other bed, in such instances the intervening beds are deficient, from some of the causes before alluded to.

By such inductive steps are we awakened to a sense of those truths which geology teaches, and come to perceive that the general arrangement of the beds composing the su-

perfcial part of the crust of the earth is not incoherent and at random, but has been produced by causes both constant and general; for since, after a mature examination of the European beds, evidences of the same geological epochs are found at the most distant points, it would be infinitely a more strange thing if affinities were not found here, than it can possibly be in the eyes of sceptical persons to find some of the beds in both hemispheres considered as equivalents.

Although this order of succession exists, yet in no part of the world have all these beds been found uninterruptedly overlying each other, as they are represented in the geological column. This perpendicular section only represents all the beds which have been described as coming into their places in succession to each other. If, however, all these deposits had been made in the same locality, and had not been subsequently disturbed, such a section might have existed in nature. But, as has been before observed, some of them are wanting in every country. In the tabular view, at page 24, the strata, for the sake of convenient reference, are grouped. The beds, from the variegated or red marl to the Portland oolite, both inclusive, comprehend what English geologists have named the oolitic series; this group has an average thickness of 2,700 feet in England, but has not yet been found on any part of this continent. Chalk, also, which has an average thickness of about 700 feet in Europe, is not found here, although many associate strata belonging to the group it is a member of, and lying both above and below it, are well developed in the United States. This remarkable deposit in the countries where it exists, contains in the upper part of its white mass numerous irregular beds of nodules and plates of the dark-colored flint of commerce. Haldon Hill, in Devonshire, consists of green sands superimposed upon red marl, the intervening beds being wanting. But the chalk which lies upon the green sands in the tabular view is not there, and an unobserving traveller would cross this lofty barrier without being re-

mind of it. A geologist, however, is struck with the immense heaps of flints deposited in various parts of this hill, some in entire nodules, exactly as they are found in the chalk, and others broken up and comminuted into a thousand pieces. Looking around him, he sees at the foot of the hill a rich and broad valley with the river Ex flowing through it to the ocean, which is visible on his right. At some distance in front he sees the white chalk cliffs of Dorsetshire. He now comprehends the phenomenon, sees that the chalk has once been in position where he now finds only the flints, and that some cause has put an immeasurable water power in motion, which has scooped out the vale of Ex, and washed out all the cretaceous matter for many miles, leaving the flints behind as monuments of the deposit in which they were imbedded, and of the irresistible force of the movement which separated them. This has been found repeated in other parts of Europe. On this continent no chalk flints have yet been found, nor any other evidences that the chalk has been removed, and the same observation may be applied to the oolitic series, wanting here, since its characteristic fossils have not been found.

Of the absence of other beds of the geological series, we have remarkable instances on this continent. On the geological line extending from the State of Maine continuously, in the direction of Boston, New York, Philadelphia, Baltimore, Washington, and the falls of all the Atlantic rivers, to Wetumpka, on the Coosa river, in Alabama, there are no beds between the primary rocks at the bottom of the series, and the loose detritus and alluvial deposits on the surface, but very important members of the upper secondary and tertiary groups are found east of that line, from whence it may be inferred that they were deposited when the ocean was bounded by that geological line. Of the causes of this deficiency of strata upon so long a line, whether it is to be attributed to the early elevation of the primary rocks above the marine

level, or to causes which have removed other strata, geologists may divide in opinion; but the absence of all evidence of a disturbing force commensurate with such extended effects, strengthens the first conjecture, which recommends itself, by the simplicity of its fitness, in accounting for the phenomenon.

The following tabular view of the principal known rocks exhibits such a section as might have existed in nature if all the beds had been deposited in one locality, and had never been disturbed. It also presents, as geologists will perceive, for the first time in any tabular view, the new arrangements of that important portion of the column hitherto designated as *grauwacke* and transition formations, by those distinguished leaders of the science, Mr. Murchison and the Rev. Adam Sedgwick.

		Superficial soil or present order of nature.	Feet.
SUPERIOR OR ORGANIC DIVISION.	Tertiary order.	Upper tertiary or pliocene.	
		Middle tertiary or miocene.	
		Lower tertiary or eocene.	
	Cretaceous group: deficient in the U. States.	Upper chalk, with flints.	} 700
		Lower chalk.	
		Chalk marl.	
	Subcretaceous group.	Upper green sand.	100
		Gault.	150
		Lower green sand.	250
	Wealden group: deficient in the United States.	Weald clay.	300
		Hastings sand.	400
		Purbeck limestone.	250
	Oolitic series: deficient in the United States.	Portland oolite.	120
		Kimmeridge clay.	600
		Coral rag.	180
		Oxford clay.	600
		Cornbrash.	30
		Forest marble.	80
		Bradford clay.	80
		Great or Bath oolite.	130
Fuller's earth.		140	
Inferior oolite.		180	
Lias.	500		
New red sandstone group: deficiency not positively ascertained.	Variegated or red marl.	500	
	Muschelkalk.	300	
	New red sandstone.	300	
	Zechstein.	800	
	Exeter red conglomerate.	500	
Carboniferous group.	Bituminous coal measures.	1,000	
	Millstone grit and shale.	700	
	Carboniferous limestone.	850	
	Old red sandstone.	10,000	
Silurian system.	Ladlow rocks.	2,000	
	Wenlock limestone and shale.	1,800	
	Caradoc beds.	2,500	
	Llandoilo flags.	1,200	
Cambrian system.	Upper Cambrian.	} 9,000	
	Middle Cambrian.		
	Lower Cambrian.		
INFERIOR OR INORGANIC DIVISION.	Serpentine.		
	Greenstone rocks.		
	Talcose slates.		
	Hornblende rocks.		
	Primordial limestone.		
	Mica slate.		
	Gneiss.		
Granite.			

N. B. The figures represent the average approximate thickness of some of the beds.

It having been already stated that the rocks belonging to the superior division of this column are constituted principally of the ruins of those of the inferior division, brought into a comminuted state by the action of water, and subsequently deposited into levels, the obvious propriety of considering the column in the ascending order will be perceived. Every practical student will also see the necessity of having some knowledge of the mineral structure of the older rocks, before he can form a judicious opinion of the mineral origin of the more modern ones. The greater number of the formations of the inorganic division are put down approximatively as to their order of succession. Some of them, as the granite, are unstratified, whilst the gneiss and some others are stratified. Although all of them are not of igneous origin, yet most of them in their turn seem to have acted in the character of intrusive rocks. In some countries we have evidence of trappean matter having been ejected from beneath the granite. Whilst, however, they are not found in all countries in the order assigned to them in this column, yet they have been found every where approximating to it. In the early days of geology, when theoretical terms had more influence than at present, they were called primitive, because it was supposed they had been produced before all other rocks. The term primary has since been substituted, as expressing their antecedent state in the column, without any theoretical assertion. Geologists, on account of the extreme interest attending the study of the fossiliferous rocks, have paid such undivided attention to them, that the most ancient formations have been comparatively neglected, and an ample field has thus been left for the arrangement of this mineralogical branch of geology, where the rarer minerals and crystals may assist in pointing out, as fossils have hitherto done, the natural classification of these primordial rocks. We are encouraged to believe that this will not be deferred a long time, when we look to the splendid results of the Silurian

system which have been wrought out of the grauwackean chaos during the last four years, by the perseverance and sound judgment of Mr. Murchison.

Before entering upon any description of these inferior rocks, some observations may be introduced here, upon the two general classes into which all deposits may be arranged—those of chemical and those of mechanical origin. Although the object of the geologist is rather to arrive at just conclusions respecting the causes to which mineral beds owe their position, than to the elementary nature of the materials of which they are composed, yet some mineralogical acquaintance with their mineral constituents is requisite to discriminate between them, and every student is supposed to have prepared himself, in some degree, to comprehend the chemical laws under the influence of which mineralogical bodies take their peculiar forms. Crystalline bodies, however imperfect, are the result of chemical agencies; and where a rock is composed of regular crystals of one mineral, imbedded in a massive paste of imperfectly crystallized mineral matter of another kind, we may come safely to the conclusion that the whole mass has had a crystalline origin. There is a porphyritic granite of this kind, called Shapfell granite, in England, which is met with in various parts of the world. It is the rock upon which the coal measures of Chesterfield, Virginia, rest, and I have observed it on the eastern slope of the Blue ridge, in Madison county, in that State, and in various parts of Georgia. This rock has evidently never been disturbed as to its aggregation since its first chemical production. The other class of rocks is of a different character. When observed by the microscope, the aggregate parts appear to consist of small fragments of crystalline minerals, having been subjected to much attrition by water, in consequence of which they have lost their sharp edges, and have become rounded. Deposits of this kind, the constituents of which have been mechanically separated from crystalline bodies,

are easily recognised for the greater part. They have all been evidently deposited from water, and are classed amongst the sedimentary rocks, in contradistinction to the others, which are deemed to be ignigenous. There are a few rocks which have an ambiguous character: those limestones which have been deposited from solutions take a crystalline aspect, and many strata proximate to ignigenous rocks have been subjected to some change in their external appearance, but the exceptions will not interfere with this classification.

The common *granite* is easily recognised by its granular crystalline structure, composed of felspar, quartz, and mica, nearly equally diffused and united into a mass without any apparent cement. The varieties are numerous, occasioned by the varying proportions of its constituent parts, and the substitution of other minerals for some of them. Amongst the most remarkable are those known as graphic granite, a beautiful mineral composed almost entirely of lamellar felspar and quartz, so disposed as to present an appearance of literal characters. This variety contains beryls, garnets, and other minerals, and, where it is found in extensive deposites, as in the State of Delaware, about ten miles from Wilmington, is valuable for the manufacture of porcelain. Another variety is the porphyritic granite before mentioned, where large rhomboidal crystals of red and white felspar are imbedded in a paste of small-grained granite.

The gneiss is generally a stratified rock, often abounding so much in mica as to constitute its base. The plates of this last mineral are distributed parallel to its strata, which occasion it to split easily in that direction. Granite often passes into this rock, the quartz being absent. There is a singular rock on the prairie at the grand portage east of *Lac qui parle*, on the St. Peter's. Immense masses, some of them twenty feet high, abound there, with a laminated structure so perfect as to form a true stratification. The lamina are in many instances only an inch in breadth, and dip to the southeast with an almost

vertical inclination. It is a red granular rock, containing little or no mica, resembling granite in every particular except its stratification. Gneiss is a very abundant rock in the Atlantic portion of the United States. It is extensively quarried in the vicinity of New York and Philadelphia for architectural purposes, whilst on the hills above Georgetown, in the District of Columbia, it is in a decomposed state; the felspar having lost its cohesion, and the mica being very much broken down. The ferruginous matter belonging to this rock has accumulated by molecular attraction, showing itself in intersecting carbonaceous-looking streaks and seams where the roads have been cut through the hills, but being more generally diffused as a red oxyde. These numerous ferruginous partings, which cause the gneiss to separate into irregular masses with bright black faces, are not found in that part of the gneiss which is undecomposed in the same vicinity along Rock creek.

The characteristic rock of the mica slate formation contains little or no felspar, and has a slaty structure, with a glittering appearance. Its fissility enables it to be conveniently used for flags on the sideways of streets. It is found in the vicinity of all the gneiss districts.

Primordial limestone is found in this part of the series, but is not constant to it. In some instances it has been called saccharine limestone, from its white granular resemblance to loaf sugar. It is the material used for statuary marbles, the most valuable beds of which, those that are unmixed with siliceous particles, are very rare. Immense blocks, weighing several tons, have been sometimes transported from Italy to England for the purpose of making a single statue, which, on account of the nests of siliceous matter found in them, have proved almost valueless when worked into. No extensive deposits of it of a good quality have yet been found in the United States. There are many varieties of this saccharine limestone, however, here. It sometimes contains mica, and is

subordinate to the statuary marble : this is the variety called cipolino. In Connecticut extensive veined beds occur, traversed by serpentine. In Maryland, several varieties occur, and amongst others a paste of fine saccharine limestone, imbedding crystals of hornblende, resembling that mentioned by Mr. McCulloch* in the Isle of Tirey, Hebrides.

Hornblende rock abounds in this country on the Atlantic frontier, sometimes dark and compact, with a granular texture, at other times greenish, with a fibrous structure, and disposed to fissility ; it is sometimes micaceous, and near Wilmington, at Quarryville, on the Delaware, a locality which has supplied the greater part of the materials for the Delaware break-water, there is a beautiful resplendent variety of ovate lamellar crystals of felspar, having a slightish red color, with a hornblende base, which fuses into a fine dark enamel. This is a true porphyritic greenstone.

The talcose slates have a base of talc, with mica and crystals of sulphuret of iron diffused in them ; they are easily recognisable by their unctuous touch and glossy appearance. In the United States these slates are largely developed in what is called the gold region, especially in Virginia, the gold being in the ferruginous quartzose veins which traverse this formation.

The Germans have called all combinations of hornblende and felspar, when they have a granite structure, *grünstein* or *greenstone rocks*, and accordingly, as they are compact or fissile in their structure, they have been designated as primitive greenstone or greenstone slate. Hornblende is heavier than quartz or felspar, and, when scratched, gives a light green streak, and where it forms the principal part of rocks, they take a greenish black color. In hornblende slates the felspar itself is often green. When the quantity of magnesia is increased in the hornblende rocks, they appear to pass in-

* McCulloch's Western Islands, vol. 1, page 50.

sensibly into *serpentine*, a rock which abounds in this country in the region of the primordial rocks.

The geological student, in entering the field of observation in the United States, will find that the varieties of all the formations which have been alluded to are very numerous, and that they occasionally succeed each other in so irregular a manner as to preclude the supposition that they have come into their places in any determinate order of succession. Regarding them theoretically as the products of igneous fusion, the embarrassment is increased by perceiving some of them to be unstratified, and others stratified. That the first may have resulted from the cooling down of mineral matter when in a state of igneous intumescence, is intelligible enough; but that contiguous rocks, having the same origin, and which form perhaps the greater portion of the surface, should be disposed in parallel strata, is not so easily explained. Yet, if any one should be disposed to attribute to them the same aqueous origin to which the sedimentary stratified rocks are referred, he must remember not only that the mineral constituents of those unstratified and stratified masses are the same, but that most of them actually pass into each other by the absence or presence of one or more of their mineral constituents. What has been called the stratification of these ignigenous rocks, may be owing to the principle which occasions their fissility, such as the distribution of the plates of mica parallel to the strata. It is evident, however, that the nature of the primordial rocks has yet to be carefully studied before we can, with perfect satisfaction, believe this difference between them to be due to modifying causes, and refer these two classes of rocks to the same origin.

Much of the irregularity with which they succeed to each other is owing in some cases to the same mineral compound being repeated in distant localities, and in others to slight variations of that compound. Most of these ignigenous masses appear in the character of intrusive bodies. Granite, the

lowest rock in the series, is found in a modified form overlying fossiliferous strata in the Alps. Serpentine, which is but a modification of hornblende matter, overlies sedimentary limestone in extensive tracts of the Appenines, and trap rocks, of which modern lavas are but modifications, are found injected into almost every formation, from the granite up to the surface; indeed, in the extinct volcanoes of Auvergne, the ancient lavas have been clearly projected from beneath the granite.

There is another important rock, clay slate, not inserted in the tabular view, which is thought to pass gradually into some of the schistose primordial masses with which it is associated; yet it is a stratified body, and in its mineral structure is sometimes hardly distinguishable from the roofing slates, which are enumerated amongst the sedimentary deposits of what have been called the transition beds.

These observations on the formations of the inferior division are offered not only for the assistance of the geological student, but in some degree to incite the able mineralogists of this country who reside in the regions of the primordial rocks, to make a precise and analytic study of their mineral structure and constituent affinity with each other, and to note all the circumstances attending the order in which they are seen to succeed and overlie each other. Repeated observations made in various parts of the Atlantic frontier, will produce a great deal of valuable information. By such means alone, we shall be able to compare the natural order and constituency of the primordial rocks of the United States with those which prevail in distant countries; and thus, in time, a unity of intellect may be directed to the development of the most ancient parts of the structure of the accessible portions of the earth, and of some principles connected with the mineral and metallic bodies, that cannot fail to be valuable in an economical point of view.

We now approach a system of rocks usually found overlying the inferior division, and where organic remains are for the first time found in the ascending series. Perhaps the formation alluded to as clay slate belongs properly to this system, the general mineral structure of which is altogether slaty. The whole of this series of rocks (a luminous account of which will soon be published by the Rev. Adam Sedgwick, under the designation of the Cambrian system, from the locality where he has principally studied them) has been hitherto included, together with the Silurian system of Mr. Murchison, under the undefined names of transition and grauwacke, terms which are now likely to be entirely abandoned. Before this portion of the geological column had been adequately investigated, the theoretical term transition was generally received. It was supposed that at the point where organic remains first appeared, there existed a true natural mineral transition from inorganic to organic rocks; and if that point were established, the term would not be misapplied to those slaty masses. But the affinity of the mineral structure of some of these rocks with that of others higher up in the series caused the term to be extended so far beyond its original meaning and application, as to comprehend deposits of from thirty to forty thousand feet in thickness; and although this great slaty system was separated from the carboniferous limestone by the old red sandstone formation, itself having a thickness of ten thousand feet and more in many localities, yet some geologists included all these formations, together with the carboniferous limestone, containing a distinct class of organic remains, in the transition rocks. Henceforward, it is probable that the term will fall into disuse, in proportion as the nomenclatures applied to the Cambrian and Silurian systems shall become generally known, they having already received the sanction of the leading European geologists.

The *lower Cambrian* of the tabular view, as it has been observed in Caernarvonshire, consists principally of chlorite

schists, passing occasionally into micaceous and quartzose slates, and contains subordinate masses of white granular limestone and serpentine rock. In other localities, masses of dark glossy clay slate, devoid of calcareous matter, are found, and passing into the inferior primordial rocks. This lower Cambrian formation appears to contain no organic remains, but lead and copper are found in it.

The *middle Cambrian* of Caerffarvon and Merionethshires contains great quantities of fine roofing slate, often imbedded in slate rocks of a coarser quality; these alternate with and apparently pass into irregularly interstratified masses of porphyry. At the top of Snowdon a few organic remains are found, resembling others observed at Tintagel, in Cornwall. Some of these slates are highly calcareous, but no continuous beds of limestone have been observed amongst them.

The *upper Cambrian*, as observed in South Wales, is connected with the superincumbent formation of *Llandeilo flags*. Beds of limestone and calcareous slates occur, together with organic remains. The roofing slate of this division splits in a direction transverse to the stratification, which is a property perhaps of all hard slates. The cleavage of this mineral is considered to be the effect of crystallization.

The *Llandeilo flags*. The Silurian system, of which this is the lowest division, abounds much more in calcareous matter than the rocks just enumerated, and organic remains are more common. These Llandeilo flags rest upon the Longmynd various-colored sandstones, conglomerates, schists, and coarse slates, and are dark-colored calcareous rocks, naturally separating into flags. They contain, also, some sandstone and schists. The *asaphus buchii*, the *agnostus*, *Brongn*, and some other trilobites, differing from those of the superior divisions, which will be described in Mr. Murchison's work on the Silurian system, now in the press, are found here.

The *Caradoc beds*.^{*} The beds of this division consist, in the lower part, of thick-bedded red, purple, green, and white freestones, conglomeritic quartzose grits, and sandy and gritty limestones. Various undescribed species of trilobites, and differing from those in the overlying beds; numerous species of the genus *orthis*, together with *nucula* and *pentamerus*, are found here. The upper beds are thin-bedded impure shelly limestone, and finely-laminated, slightly-micaceous, greenish sandstone. The organic remains are *pentamerus*, *leptæna*, *pileopsis*, and *orthis*, all of new species. There are also *terebratula*; and the *tentaculites* and *crinoidea* are abundant; corals rare.

Wenlock limestone and shale. The lower beds are liver and dark gray colored argillaceous shale, rarely micaceous, with nodules of earthy limestone. The organic remains are *asaphus caud*, *calymene Blumenbachii*, *lingula*, *orthis*, *cyrtia*, *delthyris*, *orthocera*, *crinoidea*; most of them new species.

The upper beds are that highly concretionary gray and blue subcrystalline limestone, the equivalent of the well-known Dudley limestone; abounding with corals and *crinoidea*, *bellerophon*, *euomphalus*, *conularia*, *pentamerus*, *natica*, *leptæna*, *spirifer*, *terebratula*, *producta*, *orthocera*, *asaphus*, *calymene*, and various species of trilobites.

Ludlow rocks. The lower beds of this formation are sandy, liver and dark colored shale and flags, with concretions of

^{*} Mr. Murchison, in conformity with the practice of attaching the names of remarkable localities to their rocks when first described, has here very happily associated some of the most interesting traits of British Celtic history with his geological labors. The rocks comprehended in his Silurian system were observed by him in that part of the country which constituted the ancient kingdom of the Silures, that Celtic nation which so bravely resisted the Romans under the Emperors Claudius and Nero. *Caer Caradoc*, from whence the Caradoc beds are named, is the name of a highly picturesque ridge in Shropshire. Camden, the historian, supposes it to have been the locality where the celebrated leader of the Silures, Caractacus, (*Caradoc*,) made his last stand against the Roman forces.

earthy limestone. The several species of fossils are phragmoceras a new genus, asaphus, two species of cardiola, (a new genus,) nautilus, spirulites, pentamerus, pleurotomaria, orthocera, &c.; most of them new species.

These beds are separated from the upper ones by a sub-crystalline gray and blue argillaceous limestone, containing pentamerus, pileopsis, bellerophon, lingula, atrypa, terebratula, calamopora, and some other fossil corals. The upper beds are a slightly-micaceous, gray-colored, thin-bedded sandstone, containing avicula, atrypa, cypriocardia, homonolotus, (a new genus,) leptæna, orthis, orbicula, orthocera, pleurotomaria, turbo, with gigantic serpentine bodies, &c.*

It sometimes occurs that the zones of limestone which separate the Wenlock and Ludlow divisions thin out and disappear: in such cases, the characteristic division being lost, Mr. Murchison calls the united mass "the upper Silurian rocks;" and where the same characteristic division between the Llandeilo and Caradoc beds disappears, their united mass is termed the "lower Silurian rocks."

It will be perceived that the formations which have been briefly described comprehend all the deposits lying between the old red sandstone and the primordial rocks, and that some of them must necessarily be the equivalents of those grauwacke rocks which, in all the hitherto published geological treatises, figure so conspicuously, but in a very undefined manner, as immediately subjacent to the old red sandstone, which last, notwithstanding its vast bulk, has been considered by an experienced and popular geological writer† as a true grau-

* Mr. Murchison's Fossils of the Silurian System, when published, will add weight to the opinion expressed in my report of 1835, of the "great uniformity of the genera in the inferior rocks of both hemispheres." He has compared some of the fossils of this country with those of his Silurian system, and says, in a late letter, "*many of your organic remains are specifically identical.*"

† Bakewell.

wacke also. The same objections which apply to the term transition, apply to the term grauwacke. The different formations of the Silurian and Cambrian systems are distinguished by fossil remains peculiar to each of them, and nothing would more retard the progress of scientific perspicuity, than to retain an inharmonious term which is hardly definable, merely because certain rocks having an affinity in mineral structure are found repeated in various parts of them. The term grauwacke seems originally to have been used by the miners as a provincial word to express the character of those conglomeritic beds formed of gravelly fragments of various sizes of the older rocks, imbedded in a paste of slaty matter, which are even occasionally found in the coal measures, and which abound sufficiently in the formations subjacent to the carboniferous limestone, to justify the belief that an immense period of time must have elapsed between the first appearance of these conglomeritic beds and the deposit of the carboniferous limestone. We can no longer, however, with any propriety, retain this term for the beds immediately subjacent to the old red sandstone, since Mr. Murchison shows that his Silurian system, in which those beds are comprehended, contain few if any of those beds which were first named grauwacke by the German mineralogists. This term, if at all continued, will probably be restricted hereafter to some of the beds of the Cambrian system.

Old red sandstone. Mr. Murchison proposes to divide this formation into three parts: the lowest consists of flaggy, highly-micaceous, hard, red and green sandstone, with some new species of avicula, pileopsis, some small orthocera and ichthyodorulites. The central portion is formed of red and green concretionary limestones, with spotted argillaceous marls and beds of sandstone, containing undescribed genera of crustacea. The superior portion is an inorganic quartzose conglomerate, overlying thick-bedded sandstone.

As the formations hitherto considered have a character belonging to them which is not common to the incumbent beds, especially on this continent, a few remarks here on the highly-inclined strata of the stratified masses serving to develop some important principles of the science, cannot but be useful to the practical student.

In every part of the world where geological investigations have been made, the rocks hitherto enumerated have generally been found, and always in the same determinate order, with the exception of that occasional irregularity before alluded to amongst the ignigenous rocks. They occupy, also, more extensive areas than the rocks which have succeeded to them, from which it may be inferred that the causes which produced them were more intensely in action. Granite is every where. The body of the great Himalaya chain in India is gneiss; it abounds also in the most northern known lands, in the Andes, the Alps, and the Pyrenees. In western Africa the rocks forming the banks of the Rokelle are granite, gneiss, mica slate, and the lower slates. Upon the northern Atlantic frontier of the United States, the whole series of these last-mentioned rocks can be traced, alternating variously with each other, uninterruptedly to the western lines of Massachusetts and Connecticut, with the exception of the carboniferous sandstone along the line of the Connecticut river. Further south, the same zone of primordial rocks is to be observed from the falls of the rivers that empty into the Atlantic, to the extensive Atlantic* primary chain, embracing those auriferous

* In my report of last year, at page 33, the necessity of giving a general name to this chain was urged, on account of the confusion produced by the various designations it receives in different localities, such as Blue ridge, Alleghany mountain, Iron mountain, Unaka, &c.; and Atlantic Primary Chain was proposed as expressing its general and predominant character. The mineral structure of this chain has never been thoroughly examined, but, at numerous points where I have visited it, it varies from the primordial rocks to some of the members of the Silurian system. At West Point, where it is divided by the Hudson river, the predominant character is gneiss; at Harper's Ferry, it is a variety of stratified slates; in Madison

slates and other rocks known as the gold region of the United States.

Wherever the geological student finds the strata thrown out of the horizontal line, and dipping in any direction, he may, with few exceptions, enumerate such beds amongst the formations hitherto described, the old red sandstone inclusive. Few

county, Virginia, it consists of the members of the lower Cambrian rocks, very much studded with points of native copper, with a belt of porphyritic granite running at its eastern base. In other parts of this chain I have observed quartzose sandstones and conglomerates prevailing, of undoubted aqueous origin; whilst in some districts, slates of a green quartzose character contain, imbedded and mixed up and alternating with them, true porphyritic masses. This admixture of rocks, to which different origins are attributed, appeared to me to justify a designation for this chain which expressed, in some degree, its predominant mineral character. The only proper use which those who write on this subject, at present, can make of theoretical terms, is to give the greatest degree of perspicuity to what they say. The terms primary and primordial are, undoubtedly, always very properly applied to the lower rocks, to which an igneous origin has been attributed; but may fairly be extended to any series of rocks constituting a great geographical boundary, to which they give a predominating character, especially at a period when the term Transition is passing into disuse, and leaves the term Primary freed from theoretical views, to class all the rocks in below the secondary order. I have felt myself authorized to do this by the example of one of the most distinguished men of this age. Professor Sedgwick, of Cambridge, England, in his "Introduction to the general structure of the Cambrian mountains," (Transactions of the Geological Society of London, vol. 4, part I, page 66,) observes: "I believe, however, that there is a broad mineralogical distinction between the *primary stratified rocks* (including under that term all stratified rocks inferior to the old red sandstone) and the secondary." Professor Phillips, also, the able and experienced Professor of Geology in King's College, London, has, in his Guide to Geology, page 19, classed all the rocks beneath the old red sandstone as "Primary strata," adding, "It is usual to class the upper systems under the title of Transition strata, and to confine the name of Primary to the mica, schist, and gneiss systems." And at page 72, he says: "Thus, for example, of the extinct crustaceous animals, called Trilobites, the far greater portion of those found in England belongs to the *primary strata*. They also characterize the *primary system* of North America." In fact, he generally speaks of the beds beneath the carboniferous group as the "fossiliferous primary strata," and, at page 124, distinctly includes all the beds of whatever kind, constituting what, on account of its geographical situation principally, I had named "Atlantic primary chain," in the following passage. "The older strata are now very generally called primary, and an indefinite upper group or portion of them is, by many geologists, called the Transition series, as marking

of the rocks of the United States lying above them in the geological column, are found with the planes of their strata making any sensible angle with the horizon; and as all stratified masses must be supposed to have been deposited with their planes horizontal, we are necessarily compelled to inquire why the beds of the lower portion of the column dip at very acute angles, and are frequently found vertical, when

a passage from the primary to the secondary strata. This is perhaps needless, for such passages are not thought necessary to be marked in other instances. Our knowledge of the *upper primary* (transition) strata of England and Wales has been very much augmented by the recent labors of Mr. Murchison." In speaking of the lowest crystalline rocks, I have used, generally, the term *Primordial* as expressing their place in the column, and being free from all theoretical allusion.

I have been induced to make these observations by seeing, in a geological report, made early in the present year, on the geology of Virginia, by a person in the service of that State, a remark, arising out of the designation I had applied to this chain, expressive of his deep regret that Mr. McClure, with others, including myself, should "have indulged so much of the spirit of superficial and precipitate generalization." I shall not express myself, with that writer, that it is "deeply to be regretted" that he should thus voluntarily have exposed his want of information on the state of the science, as we have too many instances of persons, engaged in a new pursuit, endeavoring to draw the public attention from their own deficiencies by rash and silly insinuations against those who have preceded them. Some more experience as a practical geologist may, in the end, teach him that an official report, at least, is not the proper place from whence to cast imputations at his senior fellow-laborers, and that he who commits so great an error incurs the risk of being deemed both superficial and presumptuous. It is to the honor of my friend Mr. McClure, one of the most zealous and disinterested geologists this country ever possessed, and who is now in a distant country, that his lucid understanding applied a designation, years ago, when the science was first raising its head here, to the district in question, which is now found to be perfectly appropriate. The decorum I feel bound to observe upon this occasion, restrains me from remarking further upon the impropriety of converting the geological literature of this country into a vehicle for impeding the progress of geological information. To make the geology of the United States clearly out, there ought to be a unity of purpose amongst our geologists, and a perfect harmony of conduct. But, returning to the designation which occasioned this note, I think, for the various reasons which have been given, that the term *Atlantic primary chain* is well adapted; yet, if, after a more minute investigation of the chain in its full extent—which I hope to accomplish hereafter—it shall be found that the sedimentary rocks predominate, which I do not believe, the term *Atlantic chain* may still be preserved, since it fronts the Atlantic, and differs from all the other Alleghany ridges in its mineral structure.

the others are horizontal. The inference is obvious that some disturbing cause operating from below has thus tilted these beds up, and that it prevailed with greater intensity and constancy during the earlier geological periods than it has done since the deposition of the old red sandstone. This striking difference in the position of the planes of mineral beds belongs to a class of geological phenomena so various and important, that it is proper in this place to mention some of them, that the student, from perceiving how cognate they are to each other, may form his judgment as to the reasonableness of the cause to which their common origin has been attributed. It will also afford an opportunity of alluding to some complicated cases under which rocks sometimes present themselves, and which, being deceptive, require accurate observation.

In diagram No. 2, the transverse lines making an angle of 45 degrees with the horizon, represent the beds formerly deposited in a horizontal plane, tilted up. Such rocks are said to dip 45 degrees, and this slope of their planes often increases until they are set completely upon their edges, and become vertical or perpendicular. But at whatever degree they may dip, the uppermost edges of the beds thus tilted up always have the same *strike* or *direction*. When they dip to the east, their edges of course run north and south. This phenomenon is a source of constant annoyance to those who travel on wheels in the Shenandoah valley of Virginia, where the roads, running nearly east and west, cross the edges of the upheaved limestone beds at right angles. It will not escape the reader that in countries where the dip, as frequently occurs, is constant through a great area of country, the *strike* of the beds, being known, may be useful to travellers in doubtful cases, and in the dark, in pursuing their course.

Amongst the instances where a student is apt to be deceived by the appearance of stratified beds, if observed at a distance, or whilst rapidly passing them, is that of his being

led to suppose he is among the secondary beds, whilst in fact they are highly inclined. He may be passing an escarpment from the north, where the stratification, as in diagram No. 3, appears to be horizontal, whilst in truth it may be highly inclined: therefore, if, whilst in a region where the beds have a constant dip, he should unexpectedly come to a section of them where they appear to be horizontal, it is always best to stop and examine with some care, as, at some turn of the line, or perhaps by partially uncovering them, he may discover that the strata have a considerable dip, as is exhibited in the diagram.*

The valley of the Potomac exhibits a great number of instructive phenomena connected with the dip of rocks, which furnish examples, upon a very large scale, of the singular manner in which the causes to which they may be attributed have operated upon the whole line from the southeast edge of the great western bituminous coal field to Georgetown, in the District of Columbia, a distance of two hundred miles, and a still greater distance north and south of the valley. All the beds, with unimportant exceptions, seem to be disposed into anticlinal and synclinal lines.† But of these I shall give some interesting instances when I come to speak of my excursion up that valley on my way to the Northwest Territory last summer.

* At the top of Cacapon mountain, about three miles from Bath, in Morgan county, Virginia, there is a remarkable locality called "Prospect Rock." From the summit of this escarpment there is a very extensive view of the course of the Potomac river across the inclined beds of the country from the great Alleghany mountain, where the bituminous coal measures begin. On descending to the foot of this cliff, and standing in front of the escarpment, the beds appear horizontal; but at the pass which leads down from the top, they are seen to be tilted up about 18 degrees.

† The first of which terms is used to express a line created by a dip of the same beds in opposite directions. Thus, a set of beds which in one part of a given area of country whose general planes are horizontal, and which lie as at A, in diagram No. 4, might, in another part of the same area, take the form of B, which is anticlinal.

There is another case of complication connected with the inclined beds, which the student will easily see the great importance of. Rocks whose planes are horizontal, or in any manner parallel to each other, are called conformable, but it frequently occurs that they are unconformable to each other. Diagram No. 5 will give an example of this. Here the stratum *a* may represent the new red sandstone (see the tabular view) at the surface; and as it most frequently, when found, lies superimposed on the bituminous coal measures, it would be consistent with practical and theoretical knowledge to dig through it at *N* for coal, the true position of which may be at *b*. In this case, the miners, beginning midway of the diagram, and sinking their shafts *o o o o* towards *N*, might come upon the strata, *e, f, g, h*, which lie at a great angle to *a*, and are unconformable to it, having been tilted up into this inclination before the horizontal beds, *a, b, c, d*, were deposited. All this expense would be wasted by unskilful persons; but an experienced miner, acquainted with practical geology, and understanding the reason of this deficiency of the intervening beds, *b, c, d*, beyond the point *+*, would sink through *a* further towards *S*, and thus be rewarded by the discovery of *b*, containing coal veins in their regular position.

The stratified inclined rocks comprehended in the Cambrian and Silurian systems of Europe, which have been spoken of, have many of their proper equivalents in the various formations which occur up the valley of the Potomac; between the great falls of that river and the southeast edge of the great Western coal field, and whose beds have been hitherto alluded to by geological writers, as constituting the transition and grauwacke rocks of the Alleghany ridges and country parallel to them on the southeast. The inspection of this valley is highly favorable to the acquisition of just views respecting the geological structure of those numerous ridges, sometimes continuous, sometimes interrupted, sometimes flexuous, and generally anticlinal. An accurate knowledge of their

mineral structure and true magnetic direction would be of singular importance to the country. No portion of the territory of the United States which I have visited appears to me so complicated in its geological structure, or is certainly so little known, as the area in question, within which all the important beds of anthracite coal are found, and which has been supposed,* but I believe erroneously, to embrace a portion of the bituminous coal field of the Western country.

All the secondary beds of this portion of North America, which are not reached by tide-water, are limited by those ridges, which have a general parallelism to each other, in a direction usually about N. N. E. and S. S. W. It is a remarkable circumstance, deserving much weight in geological theory, that the general magnetic range of all the transition chains of Great Britain, of the south of Scotland, of Devonshire and Cornwall, of Wales, of the Isle of Anglesea, and of many parts of the European and other portions of the trans-Atlantic continent, has the same line of elevation, the longitudinal axes of the principal ridges as well as those of the minor ones, trending nearly from N. E. to S. W. and several of them having an anticlinal structure; whilst in many situations the line of direction of the carboniferous limestone and incumbent coal measures is, in Great Britain as well as in the American area I am treating of, unconformable to the tilted strata below, and seldom deviating many degrees from a horizontal line. These parallel ridges come down from the N. N. E. through the Middle States, and pursue a S. S. W. course, until they are cut off in Tennessee by the Cumberland mountains, the true eastern limit there of the great Western bituminous coal field. In the State of Pennsylvania and in Virginia many of them contain rich deposits of anthracite coal, and are apparently prolonged to the south in a continuous line, and without material interruption. Yet in places

* See report of the committee of the Senate of Pennsylvania upon the subject of the coal trade, 1834-'5.

they depart from their parallelism by marked deflections from the general course. Occasionally a ridge will slope off and be discontinued, its place being supplied by another ridge holding the same parallel, or deviating somewhat from it. Sometimes by a sudden flexure they almost double back, and not unfrequently cross the valleys at right angles to the general parallel. In some localities the beds are tilted up almost to a perpendicular line, in others they are anticlinal; some sections of them give the perfect form of an arch, and occasionally they are contorted and twisted in an undescrivable manner. It is difficult for any but those who are practically conversant with the complicated state of the geology of this area, to form an adequate conception of the labor and experience requisite to disentangle the complex phenomena which present themselves in passing through any sectional line of this system of ridges. Many proprietors, deceived by the apparent continuity of a particular line of elevation containing valuable deposits at other points, have, from slight indications of coal and iron upon their lands, imagined themselves, by anticipation, in possession of inexhaustible resources, and capital has been vainly expended to bring them into action. Others, from finding coal in the anthracitic area, having slight bituminous properties, have jumped at once to the conclusion that the locality was comprehended within the limits of the Western bituminous coal field, that the coal at greater depths would have all the qualities of the best bituminous coal, and would justify a great expenditure of capital to get it to the Atlantic cities.*

* Mr. Richard C. Taylor, in his valuable paper "on the relative position of the transition and secondary coal formations in Pennsylvania, and description of some transition coal and bituminous anthracite," &c. has sufficiently proved that the supposed bituminous veins of Broad-top mountain, Bedford county, Pennsylvania, belong to the anthracite region. (See Transactions of the Geological Society of Pennsylvania, vol. 1, part 2d, page 177, 1835.) These bituminous anthracites were mentioned in my report of last year, page 24, amongst the instances which show a progression in the quality of coals inconsistent with the general opinion entertained of their vegetable origin.

These mistakes are natural, for we easily believe in what we desire. It is impossible in our present defective state of information, without a map which accurately gives the magnetic course of the ridges, to form any but a conjectural opinion whether the anthracite coal of Alleghany, in Virginia, is connected by a particular line of direction with any one of the great deposites of Pennsylvania; and any landholder who has not had leisure to pay much attention to practical geology, and who has been told that anthracite is always non-bituminous, is readily to be excused when, upon finding bituminous coal on his lands, he comes to the willing conclusion that they are within the great bituminous coal field. The public mind can only be properly enlightened on such important subjects by minute and accurate surveys conducted by men of approved experience. All the complexity of the phenomena I have spoken of would then be reduced to an intelligible and instructive system; the topographical position of the ridges would be accurately laid down, their mineralogical character would be truly described, every locality would be identified and have its proximate mineral value fixed.

The next formation succeeding to the old red sandstone, both in Europe and America, is the carboniferous limestone, the base of a group of coal-bearing beds, in which the coal is most developed in the superior member, which has consequently received the distinct name of coal measures. The order in which the members of this group succeed each other in both hemispheres, is represented in the following table;* the agreement in the mutual order of succession of the beds of this series is not more remarkable than that which prevails in the lower part of the column.

* The European part is taken from Mr. Phillips's admirable work, "Illustrations of the Geology of Yorkshire," p. 11. London, 1836.

Localities.	United States.	North of England and Scotland.	Derbyshire, North and South Wales.	Belgium, and South of England.	Ireland.
<i>Coal measures.</i> Near Cumberland, in Maryland, and Hampshire county, Virginia.	Coal, shale, grits, and iron stone.	Coal, shale, grits, and iron stone.	Coal, shale, grits, and iron stone.	Coal, shale, grits, and iron stone.	Coal, shale, grits, and iron stone.
<i>Millstone grit and shale.</i> Whitely county, Kentucky, Falls of the Cumberland.	Limestone, - -	Limestone, -	Limestone shale. (Derbyshire.)	-	Kulkeagh grit.
Near Rock Castle river, Kentucky.	Grit conglomerate, -	Grit stone, -	-	-	Lochearn shales & grits.
Down the Cumberland to the Ohio.	Shale, with coal veins,	Shale, with coal, -	-	-	Enniskillen limestone.
	Compact limestone, with numerous fossiliferous beds and bituminous shale. 8 feet vein of coal in Illinois, opposite St. Louis, Missouri.	Lower series of limestones, with coal occasionally.	Mountain limestone of England.	Limestones and shales.	
Western part of Bedford county, Pennsylvania.	Alternations of red sandstone and limestone, which pass into conglomerates of the old red sandstone formation.	Alternations of red sandstone and limestone.	Alternations of red sandstone and limestone.	Alternations of red sandstone and limestone.	Alternating red grits and limestone.
		Old red sandstone.	Old red sandstone.	Old red sandstone.	Old red sandstone.

Although there is a true succession of the beds just enumerated in this group, yet it by no means occurs that the members of the group are all found in the countries where the formations even exist. In some instances many of the beds are entirely deficient, and in numerous cases they are extremely thick, whilst in others scarce a trace of them appears even to have been deposited. In some countries the coal measures are entirely distinct from the millstone grit and shale, and carboniferous limestone, whilst in others they are almost blended together by alternations of sandstones, limestones, and shales. In the State of Maryland, pursuing the road from Hancock to Frostburg, near Cumberland, the carboniferous limestone does not develop itself, as in the Western country, in extensive horizontal areas. On leaving the highly-inclined Silurian rocks, red shales and sandstones succeed to each other. At Flintstone there are beds of limestone containing abundance of organic remains having a strong affinity to those of the carboniferous limestone, but to these immediately succeed alternating sandstones, shales, and slaty limestones; and thus the country rises from Cumberland to Frostburg, about 1,300 feet, where is one of the richest and most regular developments of the coal measures in the United States, with little indication, except what is gathered from fossils, of that carboniferous limestone which has such a splendid extension in various parts of the Western country, and through which the Mississippi flows more than a thousand miles.* It is the very reverse of the picture which the same formations present on descending the country from the Cumberland mountains, by the way of Sparta, to Nashville, in Tennessee. At the summit of those mountains, the sandstone contains nothing more than indications of bituminous coal, whilst, on descending, the carboniferous limestone immediately develops itself, in great force, to a depth of eight hundred feet, to where the Cumberland river loses

* This is the preponderating formation in Ireland.

itself in the Ohio ; resembling in a degree the calcareous masses in England and Wales which have given rise to the name of mountain limestone. The conglomerates likewise, which in some parts of the country alternate with the lower beds of the carboniferous limestone, in others are entirely detached from it, and form the upper bed of the old red sandstone, as is more frequently the case in Europe. These local differences in the condition of proximate beds, whilst they show an irregularity of action in particular localities, prove that the same cause to which they owe their origin operated to produce these analogous deposits in both hemispheres. Extreme as the difference is between the state and extent of the carboniferous limestone in various parts of the United States, it is equally remarkable in Europe, especially in Great Britain. There, no district where this formation prevails, can scarcely be said to furnish a perfect mineral type to compare with that of any other part of the country, so much are the calcareous deposits varied by alternations of shale, the thinning out of beds, and other incidents. An adequate knowledge of the organic remains belonging to this formation will however be a sufficient guide to the student to identify the deposit.

The great purity of most of the beds of the carboniferous limestone furnishes strong evidence that they have been deposited from mineral waters holding carbonate of lime in chemical solution, as we find them doing in our times. It is true some of the beds are intermixed with argillaceous matter, and hence become less fitted for economical purposes ; but this circumstance disposes to the belief that these strata had their origin from below, rather than from the destruction of pre-existent continents, an opinion which some have entertained, since, in this latter case, the heterogeneous admixture must have been more general. A great number of the beds are loaded with nodules and layers of chert, resembling, in a remarkable degree, in their connexion with the limestone, the manner in

which detached masses and layers of flint are found lying in the chalk formation. The beds of the Cumberland river, two or three miles above Nashville, and those near Herculanum, on the Mississippi, furnish striking instances, especially at this last-named place, of the parallel disposition of the cherty layers.

The next formation in the series is the *millstone grit and shale*, the inferior part of which, when well defined, consists of shales, with occasional beds of limestone and coal. The upper part is made up of coarse sandstones or grit, with pebbles of quartz. This is an extensive formation in England, occupying a considerable area in the central parts of that country, between the 53d and 54th parallels of latitude, where it divides the great coal field of the large manufacturing towns, and runs up alongside of the carboniferous limestone to the coal measures of the northern counties. As it proceeds to the north, its character is less defined, and the formations between which it lies run more immediately into each other, presenting regular strata of limestone, with numerous subordinate beds of coal. In the United States the millstone grit and shale is cut through by the Cumberland river, in Whitely county, Kentucky, to a depth of 700 feet; the conglomerate part being about 500 feet thick, and the shale, with three horizontal good veins of bituminous coal, each from three and a half to four and a half feet thick, being about 200 feet. At the gap of Wills's mountain, in the vicinity of Cumberland, there is a fine exhibition of this formation, in an escarpment between 800 and 900 feet. The inferior is a reddish chocolate-colored shale, of which the superior and greater portion is a gray quartzose sandstone. On rising the Alleghany mountain* from Shellburgh, in Pennsylvania, the quartzose conglomerate incumbent on the shale is found near the summit. Mr. R. C. Taylor, in his instructive paper accompanying "a section of the Alle-

* This is the general name given to that lofty ridge which separates the bituminous coal measures from all the other Alleghany ridges.

ghany mountain and Moshannon valley, in Centre county, Pennsylvania,"* notices the same "conglomerate rock or pudding stone, composed of white quartz pebbles, set in a coarse grit," as underlying the inferior beds of the bituminous coal measures.

The coal measures usually consist of repeated alternations of micaceous sandstones in thick beds, or, when thinner, in incoherent lamina, alternating with shales; shales, beds of iron stone, fire clay, bituminous coal, and occasional beds of limestone. In these circumstances, the great coal fields of South Wales, central England, northern England, Scotland, Ireland, and the other great coal countries of Europe all agree. There is perhaps not a section to be obtained from any mine in any of these districts, for which something like an equivalent could not be found in the other districts, as to their general approximating character. The veins vary in width, from seams of a minute proportionate part of an inch to upwards of thirty feet, and, together with the veins of iron stone and argillaceous iron ores, constitute, as is generally known, a most important part of the wealth of the British empire. The structure of the Western bituminous coal measures of the United States resembles closely those of Europe, except in the circumstance that they are not so much dislocated by disturbances from below; and one of the objects of this sketch of the structure of the geological column being principally to show the general agreement in the order of succession of rocks in both hemispheres, which the coal itself makes sufficiently manifest, I shall defer the particular consideration of the coal measures of this country to another part of this report.

Being now arrived at the point where that deficiency in the United States of no less than twenty-one important strata of European rocks, estimated to contain a geological thickness of 5,500 feet, commences, beginning with the Exeter red con-

* Monthly American Journal of Geology and Natural Science, p. 433.

glomerate, and ending with the weald clay, both inclusive, (a very remarkable deficiency, which I was the first to point out, in the year 1828,) I shall merely advert to the prominent characters of the different mineral beds, that any student into whose hands this report may come, may have an opportunity of applying those characters to any rocks he may meet with, which are not in accordance with those of the rocks hitherto alluded to. In an economical point of view, the formations in question, not containing the precious metals, or much of the useful ones, or embracing any important deposit of coal, are not so much to be regretted, except, perhaps, on the score of the fine freestones they include; but nothing, as will hereafter be seen, can exceed the surprising interest which the organic remains embraced in them have excited.

We now come to a series of formations constituting the *new red sandstone group*, which varies very much in its structure in different portions of Europe. The whole group, however, may be divided into five portions—the *variegated marls* of the Vosges in France, the *muschelkalk* of Wurtemberg and other parts of Germany, the *new red or variegated sandstone*, the *magnesian limestone* or *zechstein*, and the *Exeter red conglomerate* or *tottliegende*. These will be briefly noticed in the ascending order.

The *Exeter red conglomerate*, or supposed equivalent of *tottliendes*, is a conglomerate formed of beds which have preceded it, fragments of the carboniferous limestone forming a considerable portion of its structure. It is called in Germany *tottliegende* or dead stratum, in contradistinction to a bed of copper slate which rests upon it, and which is worked for the metal it affords, itself producing none.

The *magnesian limestone* or *zechstein* varies very much in England and Germany. Professor Sedgwick* has described

* Transactions of the Geological Society of London, vol. 3, part 3. "On the geological relations and internal structure of the magnesian limestone, and the lower portions of the new red sandstone series, &c. By the Rev. Adam Sedgwick," &c.

this formation with great ability and detail as it exists in the north of England, considering it the equivalent of the zechstein* of Germany. In Nottingham, Derbyshire, Yorkshire, and Durham, however, it differs essentially in structure and arrangement, consisting of marly slates and compact and shelly limestones, with a great central deposit of yellow magnesian limestone, both compact and laminated. Some of the beds have an extraordinary quantity of magnesia contained in them, whilst others, with irregular concretions of crystalline limestone, have no magnesia, but occasionally an oolitic structure. The fossil fishes found in this formation resemble those of the *kupferschiefer* or copper slate of Germany. The German beds of this formation are provincially called "asche," (the loose marl,) "stinkstein," (fetid limestone,) rauchwache, zechstein, and kupferschiefer. The rauchwache, when very porous or rather cellular, has often a thickness of from forty to fifty feet. The kupferschiefer has a mean thickness, in the Mansfeldt country in Thuringia, Franconia, and the Hartz, of about one foot.

The *new red or variegated sandstone* is named after the colors red, white, blue, and green, which distinguish this rock. In some parts of Germany it includes conglomerates. Rock salt and gypsum are found in it. Occasionally the mica it contains is sufficiently abundant to render it schistose.

The *muschelkalk*, which is deficient in Great Britain, is a gray compact limestone, passing into marls.

The *variegated marls of the Vosges* pass into the lias, the superincumbent formation. They are generally of a red and greenish color, and contain dark schistose seams and thin beds of quartzose sandstone. Salt and gypsum are found in the inferior part. The passage of this rock into the lias is not marked in England by these characteristic marls. If there are

* Formerly the provincial name of a single bed, now the scientific name of a series of beds.

any rocks in the United States which deserve to be examined with the most precise accuracy, with a view to institute a comparison with the members of this group, I should point to those which are included in Mr. Hitchcock's paper* on the geology of the Connecticut, where, amidst red argillaceous schistose sandstones, in the valley of the Connecticut, fossil fish are found in a bed of bituminous shale of a mean thickness of about ten feet. Mr. Hitchcock states in that paper that Mr. Brogniart was of opinion the Connecticut formation had the strongest resemblance to that of the bituminous marl slates of the copper mines in the country of Mansfeldt and Hesse, and that he did not consider the occurrence of thin beds or veins of coal as opposed to his opinion, which of course was founded upon description and upon specimens. These seams of coal are thin, not exceeding one inch, yet sufficiently numerous to have induced Mr. Hitchcock, in his minute and admirable paper for the period in which it was drawn up, (1822,) to name it the coal formation, a term which invites a great deal of investigation, on account of the great value of the results connected with it. I would remark here, that the occurrence of seams of bituminous coal by no means identifies the rocks in which they are found with the regular coal measures, since, without speaking of other portions of the geological column, it is stated by Professor Pusch† that seams of coal from three to twenty-five inches thick are found in Poland between the muschelkalk and the oolitic series, in the very group now under consideration—a circumstance which strengthens the analogy between this group in Europe and the coal formation of Connecticut. To this may be added the important fact of the presence of copper in both formations, which, although existing under different conditions in each of them, may have been produced in each by the same cause. In Germany the copper is obtained from the stratum of slate in which it is distributed,

* Silliman's Journal, vol. 6, p. 73.

† Journal de Geologie.

and which, as has before been observed, reposes upon the conglomerate bed below; whilst in Connecticut the carboniferous rocks alternate with intrusive rocks, and the copper, according to Mr. Hitchcock, is "found on the margin of the greenstone and coal formation, and the veins always pass, either laterally or perpendicularly, from one rock into the other." The presence of the copper in both instances is probably owing to the disturbance which in the one instance produced the conglomerate on which the kupferschiefer rests, and in the other to the intrusion of the greenstone beds amongst the beds of the coal formation, laying, frequently at an angle of 40 degrees with the horizon, beds which originally were deposited on a horizontal line. My own observations of these Connecticut carboniferous beds, which have been made at various intervals, whilst passing too rapidly through the country, have led me to the opinion that they form part of the regular coal measures very partially deposited in this portion of the United States.

The *lias* is considered to be the lowest formation of the *oolitic series* of rocks, so called from the calcareous beds of the series being distinguished by the general prevalence of a peculiar structure, their substance being more or less composed of small ovula or concentric egg-form grains of carbonate of lime, resembling the roe of a fish, from which resemblance it was usual once amongst mineralogists to denominate oolite rock roestone.* In Great Britain, and on the continent of Europe, this formation has a very general character, sometimes masses of argillaceous marls predominating, and at other times, especially in the lower portions of the formation, beds of limestone, with an occasional oolitic structure. In England this deposit traverses the whole kingdom, the general direction being east of north, in a somewhat curved line, from near 50°

* Some beds of the carboniferous limestone are oolitic in the United States, which is the case in the same formation in Europe.

30' to about 54° 30' north latitude. In that country the mass of the deposit consists of a blue clay, somewhat bituminous and exceedingly pyritiferous, containing numerous courses of iron stone and septarian nodules. Arenaceous limestones and beds of sandstones are enclosed in this, and, towards the bottom, very characteristic beds of pure blue and white limestones, useful as lithographic stones. This structure of the mass gives it an external appearance, which distinguishes it so much from all other formations and groups that it is impossible to mistake its characters. But the surprisingly interesting organic remains which are entombed in it, and which will be hereafter alluded to, have established its still more general character, wherever it has been observed. I have not seen any thing resembling it in any part of the United States.*

It will be evident to all who consider the general structure of the oolitic series, that it could not have escaped observation had it existed within those parts of the United States which are known to geologists; for, taking it as a mass, as it is found in Europe, where, from local causes perhaps, some of its members are irregularly distributed, it presents three distinct argillo-calcareous deposits of a mean thickness of about five hundred feet, alternating with other deposits of a calcareous and sometimes arenaceous structure. These three argillaceous masses are the lias, the Oxford clay, and Kimmeridge clay, and the causes which deposited them have been so general as to have been simultaneously in action in England, France, and Germany.

* I do not know whether the writers on American geology (Silliman's Journal, Oct. 1835, Jan. 1836,) who still continue to describe various members of the carboniferous limestone as the equivalent of the lias, have ever been in Europe and have examined the lias beds there. I should think not. Having had sufficient opportunities of comparing the American localities referred to, with the lias in various parts of Europe, I can but repeat that the characteristic fossils of the lias have not been seen here, and that the mineral affinities of the American beds in question, as well as their fossils, class them beyond a doubt in the carboniferous limestone.

Some of the English writers have found it convenient to separate the oolitic series into four divisions, placing the Portland oolite and the Kimmeridge clay in the first division, (descending-order,) the coral rag and Oxford clay in the second, the cornbrash, the forest marble, the Bradford clay, the great oolite, the fuller's earth, and inferior oolite, in the third, and the lias in the fourth.

The third division, now about to be noticed, is generally called the lower or Bath oolite formation, on account of the beauty and value, for architectural purposes, of the freestone taken from the great oolite bed near Bath.

The *inferior oolite* is in some places an arenaceous deposit, sometimes superimposed by limestones, with occasional oolitic iron ore, and underlies a stratum of pure aluminous earth, called fuller's earth. In Yorkshire this bed is ferruginous and shelly in its fracture, and is subjacent to sandstones and shales, with seams of bituminous coal.

The *fuller's earth* is not a general deposit, but is found very valuable in the useful arts.

The *great oolite* is the distinguishing member of this division, and furnishes the freestone for the public and private buildings at Bath, in England, as well as in Normandy and other parts of the continent.

The *Bradford clay* is a partial deposit, remarkable for its very perfect specimens of *apicrinites rotundus*, or the round, pear-shaped encrinite.

The *forest marble* is a coarse, shelly, oolitic limestone, associated with sands and sandy accretions. It is a remarkable bed in the geological history of the series for having produced the first specimen of a quadruped, the *didelphis bucklandi*, an extinct species of opossum.

The *cornbrash* is a coarse, shelly limestone, owing its somewhat dissonant name to the facility with which it disintegrates and yields to the plough, being, according to the old provincial term, *brashy* or breaky enough to enable the plough to

prepare the surface, where this rock prevails, for wheat, always called corn in England. In Yorkshire the sandstones, shales, and seams of coal repeated, are subjacent to this stratum, and are conceded to be the equivalents of Mr. Murchison's coal seams of Brora, in the oolitic group of Scotland, which he first described.

The *Oxford clay* is a dense, blue, argillo-calcareous mass, including stony beds called *Kelloway rock*. This is an extensive deposit, as well on the continent as in England, where, with its associate members of the oolitic series, it describes an incurved line through the kingdom, following the course of the lias.

The *coral rag* is an oolitic rock, lying between an upper and lower calcareous grit in the north of England. The ovula are frequently as large as peas, which has occasioned the rock in certain localities to be called pisolite. This deposit is remarkable in some localities for its abundance of coral structure, and deserves notice as separating those two great argillo-calcareous deposits betwixt which it lies.

The *Kimmeridge clay* is a calcareous clay, of a blue color, which, like the other great argillaceous deposits, contains septaria, besides lignites.

The *Portland oolite* is the bed which produces the fine free-stone called in England Portland stone; it is found both compact and oolitic, is disposed to be cherty, and contains, towards the bottom, green sandy beds.

The *Purbeck limestone* is superincumbent to the oolitic series; its general structure is clays, embracing beds of limestone with ironstone.

The *Hastings sand* consists of various colored sands and sandstones, containing lignites and coarse grits.

The *weald clay*, so denominated from the weald of Sussex, is a stiff, slaty clay, containing ironstone, alternating towards the bottom with sands, and embracing beds of fresh-water limestone.

We have now reached the cretaceous group, where we again find an appearance of equivalents in this country to the European formations. The lower part of this group has been usually called the green sand formation, from its abounding in green-colored grains, which, upon analysis, give silex, protoxide of iron, alumine, and potash. They are the distinguishing mineral characteristics of its structure wherever it has been observed, but do not obtain in the central portion of the formation, where a strong bed of arenaceous and calcareous clay, called *gault*, divides it into three portions, the *lower green sand*, the *gault*, and the *upper green sand*.

The *lower green sand* is very ferruginous, containing beds of sand more indurated towards the bottom, with limestone in some localities.

The *gault* is a bed of grayish blue clay, effervescing strongly, and containing fossils which have a very fine nacre frequently.

The *upper green sand* is a mass of stratified sands, containing a large portion of the green grains, and occasionally green or reddish nodules, which, upon analysis, have yielded phosphates in great proportions. Thick regular seams of chert are also sometimes found in it.

The upper part of this group consists of the chalk marl, the lower chalk, and the upper chalk, all of which appear to be deficient in the United States. The mineralogical characters of these two last members of the cretaceous group are so well known, the carbonate of lime of which they consist, on account of its pure white color and its loose state of induration, being so conspicuously different from any other known mineral, that the student is in no need for any other guide to assist him in discriminating between this and any other rocks he may meet. They have not yet been noticed in any part of the United States. This is not the case with the lower members of the cretaceous group, which form a very extensive but very irregular line from New Jersey to the neighborhood of the Mandan

country, in about latitude 47° north, a line which was more particularly noticed in my report of last year.* This lower division of the cretaceous group for a great portion of this distance has a common mineral character not much dissimilar to that of the same deposites in Europe; but the agreement in the fossil bodies found in it is so strong as to leave no doubt whatever of our having the equivalents of the green sand formation of Europe in the United States. There are also satisfactory reasons for believing that these beds are deposited for much the greater part of that line, if not upon the whole of it, on the lowest beds of the primary order, so that the line itself may be considered as representing the shore of the ancient ocean which deposited these beds. The localities of these beds in the United States are New Jersey, some points on the left bank of the Potomac river, Maryland, and near Coggin's point, on the right bank of James river, Virginia, where they are generally covered over by the tertiary. Further south the coast lies so low that the inferior beds of the tertiary are below the water level, but, scarce as natural sections are, the beds sometimes re-appear as the country rises in the interior, and at Prairie bluff, on the Alabama river, and in the neighboring country, are rich in the subcretaceous fossils. From thence they may be traced at various points along this ancient shore, on the west of the Tennessee river, in Arkansas, in Hempstead and Sevier counties, westward, to the Kiamesha, near Fort Towson, and so on up the False Washita, till the line deflects to the north and runs up to the Black hills, terminating probably south of the Mandan country.

The last three deposites of the column forming the tertiary order have also their representatives in this country, their mineral character, taking them in a mass, having a strong general resemblance, which is completely established by their organic contents, and their common position, so near the surface, in the geological column; but, in the numerous parts of

the world where they occur, the series of clays and sands and imperfect limestones which they exhibit, are so irregularly distributed, that no one locality can be set up as a general type. Formerly, their mineral character was principally relied upon for their classification, but of late a new arrangement has been applied to them, the basis of which is their supposed proximity to the present order of nature, evidenced by the respective proportions of fossil shells they contain of species which exist at present. Of this a fuller explanation will be given.

Before any thing further is said of the lower division of the tertiary, it is proper to remark that the opinion which prevailed some time ago that there was a distinct separation between the superior part of the chalk and the lowest bed of the tertiary, as if geological causes had ceased for a while, has been brought into doubt by more extended investigations. It was known long ago that the surface of the chalk had been greatly abraded, and the beds of plastic clay which succeed to it in some parts of England are exceedingly loaded with nodules of flint washed out of it. The deposit of Mont St. Pierre, also in the Maestricht district on the continent, which differs from the chalk and the lowest tertiary beds, having a distinct mineral character, and containing fossils not common to the chalk, showed a real passage from the chalk to the tertiary. Similar observations have been made in other parts of Europe. There is a most interesting paper connected with this subject in the Transactions of the Geological Society of London, vol. 3, part 2d, accompanied with plates of the Gosau and Styria fossils, and a fine lithographic view of the valley of Gosau, in the Salzburgh Alps, by Mrs. Charlotte Murchison. In this paper Professor Sedgwick and Mr. Murchison, after a careful examination of a series of beds lying between the chalk and the tertiary, have, after a second investigation made by Mr. Murchison for that purpose, come to the decision that a series of blue marls, alternating with com-

compact limestone and calcareous grit, are independent of and intermediate between the chalk and the lowest known beds of the tertiary. The developments of the tertiary beds are so numerous in this country, that a similar passage may hereafter be recognised here.

The *lower tertiary formation* is subdivided into the London clay and the *plastic clay*. The bed called plastic clay of the English geologists is found, as well as that in the vicinity of Paris, lying upon the chalk, yet the French deposit, from which it takes its name, is a true clay, applicable to the plastic uses of the potter, resembling the colored clays near Newcastle, Delaware, whilst the deposit in the environs of London consists of beds of flint and pebbles alternating with sands and clay, yet has received the name of plastic clay, because it occupied the same geological position with the French deposit.

The *London clay* is the great, dark-colored, argillaceous mass upon which the city of London stands. Its mineral character, however, varies: calcareous beds, with fossils, are enclosed in it, with large septaria. Although these two clays have acquired distinct names, yet there appears nothing in their mineral character which warrants this distinction being kept up, or their being considered other than as a series of clays, where the fossils preponderate in the upper part, and the sand and pebbles in the lower. This is the *eocone* group of Mr. Lyell, a compound Greek term, expressive of the dawn of the present order of nature, a small proportion of the fossils contained in it belonging to species now found living.

The *middle tertiary or miocene beds* have their best type in France, and comprehend the lower fresh-water, the upper marine, and the upper fresh-water of the vicinity of Paris. The lower fresh-water contains siliceous limestone, with gypsum and the bones of the palætherea and other extinct animals, and fresh-water marls. The upper marine consists of gypseous marls, sands and sandstones, and marine marls and limestone. The upper fresh-water contains millstone without

shells, and fresh-water marls. The term *miocene* is expressive of an increased number of recent shells in its deposits, but that they are in a minority as to numbers.

The *upper tertiary* or *pliocene* includes the tertiary beds of Sicily, the crag of Norfolk and Suffolk, in England, and the sub-Appenine marls. These last consist of various deposits of marl, with sand abounding in fossil shells, of which upwards of 40 per cent. belong to existing species. The crag is found sometimes lying on the London clay, sometimes on the chalk. It is a sort of ancient beach, where sand, gravel, earth, red ferruginous sand with ochreous nodules, and coarse white and other sands, containing vast quantities of fossil shells, succeed to each other. The proportion of recent shells is about the same as that found in the sub-Appenine beds, and they are, therefore, deemed to be of the same age. The tertiary beds of Sicily consist of stratified marine deposits of clay, sand, and limestone, at great heights above the sea, and which contain 95 per cent. of existing species. The term *pliocene* expresses a majority of recent shells to be present.

These tertiary beds, which occupy so large a portion of the surface of Europe, are well developed in the United States, and extend as far to the south as the country has been examined, usually accompanying the subcretaceous beds, and covering a prodigious area towards the Atlantic, south of the State of New York. The vast deposits of tertiary shells in this area are now, in situations where they are accessible, usefully applied to agricultural purposes, especially in New Jersey, Maryland, and Virginia. The mineral character of the deposits in which these fossils are found, is often formed by various-colored clays of a very unctuous character, occasionally divided by thin ferruginous seams, sometimes abounding with minute crystals of selenite, at other times containing very large aggregate crystals, all of which appear to owe their origin to the organic bodies superincumbent to them. Sometimes, as in the banks of the Choptank river, in Talbot

county, on the eastern shore of Maryland, beds of fossil shells of various genera, with a very slight proportion of marly earth strewn amongst them, rise from 15 to 20 feet by the water side, whilst in other proximate localities extensive areas seem to be formed of nothing but fossil oysters. Other localities, containing a great profusion of these fossils, are found in the vicinity of Piney Point, a summer bathing-place on the Maryland side, about twenty miles from the mouth of the Potomac. Fine exhibitions of this kind, also, are seen on the right bank of James river, Virginia, extending southeast from the vicinity of City Point, wherever the banks are high enough. Occasionally calcareous masses are found irregularly distributed beneath the greenish argillaceous marls, containing the impressions of shells only, as if their calcareous substance had been carried below by the constant percolation of water. These appearances, varying with the localities, are common to all the shell deposits of the tide-water districts of the Southern country, and may be traced, associated with the subcretaceous beds, the whole extent of the line defined by them. Little has been done hitherto to class these various beds according to the intelligent system proposed by Mr. Lyell. This is a task requiring the devotion of much time, by individuals possessing a minute knowledge of conchology, and which cannot be achieved in a very short period.*

The geological column, of which this slight sketch has been given, finishes with the superficial soil upon which we live. This consists either of the detritus of pre-existing beds brought into its place by the agency of water, or of the decomposed parts of rocks in place, the decomposition of which has been effected by external causes.

In the preceding pages it has been mainly the intention of the writer to effect three things: to furnish some guide to

* Mr. T. Conrad possesses the requisite qualifications, and has acquired so much local information of the Southern beds, that it would be comparatively easy for him to accomplish it.

the student for the discrimination of beds; to show that the strata, with the exception of the intrusive rocks, have come into their places after an invariable succession; and that the resemblance between the members of this succession in the United States and the order of the European strata is so strong as to warrant the inference that they have been produced by similar and contemporaneous causes. In the remarks which yet remain to be made, other remarkable proofs will be produced of these truths, derived principally from the organic bodies found in these strata. It cannot escape an observer that the rocks upon the habitable surface of the earth, and frequently at an elevation of many thousand feet above the level of the ocean, contain fossil shells and their impressions, of animals that could only have existed in salt water; in some instances the beds are almost entirely composed of them.* Such rocks, then, must have been covered for long periods of time by the ocean. More extensive observation would show that the greater part of the surface of the earth, if not the whole, has once been in that situation. The student will now find himself zealously engaged in an inquiry concerning the causes which have either raised the bottom of the ocean from its ancient level, or depressed it to enable the waters to recede. Happily, the progress which has been made in the investigation of facts will enable him in our day to arrive at a satisfactory conclusion, without having recourse to any hypothesis whatever. To explain this briefly and succinctly, it must be premised that we can have no practical knowledge of the structure of the earth beyond the depth of its superficial crust, whilst the semi-diameter of the earth exceeds more than five hundred times the thickness of that crust. But the mean specific gravity of the whole is about double that of the crust, a circumstance which proves that the interior is not

* The limestone near the top, on the north side of the ridge from the foot of which the Bath waters of Morgan county, Virginia, rise, is full of remains of encrinites and cardia.

composed of oxydes, as we may suppose the greater portion of the exterior to be. The contents may partially consist of ponderous bodies, of the nature of metalloids, and great cavities may exist there. The existence of volcanic action through every part of the known world, either by the eruptions of active volcanoes or by earthquakes, is an assurance that there must be vast cavities in the interior where igneous action is fiercely at work, and of which these volcanoes may be considered as the safety-valves. The disturbances resulting from earthquakes may be considered as the effect of the resistance which the solid parts of the crust of the earth oppose to the expansive power striving in those profound cavities. Applying this power to many phenomena of the science, we are able to comprehend what would otherwise be incomprehensible. The lowest rocks which have yet been met with in penetrating into the crust have been of the granite kind; but in ascending to the summits of some of the highest mountains, we find them composed also of granite. We have no method of explaining this apparent paradox but in having recourse to this subterranean force, and giving due attention to the multiplied evidences of its intense exertion. Thus, when we observe some of the stratified beds which lie much higher up in the series than the granite, reposing at high inclinations upon the flanks of the granite mountains, with accompanying marks of violent dislocation, the truth flashes upon us, and we perceive that these mountains have once existed at lower levels, and that they have been forced up through the superincumbent beds. We thus become acquainted with the existence of a power capable of the mightiest mechanical exertions. If earthquakes in our time rend the earth, dislocate its solid parts, and engulf portions of it in the chasms they produce, what were they not capable of when the subterranean force, at an early period of the deposition of strata, was infinitely more energetic, and had much less resistance opposed to it?

These conclusions, to which geological opinions have been for some time tending, and which are now universally adopted, are the result, not only of geological observations, but of mathematical and physical reasonings, which lend them every authority when applied to the causes which have determined the spheroidal figure of the earth, and the state of igneous fluidity it must once have been in to assume that figure. If this is to be called a theory, it is only another name for the incontrovertible result arising from the sound generalization of well-ascertained facts. To some, it is true, who have never reflected upon this subject, it may appear startling to hear that continents and chains of mountains have been raised from the interior parts of the earth by the force of subterranean power; but every effect is proportionate to its cause, and where the first is definite, and the last immeasurable, we must submit to the reasonableness of the proposition, remembering always, that although human power dwindles into insignificance when applied in imagination to disturb a mineral mass like the crust of the earth, yet it is demonstrable that a gaseous pressure may be generated in such a radius, to which the known mineral mass could make no resistance. In reasoning, therefore, upon these high matters, we must not measure unknown forces by our own feeble powers, but by the effects they are capable of producing, and, when causes and effects of this high planetary character are under consideration, must reason of them in relation to the proportion in which they stand to each other.

The evidences of these upheavings of land are common in all extensive countries, especially those where the inclined rocks prevail—a character common to all the strata below the carboniferous limestone; and geologists have availed themselves of this very inclined state of the beds, to establish as it were a chronology for the history of all mountain ranges, showing, relatively, the successive geological periods at which they have been thrust up. It is obvious, if any of the primary

rocks are found at great elevations, with other beds, superincumbent as to them in the column, hanging in an inclined state on their flanks, these last having other beds still newer, deposited in an undisturbed state upon their sides, that two geological epochs are represented here—the appearing of the primary rocks through the adjacent stratified beds, and a subsequent period of repose, during which a newer set of rocks had been deposited. Wherever the beds have been thus dislocated, it is evident the upheaving took place subsequent to their deposite, and before the deposite of the undisturbed rocks adjacent to them. This is more accurately shown by the two following diagrams from nature.* In Leicestershire, England, (diagram 6,) the granite, *b, b*, and slate, *c, c*, present beds highly inclined, but on the edges of those beds, new red sandstone, *a, a*, and lias, *e*, are found in a horizontal position, showing that these last have been deposited subsequent to the upraising of the first. In the system to which Mont Blanc and the western Alps belong, the primary beds have the oolites, the green sand, and the tertiaries, lying in a disturbed manner upon their flanks, showing that this system of mountains was upraised since the tertiaries were deposited. Diagram No. 7 represents a section of Alpine beds, near the Col de Balme and Mont Blanc, where *a, a* are alternate beds of lias and oolite, the equivalents of those horizontal beds *e*, in diagram 6; *b, b*, are beds of pudding-stone, tilted up at a high inclination, with the pebbles lying vertically, and not, as they were first deposited, on their longest axes; *c, c*, a col, or passage excavated in the soft slate of the mountains; *d, d*, perpendicular plates of granitic beds, with pyramidal caps, called aiguilles or needles. The dotted lines mark the supposed original prolongation of the beds, before the granite came up, on the flanks of which they lie at an inclination varying from 65° to 80°. Mont Blanc is 15,534 feet high, and the pyra-

* From Bakewell's Geology.

midal peaks, which time, and the abrasions consequent upon their uprising, have worn into their present forms, were once, in part, many thousand feet beneath the now lateral surface of the stratified beds they have thrown into this high inclination. These sections show that mountainous chains may have been upraised at any of the periods belonging to the succession of strata, and that each period may have its peculiar system of mountains. To a great extent, this has been found to be the case, and geological periods of elevation can be distinguished, establishing, not chronologies belonging to the present order of nature, but to the great history of subterranean dynamics, to which the present varied form of the earth must be referred, modified, as it has often been, by the action of the waters invariably displaced by these elevations. The practical uses to be derived from the detailed geological examination of mountains and ridges are numerous. Where any chain or series of parallel ridges is productive of useful metals, combustibles, or mineral bodies, all its parts may be investigated with a view to trace its continuities; and by connecting distant points having the same mineral structure, deposits may be identified, known in some localities to be productive. The series of Alleghany ridges, hereafter to be spoken of, are a proper field for the exercise of these investigations.

It is deserving a remark here, that some geologists in Europe who have bestowed much investigation on this subject, have supposed that mountain chains elevated at the same period of time have a general parallelism in their magnetic bearing. It has been already stated that many of the transition chains of Europe trend from northeast to southwest, which is the general direction of the series just spoken of. If this conformity of bearing could be established, it would lead to speculations on the laws of the elevating power, and perhaps eventually open the way to an explanation of the principle upon which the structure of anticlinal rocks depends.

In this country our investigations on this subject must be limited to the Alleghany series, having nothing higher than the coal measures, except the tertiary beds of flat districts; the upheavings therefore of some of those secondary chains which have been described by that eminent geologist, Elie de Beaumont, as forming part of the geological phenomena of trans-Atlantic countries, are not exhibited here. There being no evidence of other rocks having been deposited on the eastern flanks of the Alleghanies since their upheaving, a very extensive portion of this continent must probably have been upraised before the oolitic system in Europe was deposited.

Many circumstances concur to prove that some of these elevations were of a sudden and violent nature, the chains coming up by paroxysmal movements through the superincumbent ocean, and fracturing and contorting the strata through which they were forced. Thus, in that system of elevations which includes the Pyrenees, the northern Apennines, and other parts of Europe, the cretaceous beds are found lying in the greatest disorder on the tops of the highest mountains, with the tertiary beds undisturbed and horizontal in their vicinity, showing that the movement took place between the deposition of the chalk and the tertiary. Every cubic foot too of mineral matter would displace another of water. Here we have a phenomenon of another kind, producing singular effects, the evidence of which is constantly before us: the ocean thrown out of its bed, mighty currents created, the ruptured mineral matter broken into boulders, rounded off into pebbles and gravel, and the whole deposited in situations where their relative specific gravity and the intensity of the moving power would carry them. Here we have the origin of all the conglomerates, those indurated gravels which are found even in the tin mines, low down in the primary rocks, proving the great antiquity of movements of this character. Hence are derived the great gravel beds in which are found entombed the remains of the ancient masto-

don and elephant, the victims probably of the movement of their period. The detritus in the common superficial soil of the country is an admirable study for the young geologist. The vast collection of gravelly matter which is found almost every where on the surface is formed from the ruins of rocks of anterior periods, and brought there by the agency of water. There is an immense collection of detritus of this kind at the city of Washington, and especially near the margin of the Potomac, at the western termination of New York avenue, where fragments even of the fossiliferous rocks of the Alleghany ridges, together with every variety of specimens of the rocks constituting the Atlantic primary chain, are found, all of which detritus appears to be consequent upon their elevatory movements.

In bringing together these notices and views, the intention has been merely to give a direction to the investigations and reflections of the student. In the numerous geological treatises which have appeared of late years, he will find the most interesting details respecting all the phenomena which have been alluded to. He will there also find abundant information respecting the metalliferous rocks, and the nature and direction of mineral veins. The subject, however, is too interesting to pass over without pointing to some phenomena that will be found extremely interesting to those who are turning their attention to mining in the United States, since they constitute some of the principal guides of practical miners in their operations.

It is worthy of remark that iron, without the use of which man could scarcely have achieved his own civilization, is the most abundant of all the metals, and is found more or less in all the rocks. In the inferior rocks it is found in veins or immense fissures produced by dislocation, in the compact metallic state. Immense masses of this kind are found in the State of Missouri,* in New Jersey, and in Franklin county New York. These have all evidently had a direct subterra-

* Report 1835, page 52.

nean origin, whilst the hydrates or ferruginous ores of the superior beds are to be considered generally as oxydes derived from them. Many of the ferruginous sand rocks were doubtless once in the state of our recent bog ores, just as many conglomerates and great rocks were once in the state of loose gravel. The compact metals, with the exception of the sulphurets of lead and zinc, have their principal seat in the primary beds, either in veins which traverse mineral masses, or disseminated in these last. These veins may have either mineral or metallic matter, or both, in them. They are vertical, inclined, and horizontal, often running in parallel courses as if they had a contemporaneous origin, and intersecting each other in such various ways as to leave no doubt that many of the intersected ones have been formed prior to those by which they are intersected. There is a very instructive exhibition of this kind at Fudia, one of the Western islands.* In diagram No. 8 is a representation of different kinds of mineral veins intersecting the gneiss, and of the dislocations which have taken place during the injection of some of these veins. It will be observed that the striped laminæ of the gneiss, produced by the plates of mica, which once were continuous, have their continuity interrupted, as if they had been violently separated, and one portion shifted higher up, or depressed below the natural level. To the left is a vein of granite intersecting the gneiss, and itself intersected and shifted by a vein of quartz. At the top is another vein of granite intersecting the gneiss, and again intersected by a vein of trap. It is to be inferred from these appearances, that the veins of granite, and perhaps the trap vein, had penetrated the gneiss before it had taken its indurated state, and that, posterior to its induration, a dislocation or shifting took place, occasioning the fissure filled by the vein of quartz. The dislocations of strata occasioned by the exertion of such intense subterra-

* McCulloch's Western Islands.

nean power frequently interrupt the operations of miners, who, finding the continuity of the beds interrupted by the sinking or rising of one portion of them, have applied the technical term *fault* to them. Where these occur, a mining district has to be studied very accurately in relation to them, for it is evident that no mining operation upon a large scale can be carried on with proper economy, both as to drainage and arrangement, without their extent and direction being first known.

By studying the veniferous rocks we perceive that veins are not only earthy or mineral, but metallic in their nature, and that some are posterior to others. This last fact has induced some persons to entertain the opinion that metals are of different ages; and it is certainly true that the rarest are usually found amongst rocks of the highest antiquity. The interesting fact also has been established, that the most productive veins have a general direction from east to west. This is the case with the tin veins or lodes in Cornwall, as well as those lodes containing copper. The veins which run nearly north and south are not as metalliferous as the others which they intersect. Many of these, called *flucan*, in Cornwall, are filled with clay. Clay is sometimes found in the copper veins; and as other metallic veins which deviate from the east and west course contain increasing quantities of clay, and the flucan or clay veins running from north to south, the evidence seems to be strong that there are different systems of veins, the more minute study of which may hereafter lead to important results respecting their general origin, and the causes which have modified their contents. The ancient Wernerian notion, that minerals and metals settled into fissures, from aqueous solutions, is now exploded, and the more general opinion that they have been injected from below has been substituted for it; still they present themselves occasionally under such circumstances as baffle our judgments. We do not understand why veins are sometimes extremely dilated,

then contracted into a very small space, and afterwards dilated again into pockets, resembling a number of blown bladders connected by a long wire. Another curious phenomenon is, that their contents are modified on entering a different rock; they usually have a case or sheath differing from the mineral matter of the rocks they are found in. The walls of sulphuret of lead, in passing through sandstone, are often formed of sulphate of barytes, but, on entering the limestone above, they change to carbonate of barytes, in balls, with a radiated diverging structure. Sulphuret of zinc is sometimes abundant in the upper part of veins, that lower down become rich in copper; and in the mine of Cook's kitchen, Cornwall, after first working through tin, and then through copper, to the depth of eleven hundred feet, tin is again found, and worked to the depth of near thirteen hundred feet. The same vein, at Dalcoath mine, is sometimes contracted to six inches, and sometimes dilated to forty feet. Although it appears demonstrable that the contents of many metallic veins have been injected from below, it appears probable that the contents of others have been modified by chemico-electric action, and that metals may be formed by processes analogous to those upon which the formation of saline crystals depends. Mines which have been closed, on account of inundation, for two centuries, have, on being re-opened, exhibited the curious spectacle of native silver coating the wooden supports which had been left there. The walls of veins and the atmosphere may stand in the relation of galvanic plates to each other, and decompose and recompound gaseous bodies.

Many of the appearances which have been alluded to are of constant occurrence in the United States. In the auriferous region of this country the course of the principal productive veins is from northeast to southwest.

Where metalliferous veins abound, red earth is usually found in great abundance. It seems to have a constant connexion with them. It is very much the case in the United States, is

general in Mexico and in Brazil. In Spix's* account of this last country, it is stated that the granite hills, both on the coast and in the interior, are "covered by a pretty thick stratum of a red ferruginous clay." The same deposit of red clay is found in the lead-mining district of this country, near the surface of the earth. Upon the occasion of my visit to the Missouri mines in 1834, I was exceedingly struck with the appearances which presented themselves in a gallery† upwards of one hundred feet from the surface, and which was below the surface by at least ninety feet of the rock formation. There the broad veins of bright galena were incased in a thick wet paste of red argillaceous matter, cutting with a waxy aspect. In one of the pockets, about forty feet from top to bottom, and about the same width in diameter, the cavity was filled with this red clay, except at the bottom, which was occupied by a large plate of galena, that seemed to have sunk there by its own gravity. Although some of the red soil of the metalliferous districts of the Southern States may be derived from the decomposition of ferruginous slates and rocks, a great portion of it may have been brought to the surface from situations analogous to those where it is found incasing the sulphuret of lead in Missouri.

In the United States both copper and iron are associated with the gold, especially the last. In the galeniferous districts, the lead is found associated with zinc, and is usually confined to the carboniferous limestone. Some of the metals, however, which are usually found in veins, form occasionally a constituent part of the solid rock: thus, tin is incorporated with the granite in England; and the sulphuret of lead in Missouri, at Mine la Motte, is sometimes disseminated for a great extent in specks through the rock, as though the stony and metallic matter must necessarily have been deposited at the same time: for, as I stated upon a former occasion, if either of them were

* Vol. 1, page 251.

† Taplit and Perry's Mines.

abstracted, no principle of adhesion would be left for the remaining mineral.* Very little attention appears to have been paid to this circumstance, which, as respects the origin of rocks, deserves some consideration. If such strata as the carboniferous limestone, bearing galena, were deposited by water, how came the metal to be so singularly suspended in and intermixed with the stratum, when, by the law of gravitation, it should be found separated from the calcareous matter? I have seen in the gold region of this country deceptive veins, which have been the occasion both of disappointment and litigation. Veins, apparently very rich, have suddenly been stopped by slates coming in below. Upon examination, these turned out to be flat veins, or the overflow of true veins, as trap is sometimes known to come up vertically, and overflow to the right and left.

The successful pursuit of the art of mining for the metals which have now been mentioned, essentially depends upon the application of some scientific information. The want of a proper degree of information on this subject has occasioned hitherto, in this country, as it did heretofore in older mining countries, the rejection of many valuable minerals, from ignorance of their natures, to say nothing of the losses sustained by the rude and unskilful manner in which the mines are often worked. There are instances in Cornwall of silver and cobalt having been thus thrown away from a mine which, since the discovery of their value, produces £10,000 sterling a year from the same ores. The mines of Missouri have been worked a long time, but it is only recently that cobalt has been observed there. Whilst Cornwall was esteemed only as a tin country, the copper ores were considered to spoil the vein, and were used to mend the roads; and in Derbyshire, a public road has actually been taken up, and smelted profitably from the rejected lead ores that had not been in familiar use. It is

* Report 1835, p. 48.

the cultivation of geological knowledge that has led to so much minute investigation of the nature of veins, and to that proper degree of chemical information which has redeemed the mining interest from the rude management of the common miner, and introduced those truly economical practices which are only united by science and experience.

An opinion once obtained that below a given depth the veins ceased to be productive; tin from twenty to sixty fathoms was supposed to be most abundant, and copper from forty to fifty. This has become a speculation of some importance to the gold mining interest here, some of the mines having been abandoned because the veins seemed to fail even at twenty fathoms. Of late, the mines in Cornwall have been worked at very great depths, with the best results. Being a few years ago in the Botalloch mine, in that country, I found them working in a copper vein at the depth of 950 feet, which I was informed was the best ore they had yet met with. Others, such as the consolidated mines, are worked in England at a depth of more than 1,600 feet; and one of the continental mines, the Kits Pübl copper mine, in Tyrol, at a depth of near 2,800 feet. Reasoning from analogy, it would seem a hasty proceeding, after expending a capital in mining machinery, to abandon before a depth of at least 500 feet had been investigated. If the mineralogical structure of the mines was totally different from that of the older mines, there would be greater grounds for apprehension, working in the face of an unknown state of things, but the analogical structure of the metalliferous rocks in both hemispheres holds out every encouragement to the mining interest in this: the veins are found in the same kind of rocks, and have nearly the same magnetic direction. In the gold countries the mass of the veins is usually quartz, bearing visible native gold, and associated with iron, as well as gold in a mineralized state with that and the quartz when invisible. In the gold region of the United States, these veins are easily distinguished, consisting

of extended lines of white quartz running on the surface in a direction from N. N. E. to S. S. W., and frequently with an almost vertical inclination. In the great geographical extent of that region here, many portions of which are yet unexplored, there may be rich deposits contained in mineral masses of a different character, as is the case in Brazil, upon the Gongo Soco estate, of which a brief description may be useful.

The gold in this locality has been occasionally so abundant, that 140 pounds have been extracted in one day. The bed in which the gold is found is called *jacotinga* in the country, and rests upon a ferruginous talcose state, resembling that of various localities in Virginia. The *jacotinga* itself consists of quartz and micaceous iron, and the whole mass is in a somewhat soft state of decomposition. It has a direction from east to west, and is of a variable thickness, with a limited extent. Towards the centre of this bed, a subordinate bed or vein is found, of a brownish-black color, of a softer quality than the general bed, and more or less distinct from it. It is from three to six feet in thickness, and consists of layers of manganese from thin lines to two or three inches in thickness, with talc and iron glance in irregular strings and nests. It is in these dark-colored layers of manganese that the rich strings and bunches of native gold are found, which is also invisibly disseminated among the layers.

When the auriferous region of this country shall have been more generally examined, other associate metals may possibly be discovered. In the Ural, platinum has been abundantly found, but more generally on the western or European side; the gold washings on the Asiatic side giving comparatively a small quantity of platinum. Baron Humboldt also states that the Cali chain of the Cordilleras, in South America, separates the gold-bearing sands of the eastern declivity of Popayan from the sands of the isthmus of the Rispadura of Choco, which are rich in platinum as well as gold. These analogies are interesting to this country. Engelhardt remarked, when

in Russia, that the sands of some of the platinum mines resembled those Brazilian sands in which diamonds were found. Humboldt subsequently perceived the same resemblance; and in consequence of his suggestions, a search was made, and very fine diamonds discovered: so that the Ural mountains, which bear a strong resemblance to portions of the gold region of the United States, produce gold, silver, platinum, and diamonds.*

The carboniferous limestones are the next metallic depositories, both in Europe and the United States, of which some account was given in my report of last year; and as it will occur to me in another part of this report to speak of the coal measures of the United States, with their associates, salt and iron, I shall pass on to a brief review of the organic remains found in the beds which have been enumerated—a subject of

*A late paper by Sir David Brewster, in the Transactions of the Geological Society of London, vol. 3, part 3, on "the structure and origin of the diamond," brought to my recollection a note which Professor Del Rio sent me some years ago, of which the following is a translation:

"I was shown, towards the end of 1822, two small diamonds, which were stated to be brought from the environs of Sultepeque; that is not exactly their locality, but it is upon that route. In truth, D. Vincente Guerrero found in the Sierra Madre, in the south of Mexico, upon a height of land distant a day and a half from Totela del Rio, in descending by Coronilla, some geodes, with amethyst and rock crystal in their interior. These geodes were smallest towards the surface, and only became larger in digging deeper down. On breaking these geodes, true octohedral and dodecahedral diamonds were found in some of them, resembling those of India and Brazil. I am not too credulous, but I have been assured of the fact by persons who deserve to be confided in. This unexpected manner of finding diamonds becomes the more remarkable, because the geodes are not found disseminated in the loose soil, but are imbedded in a hard and stony mass, rendering it necessary to get them out with pickaxes and crowbars."

Mr. Del Rio subsequently informed me that General Guerrero had personally confirmed this account to him, adding, that the geodes containing the precious stones rattled when shook; but he had never been able to ascertain, from any quarter, the geological character of the bed containing the geodes. The late Dr. Voysey states the matrix of the diamonds in southern India to be a sandstone breccia, of the clay-slate formation, which may be the case with this Mexican locality. I have frequently written to Mexico without obtaining any satisfaction on this subject.

the highest moment, replete with phenomena which serve to prove that the succession of strata produced by such various and wide-spread convulsions as would seem to belong to the chaotic energies of a system of destruction, are the progressive steps of a most singularly beautiful plan of creation, in the study of which we may not only advance our personal interests, but acquire for ourselves an elevation of mind still more valuable.

An opinion formerly obtained that there was a point in the ascending series of rocks at which the evidences of a commencement of organic forms was to be found, the earth passing by transition as it were, from an inorganic to an organic state. This appears to have been conjectural. It is true, calcareous matter, so essential to organization, is comparatively scarce in the primordial rocks, and only begins to abound where organic life appears. The high temperature of the planet before the deposition of the stratified rocks would preclude, perhaps, the possibility of organic existence, and we may, therefore, naturally expect to find the evidence of it first in beds deposited from water, where the temperature, though high, would be tolerable, and where the means of self-preservation and perpetuity of kinds would not be wanting; but it is no longer pretended that the first rudiments of organization have been observed, or even that we know what they were. There are observations, however, of importance to be made on this subject in the early periods of stratification. If primordial rocks of the same kind, separated by the greatest geographical distances, have the same species of crystallized minerals imbedded in them, we also find organic affinities very general in the older stratified rocks, from whence the inference may be drawn that the influences prevailing at these two periods, though distinct, were general to the planet. At an older period of the history of the planet, we do not find this to be the case: the increase of genera and species seems to mark great changes in the temperature, as well as in the surface of the crust of the

earth, as it gradually emerged from the water, and approached more to the present order of nature. Although we cannot say that we have any evidence in the rocks of the germs of organization, yet the fossils of the first great transition group, as it has been called, appear to be the types of what have succeeded to them. The crustacea of that period naturally fall into the class of their order which has been established from recent genera, as well as the prodigious abundance of madrepores and corallines, whose structures in those ancient geological times were apparently reared with the same instinctive designs, and principally by the same genera of which we have evidence in the reefs of eastern Polynesia.

The *crinoidea* also, or encrinites, now nearly extinct, are abundant. In these ancient times this family, as if less exposed to destruction from the existing state of organization in the then seas, had their soft parts but slightly protected, whilst in the succeeding formations in the older groups, where the predacious classes increase in number, they are much better secured. The sole species now existing, the pentacrinite, agrees with these last in its more perfect osseous structure, which still seems to have been insufficient to protect the family.

The beds of this group also contain fine specimens of another family which appears to have become extinct at an early period of the secondary rocks. These belong to the genus *orthocera*, a long straight fossil, consisting of various chambers, with a siphon or tube, by the aid of which the cephalopodous animal is supposed to have been able to pass from the top to the bottom of the sea at its pleasure; resembling in this the ammonite, another concamerated shell, not straight but spiral in its form, and which, with other concamerated shells, is found in the limestones of this lower group.

The *trilobite*, a singular marine crustaceous animal, is a fossil almost peculiar to the period of this group, since it appears to have become extinct in the early part of the deposition of secondary rocks. Some of the lower slates are covered with

their impressions, showing that the same species lived and died in the same localities. A great variety of forms belong to this family, and new genera are constantly being discovered, perhaps some of them, as the *agnostus pisiformis*, may be the young of another kind, before the change of form. Some of the species are found identically diffused in very distant parts of the earth.

The bivalves of this group consist of a very preponderating number of the brachiopode family, the *producta*, *spirifera*, and *terebratula*. The fossiliferous beds of this group are generally, in all parts of the world, characterized by these shells, and sometimes almost entirely consist of them. The *spirifera* receive their name from one kind having a spiral structure inside, which is calcareous in calcareous fossils, and siliceous where, as frequently happens in the calcareous beds of the United States, the fossils are entirely siliceous. The *producta* appear to have become extinct before the deposition of the oolitic system, and the *spirifera* only to have been continued into the first beds of that series. The *terebratula* have survived them both, and exist now as recent shells. The *cardia*, likewise having a strong resemblance to existing shells, are contemporaneous with the last.

All these families of marine fossil remains are found in this lower group in the United States. In the lower limestones of the Shenandoah valley, in Rockingham county, both trilobites and ammonites are found. Near Kingsport, in Tennessee, orthocera abound in the same formation, as well as other spiral concamerated shells. At Trenton falls, in the State of New York, fine specimens of trilobites are collected. A great number of localities might be added.

Mr. Agassiz, in his work,* gives admirable figures of the fossil fish found in this group. In this remarkable production, the author has begun to throw light from another source upon

* Recherches sur les Poissons Fossiles. Neuchatel, 1835.

the history of the ancient ocean, which harmonizes with every other branch of organic existence. Of the four orders of fish established by him, the two first, *placoidians* and *ganoidians*, exclusively occupy the groups below the chalk. It appears that the vertebrated animals of the waters of that period belonged altogether to a class which constitutes a very small portion of the existing ones. The fishes of this period, all of which preceded the saurians, show an approximation to their structure, as if nature was preparing for them. Those long pointed substances called *ichthyodorulites*, which are also found in the lowest parts of this group, Mr. Agassiz considers to have belonged to a large shark-like fish. This ancient period, therefore, instead of being almost devoid of life, appears to have possessed the types of a great portion of the different orders of marine animals now existing, the individuals of which were all perfect in their structure for the ends they were intended to accomplish, and had a sufficient analogy to what exists at present, to warrant the opinion that they were amongst the steps of a general plan of progression, accommodated entirely to the then existing state of the surface of the planet, and only preceding others, which further changes in the surface would call into existence.

Nor was this group, which includes all the anthracite beds, without its proportion of dry land, as we find from the vegetable remains accompanying that carboniferous deposit, and which have a common character both in North America and Ireland. The *equisetacea*, or horse-tail tribe, not of the limited height of recent plants of this family, three or four feet high, but many of them equalling forest trees in size. A preponderating number of *filices*, or the fern tribe, both herbaceous and arborescent. The *lycopodiacea*, or club-moss tribe, there also attained a size equal to existing forest trees, whilst their puny recent representatives are seen creeping, as it were, in a moss-like form, not more than two or three feet long, over the beds where their gigantic predecessors are entombed. All

these plants are closely allied to the ferns and fernlike plants which grow in such luxuriance in the hot and moist situations of tropical climates, especially in small insular localities, and which are never found out of the tropics. These are amongst the first and decided evidences we have that the climate in those remote times must have been of a constant high temperature, far exceeding any thing known to the present order of nature, and equally humid, for these immense plants of a tropical growth, which, also, with occasional palms, form the great mass of the fossil plants of the bituminous coal measures, are found in a fossil state in very high northern latitudes, and under circumstances which prove that they grew there. Coniferous plants also have been found, showing that the low regions had their elevated countries, like the tropical regions of our own times.

Taking fossils for our guide, the carboniferous limestone, millstone grit and shale, and the bituminous coal measures, may be viewed as the upper part of the group which has been considered, on account of the strong generic resemblances of their organic remains; for although the trilobites, the producta, and some other genera become less abundant, there is a surprising increase of the zoophytes and radiaria, many of the beds being entirely composed of corals and encrinites. The environs of Nashville, in Tennessee, where the genus *asterias* has been found, the rocks of the falls of the Ohio at Louisville, and the shore of the Mississippi between Herculaneum and St. Louis, are amongst the richest localities for fossils of the carboniferous limestone.

Looking, therefore, at the whole of the fossiliferous beds hitherto considered, the student of ancient nature can here contemplate a spectacle of the most surprising character, and of which no pursuit but geology could lead to the disclosure. He sees the types of much of what exists in the present order of nature in the rocks that bear the first evidences of organization, and inferring from the resemblances what their probable

habits were, he can, with the aid of contingent observations, decide upon reasonable grounds, where were the deep and where were the shallow places of these now petrified oceans. Turning to the land, he sees the proofs of a luxuriance of vegetation unequalled by any thing in modern nature, yet in strict harmony with natural principles: still the evidences of terrestrial animals, for whose use plants are supposed to grow, are wanting; but he is satisfied to believe they might then not have been called into existence, and that an extent of vegetable growth, of which we cannot form an adequate conception, was intended solely for the accumulation of those carbonized deposits without which our own race must ever have remained in the most rude and comfortless state.

The next great group of organized bodies may be considered as extending to the tertiary, and is, as has before been remarked, with some exceptions, deficient in the United States, but in Europe it discloses organized forms of a character that almost places them in the regions of romance. Although some changes are observed, the general progression is going steadily on. The belemnites take the place of orthocera, to which they are akin in structure; ammonites begin to appear in great abundance, especially in the oolitic system, the floors of some of the beds of the lias and Oxford clay being sometimes found studded with them, furnishing a certain key to the identification of rocks. Trilobites give place to other crustacea, the astacus, or representative of the recent cray fish. The fishes are continued in this group belonging to the same orders as the last, but the species of the successive formations are always distinct. The saurian reptiles now begin to appear. The monitor is found before the deposition of the oolitic series, together with various saurians in the beds which precede the lias. Here we find an astonishing quantity of these voracious animals, allied to those crocodilean reptiles which frequent the bays, the estuaries, and the rivers of our own southern latitudes. Various species of the *ichthyosaurus*, some individuals

of which have jaws near nine feet in length, with strong paddles to enable them to go through the waters. This animal, to the vertebra of a fish unites the head of a lizard and the powerful teeth of a crocodile. The *plesiosaurus* is another monster with the head of a lizard and a singularly long neck, which at one time it was supposed to carry after the manner of a swan in the shallow waters near the shore, but which it perhaps projected in the water rather after the manner of a serpent. This animal also has paddles. But the most curious, because we have nothing which resembles them nearer than the vampire bat, is the *pterodactylus*, a saurian animal, with extended membranaceous wings; this is the first decided case of an aerial animal, and, like the rest, was undoubtedly of the voracious kind. The smaller skeletons of these animals are usually found in the lias, much flattened from the great pressure upon them, but often entire, with even the *fæces* in the visceral region, as if they had been surprised by a violent and sudden death from some extraordinary convulsion which had happened and in the consequent results of which their remains had been immediately enveloped and preserved. The *fæces*, or *coprolites*, as they are now termed, have been analyzed, and their true character ascertained. In most of them, the scales of fish are found, and in some, the undigested remains of the young of their own kind. Notwithstanding the immense period of time they have been entombed, some of the teeth and bones of these animals have yielded about 50 per cent. of phosphate of lime. A great number of species of these saurians occur, besides other genera which are not mentioned here. The saurian remains of the United States have been hitherto fragmentary, and belong to the subcretaceous beds. This group is also further remarkable for having produced the first unquestionable remains of terrestrial mammalia, in the didelphoid quadruped, as it is usually termed, an extinct species of opossum, first found in the slaty oolitic beds of Stonesfield, in Oxfordshire, lying beneath the cornbrash. Some doubt was for-

merly expressed on this subject, but the multiplication of specimens of late, many of them in good preservation, have decided the question.

The wealden group is too remarkable to pass over. It consists of a series of strata of limestone, sands, and clay, deposited from fresh water, enclosed as it were between formations of marine origin. The fossil shells found in it are analogous to the shells now living in fresh water, such as *cyclas*, *unio*, *paludina*, and *melania*, with the exception of some that can live in brackish waters. In the Purbeck beds, a stratum of oyster shells occurs in the midst of a series of other strata, some exclusively containing fresh-water shells, and others a mixture of both fresh-water and marine. These beds are not only extremely interesting on account of the very rare nature of some of their organic remains, which form the greatest ornaments of geological cabinets, but on account of the illustration they furnish of the changes of level to which strata have sometimes been forced by geological movements, as well as of the fact that each stratum has in its turn been the bottom of the waters, whether marine or fresh. In the Isle of Portland, a small tongue of land which projects into the English channel, near Weymouth, a fine building-stone is quarried, which is of undoubted marine origin, and of course was once the bottom of the sea. We have the perfect evidence of this ancient floor of the ocean having been uplifted beyond its level, in another bed, superincumbent to the marine one below, containing the remains of an ancient forest of cycadeæ. The stratum in which this forest grew, extends through a considerable area in England, and has been recognised on the opposite French coast. The trees, now silicified, are in many instances buried in a black earth, in which they grew, which is about a foot thick, and is called by the quarry-men "dirt-bed." Some of the trunks of the trees are thirty feet long, and have a diameter of three or four feet. Stumps, also, from one to three feet long, separated by the usual distance at which forest trees

grow, are there in abundance, with their roots struck into the black dirt; these stumps are also silicified. At Ludworth cove (see diagram No. 9) these beds are at an inclination of about 45 degrees: The thickness of this bed of black earth furnishes some measure, though of an indefinite kind, of its duration, since it must be considered as an accumulation of vegetable matter formed subsequent to its elevation from the sea. Granting to the forest lands of the United States the entire duration of our own chronology, they do not show evidences of having accumulated vegetable matter to that extent, and allowing for the luxuriance of vegetation consequent upon the ancient climate, a very long period may at least be conceded for its accumulation. But the terrestrial level of this bed was again changed, and a basin-like form given to it, for the collection of fresh waters, which at various periods have deposited lacustrine sediments, 1,000 feet thick, including the whole wealden group. During the existence of this lake, a new race of monstrous reptiles appears—the *iguanodon*, which, from the organic remains collected, appears to have abounded there. Mr. Mantell, the discoverer of this fossil animal, has named it thus from its analogy to the recent iguana, which is an omnivorous animal, and from various fossil bones he possesses, has made a comparative proportional estimate of the probable size of the individuals of some genera, of which they formed a part, and it has resulted that they were seventy feet long from the snout to the end of the tail, were near fifteen feet in circumference, and that the tail was upwards of fifty-two feet long. Besides this animal, the megalosaurus, with more than one species of crocodile, and various fresh-water fish, were inhabitants of the waters. The generations of these animals were, however, to cease, for we find these fresh-water strata changing their character and becoming the floor of the ocean, the whole cretaceous group, of marine origin, and about 1,000 feet thick, being deposited upon them. This was probably produced by a reaction of the cause which first

elevated the whole area, and afterwards depressed it so as to give the ocean once more dominion over it. The wealden group, a great part of which is in our day a portion of the earth's surface, furnishes most instructive proofs of the changes of level to which the land was subject in ancient times. In these particular instances they seem to have been accompanied by no violence, and no evidences of great abrasion being present, the movement would seem to have been a quiet vertical one, up and down; for the high inclination of the beds at Lulworth cove appears to belong to another movement, which took place subsequent to the deposition of the chalk, and which threw the thick beds of the Isle of Wight upon their edges, in the manner that the oolitic beds of the Alpine chain are represented in diagram No. 7. In the cretaceous group, most of the organic remains are marine; marine plants, corals, and sponges abound. New genera of fish are found in the chalk, with the mososaurus and turtles. Some of the chalk fossils are extremely beautiful.

In regard to the vegetation of this secondary period, a change is perceived even in the new red sandstone group. The cryptogamous plants of the ancient period become less numerous and of diminished size, as if the temperature already was abating, whilst the coniferous or fir tribe begins distinctly to appear. In the beds of the oolitic and chalk formations, this last constitutes a very large portion of the vegetation. Of the cycadeæ, several species of zamia occur amongst the imperfect coal seams of the lower series, and constitute a forest, as has been before shown in the wealden group.

The tertiary order extends, in a surprising manner, the progressive advance towards the present order of nature, as has before been noticed in the remarks on Mr. Lyell's arrangement; changes of level appear to have been frequent, marine and fresh-water beds alternating. Lacustrine remains increase, and show that dry land and fresh-water streams were giving a new character to the earth. In the lowest part of the group

we have the first evidence of varieties of terrestrial mammalia, the bones of palæotheria, and other genera, imbedded in gypseous matter, apparently derived from springs charged with sulphate of lime.

It was the admirable memoir of Cuvier and Brogniart, of 1811, unequalled in interest by any work except Buckland's account of the Cave of Kirkdale, which announced the discovery of these extinct quadrupeds in what has been called the Basin of Paris, that first drew public attention to the importance of zoological geology: nor could there be a more happy coincidence for this science than that, whilst in the immediate vicinity of one of the largest European capitals, some of the rarest monuments of the ancient world were laid imbedded and unnoticed in the common quarries of the country, two individuals should be residing there singularly fitted by their attainments and genius to comprehend and explain the true characters of these palæotheria, and the geological period of their existence. The Rev. W. D. Conybeare, one of the soundest philosophers and most attractive writers of the age, in his "Report on the progress, actual state, and ulterior prospects of geological science," says that Smith's original observations respecting the distribution of organic remains were received with indifference, "until the high scientific distinction of Cuvier, and the striking and interesting nature of the facts developed in his brilliant memoir, excited a marked sensation, and commanded the general attention of men of science: for none such could peruse with indifference those masterly descriptions, which exhibited the environs of one of the great metropolitan cities of Europe as having been successively occupied by oceanic inundations and fresh-water lakes; which restored from the scattered fragments of their disjointed skeletons the forms of those animals, long extinct, whose flocks once grazed on the margins of those lakes; and which presented to our notice the case of beds of rock, only a few inches in thickness, extending continuously

over hundreds of square miles, and constantly distinguished by the same peculiar species of fossil shells."

But, as these new genera come on the stage, the saurian reptiles disappear, and are replaced by crocodiles coming near to existing species. Ammonites and belemnites cease, and the buccinea begin to increase. Many of the fish in the lower part of the group are now extinct, but the greater part of the genera approach the living ones, and are most analogous to those now found in the tropical seas. The mastodon, the elephant, and the rhinoceros, appear in the upper formations, as well as on the existing surface, both in Europe and America. The vegetation of these periods is the converse of what it appeared to be in its dawn, dicotyledons, or plants having bark, wood, and pith, being the most numerous, and cryptogamous plants, without sexual organs, being least in number, in accordance with the present order of nature.

In looking over this imperfect, but still faithful, as far as facts are concerned, sketch of the geological state of the planet, the student will perceive the elevated character of this science, furnishing, as it does, such conclusive reasonings for natural theology. In all these phenomena we see the evidences of design. If we try them by physical laws, the spheroidal form of the earth reveals to us its once fluid state, and chemistry informs us it was igneous fluidity. Here we see the truly magnificent means provided for causing "the dry land to appear," through the once circumambient waters of the globe. Every new exertion of this subterranean power is a page in its ancient history, and as history shows the beginnings of nations and their progress onwards to civilization, so does each additional formation of rocks, with its imbedded fossils of distinct species, from the earliest zoophytes to the elephant, show the design of creation was a progressive one, whether we look to the aquatic or the terrestrial organic bodies. For those ancient remains do not consist of forms and of a structure so strange as to separate them entirely from the more

recent acts of creation; on the contrary, the earliest which appear are the types of all which succeeded, entering naturally into all the classifications which have been devised for the illustration of the present order of nature. Of this progression clear proofs have been adduced in the preceding pages. In the lowest group we have seen that the fossils were all marine, and consisted of corallines, encrinites, bivalves, concamerated and other molluscous shells, extinct crustacea, and fishes of a voracious character approaching the saurian family. Such a state of ancient zoology is in perfect harmony with that condition of the earth's surface which we deduce from other considerations. The ocean, though not deep, as it is now, constituted almost every thing; dry land was comparatively rare, together with rivers, bays, and fresh-water estuaries, the proper haunts of the saurian race. Still land existed at the latter period of this group, as we find by the associate plants of the anthracite coal beds, which themselves belong exclusively to a low degree of organization. During this period we find generic resemblances very common in all parts of the world, the evidence of a common temperature. In the next group we find strong resemblances to the first, in organic remains, but with a character both generally and specifically so distinct as to admit of an undoubted recognition of the beds of the group in whatever part of the world they may be found. The saurians, the pterodactylus, the monitor, the crocodiles, the iguanodon, the deposition of extensive fresh-water areas, the existence of tropical forests, of the bituminous coal measures, the changed character of the fish, the existence of fresh-water streams and lakes, and a gradual approximation to the present superficial arrangements, show a very great increase of the land. These changes of elevation were necessarily accompanied with increased depths of the sea, and the consequent introduction of numerous genera, with appropriate habits, not before noticed. We find also, in the lower part of this group, important deposits of

salt. Before these greater depths of the ocean had been produced, its mean depth was more equally distributed over the surface, and it is not difficult for us to understand how vast beds of rock-salt might, under such circumstances, be formed, by the evaporation of the waters of a high temperature. In Europe the salt is usually found distributed above the coal measures, but in the United States it is uniformly found lower down. In both countries, however, the saline deposits generally approach, and indicate a common origin, as if bodies of salt water had existed in such situations, perhaps in some cases insulated, as to produce their evaporation. Superficial incrustations of the same mineral are now found in various parts of the west of Arkansas, caused by solar desiccation of the natural salines. In the tertiary group, the fossils are equally characteristic of the beds of the group in every part of the world, receding in affinity from all previously examined in proportion to their periods, but united by a common plan and analogy. A slight acquaintance with the fossil shells of the tertiary strata, will enable any individual to identify the beds. Here the ammonites become extinct, and cones and volutes begin to abound. Although it may be asserted that the various fossiliferous strata contain characteristic organized bodies by which strata can be identified, and of course which separate them from other strata, yet it is not to be expected that all the fossils of equivalent strata are identical in all countries, although some of them are, as is the case with many living species in both hemispheres. Whilst congeners in age and in fact, their forms are influenced by physical laws, and particular species are necessarily geographically limited by climate and food. Where these are favorable, all the species having a close affinity to each other may be found;* and

* Since calcareous matter is necessary to testaceous animals, we must infer that a change in the mineral nature of their beds would be inconsistent with the prosperous existence of any animals unsuited to it: hence we find the greater number of fossil shells in limestone beds, and in calcareous sandstones and shales; very

where climate and food are not favorable, animals of the same species may be expected to present a marked difference in their external characters. The fine horse of Arabia, which is cognate with the zebra of Africa, is a dwarf variety in Shetland, where climate and food have limited its stature and even its functions so much that the mare only breeds once in two years. This variety of external configuration is common to the mollusca, which differ almost at every point of a coast, as we see from the great variety of the forms of oysters; the same may be observed in the unio of fresh waters; where those of the same kind affect the same kind of locality. If such laws influence animals and plants now, we may reasonably suppose them to have influenced them in geological times, under similar circumstances. Of this general adaptation of causes we have singular evidences in the tertiary group: the surface of the earth being at length brought into a new and appropriate state, we find quadrupeds, and of various kinds, beginning to multiply, all of them, however, no doubt suited to the temperature, which appears from the fossil vegetables found in high latitudes to have still had a general tropical character. We find the elephants of our own period thus accommodated to particular regions, that of the arctic circle, as well as the rhinoceros, being prepared with a fleecy covering. But although about one-fourth of the superficies of the globe has become dry land, and that abundantly fitted for every class of terrestrial animals known to us, yet most important races continue to disappear, not the species only, for with the exception of some found in the tertiary, all the species in whatever strata found are extinct. The palæotheria and the mastodon are extinct everywhere; and the elephant, whose remains we find scattered over this continent, is extinct here also. The mastodon was common to America, to Asia, and to Europe, and

few comparatively are in the pure argillaceous shales, which were probably the ancient muddy bottoms of the waters. It follows from this reasoning that we may expect to find, as we generally do, the same class of animals in the same strata.

we know nothing of the causes which could have produced its universal extinction, if they were not of the diluvial character. Its bones have been found here mixed up with those of the elephant, and the megalonyx, in deposits brought together no doubt by local floods. In other instances skeletons have been found nearly entire, buried in lacustrine marls of a late period, and in one instance a skeleton was found not quite covered up on the surface. They appear to have existed during the present order of nature, but in no instance have we any evidence of their being contemporaneous with what may strictly be called the historic period, no vestige of any thing which has any relation to the human race ever having been found mixed up with their remains.

One of the circumstances which makes this science so interesting to all reflecting beings, is, that in no deposit, whether of gravel, of sand, or of clay, whether in caves or in streams, have any human remains ever been found, that were apparently connected, in the most remote manner, with any of the geological periods which have been reviewed. These have disclosed to us surprising instances of progressive advance in organic structure, adjusted to the gradual changes produced in the level of the ocean and the consequent increase of dry land. But what crowns the consideration of this lofty and attractive subject is, that, reverting from these imbedded records of creative power to ourselves, the full evidence seems to be before us and around us, of a providential preparation for the reception of our own race, and of our being placed here at an appointed time ; not like the animals, with a capacity for self-preservation only, but of rising to that sense of the responsibility we exist under to the universal Creator, which may guide us to another existence when our bodies are consigned to the common receptacle of organic nature.

RECONNOISSANCE FROM WASHINGTON TO THE COTEAU DE PRAIRIE.

Trusting that the explanation of geological principles which I have given in the preceding pages will enable uninitiated readers to comprehend more easily the unavoidable technicalities of geological descriptions, I proceed now to a relation of my reconnoissance, during the past season, from the seat of Government to the Coteau de Prairie, a ridge of high prairie land lying between the Missouri and the Minnaya Sotor Wata-pah (as it is called in the Nacotah or Sioux language) or the St. Peter's river. Desirous of making the opportunities for observation which would occur on my route to Green Bay as interesting and useful to the country as circumstances would permit me to do, I determined to follow the valley of the Potomac into the great Western bituminous coal field. To this I was induced by various considerations. This route would lead me along the line of the Chesapeake and Ohio canal, a work which deserves to be considered of great magnitude, as well in relation to the extraordinary difficulties which have opposed themselves to its construction, the amount of capital involved in it, in which the Government is so deeply interested, and the real state of the resources of the country through which it passes, upon which a dependance is placed for the eventual indemnification of its cost. The inspection of this valley could not but be favorable to a correct apprehension of the geological structure of the country from the falls of the Potomac towards its sources: the natural sections on the river were numerous, and the works on the canal had laid open many others, so that any one who had before traversed this region by land, with sufficient leisure to note the most interesting features of the mineral formations, could not but receive an instructive lesson on a line where the formations are so repeatedly laid open as they are on the banks of this river.

Washington and Georgetown are immediately overlaid by the gneiss, and in the environs of this last place, especially along the line of Rock creek and on the canal, evidences are already perceived in the alternate southeast and northwest dip of the rocks, of that extensive anticlinal movement by which all the rocks along the entire line of the Potomac have been affected, as high up as the great bituminous coal field. In the various localities here, where the rocks are exposed, the true dip of the rocks is so contradicted by the cleavage, that great and patient attention is required to distinguish between that and the stratification; but there are some instances on the canal, on leaving Georgetown, where the southeast dip of the gneiss is sufficiently clear; after some distance the strata become fissile, with large veins of quartz, are elevated into an almost vertical position, and then dip to the northwest, at a very high angle, as far as the great falls. On approaching the falls, the bed of the river presents a singular spectacle: sharp, isolated masses of dark, glossy, micaceous slate, turned upon their edges, lie bare for a great distance, and occupy a large area, resembling the breakers of a boisterous sea suddenly petrified. But the river has long ago abandoned this part of its bed, whilst the proof of the rocks having been reduced to their present state by its former action, is abundant in the immense quantity of pot-holes in the rocks, some of them two or three feet in diameter, occasioned by the whirling motion of fragments of quartz or other hard mineral matter, in depressed parts of the slate, which, when continued a long time, make very deep holes, as may be seen in the beds of all rivers where the water is low and runs quick. This perforating process is one of the causes of the destruction of strata upon a large scale, the holes becoming so deep and numerous that at length the floods have strength enough to disintegrate the strata, and subsequently break up the fragments. In long periods of time, water has power to wear its way through the stoutest mineral masses; and I know of no place which affords a better study of the

power of water to deepen its own beds, than the singular area I have mentioned, as well as the falls themselves, which are amongst the most picturesque localities of this country.*

A little further to the westward, the slaty rocks again dip to the eastward, and are occasionally almost vertical, become contorted, and vary in color. At Seneca creek the soil begins to be reddish, and on the west side a soft red sandstone comes in, the beds of which appear horizontal from the canal, but upon examination have a regular anticlinal structure. Seams of loose red shale abound between the strata of sandstone; specimens also of anthracite coal have been obtained from this neighborhood, the nature of which not having been well apprehended, has induced some persons to suppose that this locality might be a continuity of the Chesterfield coal field of Virginia. It deserves a remark that the red shale is a constant concomitant of the anthracite coal of the Alleghany system. A few miles from Seneca creek, and 24 miles by the canal from Georgetown, the strata dip again to the westward. At Mr. Lee's quarry, from whence valuable slabs are obtained for the public works at Washington, fine casts of calamites, with impressions of other plants, are found. Seams of red shale separate the beds of sandstone occasionally; carbonate of copper is frequent, and small veins of anthracite coal. The country for the next fourteen miles presents fine slopes and levels, and is occupied for agricultural purposes, when an anticlinal ridge of soft red shale comes in upon the river at right angles, dipping to the southeast. About five miles before

* The nature of the power of the water in this locality in ancient times, before the bed of the river was contracted, will be better understood by stating that the falls are nearly at the head of a natural inclined plane, measuring, by the bends of the river, upwards of 11 miles to Georgetown, and having a fall of 168 feet to the tide-water level. This gives an average of $14\frac{1}{2}$ feet per mile, a force which, added to the immense period it operated upon these rocks, probably ever since the elevation of the Atlantic primary chain, sufficiently adequate for the phenomena now presented in the bed of the river. In the succeeding inclined plane of 8 $\frac{1}{2}$ miles, the fall is only 32 feet.

reaching the Monocacy river, a calcareous breccia, coming in from the northeast, the same of which the columns in the legislative halls of the Capitol are made, appears in the ridge, alternating with the red shale in broad seams, and in many places mixed up with it. It is quite apparent that the breccia and the shale have been contemporaneously deposited. Thirty-eight miles from Georgetown the ridge is about eighty feet higher than the canal, and still dips east, but the breccia soon discontinues, and the red shale presents a more horizontal appearance, when the ridge ceases, and a small valley occurs, until, at forty miles, the country rises into a ridge again of red shale and sandstone, still with a southeast dip. At forty-six miles and a half, the ridge is distant about two hundred yards from the canal, but shows a good section dipping to the west. At forty-seven miles the breccia comes in again in broad seams, dipping to the west, and unmixed with any other rock, although the pebbles are in many instances set in the red shale. As this breccia is one of those geological phenomena which explains in a most satisfactory manner the nature of the causes which have in ancient times modified this portion of the surface of the earth, I shall revert to it after pursuing the line of the river somewhat further to the northwest.

At the Point of Rocks, forty-eight miles from Georgetown, the Potomac issues from the Cotoctin mountains, which form the eastern flank of the Atlantic primary chain. This chain, mineralogically considered, is a mass of primary slates, sandstones, and quartz, having a northnortheast direction, and running, with a breadth of about fifteen miles from its western to its eastern flank, through an extensive area of limestone. Geographically considered, it consists of two ranges of hills, divided by the Middletown valley, the westernmost of which, in this neighborhood, is called the Blue ridge, and the eastern one the Cotoctin mountains. On arriving at these last, a remarkable change takes place in the aspect of the country; mountainous masses, formed of many varieties of primary slates,

exceedingly contorted at times, but with a general dip to the east, break through the common level. At Harper's Ferry, twelve miles further, these slates, which rise to a very lofty mural escarpment of eight or nine hundred feet, dip almost in every direction; sometimes the seams appear to form round nodules of one hundred feet in diameter, often are vertical, then again become concentric. The whole mass is in a state of great confusion, which is increased by the cleavage, here exceedingly deceptive. One mile, however, further west, the laminæ of the slate become thin and numerous, and show the true dip, which is easterly. This is confirmed by the edges of the beds in the Shenandoah at low water. A few miles beyond this point, the character of the country again changes, the slates disappear, and we come upon vertical laminæ of limestone, which, somewhat further on, dip to the west.

Reverting to the breccia, and with a view to give a more satisfactory explanation of it, I shall now trace another sectional line, parallel to the one which has been described, but reversing the direction, and descending the country from northwest to southeast. By following the edge of the limestone spoken of as lying in vertical laminæ, the traveller comes upon Boonsborough, in Maryland, a town which stands upon the western flank of the Blue ridge, where it joins the great formation of transition limestone, as it has hitherto been called. On this line he finds the Blue ridge composed of primary slates, chlorites, and sandstones, with conglomerate grits, to the eastern foot of the ridge, all dipping east. Entering the Middletown valley, he finds a decomposed red shale and talcose slate. Leaving Middletown, which is eight miles from Boonsborough, he crosses the Cotoctin mountains, composed of chlorite rocks and slates, with green epidote and whitish slaty sandstones, and advances towards Fredericktown, also distant eight miles. When he has left the mountains behind him, and has advanced to within two and a half miles of the city, he finds the ground covered, for a breadth of several hun-

dred yards, with immense dislocated masses of the calcareous breccia, some of them weighing fifty tons, and the fragments and pebbles of which it is composed cemented together with a red argillaceous earth. One mile from Frederick he finds the limestone as regularly in place as it is west of the Blue ridge, its edges crossing the road in a direction of north-north-east to south-southwest, sometimes dipping easterly, and frequently vertical. The limestone continues uninterruptedly to the Monocacy river, on the eastern side of which laminated slates and shales commence. We have thus all the proofs that the Atlantic primary chain has come up from below through the limestone, triturating and breaking it up into fragments of every size, which were subsequently transported to the east side of the chain by a current from the west, and deposited there, intermixed with the decomposed red shale, for no conglomerate has yet been found on the western side. This great elevatory movement seems to have been followed by another, which has given the anticlinal arrangement to all the rocks of the country; for, after the first deposition of the breccia, we find it dislocated and broken up into the masses before spoken of. This must have taken place posterior to its semi-induration, for, where it lies undisturbed, the fragments of which it is composed are, in numerous localities, rent in every direction, their corresponding parts often shifted, and the fissures filled up with the carbonate of lime. This curious state of the breccia is well exhibited in the columns of the Senate and House of Representatives at the Capitol. I have followed this breccia for great distances along the eastern flank of this chain, and have found it always similarly situated; only in some localities, as in Fauquier county, Virginia, to the northwest of the town of Buckland, the breccia is not composed of limestone, but of slates, sandstones, and quartz, because the limestone has never extended to that parallel. We may safely infer, from all these circumstances, that the Atlantic primary chain was elevated posterior to the deposition

of the limestone, which may be considered the equivalent of the lowest beds of Mr. Murchison's Silurian rocks.

These non-fossiliferous beds extend now a long way up the river, which is very tortuous, embracing many beds of hydraulic lime, which, as well as the common limestone, when pure, has added much to the value of real estate here since the construction of the canal. The compact dark blue kind makes an excellent mineral manure, but cracks when used as plastering for rooms, an objection the whiter kinds are not so obnoxious to, they being less ferruginous. The whole distance up the river, the beds are anticlinally arranged, often forming complete arches, and occasionally the seams, not more than eight inches wide, are disposed into concentric forms of forty feet diameter. At Shepherdstown a band of quartzose red sandstone, about three feet broad, sometimes crossed with small seams of carbonate of lime, runs through the strata of limestone due north and south. I obtained a singular specimen from it, with septæ standing on its face in relief, like chain coral. Higher up lofty bluffs of limestone approach the river on both sides; some of them on the left bank are cavernous, with pendent stalactites inside. Near Williamsport the beds frequently dipped both ways in a short distance; indeed, in some localities they have a wavy structure, forming a set of anticlinal and synclinal lines, as in diagram 10, where, at *a*, a ravine, the continuity is interrupted by the removal of mineral matter. Diagram No. 11 represents another locality near Williamsport, where, at *a*, a part of the beds seems to have slid off, and to have left a ravine, where trees are now growing. The main beds of limestone here are about three feet wide. In approaching the Alleghany ridges the evidences are abundant of a great disturbance in the beds. I copied the appearances exhibited by them in diagram 12, within the space of three miles. At Williamsport a slaty shale comes in at the river, through which a road has been cut to the canal bridge, which exhibits the laminæ standing in every possible direc-

tion. The canal not being navigable beyond this town, which is one hundred miles from Georgetown, I abandoned those instructive banks of the river, and continued over the limestone, occasionally alternating with shale, by the upper route, to Clear Spring, about seven miles. A little beyond this place the formations change, and the heavy limestone water is exchanged for the pure springs flowing from the shales and sandstones of the north mountain, the first in advance of the Alleghany system of ridges west of the Atlantic primary. Further on, about nine miles, a fine fossiliferous bed of limestone comes in on the Licking creek, containing producta, spirifers, cardia, and some goniatites. There is, however, a lower route, by the way of what is called Big Spring, betwixt the North mountain and the river, where the limestone, with the exception of a few continuous beds of shale, is continuous; and as the North mountain, on the Virginia side, across the Potomac, continues its course to the S. S. W., it is evident that the bed of the river has been excavated subsequent to the deposit of the North mountain, and that the shales and sandstones have been removed from the limestone occupying the space between the now separated portions of the mountain. I have subsequently had an opportunity of examining the country on the Virginia side, and found every thing in correspondence there. The limestone extends from Shepherds-town to the east flank of the North mountain, near Hedgesville, and the same beds of shale which are observed on the opposite side, occur on this side, betwixt this last-mentioned place and Martinsburg. Pursuing the road from Licking creek to Hancock, there are numerous sections of shales and sandstones, dipping alternately east and west, the strata frequently exhibiting imperfect arches. On the route a very distinct view is had of a narrow valley, on the Virginia side, lying between two subordinate ridges, called the Third hill and Sleepy-creek mountain. Here the first veins are found of anthracite coal of a good quality; and although they are

known to extend many miles to the S. S. W., no examination of them has yet been made minute enough to ascertain their capacity. This I learned from some of the proprietors is about to be done.

From Hancock to Cumberland, the proposed termination of the Chesapeake and Ohio canal, about forty miles, a great number of subordinate ridges are crossed, consisting of red shales, sandstones, ferruginous ores, grits, and occasional bands of encrinital limestone. Some of these are the bifurcations of one principal ridge, as Town hill is of Sidling hill, which extends up to the Juniatta, in Pennsylvania; all, however, appear to have one general magnetic direction, running between north and northeast.* At Flint Stone, twelve miles from Cumberland, are beds of limestone, containing fossils analogous to those of the carboniferous limestone of the Western country, bellerophon, lingula, avicula, turbo, a great variety of favosites, madrepores, and other zoophytes, and beds of encrinites, converted into calcareous spar, which would make very beautiful marbles. These beds appear to me to be the equivalents of the Ludlow rocks. The country again rises with shales and sandstones, but on approaching Cumberland, beds of limestone are again met with, but very slaty, and alternating with shale and sandstone; sometimes they are horizontal, sometimes contorted, and are thrown even into vertical inclinations. The fossils here again come near to those of the carboniferous limestone. To the west of this place rises a lofty ridge, called Wills's mountain, about 900 feet in height, with an immense gap, through which Wills's creek

* Charles B. Fisk, Esq., the intelligent chief engineer of the Chesapeake and Ohio canal, was obliging enough to have parallel lines run for me, to cover points of white granular sandstone, and red sandstone, which had been identified as belonging to the anticlinal strata, following the magnetic direction above alluded to. These lines, which extended from the neighborhood of Hancock across the Cacapon river to a point west of the Cacapon and south of the Potomac, gave a course of S. 34 degrees W.

finds its way to the Potomac. East, however, of this mountain is a small ridge, which stops short of Cumberland to the northeast, being divided from its southern portion, which continues its southern course across the Potomac in Virginia, by a basin about a mile and a half wide, in which Cumberland is situated, and through which the Potomac flows. This ridge is composed of shale and limestone, with producta, spirifers, and cardia. It is evident that the ancient floods which have retired from this part of the country at the period of its becoming dry land, have carried away the subjacent shale, and that the superincumbent limestone has fallen in for want of support. The gorge of Wills's mountain is a very remarkable locality; it extends about 3,000 paces, and is in some places 500 paces wide, presenting a very curious and quite a magnificent section of the mountain. This consists of red shale, subjacent to grayish sandstones and grits. On the north side the summit is about 850 feet from the creek, showing a bold mural escarpment, with an immense talus of fallen masses, extending two-thirds of the way up the cliff. On the south side, at the eastern end, the base rises by a slight inclination into a regular curvature of the beds, the lowest being a red shale, and the upper beds consisting of grayish sandstones and grits. The curvature presents a segment of an arch, the base of which would be about 9,000 feet. On reaching the western end of the gap, I observed that the flexure of the beds had as it were collapsed, and that a great many of them, to the amount of about 200 feet in thickness, were hanging vertically upon the flattened side of the arch, as in diagram 13. Amongst the rubbish I had seen some specimens of *fucoides Alleghaniensis*, and as soon as I fully comprehended the collapsed state of these rocks, it occurred to me that I might possibly find the beds to which they belonged, and climbing the cliff and looking diligently about, I had the satisfaction of finding them, with several other varieties of *fucus* in place on the outermost of the vertical beds. The

fuci all belonging to the seaweed tribe of plants,* these must have grown upon the flat bed of the sea. It is evident, therefore, that all the beds had been bent up by some action from below, and that, from some inequality in the action, or from some external cause, the bed on which they lay, together with its associate strata, had collapsed towards the centre, in such a manner that they would appear to have been thrown up into a vertical position, if the incurvated part had been concealed.

A few miles from this remarkable gap, on the road towards Frostburg, a change in the formations takes place; the sandstone becomes micaceous, and the shales alternate with bands of limestone. The country now rises over Dan's mountain, the eastern limit here of the Western bituminous coal field, to Frostburg, ten miles from Cumberland, and it is in the vicinity of this place, which is about eighteen hundred and fifty feet above the level of tide-water, that those fine veins of bituminous coal have been opened which are hereafter, when the canal is finished, to come in competition with the other bituminous coals on the Atlantic border. One of the veins here, of which there appear to be four regularly developed, giving twenty feet of coal, is ten feet thick, and would be all of a very excellent quality, if it were not for a deposit of shale, from six to twelve inches thick, in the centre of the vein. A very great advantage which this coal, in common with all the bituminous coal mines of the West possesses, is, that in consequence of the deficiency of the several formations of the geological column, which has been before mentioned, and the elevation of the region above the river levels, the coal is excavated with comparatively little cost, and, dipping gently to the west, the drainage is easily effected. The hydrates of iron, also, of this neighborhood, are very promising, but the

* Some of the recent species of fuci are many hundred feet in length, and have a small bladder at the end of their leaves, by the aid of which they float.

continuity of deposits of this character is very variable, and no calculation can be made either of their extent or thickness, unless the beds have been very generally worked and for a long time. This is not the case with the coal, which takes its origin from a different cause, and which develops itself in many neighboring localities, with the greatest assurance of its being continuous. Frostburg is the summit level of the country, and the beds lie generally in the same horizontal manner in which they were deposited; from which the inference may be safely drawn that they were deposited posterior to the movement which has given an anticlinal arrangement to all the beds lying between them and Georgetown.

From Frostburg I descended the valley of George's creek eighteen miles, to the village of Westernport, on the northern branch of the Potomac. The valley is hemmed in by lofty hills, containing various veins of coal. Three miles beyond Westernport and one beyond the mouth of Savage river, the Potomac has worn its way through a ridge, apparently nine hundred feet high at least, making a gap of a mile wide. On the south side is a very curious vertical section, (Diagram No. 14,*) exhibiting the rare spectacle of six workable veins of coal, containing near forty feet of coal and two bands of iron ore. The uppermost of these veins is about sixteen feet thick, and is about eight hundred feet from the level of the river. The six-foot vein of this locality has a band about one foot thick of argillaceous shale in the centre, like the vein at Frostburg, and the three-foot vein is somewhat pyritiferous. These circumstances may assist future observers in their inquiries whether these veins are continuous and identical. The coal is nearly at the same height at both localities, Frostburg being one thousand two hundred and seventy-five feet above the level of Cumberland, and the summit of the section near Savage river having about the same elevation, the truncated

* In this diagram, the thickness and succession of the coal veins are put down without reference to the thickness of the beds of sandstone which separate them.

mountain being perhaps nine hundred and fifty feet high, and the fall to Cumberland from thence being about three hundred and thirty feet. The veins at both places dip to the west. I regretted at the time not having leisure to examine this subject more minutely with reference to the general continuity of the veins. When the impediments* to the navigation shall at some future period be overcome, there will be no part of the world perhaps where coal can be mined and shipped with greater facility than at the Savage mountain. The galleries can be constructed in the broad face of day, and the coal let down by drops to the boats below. I remember seeing this admirable contrivance at Sunderland, in England: the coal being brought from the mines to the river at an elevation of several hundred feet, one car at a time, laden with coal, was carried out by machinery, and suspended over that part of the river where the vessel lay; it was then let down, with the man accompanying it, within a moderate distance from the open hatches; the man then touching a spring, the bottom of the car was let go and the coal dropped into the hold; the car was then hoisted up again, and another let down.

Returning to Cumberland from Westernport, a distance of twenty-eight miles, by the banks of the Potomac as far as it was practicable, I had a fine opportunity of observing the river sections in a part of the country remarkably wild and picturesque, where the river occasionally wound its way through very narrow mountainous gorges. Not far from Westernport, on the left bank, there is another coal vein, of about twelve feet, which I was told reappeared on the southern or Virginia side, at nearly the same level, about three miles distant. The termination of the coal field was soon marked by the reappearance of anticlinal and contorted limestone beds alternating with shale. Sometimes the hills come down to the left bank so abruptly as to make it necessary to cross to the Virginia shore. At one place the mountain descends in an inclination of seventy degrees to the river, and a bridle-path has been

* In thirty-one miles the fall is three hundred and twenty-four feet.

made, which crosses this slope at an elevation of five hundred feet, over which a careless traveller might be easily precipitated. This was a section of Dan's mountain, which I had before crossed on my way to Frostburg. On descending the east side of this mountain, I came in view of a most striking section of the limestone beds on the opposite bank of the Potomac, where the flexure of the rocks was occasionally continued in an anticlinal and synclinal line, upon a large scale, and the surface had been so curiously removed in various parts, that sometimes a perfect arch was left, and at other times an inverted one. Diagram No. 15 represents one of these sections.

From Cumberland I now went in a northerly direction near forty miles to Bedford, along a valley between Wills's mountain on the west, and Evitt's mountain, a somewhat smaller ridge, on the east. The red shale which underlies Wills's mountain at Cumberland, constantly appears subordinate to the sandstone on this route. The valley abounds with knolls of limestone, containing fossils of the carboniferous limestone, resembling the knolls in Alleghany county, Virginia, lower down on this range, about two hundred miles south, in the vicinity of the Sweet springs. The constancy of the phenomena connected with the anticlinal arrangement of the whole series of Alleghany ridges, seems to suggest the true explanation of their origin. Prior to this undulating elevatory movement, the level of these beds seems not only to have been higher, but to have been continuous and without valleys. Whilst some parts of the strata were forced up into the anticlinal form, in a constant magnetic direction, the intervening distance betwixt each axis or ridge would probably be thrown into a ruinous state, and as the dry land rose and the waters retired, the ruins would at length be borne away, and the valleys remain. All these ridges, however, are not in a perfectly anticlinal state at present. At Prospect rock, at the top of the Cacapon mountain, in Morgan county, Virginia, the strata have

an easterly dip, whilst on the west side the beds are truncated, and the greater portion of the mountain on this side seems to have been carried away. The origin I have here attributed to these ridges seems the more probable, when it is considered that they only commence where the shales come in, which being easily removed, soon cause the ruin of the superincumbent strata.

In the vicinity of Bedford, which is remarkable for its efficacious mineral waters, the limestone and shale alternate. The limestone, in strong strata, contains impressions of products, spirifers, and cardia, and in a crumbling shale superincumbent, I found great quantities both of bellerophon and goniatites.

From this place I pursued a northwesterly course again, towards the bituminous coal field, passing over the usual beds of limestone, shale, and sandstone. Fifteen miles from Bedford I again came upon the great horizontal deposits of the country, from whence the waters flow to the Ohio, called here the Backbone mountain, in many places the great Alleghany mountain, but which, from its being the constant limit, during its long course, of the great Western bituminous coal field, should be known by a general characteristic name. Here, on the Shellburg road, the mountain is twelve miles from base to base, and has a table land at the summit of eight miles broad. Advancing to the summit, a regular millstone grit occurs, with beds of conglomerate, underlain by shale; and at the top, about half a mile to the right of the road, there is a coal vein, worked by a person named Stotler, about seven feet wide, with two feet of bituminous shale in the centre. This vein is perfectly horizontal, and conforms to the subjacent strata.

From hence to Pittsburg, about eighty miles, the coal constantly *crops out* in all the ravines and in descending most of the hills. Opposite to this prosperous town, at the junction of the Monongahela with the Ohio, there is a fine section,

about 400 feet high, containing a six-foot vein, which has been long worked for the use of the city. It would be superfluous in me to allude to other localities, or to those which are so exceedingly interesting up the valley of the Monongahela, it having been recently done with much detail and accuracy.* The great extent also of this Western coal region is sufficiently known to convey an adequate idea of its vast resources.† Mr. R. C. Taylor estimates the area covered by certain counties in Pennsylvania which lie within it, to cover twenty-one thousand square miles, exclusive of other counties which lie partially out of it. If to this are added the extensive deposits in Ohio, Virginia, Maryland, Kentucky, Tennessee, Indiana, and Missouri, we see sufficient reasons for indulging the most sanguine anticipations of the future wealth to be accumulated in this part of the country. But it is not the coal alone—its concomitants, iron and salt, will aid in accelerating its prosperity. Although the general geological arrangement of the coal measures in the United States and in England is very similar, as to the mineral structure of the beds, the organic incidents, and the associate deposits of iron, yet the analogy does not hold as respects the salt. I shall make a few remarks on this subject by-and-by, which will be comparatively useful to observers here. The beds of the coal measures in the northern counties of England, are irregular alternations of sandstones, composed of fragments of silex, mica, and felspar with a mineral cement, schistose clayey beds, and veins of bituminous coal. The schistose beds contain ironstone, in nodules and layers, which appear to be formed by molecular attraction in the ancient muds, now become shale.

* Dr. S. P. Hildreth "on the bituminous coal deposits of the valley of the Ohio," &c.—See Silliman's Journal, October, 1835.

† Besides the numerous quantity of veins lying high and dry above the streams, there are the yet unexplored ones lying beneath them. In boring for salt water in many parts of this region, many coal veins have been passed through, some of them six and eight feet thick. Those in the Newcastle district, England, known as the high and low main seams, which are worked at great depths, are known to extend over 150 miles square, and have been mined for several years.

The sandstones are very fissile, owing to the disposition of the mica; they consist of rounded granular quartz, from masses of which their constituent parts may have been detached with the mica. In this country there are numerous thick beds of sandstone formed with rounded grains of quartz in the upper part of the carboniferous limestone formation as well as the millstone grit, which have no mica. The sandstones with mica, here spoken of, are much less coherent than the micaceous sandstones in connexion with the primary rocks, of which there are some fine examples up Rock creek, in the District of Columbia.

These fissile sandstones frequently contain stems and fragments of terrestrial plants, and are often separated by beds of limestone containing marine shells. The abrupt changes of these mineral strata, and their organic contents, often without admixture, show that they have been deposited not at distinct periods alone, but under circumstances widely different. The strata appear at one time to have been covered with calcareous salt waters, which subsequently became dry land, and afterwards received argillaceous deposits of mechanical origin, brought by fresh water, in the manner alluded to when the wealden group was treated of. In some of these shales, the remains of fossil unios are found associated with the plants, showing that the same state of things existed in the muds of the estuaries and rivers of ancient geological periods, which we are constantly observing on this continent under the present order of nature. These unios are found in great abundance in the Jarrow colliery, in the Newcastle district, many of them lying with the valves gaping open, and proving conclusively that the bed where they are now found was once the surface of the earth, though now many hundred feet below it.* This bed is only one of a number similarly situated, and

* Similar observations have been made here. Dr. Hildreth, p. 69, 70, observes that fossil unios, melania, and lymnea, all fresh-water genera, are found "in a bed of dark carbonaceous clay," at a level many feet below the coal.

if it constituted the surface a sufficient period of time, as we see it did, to admit of successive generations of plants and fresh-water mollusca growing on it, what duration of time must be allowed for the aggregate formation of the whole coal measures, when each bed in its turn constituted the surface for an undefined period? And then what are we to think of the period necessary for the deposition of all the stratified portion of the earth, when the coal measures stand in so small a relation to the whole?

This portion of the carboniferous group presents, also, the singular spectacle of vegetable fossils prevailing almost to the exclusion of all others, a circumstance which gives weight to the vegetable origin of bituminous coal. Besides the profusion of vegetable fossil impressions found on the bituminous shales superincumbent on the coal veins, we find the leaves and stems of great varieties of plants dispersed in the slaty and siliceous beds alternating with the coal, as if they had been deposited at a geological epoch devoted almost exclusively to the vegetation of plants. Assuming the vegetable origin of coal, it appears most probable that coal veins must have been furnished by plants which grew on the spot, as peats do at present. In cases where plants have accumulated by being swept from a distance into particular situations, as at Bovey Heathfield, in Devonshire, where whole forests seem to have swept off from the Dartmoor granite, and collected in a basin lower down, we must expect to find them, as they are there, mixed up with gravel and detritus; but that does not occur in the coal veins, they are composed of pure combustible matter, although, as has been seen, they are sometimes divided by argillaceous layers. If we were to endeavor to account for the coal measures upon the hypothesis of plants transported from more elevated and distant districts, in vain we look for vestiges of such districts, lost in admiration at the changes which the surface has undergone. The degree of bitumination belonging to the many varieties of coal, and upon which

their excellence for particular purposes depends, may be caused by the inherent qualities of the plants of which they are the supposed residuum. There is one particular in which the bituminous coal region of this country differs widely from that of England: here the beds lie generally as undisturbed as when they were deposited; there they have been dislocated and shifted in a surprising manner. There are instances of *faults*, in the Newcastle district, where the strata have been rent, and a subsidence of one portion has taken place to the extent of 140 fathoms, near 850 feet. When this was effected, of course the corresponding part would have formed an escarpment to that extent; yet all this has been removed, for the surface of the country is now level.

Not having, upon this occasion, passed through the great deposits of anthracite coal, I shall not refer to them any further than to observe that they are totally distinct, as to their geological position, from the bituminous coals, and of a distinct quality. With some exceptions, as at Broad-top mountain, in Bedford county, Pennsylvania, they are entirely non-bituminous, and are all, without exception, deposited low down, amongst what have been called the *grauwacke* rocks, and in that group which, when it comes to be minutely examined and compared, will, I have no doubt, prove the equivalent of Mr. Murchison's Silurian rocks. There are very strong resemblances amongst some of the fossil plants found in the shales of both the bituminous and non-bituminous beds, but I believe the amount of the differences, when they are carefully compared by experienced observers, which measures are taking to have done, will prove to be great and characteristic.

Deposites of hydrate of iron accompany the bituminous coal measures, as they do in England, but in this country they vary exceedingly in their extent and capacity. The beds in the neighborhood of the Potomac appear to be thick, and, if they are continuous, will be of immense value. The deposits in the

vicinity of Frostburg are said to give a thickness of fifty-four feet.* A section of the strata at the Junior Furnace,† Scioto, Ohio, shows a mean thickness of about six feet in three beds alternating with coal. The deposits of this kind which I have examined in the United States appear to have been made almost all from fresh-water chalybeates, loaded with ferruginous matter, which accords with similar beds in Europe. At Abersychan, in South Wales, England, the beds, in a breadth of 119 yards, give an aggregate thickness of 42 feet 8 inches of coal, yielding upwards of 30,000 tons to the acre, whilst the numerous deposits of hydrate of iron alternating with the coal veins, give at the rate of 15,000 tons per acre. Mr. R. C. Taylor states‡ that, by the official returns of the Monmouthshire Canal Company, there were brought down to the wharves of Newport from that district alone, in one year, 513,974 tons of coal, and 104,129 tons of iron.

Thus far the analogy between the structure of this portion of the geological column in both hemispheres seems to be perfect; it fails, however, as it respects the salt, which in England is drawn from the new red sandstone group, higher up in the series than the coal measures, whilst in this country, in Pennsylvania, in Ohio, and on the Kenawha in Virginia, the coal strata have to be penetrated to arrive at the salt. In my report of last year§ I gave a section of this kind 700 feet deep, at Kiskiminetas, in Pennsylvania. Dr. Hildreth states that, twenty-five miles from the mouth of the Muskingum, wells have been sunk 900 feet deep for salt, which is 300 feet below the level of tide-water. It is a very general opinion that these wells are supplied from the percolation of fresh water through certain saliferous strata, charged with particles of

* Report of an examination of the coal measures, including the iron ore deposits, &c. George W. Hughes, U. S. civil engineer. Page 20.

† Dr. Hildreth's observations, &c. Silliman, Oct. 1835. Page 133.

‡ Transactions Geological Society of London, vol. 3, page 436.

§ Page 36.

salt, and of course sufficiently porous to be pervious to water. These strata consist of porous, whitish-colored, fine-grained sandstone, often tinged with a red color; calcareous rocks of a harder structure; marly clays, containing particles of salt; and cavities, formerly containing large crystals. These general characters seem to be common to all the borings. From the general direction of the salt-works of this country an inference may be drawn that these saliferous rocks run parallel to the direction of the great bituminous coal field, and may, in fact, constitute a mineral zone, saturated with salt, and conforming in its general direction to other great mineral zones parallel to it on the east. This is a subject highly deserving the most accurate observation. The deeper the wells are sunk, the stronger the brines are found, probably on account of the exhausted state of the rocks previously used. Generally speaking, also, the brines only become gypseous at the greatest depths.

Considering, however, the Alleghany or Backbone mountain alluded to, near Shellburg, in Pennsylvania, as a great geographical boundary separating the Western bituminous coal measures from all the anthracite beds of the Silurian rocks, running in a southwesterly direction to join the Cumberland mountains, and having the salt deposits west of it, we find some important salines east of this great boundary, as at Saltville, near Abingdon, in Washington county, Virginia; but the floor of this valley, lying between Clinch's and Walker's mountains, is the highly-inclined limestone found east of Hancock, in Maryland, alternating with shale, and carrying older fossils than those which are found even in the carboniferous limestone. The Abingdon wells, which I visited in 1834, are in a totally different deposit from those stony strata west of the boundary just described. The valley in question has, before the deposit of the salt, been much deeper than it is now, and has been partly filled up by gypseous and saliferous clays. In digging the first ten feet, they go through a blackish loam which forms the surface of the whole valley, then twenty feet

of blue and reddish clay, then thirty feet of clays very much intermixed with gypsum, and lower down, to about two hundred and twelve feet—the greatest depth they have been obliged to go, for here the boring instruments drop into an unmeasured deposit of brine—through masses of gypsum,* sometimes containing a little clay, and occasionally compact argillaceous laminæ, with ferruginous pebbles and pieces of sandstone. In the immediate vicinity of these salt-wells are extensive dry deposits of gypsum, where it is quarried for the use of the adjacent country. There are also others higher up the valley, nearer the sources of the Holston. The average quantity of brine necessary to make a bushel of salt at Kenawha is said to be about seventy gallons, but at Saltville, twenty-four gallons are sufficient to make one bushel, and this of the purest kind, there being no traces of muriate of lime in it, which is so troublesome at the other salt-works where the brine acts upon the calcareous rocks. The brine here comes from the pumps loaded with sulphate of lime or gypsum, which is deposited in the form of blocking in the pans where the brine is boiled. These salines appear to be inexhaustible. Ligneous fuel, however, is rapidly disappearing from the neighborhood, and the proprietors would do well to institute a search for coal, which may probably be found in the vicinity.

The geological position of Pittsburg is interesting. The Alleghany and Monongahela rivers unite here to form the Ohio. In ancient times, before the streams of this continent

* There is a striking analogy between this deposit and those of Ischil, on the Grunden lake, in Germany, which originally gave its name to Salzburgh. There is an interesting paper in the *American Journal*, &c. for January, 1836, from an officer in the United States navy who visited those salt-works, in which he says, "The gangue of the salt, if the word may be used, is composed chiefly of a clayey earth, mixed up with irregular blocks of sulphate of lime. The salt is mingled with these, usually in strata of from six inches to two feet in thickness." Fresh water is let into the chambers of these deposits, and when saturated is drawn off. This is probably the natural manner in which the brine is formed at Saltville.

were reduced to their present level, the mud they brought down was deposited at the point of their confluence; this, since the lowering of the streams, has become the triangular alluvial deposit where Pittsburg is built, and which now occupies almost the whole area. From this place the country descends parallel with the Ohio river, whose banks of alternate sandstone, shale, and limestone, are from 350 to 450 feet high, to Beaver, in Ohio, where, in the valley of the Big Beaver river, several coal veins are observed. The country now rises to Ravenna, the summit-level of this part of Ohio, about 1,140 feet above tide-water. Boulders and gravel of primary rocks are for the first time found on the route here, and continue to increase in proceeding westward to Cleaveland, Ohio, upon Lake Erie, sixty-four miles distant. Here we have the evidence of a lowering of level of the Western waters, a low rich alluvial flat extending from the banks of the lake, about fifty feet high, three miles east, to its ancient border. The same appearance presents itself in various parts of the shore of this lake, as well as on the shores of Lake Ontario. At Sandusky regular beds of the carboniferous limestone, with its usual fossils, are found. On this great level the formations change no more for an immense distance in the line of my route. On the approach to Detroit nothing is to be seen but a low sedgy shore to the west, and a flat country to the east, consisting of sand and clay, without any sensible inequality of surface, being the old lacustrine deposit, when the whole of this region formed one large lake. This appears to have become dry land at the lowering of the level of the waters of this continent, more than once already alluded to. At Fort Gratiot, seventy-five miles from Detroit, finding some anodontas on the shore of the St. Clair river, I had the curiosity to dig into the sides and bottom of the bank of the river, about thirty-feet high, where I found great quantities of unios, anodontas, and numerous fresh-water shells enclosed in the clay; those near the level of the water were quite soft, but indu-

rated afterwards, and proved to be the same species as others now found in the neighboring parts of the lake. The next two hundred and thirty-five miles, to the island of Michilimackinac, I made on the lake.* This is a small island, formed of a soft and extremely porous calcareous rock, broken down from top to bottom into a breccia, and re-cemented. It has at some period been much higher than it is, isolated portions still remaining far above the general level. The Sugar-loaf, a sort of pinnacle, or out-lier, is an instance of this. It is a brecciated pillar, composed of adhesive portions of the old calcareous beds, which have resisted the causes that have overthrown the stratification; some of the masses are vertical, others highly inclined, and some horizontal. In some parts of the island the beds were not so much disturbed, and were underlain by soft, marly, broken-down, calcareous matter. I saw very heavy masses of the same porous limestone which had been fished up in the bay, which proves that the island is an out-lier, greatly reduced in size, of what was once connected with the adjacent country. This my time did not permit me to visit. There is not much to occupy a geologist on this island, but in my walks to a small plantation called the Farm of the Mission, I saw an extensive lacustrine deposit, full of various species of planorbis, &c. of the usual kind, the which,

* It appeared to me somewhat remarkable that on this already important line of navigation to Michilimackinac and the Wisconsin Territory, frequented by the craft of the country and by steamboats of the largest burden, the maps should be so absurdly erroneous as they are, as to the distances. In those which I had, and I believed myself to have the best, Presqu'isle is put down a great deal too near to Michilimackinac, and Middle island occupies the place where Thunder island ought to be. The following table of distances was corrected for me by an experienced navigator on this lake :

Fort Gratiot to Point aux Barques	-	-	-	-	70 miles.
to Thunder island	-	-	-	-	70
to Middle island	-	-	-	-	12
to Presqu'isle	-	-	-	-	18
to Bois Blanc, called Bobbello	-	-	-	-	55
to Michilimackinac	-	-	-	-	10

if I had seen any one to impart the information to, I should have informed them would have greatly improved their scanty crops, if they had thought proper to dress their lands with it.

Intending to strike the Mississippi by the way of the Wisconsin river, I proceeded from this point to the mouth of Fox river, at the bottom of Green bay of Lake Michigan, where Fort Howard is situated, and where a flourishing village, named Navarino, is rapidly growing up. I had no opportunity of landing at any of the islands in Lake Michigan, but passed sufficiently near to the fine sections exhibited in the lofty banks of the southernmost of the Wagooshugamessun, or Fox islands, to perceive they were a white incoherent sandstone, such as I subsequently met extensive beds of further to the southwest. On examining the country as rapidly as my time permitted, I found a ledge of strong horizontal beds of carboniferous limestone, about eight miles from Navarino on the east, and distant about two miles from the lake; these contained orthocera, together with the characteristic fossils. Between this ledge and the shore other indisputable evidences present themselves of the recession of the waters of the lake. The soil about Navarino is a rich siliceo-calcareous loam, of the greatest fertility.

At this place that singular phenomenon which was observed by the old French discoverers, and which is mentioned by Charlevoix, still attracts the attention of the traveller. I had observed in the neighborhood of Fort Gratiot, on Lake Huron, evidences of a varying level of the waters; but as it did not differ from that of all large bodies of fresh water, I attributed it to the influence of the winds on the surface; but here is a perfect representation of a tidal shore. I had put rods down to form some estimate of this movement, and ascertained, soon after my arrival, that from 6 P. M. to 11 A. M. of the succeeding day, the water had ebbed twenty-four feet, and one foot perpendicular. Subsequently I found the flux and reflux to be quite irregular as to periods, although the phe-

nomenon is of daily occurrence ; and this was confirmed to me by an intelligent resident of the place, who was in the habit of observing it both winter and summer. In the winter, he informed me the ice forms in a solid mass to the bottom near to the shores, whilst in the centre of the river, the water at the flow lifts up the ice, which, when the reflux takes place, cracks, and is swayed down again. The observations which Governor Cass made near the mouth of Fox river in 1828,* show an extreme irregularity in the periods of this rise and fall, and which is totally inconsistent with the regular recurrences of lunar influence. In the paper referred to, which is from the able pen of Major Whiting, U. S. A., there is a letter from Governor Cass, which explains the phenomenon by a reference to causes as constant and irregular as the phenomenon itself. Green bay is an arm of Lake Michigan, running nearly parallel to it, and about one-fourth of its length. Lake Michigan is about three hundred miles long and fifty broad, holding a straight course somewhat east of north, (parallel to all the characteristic mineral directions of this continent.) Governor Cass supposes that when the northerly winds are packing up the waters at the mouth of Fox river, the wind-tide continues still driving on towards Chicago, at the southern end of Lake Michigan ; the effect of which, by lowering the level at the mouth of Green bay, will cause an ebb from the bay into the lake, which will equally prevail at Fox river, and this even during the existence of the wind that had caused the flow there. This would explain the reason of Charlevoix's surprise at seeing his canoe floating off in the face of the wind. A series of observations made in the neighborhood of Fort Gratiot, at Saginaw bay, at Chicago, and Green bay, noting accurately the contemporaneous state of the winds, and any change of level at Michilimackinac, where the same wind

* "Remarks on the supposed tides." Silliman, vol. 20, p. 205.

would act upon Lake Huron, would probably confirm the very judicious opinion of Governor Cass.

From this place there is canoe and flat-boat navigation up Lower Fox river to Lake Winnebago. At a distance of about forty miles, the banks of the river are quite remarkable for the beauty of their slopes; and the general fertility of the soil, composed of siliceo-calcareous earth, mixed up with vegetable matter, will soon bring a great population into this part of the country. On approaching the rapids of Kahkawning, called Cocolo by the Canadians, the well-wooded banks of the river slope in such a uniform and graceful manner, that the broad stream seems to be gliding through an amphitheatre. There is a large flat area at these falls, which seem to have a descent of about twenty feet to the mile, across which is a portage, served by the drunken Winnebagoes of this place. The water falls over horizontal beds of the carboniferous limestone. Twelve miles further the river falls about six feet over another ledge of the same formation, at a place called La Grande Chute. Coasting the west shore of the lake, which lies low, and is crowded with fine forest trees springing from the richest soil, I reached the Pawaygun, or Wolf river, in about twenty miles. The shores of all the waters here produce great quantities of *zizania aquatica*, or wild rice, from which the Menomones, or rice-eaters, receive their name. From this place, for about one hundred miles, the country lies very low, the elevations of land being trifling, and principally composed of the sand resulting from the disintegration of ancient beds of sandstone; it may be considered, with this exception, a great rice-swamp. At a place called Apackquay, or Rush lake, I saw several thousand acres of *zizania* together, two miles in one direction and five or six in another, resembling an immense field of wheat, with the heads just formed and waving about. At other places the channel went for great distances through dense areas of wild-rice stalks, ten feet high, mixed up with rushes and other aquatic plants, so as to exclude every object

but the sky. At times the water was so shallow it was with difficulty the canoe could be forced through it. Often it was necessary to trust altogether to the compass, and the immediate approach to Fort Winnebago was so tortuous, the channel so often turned back upon itself, that the compass was quite useless. Whatever the direction, the country is covered with these tall plants, and the grasses on the land, when you succeed in getting there, are so rank (now that the buffalo has left this part of the country) that it is difficult to advance. It is in fact the summit-level of this part of the country, the Fox river draining it towards the north, and Rock river and the Wisconsin draining it towards the south. Before the retreat of the waters, which has been before spoken of, which perhaps was contemporaneous with the disintegration of the sandstone, these extensive rice-swamps have been lakes, and it is only since their subsidence that the zizania has begun to grow.

In the neighborhood of Fort Winnebago the country begins to rise, and the beds of carboniferous limestone observed in Lower Fox river, are overlain by beds of quartzose sandstone, having occasional siliceo-calcareous seams amongst them. The sandstone beds are horizontal, disintegrate easily, and are often variegated in color, having red, orange, and dark tints. I was taken to a locality in the neighborhood of the fort where this stone had been quarried, and became immediately aware that I was in the vicinity of a galeniferous district, for I was well acquainted with the analogous formation in the State of Missouri, and which is spoken of in my report of last year.*

From Fort Winnebago there is a portage to the Wisconsin river of about two thousand five hundred yards. This is a dead flat of black mud and sand, occasionally overflowed so as to admit of canoes passing to Fox river, and from which the waters have retreated. The Wisconsin is an ample stream,

with numerous islands and sandbars. The low alluvial banks are sand, with seams of red oxyde, showing that they are derived from the old sandstone beds. These banks are always well wooded, and pine, as in all sandy countries, is of frequent occurrence. The sandstone strata soon occur after getting upon the swift current of this river, in banks about sixty feet high, which become loftier as the stream deepens its bed. One of these localities, where the escarpment is near two hundred feet high, is an isolated ridge, a little in the rear of the left bank, with a crest resembling, in an obscure manner, walls and batteries, and has obtained the appellation of Fortification rock. Great quantities of the valves of unios and anodontas are found all the way from Green bay to the mouth of the Wisconsin, at the edge of the stream, left there by the muskrats and otters. About forty-five miles from the portage, another picturesque mass of horizontal sandstone presents itself, called *Petit rocher*. There is a remarkably fine view from a lofty hill at a place called Helena, where a shot-tower has been sunk near two hundred feet in the sandstone: the river is seen for a great distance winding through the rich flat lands of the valley, which is bordered on both sides by high rounded hills, with occasional escarpments, separated by well-wooded coves or vales, called by the French *coulées*. Boulders and fragments of limestone are found in the vicinity, resembling the Missouri galeniferous limestone, with occasional narrow seams of sulphate of barytes in it. A little lower down, the river has undermined the strata, and a mass of sandstone, about thirty feet high and two hundred feet long, has scaled off from the body of the rocks, leaving a smooth face. This place is called the Fallen rocks. The nature of the scenery is much the same to the mouth of the Wisconsin: rich flat lands are of frequent occurrence, the slopes, somewhat more sparsely wooded, are covered with high grass, except where broad spaces of escarpment (so soft that the swallows in great numbers have been able to pick holes in it and

build their nests) peep out and give the general line of the river a castellated appearance. Upon the face of these white sandstone beds, figures of deer, men, and horses, have been painted in red, after their manner, by the Indians. The islands in the river are very numerous, as well as the sandbars, which sometimes scarcely admit of the passage of a canoe in a low state of the water, and several extensive prairies are passed. Below Pine river, which comes in west of Helena, on the right bank, limestone is found in place on the sandstone, and increases in thickness towards the Mississippi. Mineral blossom, as it is called, or mamillary quartz, siliceous matter coating the cherty limestone in chalcedonic layers, barytes, and other indications, announce the vicinity of the galeniferous rocks. Frequent indications also of carbonate of copper are found, of which the veins show themselves on the south side of the Wisconsin, in the neighborhood of Mineral point.

On reaching the mouth of the Wisconsin, and reviewing the appearances presented by the country left behind, it becomes apparent that evidences of a great aqueous movement are constant along the whole line from Michilimackinac to the Mississippi, the extent and direction of which cannot be reasoned upon until the whole area lying between the Wisconsin and Lake Superior is examined. At Michilimackinac the calcareous strata, which are analagous to those on the Wisconsin, are broken up into brecciated masses. The islands in the vicinity of Green bay are the remains of sandstone beds once continuous through the country, and overlying the beds of carboniferous limestone near Navarino and at Kahkawning. On rising the country to the Apackquay lake, the incoherent sandstone appears to have been broken down to form the present loose sandy soil of the adjacent country. There is, upon the whole, reason to believe that the denuding forces which acted when the general water-level was lowered, and which probably brought the primary boulders from the northwest, (found all the way from Beaver river on the Ohio,)

have carried away a vast extent of mineral surface, and that all the great sand deposits from Lake Winnebago, as well as those in the valley of the Wisconsin, the valley of the Wisconsin itself, the coves and dells and coulées between the sandhills, which now so much diversify the face of the country, are the result of the same denuding force. The very great extent of the arenaceous deposits can only have been caused by an ancient breaking up of these incoherent sandstone rocks.

On approaching the mouth of the Wisconsin, west-by-south, the right bank of the Mississippi appears, about 450 feet high, and the river perhaps 900 yards wide, its water somewhat clearer than that of the Wisconsin, and the zizania continuing along its banks. Four or five miles N. N. W. from this point Prairie du Chien is seen, a fine flat, where Fort Crawford is built. East of the garrison and on the edge of the prairie there is a fine continuous escarpment of calcareous rocks, from three to four hundred feet high, alternating with sandstone. This limestone very much resembles that in Missouri before alluded to; the beds are horizontal, of a grayish buff color, some of them compact, others with cavities containing crystals of carbonate of lime. These bluffs are cherty towards the top, and where this commences I observed the beds to be occasionally made up of concentric circles. I found one mass, nine feet long and six feet wide, entirely made up of such circles, some of which were two feet diameter. It was sufficiently curious to make a drawing of, of which diagram No. 16 is a representation. I also brought a fragment of it away with me. This is a sort of oolitic structure upon a great scale.

From Prairie du Chien I commenced ascending the Upper Mississippi, which flows the whole distance (about 260 miles) from this place to Fort Snelling, near the mouth of the Minnaya Sotor or St. Peter's river, through the same formations that prevail on the Wisconsin, the calcareous rock, however, predominating on this upper line. It would not be consistent with

the nature of this report to enlarge it with repeated relations of the great beauty and amenity of the scenery of the upper portion of this often-described river; the formation being the same along the whole line, the geologist has to limit his observations to incidents connected with geological causes, and reserve what belongs to descriptive geography, and the manners and customs of the Indian nations he passes amongst, as I shall do upon this occasion, to a work of appropriate character. It is one of the great advantages of geological science, that where interesting minerals and metals and fossils are wanting, there is always instruction to be received in the study of the causes which have modified the surface of the earth in whatever direction we move. This is particularly true as it regards the bed of the Mississippi and the surrounding country, the physical geography of which is remarkable. The valley through which the stream flows is generally, below Lake Pepin, from one and a half to two miles wide. There has at some time been a continuous alluvial deposit through its entire breadth, and over which the water has flowed in a stream, as it does now in the Lower Mississippi, uninterrupted by islands. Since the reduction of the general water-level, the river, often divided into more than one channel, now cuts its way through the ancient deposit, sometimes the main channel being on one side, sometimes on another, and separating the old bottom into innumerable islands, some of them, at times, being several miles long, and all of them having a level of from six to twelve feet above the streams. This state of things makes the navigation difficult to strangers, who, believing themselves in the channel, get into bays from which there is no egress. Whenever the current slackens there is always reason to doubt the channel. These islands are extremely well wooded, and afford generally excellent situations to "camp out" at night, as it is called, the soil being dry, the situation sheltered, and dry wood abundant. The banks of the valley (for they can scarcely be called the banks of the river, since where the stream runs close to one

shore the other side of the valley can seldom be seen on account of the intervening islands, or bluffs, as they are more generally called) are from 300 to 400 feet high, consisting of horizontal strata of alternating cherty limestone and sandstone, the principal ledges of which mark, for great distances, the continuity of beds, giving thus a particular character to the bluffs; these are frequently prolonged into extended escarpments, and at other times are broken and rounded off by the weather into sharp peaks and grotesque castellated appearances, at the termination of the small vales, or coulées, from 500 to 1,000 yards wide, which come in at right angles to the river, but do not usually extend far into the land. Sometimes other coulées, parallel to the valley, come into these last again, for the distance of 800 yards from the valley. Beyond them the land is generally level, forming a very extensive plateau of country. The soil, from the admixture of lime, sand, and vegetable matter, is of a superior kind, as is proved by the rank vegetation, and the luxuriant growth of trees on the pleasing slopes and vales of this very beautiful country. These various modifications of the surface are to be attributed to the denuding power of the ancient floods which have passed over the face of the country, and the agency of the weather acting upon them during long periods of time. Among the most remarkable of these peaks is a sort of truncated cone, on the right bank, called *Cap à l'aisle* by the old French settlers, on account of the wild onions which grow in the bottom of the adjoining valley, which appears to extend far up into the country. The first stream of any importance on the right bank, beyond this cape, is the Upper Ioway,* then Root river; on the left bank the Bad-axe river flows through a very beautiful valley; between this stream and Racoon river is a small prairie, but a more extensive strip of low land of this character is found a

* I found the rivers very erroneously put down, and Lake Pepin disproportionately long on the maps. In the chart of the Indian country east and west of the Mississippi, which accompanies this report, I have endeavored to adjust these mistakes.

little higher up, at Prairie la Crosse, or Ball-game river, where the Indians formerly used to convene to play at their favorite game. The bluffs are about two miles inland, and before the reduction of the water-level, this, like all the other prairies similarly situated, must have been a lake. There are three remarkable capes at the south end of this prairie, with singular mural escarpments, the most northerly one separated from the rest by a coulée. Beyond this point all the Indians are Nacotahs, or of the Sioux nations.*

Beyond Ball-game river, on the left bank, is an important stream, named Black river, down which stream a great deal of fine pine timber is floated. The country all around here is remarkable for its fertility and beauty. The most conspicuous locality on this portion of the upper Mississippi, is a place called by the French *La Montagne qui trempe à l'eau*, or the mountain which is steeped in the water. I ascended to the top of this peak, which has a steep ascent of about 500 feet; the crest at the top runs about north and south for 200 yards, and is not more than three or four yards wide, falling off in a precipice to the west, and having a sharp slope of rich soil to the east, well covered with trees and shrubs. From the top there is an extensive view of the course of the Mississippi and the country in the interior beyond its banks. The same constant character of the valley is observed here: a rich bottom, two or three miles wide, broken into islands and swamps and ponds, and the main channel of the river flowing down between *Trempe à l'eau* and the right bank, about 1,200 yards wide. This curious peak has been represented as "a rocky island, separated from the left bank of the river," and to be "very near the east bank of the river."† This error was no doubt occasioned by the writer's looking at it from the right bank, and not stopping to examine it. It is, in fact, an isolated bluff, about a mile and a quarter in circumference, separated from

* Sioux is an abbreviation of Nahtowessieux, Men of the Woods.

† Keating's Narrative of an Expedition, &c. vol. 1, p. 271.

the right bank, and not from the east, the intervening space being occupied by the present main channel. From the top of *Trempe à l'eau*, its whole history is seen at a glance: the eastern bluffs are distant at least five miles from it, and in one part recede still more; an extensive prairie, having few or no trees, extending east and west about twenty-five miles, and from five to six miles wide, north-by-east, by compass, separating this out-lier from those bluffs to the east. It is evident that the Mississippi has once passed north of this out-lier, has covered the prairie, then a lake, and has coasted the distant eastern bluffs. This affords another incontrovertible instance of that remarkable reduction of the fresh-water level of this continent, before alluded to, at which period the contracted channel left the then lake, and cut off the *Trempe à l'eau* from the right bank. Ompedo Wakeen, brother to Wābeshah, a celebrated chief of a neighboring band of Nacotahs, told me, on the evening of the day I visited the place, that the Indians called it Minnay Chonkahāh, or Bluff in the water, and that they resorted to it at the beginning of the wild-geese season, to make offerings to Wakon, or the deity, for success in hunting.

A few miles higher up, there is another prairie on the right bank, where Wabeshah's band have their lodges; and about half way from this place to Lake Pepin, is another, on the same side of the river, still more extensive, and bordered with cedar trees. Having a copy of Carver's Travels with me, and having always found his descriptions deserving of very great confidence, I had been anxious to discover a remarkable locality he speaks of,* and which, from the doubts expressed by other

* "One day, having landed on the shore of the Mississippi, some miles below Lake Pepin, whilst my attendants were preparing my dinner, I walked out to take a view of the adjacent country. I had not proceeded far before I came to a fine, level, open plain, on which I perceived, at a little distance, a partial elevation, that had the appearance of an intrenchment. On a nearer inspection I had greater reason to suppose that it had really been intended for this many centuries ago. Notwithstanding it was now covered with grass, I could plainly discern that it had

travellers,* they evidently had never seen. The passage in Carver is so minutely descriptive, and the existence of the remains of a work capacious enough to hold 5,000 men was something so remarkable, that I was solicitous not to miss the place, however troublesome the search, since he does not say on which bank of the river it is, and merely speaks of it as "some miles below Lake Pepin."

On climbing the bank where these evergreen trees were, which is the right bank of the Mississippi, about eight miles S. E. of Roque's† trading-house, near the entrance of Lake

once been a breastwork of about four feet in height, extending the best part of a mile, and sufficiently capacious to cover five thousand men. Its form was somewhat circular, and its flanks reached to the river. Though much defaced by time, every angle was distinguishable, and appeared as regular, and fashioned with as much military skill, as if planned by Vauban himself. The ditch was not visible, but I thought, on examining more curiously, that I could perceive there certainly had been one. From its situation, also, I am convinced that it must have been designed for this purpose. It fronted the country, and the rear was covered by the river, nor was there any rising ground for a considerable way that commanded it; a few straggling oaks were alone to be seen near it. In many places small tracks were worn across it by the feet of the elks and deer, and from the depth of the bed of earth by which it was covered, I was able to draw certain conclusions of its great antiquity. I examined all the angles and every part with great attention, and have often blamed myself since for not encamping on the spot, and drawing an exact plan of it. To show that this description is not the offspring of a heated imagination, or the chimerical tale of a mistaken traveller, I find on inquiry since my return, that Mons. St. Pierre and several traders have, at different times, taken notice of similar appearances, on which they have formed the same conjectures, but without examining them so minutely as I did. How a work of this kind could exist in a country that has hitherto (according to the generally received opinion) been the seat of war to untutored Indians alone, whose whole stock of military knowledge has only, till within two centuries, amounted to drawing the bow, and whose only breastwork even at present is the thicket, I know not. I have given as exact an account as possible of this singular appearance, and leave to future explorers of these distant regions to discover whether it is a production of nature or art."—*Travels through the interior parts of North America, in the years 1766, 1767, 1768, by J. Carver, Esq. Page 57, 58. London, 1778.*

* Keating's Narrative, &c. vol. 1, page 276.

† A half-breed known in the Indian country by the name of Wahjustabchay or Strawberry.

Pepin, I found myself on an extensive and beautifully smooth prairie. At a distance not exceeding two miles, I saw some unusual elevations to the south; and, hoping I had had the good fortune to find, at length, the true place, I walked to them, and, on reaching them, was at once persuaded that I had found the locality described by Carver, and which was sufficiently remarkable to justify the description he had given of it. The elevation had the appearance of an ancient military work in ruins; externally there was the appearance of a ditch, in places filled up with the blowing sand, and having a slope coming down from what might be supposed the walls of the work to the ditch, of about twenty yards. Inside was a great cavity, with irregular salient angles; and at three different parts were the more regular remains of something like bastions; the cavity was seventy yards in diameter, N. W. and S. E., including the ruins of several terraces; the circumference of this singular place, including the angles, was four hundred and twenty-four yards. Seven hundred yards S. S. E. of this was another, resembling it in form and size; and at an equal distance, E. S. E. from this last, was a larger one, eleven hundred yards round, with similar remains of bastions; this cavity would easily contain one thousand people; its walls, if the word may be applied to them, are lofty, and there is a deep ditch on the south side. In the area to the south I counted six more of these elevations, each having a rude resemblance to the other, with what also appeared to be a line of defence, connecting these works with each other. At the northern end of this singular assemblage of elevations, every thing bears the appearance of rude artificial construction; at the southern end, however, and not far from the river, the works pass gradually into an irregular surface, a confused intermixing of cavities and knolls, that might be satisfactorily attributed to the blowing of sand.* There is a growth of oak timber, as Carver observes, upon all this part of the elevations.

* It is a sand prairie, covered with a foot or two of vegetable matter.

All the angles and bastions are very much rounded by the weather, and some of the slopes outside consist of sand brought there by the wind. It is undoubtedly true that all the appearances I have described may have been produced by the action of the wind; but those who think so, after personal inspection, are bound to account to themselves why other parts of this prairie, and of other prairies similarly situated, are not blown up, and why the ground covered by these elevations is blown up in such a manner as to resemble artificial works so closely. If, when this curious place becomes more known and investigated, Indian antiquities should be discovered commensurate with the extent of the work, such as the stone instruments and weapons of offence usually found about Indian encampments, it would decide with me the question. If any thing of that kind is there, it is probably buried beneath the sands too deep for passing travellers to find. I brought nothing away with me but a plan of the general appearance of the locality, and one or two of the principal elevations.

At the southernmost end of Lake Pepin, Chippeway river comes in on the left bank, a stream of considerable magnitude, from four to five hundred yards wide where it joins the Mississippi; the volume of water is said to be great for sixty miles.* Having passed its mouth the scenery becomes changed, and, instead of a valley two or three miles wide, full of low wooded islands, Lake Pepin presents itself, a sheet of water about twenty miles long and nearly three miles wide upon an average, perhaps. This is nothing but a continuation of the Mississippi valley without any islands, with this difference, that the river occupies all the space between the banks, whilst the bluffs and coulées present themselves with the same general character as below. Why there are no islands in this part of the valley, and why it is a lake, deserve an inquiry. It

* At the falls of this river, which are very extensive, there is an indefinite quantity of water-power. The tracts of fine pine timber will, if preserved by order of Government, be extremely valuable. It will be indispensable for building purposes when settlers get into that country.

will occur to every observer, that the entrance of a stream of such magnitude as the Chippeway river, coming in at right angles to the Mississippi, must necessarily dam up the water above it. Thus, at the general subsidence of the water-level, when the alluvial bottom of the other part of the valley would be left dry and plants begin to grow, it would here be covered up to the northwest for a certain distance, whilst the wind and high waves to which this lake is now so much exposed as often to make the passage a dangerous one, would keep the alluvial matter in a state of suspension, and, finally wearing it away, the whole breadth of this part of the valley would be necessarily covered by water. This is the way in which I would account for the origin of this lake, the only one in the whole course of the river.

The strata towards the N. W. end of the lake on the north side are very cherty, and agates are frequently found amongst them. Opposite to a small stream called Marchessau, on the south side, an intelligent trader, well acquainted with this part of the country, told me he had picked up pieces of galena. There are two channels at the head of the lake; the southwest one passes between the right bank of the river and a low narrow island, called Twelve-mile island, edged by lofty and beautiful trees. Up this channel, and near a lofty out-lier about three hundred feet high, called La Grange, is the village of the Indian chief Machpayah Muzah, or the Iron cloud, Dootöh, or Redwing, the celebrated old chief, being now dead. Two streams, the Vermilion and Cannon river, fall into the Mississippi a few miles higher up. Between them and at a distance not exceeding thirty miles from the mouth of the St. Peter's, there is a singular out-lier of sandstone, which shows how the continuity of the strata has once existed, and how much the general mineral level has been reduced. Diagram No. 20 represents this curious pillar, to which the name of Castle Rock has been given. It is situated on what is called the Big Prairie, and can be seen for a distance of twenty

miles, appearing like the remains of a castle, or a church with a cupola. The total height is ninety feet, the lower part being about sixty feet high and twenty-five feet in diameter; the upper part is thirty feet high and varies from two and a half feet to fifteen feet diameter. I had these particulars from a gentleman who had visited the place and taken a drawing of it, of which he presented me a copy.

The banks of the river now gradually lose their escarped character, the left bank especially being low and rolling, having generally a gentle slope of grass and trees to the water side, and rarely exceeding one hundred feet high. About forty miles from Lake Pepin, St. Croix river comes in from the left bank, about 120 yards wide. This stream, after following it north about two miles, expands into a small lake of nearly the same breadth. Beyond the St. Croix the Mississippi becomes narrow, and at one place, where the limestone beds on the right side come to the waters edge, is only about one hundred yards wide, and winds very much. From this place I could hear distinctly the noise of the falls of St. Anthony. Four or five miles before reaching the village of Tchaypehahmonee, or Little Crow, the limestone on the left bank becomes very tenacious and twisted; the beds become cavernous, are wavy, and large concentric masses are formed resembling those at Prairie du Chien; the whole mineral substance appears to have had a tendency to resolve itself into globular forms. The river is very beautiful about here: an open stream, without islands, about 300 yards wide, flowing between banks covered with handsome trees, vines, and grass; the soil is exceedingly rich, being composed of decomposed limestone, sand, and vegetable matter, black and deep. A short distance beyond the village there is a bluff of soft sandstone, in which the Indians say there is a cave, but the rock from above has fallen down with hundreds of tons of sandstone, and has concealed the entrance. Somewhat higher up, and only a few miles from Fort Snelling, is another sand-

stone bluff, with a narrow ravine, down which trickles a small stream of good water. I followed this ravine about 200 paces, and found that it led to the cave which Carver has so accurately described.* The Nacotah Indians call it *Wakon Teebee*, or House of the Great Spirit. The ravine ends at a circular wall of very soft sandstone, about forty feet high to the left; to the right is the cave, the entrance to which is formed by an arch about eighteen feet high, and thirty feet wide. The stream of water comes through this cave, into which I advanced about forty paces, when the water became too deep. I heard a rumbling sound, at a distance, of falling water, and threw stones in at random, it being dark, which fell into deep water, as I could ascertain by the sound. After advancing a few paces into the cave it loses its dimensions, being little more than six feet high and about ten feet wide. The rock is composed of a white crumbling sandstone, easily cut with a knife. The cave, like most others, appears to owe its origin to a spring of water which passes through it. The Indians have cut many of their hieroglyphics upon the rock. Five miles beyond this cave the *Minnay Sotor Watapah* or *St. Peter's* river comes into the *Mississippi* on the right bank; and, a short distance above, at a cut-off which the *Mississippi* has made by forcing its way through the alluvial bottom to the *St. Peter's*, *Fort Snelling* appears, at the top of the escarpment, on the right bank of the *Mississippi*.

This is the last military post of the United States to the northwest, the natives having exclusive possession of the country as far as the British settlements, about latitude 49 degrees. The fort is built upon the bluff, which overlooks both the *Mississippi* and the *St. Peter's*, resting upon grayish, buff-colored, fossiliferous beds of the carboniferous limestone, containing zoophytes, many specimens of large orthocera, fragments of which measured a foot long and more than four inches wide. The faces of some of the rocks are covered

with fuci, and in some beds producta form almost the body of the rock. These fossiliferous beds are separated from the great sandstone beds of the country, which here go far below the level of the river, by a thick stratum of eighteen feet of compact subcrystalline limestone without fossils. Below this stratum nothing but sandstone appears.* The fossiliferous beds are accessible in numerous localities as far as the falls of St. Anthony. A stream which runs from Lake Calhoun—a beautiful sheet of water, about eight miles from the fort—to the Mississippi, has worn its way back through the rocks from the river a short distance, and makes a fall there about fifty feet high, the stream being twenty feet broad. I obtained many fine fossils at this place, as well as at both banks of the Mississippi, up which I went to the falls of St. Anthony, a distance not much exceeding eight miles by water, and the banks not exceeding eighty-five feet, to the flat prairie land of the country.

An island about 450 yards long divides the Mississippi into two parts at the falls of St. Anthony, which have a very irregular outline, owing to the soft sandstone being washed out unequally in places, and the superincumbent strata of limestone falling down in large blocks; these are piled up in great quantities on the bed of the river immediately at the foot of the falls. That part of the river on the north side of the island is about two hundred and twenty yards in width. There is a very fine smooth section of the rocks here to the water, about 90 feet high. I should think the fall would not average more than twenty feet. The immense slabs which

* In Mr. Keating's narrative of Major Long's expedition to the source of St. Peter's river, before referred to, it is stated, vol. 1, page 308, that this sandstone rests upon a slaty limestone, with a striped aspect, and that again upon other calcareous beds lying beneath the water level. This error is to be attributed to a hasty examination. At the bottom of the talus are heavy blocks of limestone, many of which lie flat in the river, but they have all fallen from the top. I not only compared and identified them, but examined the sandstone often at leisure, and it is never superincumbent to any bed of limestone there, descending much further below the water-level than it was possible to examine it.

have fallen from the limestone beds at the top are covered with producta, mixed with spirifers and cardia. On the south side of the river the line of the falls is a very irregular curvature, and measures about four hundred and fifty yards to the island; the height of the fall does not appear so great on this side, owing perhaps to the bed of the river being so much choked up with the fallen slabs. It is a wild, rocky scene, but deficient in interest as a waterfall on account of its want of height. To a geologist, however, it is exceedingly interesting, finding here the uninterrupted continuation, for one thousand miles, of the carboniferous limestone, with its characteristic fossils. At the south side of the falls I got some exceedingly fine ones, including beautiful specimens of delphinula, bellerophon, nautilus, euomphalus, &c.

At Fort Snelling, the St. Peter's comes winding in from the southwest, through an ample valley, the banks or bluffs of which vary from one hundred to one hundred and fifty feet high. The valley is about a mile and a half wide, and contains a great deal of rich alluvial soil. On the right bank of the St. Peter's, about a mile from the fort, is the head establishment of the American Fur Company* for the trade with the Nacotah or Sioux Indians.

The St. Peter's,† which remained for me now to explore, is about one hundred and twenty-five yards wide at the nearest point to the fort, looks as if whitish clay had been dissolved in it, and runs with an extremely winding course, somewhat represented in the accompanying map, through the alluvial bottom, with low prairies on each side, and fine wooded slopes in the distance. The general direction of the river, as far as the Makato or Blue-earth river, is about southwest; from this point

* From the gentlemen at the head of these establishments I received many obliging attentions; and to Mr. Sibley, of this trading-post, I am indebted for an excellent guide and interpreter, an intelligent and faithful half-breed, called Milor, a man universally known in the Sioux country.

† Called by the Nacotahs, Minnay Sotor, or Turbid Water, in contradistinction to the Mississippi, which, coming from a siliceous country, is clear.

it bends and describes nearly a northwest course to its source. Numerous chiefs of bands of the Nacotahs* have their villages on its banks, where they reside during the season of cultivation; and which are evacuated by them and their families during the hunting seasons. About six miles from the fort, on the right bank, is the village of Wahmundeetanka, or Big Eagle, called also by the Canadian traders Chien Noir, or Black Dog. A little higher up on the same bank is the village of Penichon. About sixteen miles from the fort a stream comes in from the right bank called by the Canadians Credit river, the Indians call it Kakahinhahāh, or River where the elk was put, to commemorate, no doubt, some incident. A little beyond this the river narrows to about eighty yards, and has a N. N. W. course, but soon widens again with high grassy slopes of prairie land. About twenty-five miles from the fort the village of a chief called Six, is passed on the right bank. Passing a place on the left bank called La Petite Prairie, a stream comes in from the same side, which, from the distance from the fort, about forty miles, and other circumstances, appears to be the river which Carver† gave his own name to. The Indians call it Do-do-do-ah, or Who sings of war. Something short of fifty miles from the fort, there is a short rapid with a strong current: the passage is on the right bank which we soon got through by holding on to the bushes and vigorously applying the paddles. Above this is another rapid with sandstone in place on the right bank, the same as that at the fort. Further up, at a place called Weahkotee, or the Sand hills, there is another Indian village. Beyond this, for a great distance, the course of the river is very beautiful: a great profusion of trees, shrubbery, and high grass on the bot-

* In Major Long's expedition to the source of the St. Peter's river, these Indians are uniformly called Dacotahs. I made particular inquiries amongst the chiefs, through my interpreter, and they all concurred in the assertion that their proper name was Nacotah. This word means a united or allied people. Dacotah means "my relations."

† Carver's Travels, page 74.

toms and slopes, when rich prairies with black fertile soil commence. The river is very serpentine in its course and is continually opening new scenes: sometimes smooth conical hills, one hundred feet high, with coves like amphitheatres, present themselves, covered with verdure, and crowned with trees at the top, when, at another turn, a fine level prairie country comes in. Kēetahmēmeh, or Round Prairie, is about one hundred feet high, with a fine slope, covered with grass. The Indians have given it this name because it is encircled with trees. Beyond this is the village of Wakondoanka, or Lively Spirit, whom the voyageurs call *Le Bras Cassé*, having once had his arm broken. Before reaching Chankeootah or Bois Franc river, the river narrows to sixty yards. This last stream comes in on the right bank, and is the northern limit of the Bois Franc district. This is in fact an extensive forest, from twelve to fifteen miles broad by land, through which the river passes for upwards of thirty miles, on account of its very winding course. It is said to extend thirty or forty miles on each side of the St. Peter's. It is difficult to traverse by land on account of the swampy nature of the ground. I was also informed there was an extensive lake in the central parts of it, on the south side. The current becomes strong after entering the Bois Franc. As an evidence of the nature of the incidents which induce the Indians to give names to a locality, Mahāhbohpa, or Swan on the ground, an elevated piece of ground with trees on it, on the right bank, may be mentioned. A Sioux shot a swan flying there. The islands in this river are small and are edged with willows. On the banks of the river I have seen them forty to fifty feet high. Further up the Bois Franc district a stream comes in from the left bank, called Wēetah-wakātah, or Tall island, and about five miles higher up some ledges of horizontal fawn-colored limestone jut out on the right bank, very cherty and somewhat vesicular; near the surface it takes a reddish salmon color, resembling very much some beds I had previously seen on the

Wisconsin and Upper Mississippi. Within a few yards of these ledges, and north of them, a beautiful pellucid stream comes in, containing the purest water I had seen in the country. I could not learn that any name had been given to it, and as it is in the immediate vicinity of the first calcareous rock I had met with in place here, and its purity rendering it a very rare stream in a country where all are turbid, I named it Abert's run, after Colonel Abert, of the United States army, and chief of the Topographical bureau. Higher up on the right bank is the village of Wahmundeé Indootah, or Red Eagle. The next stream is Wointseah Watapah, or Rush river, rising far up in the country, and comes in on the left bank; after it succeeds Chankeoota Oeanka, or the end of the Bois Franc or Free Wood district, a stream coming in on the left bank. About fifteen miles further we came to a place called Myakāh or White Rock, on the right bank, an escarpment consisting of about forty feet of granular sandstone surmounted by ten feet of fawn-colored limestone, the same as that at Abert's run. This sandstone is formed of semi-transparent grains, loosely adhering, with nodules here and there, where they are cemented by a paste of clear siliceous matter, the whole making a hard, flinty mass, resembling siliceous oolite. At the junction of the limestone with the sandstone, there is a seam of marly mineral matter, containing a great deal of silicate of iron, of a bluish-green color. I had seen traces of this in the bluffs at Prairie de Chien. Eight or nine miles further on is Traverse des Sioux, an establishment of the American Fur Company. This is a noted crossing place of the Sioux Indians in old times. A short distance from this trading-place, a small stream comes in on the right bank, called Wee-wee or Moon creek. This stream, before it falls into the St. Peter's, recedes a little, and describes a semi-circle before it approaches the river again, and repeats this several times, so that several small crescents are described by the stream before it joins the river. In the Nacotah tongue wee

signifies the sun, and wee-wee, the moon, after which planet the Indians have named the stream, from the half-moons it forms. I was very particular in examining this locality, because it is the place where Major Long* abandoned the St. Peter's, to perform the rest of the journey by land.

About two miles further on the limestone and sandstone are again in place, and about three more a long bluff, about twenty-five feet high, presents itself on the right bank with the same beds. These are succeeded in about five miles by a rocky bluff on the right bank, called Makassa-usa, or White-earth bluff, about seventy yards high. On reaching the top of this bluff a curious spectacle presents itself. The horizon to the east is bounded by a belt of wood about four miles from the river; from the wood an elevated terrace extends westward about one mile of smooth prairie land, whilst the remaining sunken portion is covered with tens of thousands of boulders of limestone and granite, some of them standing in the most grotesque manner, and separated from each other as the wild buffalo are when grazing; indeed, at a distance, they might very well be taken for them. Some of the boulders weigh, I should think, one hundred tons. To the south is prairie land, at a much lower level, with a lake; whilst on the opposite side of the river nothing can exceed the beauty of the wooded slopes, with a continuous smooth prairie beyond them. These are amongst the interesting proofs of the retreat of the waters in ancient times, and of their power to break up even the beds of the primary rocks. Beyond this point an island is passed about four hundred yards long, the largest yet met with. The current is now very strong for some distance, and from the continuation of bold bluffs, many of them with boulders on their sides, it is evident the river has worked its way through a ridge here. Chaneaska, or Fort river, has received

* Mr. Keating supposes the locality to have received the name of the Crescent, "from a beautiful bend which the river makes." Keating's Narrative, &c. Vol. 1, p. 337.

its name from a strong hold which the Nacotahs had on the heights near it, during their wars with the Hā-hah-tona, or People of the Falls, the name they give to the Chippewas. About sixteen miles beyond this point, the bluffs on the left bank are about one hundred and fifty feet high; and here, after a very severe struggle with the current, we got the canoe into the mouth of the Makato Watapah, or Blue-earth river, the principal tributary of the Minnay Sotor. This is a bold stream, eighty yards wide at its mouth; and the St. Peter's, whose general course from its sources having hitherto been about northwest, now joined by the Makato, forces its way through the lowest part of the ridge, and gains the Mississippi in a course nearly northeast.

Having reached the Makato, it became my duty to enter it. Expectations had been raised by the publication of Major Long's* expedition, respecting some supposed copper mines which M. Le Sueur was said to have discovered about the beginning of the eighteenth century, not far from its mouth, and which Major Long, in passing up the St. Peter's, had not visited. The following passage,† with others, in the publication in question, gave so much importance to the affair, that it was deemed proper to make an investigation of the locality part of my instructions:

“Charlevoix states that Le Sueur was sent by M. D'Iberville to make an establishment in the Sioux country, and to take possession of a copper mine Le Sueur had there discovered. He ascended the St. Peter's 40 leagues, to la rivière Verte, which comes in on the left. Though only the last of September, the ice prevented him from ascending that river more than a league: he therefore built a fort, and spent the winter at that spot. In April, 1702, he went up the rivière Verte to the mine, which was only three-quarters of a league

* Narrative of an expedition to the sources of St. Peter's river, &c.; 2 vols. 8vo. By William H. Keating. Philadelphia, 1824.

† Vol. 1, p. 316.

above his winter establishment. In twenty-two days they got out more than thirty thousand pounds of ore, of which four thousand pounds were selected and sent to France. The mine was at the foot of a mountain ten leagues long, that seemed to be composed of the same substance. After removing a black burnt crust as hard as rock, the copper could be scraped with a knife." A manuscript in the possession of the American Philosophical Society, written by M. Bénard de la Harpe, is also cited :* " It appears from this manuscript that Le Sueur's discoveries of blue earth were made in 1695, but that all further operations were interrupted until 1700. We find in the same manuscript, under the date of the 10th of February, 1702, that Le Sueur arrived at the mouth of the Mississippi that day with two thousand quintals of blue and green earth." The same manuscript is also said, in giving the details of Le Sueur's progress up the Mississippi, to state : " Finally, on the 19th of September, he left the Mississippi, and entered the St. Peter's river, which comes in from the west bank. By the 1st of October he had ascended this river forty-four and a quarter leagues, when he entered the Blue river, the name of which is derived from the blue earth found on its banks." " On the 26th M. Le Sueur went to the mine with three canoes, which he loaded with green and blue earth. It was taken from mountains near which are very abundant mines of copper, of which an assay was made in Paris by M. L'Huillier, in the year 1696."

I had, through my guide, (Milor,) neglected no opportunity to inquire amongst the Nacotahs respecting these mines, but I never could obtain any information, or even a traditional report, of any thing like a copper mine in that region. Many of the chiefs concurred in saying that there were some bluffs a few miles beyond the mouth of the St. Peter's, to which the Indians had, at all times, resorted to procure a blue earth with which they were accustomed to paint themselves; and one old chief had described the locality with great precision. He

* Keating, vol. 1, p. 319.

was very well acquainted with the whole country between the St. Peter's and the Missouri, and had often crossed the Coteau de Prairie, but he had never heard of or seen any thing like copper. This, however, was not particularly discouraging, as Le Sueur's mineral was described as being a green and blue earth; and it might very well be an oxyde or carbonate in the carboniferous limestone, as it is found in the Wisconsin Territory. I therefore entered the Makato with some confidence. Its waters were extremely discolored, and I immediately saw they were the cause of the turbid state of those of the St. Peter's. When we had proceeded about a mile, we found a family of Nacotahs, of the Sissiton tribe, encamped on a sand-bar, taking care of some venison they had just killed. The locality I was in search of was well known to them, and they gave us very intelligible directions. The current was exceedingly strong, running about two miles an hour, and the stream appeared to furnish about one-half the volume of the St. Peter's. About three miles from the entrance of the river there is a singular conical hill covered with grass on the right bank, which I thought a very probable situation for M. Le Sueur's Fort L'Huillier, and I should have landed to examine it but for my anxiety to reach the blue-earth locality, and on account of the weather, the snow falling as we passed it, (September 22.) Near six miles from the mouth, a fork of the river came in from the left bank, about forty-five yards wide, on the right bank of which is a ridge of from eighty to one hundred feet wide, very well wooded, and fronting a prairie on the opposite side. We found very little current, the main stream having forced it back for some distance. About two miles up this fork, we at length came to a bluff, about one hundred and fifty feet high, on the left bank, containing the blue-earth locality. On climbing it, I found the same horizontal sandstone and siliceous sandstone common to the whole country. Towards the top was a broad seam of bluish clay, intermixed in places with silicate of iron, being a

continuation of the deposit I had seen before at Myakäh, and valuable only for the savages to paint themselves with. From this bluff, I advanced in a westerly direction about two miles, over a part of the country grown up with small poplars, hazels, wild roses, and grass, in the hope of seeing the Coteau de Prairie, and making arrangements to proceed to it from this quarter; but I saw nothing of the kind from any eminence which I could gain; and having in my hand, and reading on the spot, what had been said of M. Le Sueur, his mountains, and his copper mines, I found myself obliged to come to the conclusion that these discoveries were fables invented to give him influence at the court of France. Before I left the north-west country, and after I had visited the Coteau de Prairie, I found it was distant at least sixty miles from this spot, which leaves only the bluffs of the river to represent the mountains spoken of in the manuscript of La Harpe.

Seeing the state of the country here, and having made up my mind to proceed up the St. Peter's to its source, and strike the Coteau de Prairie there; if the season admitted of it, I descended the Makato, which the natives informed me had eleven forks and was full of rapids, and regained the St. Peter's. The water above the junction was very clear, and had but little current for several miles, being somewhat kept back by the Makato; the stream is about one hundred yards broad, and runs for some distance through low, well-wooded banks, forming a very pleasing country. About twelve miles up the river, the slopes are covered with large boulders, near which the river narrows to about fifty yards, and gradually becomes shallow, its sandy bed being covered with very beautiful unios of various species, the beaks of which were not at all decorticated. Twenty miles from the Makato, the St. Peter's has made a recent cut-off and abandoned its old bed; not far from this place a large mass of sandstone is in place in the middle of the river. Minday Mahā-tanka, or Great-goose (Swan) lake, lies nearly five miles north of this

point. Further on, the banks of the river consist of about twenty feet of alluvial sandy loam, containing great quantities of planorbis, ancylotus, and helices, to the bottom, of the same species now found.* About twenty-five miles from the Makato some red-earth bluffs occur on the left bank, with numerous boulders; from this point the general appearance of the soil and country begins to vary and announces a change in the formations, and five miles further some rocky bluffs come in at the left bank, the lower beds of which are a brick-red color and of a fine grain. On landing and leaving the bank, I found the country covered with beds of red gritstone, of a very hard quality, inclined about fifteen degrees. These rocks are full of pot-holes, some of them a foot in diameter and eight inches deep, and are as smooth as metal. The carboniferous limestone formation seems to terminate here, and to be stopped by a conglomerate resembling in its mineralogical characters the upper beds of the old red sandstone. The river has in old times passed over these rocks, worn the pot-holes, and made them so glassy smooth. The Warhajoo, called by the voyageurs rivière aux Liards, or Cotton-wood river, comes in from the right bank, at a short distance beyond this point; we turned the canoe into it for awhile, but were obliged to return on account of the shallowness of the water. Our distance by computation from the mouth of the St. Peter's at this place, was two hundred miles, estimated by the windings of the river, and we had more than three hundred yet to accomplish before we could reach the sources of the St. Peter's. There is a village of Sissiton Indians a little west of the Warhajoo. Five miles from this last stream, the St. Peter's winds, in a very curious manner, through rich alluvial bottoms, covered with sugar-maple trees: it goes round a tongue of land, at one place, the distance of one mile and five-sixths, which is only twenty yards across at the base. It is

* The alluvial banks of the Mississippi at Quincy are in like manner filled with these univalves; these deposits being the old beds of streams, like those before mentioned at Fort Gratiot.

called Eepah-haska, or Long point, by the Nacotahs. There is another, a little higher up, of a similar kind: the river here is about one hundred and ten yards broad, varying in width, and gliding sometimes on one bank, sometimes on the other, in a serpentine course, through a valley of rich, black, sandy loam, about one and a half mile wide between the bluffs. The zizania is frequently abundant about here. The guide pointed out to me, on the right bank, the place where, in 1811, he had buried his employer, a trader of the name of Cameron, who, like many others of his vocation, go on struggling for wealth, and die unnoticed in the woods. About forty miles from the Warhajoo, I for the first time came upon a mass of granite in place, the river narrowing to about fifty yards. The voyageurs call this Petit Rocher. Further on there are large granite rocks in the river. Mr. Moore's trading-house is in this vicinity, on the right bank. The granite henceforward is of constant occurrence, nor was any other kind of rock seen in place during my further progress to the northwest. From hence to a stream coming in from the left bank, called by the Nacotahs Weetah-chantah-eahantah, or Island of dead wood that falls in the lake, and by the traders Beaver river, is a succession of rapids, masses of granite, and shallow water, often not more than one foot deep on the sand. Beyond this point, on the right bank, are huge out-liers of granite for many miles on the prairie bottoms. The Chanshyapay, or Red-wood river, comes in a little further on, taking its name from a tree painted red by the savages. The St. Peter's is much obstructed by rocks and rapids before reaching this stream, but is wide and shallow after passing it. The voyageurs call it forty leagues, or one hundred and twenty miles, from the Warhajoo to Chanshyapay. Twelve miles further to the west, an out-lier of granite, of great dimensions, stands alone on the right bank; and about eight miles further, there is a fine stretch of granite rocks, on the right bank, about fifty feet high and one hundred and fifty yards long. The

interrupted state of these masses, and the numerous boulders found east of this formation, show the nature of the force required to tear up these unstratified masses from the valley, and transport them to so great a distance. The sandy bed of the river about here was covered with living unios. At one point, called by the Nacotahs Hahhāh, or the Cascade, the granite stretched almost across the river, and made a fall sufficient to oblige us to unlade the canoe. The fall here throws an eddy on the right bank, which has worn out a basin about fifty yards by forty, and a broad ledge of granite is formed, about one hundred yards long and twenty wide, sloping to the southeast. The bed of the river is thus restricted to a passage of about thirty-five yards wide. South of this are numerous rugged granite hills. In this granitic country the bends of the river become short, the water being turned away by the rocks. Three or four miles beyond this point the river is almost choked up with masses of granite, at a place called Patterson's rapids, from a trader of that name who once wintered there. There is, in fact, no rapid at all; the progress however becomes difficult, and much care is required in getting a birch-bark canoe through this part of the river. I had come about one thousand miles in mine, and it had hitherto required very little repairs. An accident would have been a serious embarrassment, as there is no birch in that part of the country, and the Nacotahs do not, like the Chippeways, use canoes made of its bark.

Beyond Patterson's rapids the prairie-grounds come down to the banks of the river without a tree. There may be said to be two kinds of prairie: the alluvial bottom, a rich black soil, with wild grass from four to six feet high, sometimes a mile in breadth, and thrown up into innumerable small hillocks by the moles of the country; and then the upland prairie, forming the common table-land of the region, less rich than the other, but good soil, generally with low coarse grass, and the horizon uninterrupted by a tree. On the upland prairies here,

I began to find calcareous boulders, formed of flat laminæ of salmon-colored limestones, with impressions of producta and spirifers, from which I concluded myself to be upon the southern edge of the granite coming in from the north, and that I might probably come upon the limestone again, if I should get far enough to the west.

The river now narrowed again to about seventy yards, and became so shallow that we were in constant expectation of being obliged to stop, notwithstanding I had made *caches* of our heaviest articles, by burying them in the ground. The daily fall of the water, too, created apprehensions as to the manner in which we should be able to accomplish our return. After walking through the brakes for some time, I came to a small stream on the left bank, called Chahtahnboah, or Sparrowhawk river, which the voyageurs, for some idle reason, have named Eau de Vie. Nearly opposite to this the Pahjeeth Zcezeehah, or Yellow Medicine river, joins the St. Peter's, its mouth almost choked up with wild rice. The main river now becomes about eighty yards wide again, the banks low, with great quantities of zizania; the slopes of the upland prairie on the right bank are well wooded; and a very good channel, from five to eight feet deep. At the termination of this channel there is another hahbäh, or fall, with a rapid about one hundred yards long, through which the canoe had to be dragged by the men up to their waists in water. From here to the Grand Portage there is a succession of rapids. At this point the river makes a detour of three miles, the whole distance being one continued rapid, through which the canoe had to be dragged. The portage is one mile and three-quarters across, by land, and it was here the singularly-laminated rock occurred, which is spoken of at page 27, and which resembles granite in every particular except its stratification. The strike or direction of these masses is N. E. by E. and S. W. by W., dipping S. E., and I of course crossed their whole breadth at right angles. After passing the portage and re-

embarking, four other rapids occur, three of them near to each other, and the fourth about a mile distant. The river soon re-assumes its ancient breadth of one hundred yards, and winds through an extensive meadow edged with zizania. The otters were swimming about in numbers among the wild rice, and the water was almost covered with wild ducks and teal. The muskrats had already begun to build their tall conical houses in the water, formed of the straw of the zizania. Beyond this we passed a broad coulée, made by an immense herd of buffaloes, fifteen to twenty thousand in number, which had crossed the river here. The channel now becomes contracted and rocky again, a stream called Mea-wakon (by the traders Chippeway river) comes in from the left, about fifty feet wide at its mouth, soon after which the St. Peter's narrows to thirty-five yards. Here the prairies were on fire, and further on were burnt quite black down to the water's edge. The valley still continues about two miles broad, and the bends of the river are so numerous that I could see it in six different places from the slope of the upland prairie. These bends would be sometimes fifteen hundred yards round, and only sixty at the base. The river at length became very narrow, and so blocked up with fallen trees, that we were often delayed by being obliged to stop and cut our way through. The last stream which falls into the St. Peter's south of Lac qui parle, and which comes from the right bank, is called Chan-ikpah-watapah, or the last wooded river. At Lac qui parle there is a stockaded trading-house of the American Fur Company, the residence of Reinville, one of the partners, an intelligent man, possessing a great deal of influence with the Nacotah tribes, having been brought up amongst them. The post is about a mile east of the lake, and is the rendezvous of great numbers of the natives. The voyageurs estimate the distance from the Warhajoo to the lake at eighty leagues, and as this estimate is the result of great experience, it is probably more accurate than any one that can be made by a traveller, whose progress

is necessarily so irregularly conducted during a single expedition. Mr. Reinville informed me that the lake takes its name from a tradition that it had once spoken to a Nacotah chief when crossing it. The valley here is of the usual breadth, bounded by the upland prairies, and the lake is but a prolongation of it. The river dwindles into a mere half-choked-up channel at low stages of the water. The country around continues to be very fertile, the potatoes at the post are of a superior kind, dry and large, and the corn ripens well, so that the country is sure, some day or other, to have a full population.

Here I deposited my canoe, finding it delayed our progress, and took to the land, coasting Lac qui parle on the northeast side, which is nine miles long, to the Wahboptah or Prairie-root river, where the natives dig a sort of ground-nut they are attached to. This stream, which has some trees on its banks, is about thirty feet wide, and is estimated to be about five leagues from the post. From hence I advanced across the Bald prairie about seven leagues, one-half of which was quite black with the extinct fires. During the march there was no protection against the piercing northeast wind, full of humidity. The whole distance was strewed with boulders of granite rocks, flat pieces of yellowish limestone, with impressions of encrinites and other fossils of the carboniferous limestone, and skeletons and detached bones of the buffalo. No rock in place was seen of any description whatever. Numerous small stagnant pools of water occurred, but none that could be drunk. On reaching, at sunset, after making painful efforts to do so, the only trees, at a place called Grosses isles, where materials were to be had to make a fire for the night, we were so sick at the stomach, from cold and inanition, that it was with much difficulty we succeeded in producing a light, and then we had to boil, skim, and strain the stagnant water, before we could use it. The succeeding day we had to march eighteen miles during the most severe weather, to a place where some

bushes grew, but without trees. On approaching it within a mile, it looked like a pond of bright water; innumerable quantities of wild geese, and large white ducks with black-tipped wings, were hovering about it. When we reached the place we found it was a dried-up pond without a drop of water, the surface being covered with a white pellicle of carbonate of lime. It was from the neighborhood of this place I first saw the Coteau de Prairie stretching up and down S. S. E. and N. N. W. There was a great abundance of planorbis and lymnea here, larger than any I had seen before. The Coteau appears to have its name very appropriately, being to the prairie that sort of termination to the horizon which a coast is to the sea. After another inclement march the joyful sight of a few scattered trees presented itself, and descending the upland prairie, I reached the last trading-post of the American Fur Company in this quarter, on the east side of Lac Travers. This body of water, so called from its running *à travers*, or at right angles from the course of the adjoining lakes, is about twenty miles long, and runs N. E. by N., by compass. The waters were turbid, having no outlet in the dry part of the season, and were at this time, from continued evaporation, not very palatable. At other times of the year it discharges its water in a northerly direction, into Red river of Lake Winnipeg, and during the greatest freshes it overflows the valley which separates it from Lake Eatatenka, at its south end. The greater part of the boulders in this neighborhood are flat pieces of limestone, but I never could find any in place. The sandy loam of the prairies is about one hundred feet deep, judging from the water-level, and effectually conceals the rock formation below. From this place I proceeded to the Coteau de Prairie, keeping down the southeast side of the lake, and crossing a valley about one mile broad, which separates the lakes, the north end of Minday Eatakenka, or Big-stone lake, as it is vulgarly called, being two miles from Lake Travers. Having regained the upland prairie to the

northwest, where there are some large mounds, and following the northwest branch of the St. Peter's, (now an inconsiderable rivulet, running in a very deep ravine, and often not more than six feet across, but very pure water,) I came quite in front of the Coteau de Prairie, separated from it only three or four miles, covered by a vast number of sand-hills.

In this part of the Northwest Territory it is very seldom that trees are found where there is no water. The first care of the traveller, in a region where there is nobody to assist him, is self-preservation; his principal attention, therefore, is directed to trees, especially at the setting in of winter; without fuel he would be frozen to death in the night, and fortunately where there is fuel there is also water, unless it has been absorbed. The course of the small streams which form the principal sources of the St. Peter's, is along the wooded lines on the flanks of Chhray-tanka, or the Great Hills, the name given by the Nacotahs to the Coteau. This word is pronounced very guttural and rapid. Wherever those dark spots and lines were seen on its side, water was generally found. On these extensive plains objects are deceptive, from there being nothing to compare with them. An eminence at a distance will appear two hundred feet high, which, when reached, will not be fifty. A prairie-wolf looks, when running, like a deer; a small rock like a buffalo. I have seen an antelope rear up on its hind legs, as they always do to look at objects, and could have thought it a camelopard. At a distance of fifteen miles the Coteau looked like a lofty chain. Mr. Keating assigned to it a height of one thousand feet.* The illusion was dispelled as soon as I came near it. The ascent is so gentle at the place where I began to ascend, that I was hardly aware I was going up hill. The ascent perhaps continues two and a half miles, and is not more than at the rate of one hundred and sixty feet to the mile. I do not suppose the Coteau to rise more than four hundred and fifty feet above the level of the

* Vol. 1, page 360.

upland prairie. The Coteau itself is another upland prairie, somewhat more diversified than that I had left behind, having numerous small wooded lakes on its surface, which have a very picturesque appearance. From the plateau here there is a very extensive view of the prairies below, with the lakes. The prairies in every direction are bounded only by the horizon; a few occasional trees indicate stagnant water. It is two good days' march from hence to the river Shyan, and eight further to Pembina, on Red river of Lake Winnipeg, the whole of it over a prairie country with many small lakes and occasional wood. The Nid de Tonnerre, or Nest of Thunder, a name derived from some Indian tradition, comprehends a small tract of country with a very irregular surface, where knolls, depressions, and small wooded lakes prevail. The sand-hills I have before spoken of as lying in front of the Coteau de Prairie, extend into this vicinity, and still farther to the northwest. Farther to the northwest are several saline lakes, one of which, named Saline lake on the map, is about ten miles long. On the shores of these lakes crystallized salt is found in dry seasons, when the surface has been much evaporated; muriate of lime appears to be mixed with it. As there is no rock in place around here, conjectures only can be formed upon the nature of the subjacent beds. About thirty miles from Lake Travers the Psee, or Wild-rice river, flows east of north to Red river, rising principally in a small lake at the foot of the Coteau. From this stream there is a constant line of sand-hills to the Shyan, a shallow stream about thirty yards wide, with plenty of wood. The buffalo abound about here, but seldom come much farther south. For twenty to twenty-five miles from this stream, the country on the left bank is hilly and dry, and more easily travelled over than on the opposite bank, which is much cut up by coulees. Another Indian locality now presents itself, called the Grizzly Bear's Den, a lofty hill on the south side of the Shyan. From this place it is five days' march to Lac du Diable.

The Coteau de Prairie, about which very little has been known, is a very broad ridge of land dividing the waters tributary to the Missouri from those which discharge themselves into the St. Peter's, and into Red river of Lake Winnipeg. Its general direction is about N. N. W. and S. S. E., though in places it appears to be irregular. To the south it comes down to the sources of the Makato, whilst to the north it terminates for a while near the sources of the Psee, when a flat country comes in, intersected by the Shyan and Goose rivers. Lac du Diable* is in this area, with Turtle river. Here the Coteau rises again to the north, but is called the Pembina hills by the traders; these extend beyond the Assinaboin river, and die away about Flat lake, near seventy miles from Lake Winnipeg.† East of the Pembina hills there are salt-springs, and from the somewhat vague accounts I received from the Indians, there is coal in their vicinity. A very respectable trader informed me he had once picked up some bituminous coal on the shore of Lake Travers.

Between Lake Travers and the Missouri there are four of these ridges: Coteau de Prairie, on the surface of which there is nothing to be seen but small wooded lakes, with immense quantities of muskrats, and which extends four days' easy march to a valley through which a fine stream called Chaneaska or White-wood river flows. This stream, which the voyageurs have named *rivière au Jacques*, rises in the flat area where Lac du Diable is; it is well wooded, and joins the Missouri about the forty-third degree. The next parallel ridge is about one day's march to *rivière aux Ormes*; then

* The Nacotahs call this Lake Minday Wakon, or Great Spirit's lake; but as they attach a supernatural feeling to many things they do not comprehend, and apply the name of Wakon even to a powerful magnet, the Canadian voyageurs often mistake the Indians, and in this instance have given to this lake the now popular name of the Devil's lake.

† I have thought it might be useful to give geographical notices of some localities of this unfrequented region: those which I did not visit myself are from good authority.

another small ridge occurs, with a stream separating it from Minnay Shoshoh-chhray,* the "high hill of the muddy river," which the voyageurs going up the Missouri, have called Coteau de Missouri, having it on the right. The distance from Lake Travers to the Missouri, across this part of the country, is equal to seven days' march, and the Mandan village, in 47° 30', can be reached in the same time.

Finding the whole country buried up in sand and clay, no rock in place of any kind, and constantly admonished by the approach of the winter, I determined to return by the south side of Minday Eatatenka, or Big-stone lake. Descending the Coteau, I had a weary march across the burnt prairies, and with nothing to attract attention but the extreme beauty of the mirage and the distant tops of a few trees, I reached Eatatenka, an extremely beautiful piece of water. Where I struck the lake it was impossible to get to the water's edge, on account of the great breadth of the swampy ground, covered with rushes eight feet high. From the high land there was a fine view of the lake, curving for a great distance, with occasional bluffs two hundred feet high. Near its banks the land is of the finest quality, but is sometimes intersected by coulées. I went down one of them towards the lake, and found it terminate in about one hundred and fifty acres of very rich land, forming a singular wilderness of trees and briers, with a stream of fine water flowing through it. The remains of a large Indian village were there, and on rising the east bank of the coulée there was a mound which overlooked the country. Towards the southeast termination there is a fine low dry prairie, and a good beach, which enabled me to get some unios and anodontas. Below this are some large islands, with Indian villages. The lake, which is generally very well

* It is extremely probable that this is the origin of the word Missouri. The first time I heard a Nacotah pronounce Minnay Shoshoh-chhray, slurred rapidly together, as is their way, it produced just such a sound as an illiterate voyageur would convey by *Mishouray*.

wooded, terminates in a low marshy piece of ground, and was here covered with such great quantities of wild fowl, that they made a noise like thunder when they arose. Its extreme length is about thirty-six miles, and it averages about one mile and three-quarters in width; the north end for a short distance runs north and south, the central part bears nearly east, and at the other end it inclines to the southeast. From here the distance to Lac qui parle is about thirty miles by the St. Peter's, which is only navigable when the waters are high; the stream was very small when I crossed it, and ran through low meadows of tall wide grass, which fill this continuation of the valley between Lac qui parle and Eatatenka. Having crossed the valley here, I found myself suddenly amongst immense masses of granite in place, isolated from each other, and occupying several hundred acres. Some of these masses are twenty-five feet high, they extend six or eight miles down the valley, and give its name of Eatatenka, or Great Rocks, to the lake. On the south side of this valley, not far from the lake, a stream comes in called Zoozoo Watapah, or Sandstone river; it rises high up in the prairie, and is a large stream at some seasons. Lower down another stream comes in on the same side, called Chhray Wakon; this also rises far in the Coteau, and takes its name from a lofty mound near which it passes, named Chhray Wakon, from a miraculous tradition which the Indians have preserved. As they esteem all medicine to be miraculous, the voyageurs frequently translate the word wakon, which generally means something supernatural, by "medicine." Thus the French have called this stream *rivière de la Montagne Medicine*. Advancing to the southeast I found the prairies on fire in every direction, and having regained the canoe, succeeded, with a great deal of exertion, in descending the St. Peter's and in reaching Fort Snelling, which place I left with two feet of snow on the ground, and exceedingly severe weather.

Being desirous of examining the country from Prairie du Chien to the mouth of the Missouri, more in detail than I should have been able to do if I had taken my passage in the steamboat, I continued on to Dubuque's and the town of Galena in my canoe. Sulphuret of lead is found in various places between Prairie du Chien and Cassville, a new settlement on the left bank of the Mississippi. At Dubuque's lead mines the limestone appears identically the same with the galeniferous beds of Missouri. The fossils also are the characteristic fossils of the carboniferous limestone. The galena itself, however, differs in appearance from that which constitutes the solid and brilliant bands* of sulphuret in the Missouri mines. There, although it has an evident tendency to separate into cubes, the lines of cleavage are generally obliterated, whilst here the sulphuret consists of aggregates of perfect cubes, of a very dull and rubbly appearance, and lying in loose masses in cavities of the limestone beds, mixed up with ochreous earth. I found this to be the universal state of the metallic beds also on the left bank of the Mississippi. In Missouri the veins of galena are exceedingly bright, and are encased in wet, waxy, red, argillaceous matter, whilst in the galeniferous region of this part of the country, some electric action seems to have dried up the argillaceous matter, and to have separated the metal into cubes, and broken it up into masses. In the neighborhood of the town of Galena, I perceived the veins went very much into those pockets common to metallic countries; † here they appear to prevail through extensive areas of country; shafts are sunk to great depths through the dry red earth, and the masses of cubical sulphuret are always found in the condition I have described. I think it very probable that the lead formation of this part of the United States extends to the north far beyond the places where excavations are now carried on, but the activity, perseverance, and great respectability as to character and resources of the population engaged in the lead business of the Galena district, will in time lead

* Report 1835, p. 48.

† Report 1835, p. 49.

to its development wherever it may be. When the present veins are exhausted, shafts will be sunk still deeper. There is in fact good reason to believe that the whole distance between the lead mines of Missouri and those of Dubuque's, is comprehended in the galeniferous formation. At Mineral point, a day's ride from Galena, there are also copper veins, indications of which I saw in coming down the Wisconsin. The veins are nearly vertical, and the carbonate produces thirty-five per cent. of copper.

The Mississippi, from Fever river, continues about the usual breadth, but has comparatively few islands in it; the country is exceedingly beautiful, the banks abounding in gentle slopes, with scattering trees and occasional escarpments. In the vicinity of Rock river bituminous coal is found in many places, lying in the beds of the carboniferous limestone on both sides of the Mississippi, like those previously described in the State of Illinois. At the foot of the Des Moine rapids, near the place called Keokuk, the beds of carboniferous limestone are full of siliceous geodes, some of them a foot in diameter, and of great beauty and variety. In some instances I found the geodes containing accidental minerals; pearl spar covering the faces and terminations of the quartz crystals, and this again sprinkled over with a profusion of minute cubes of sulphuret of lead. Continuing down the Mississippi, along the bluff of the carboniferous limestone, and passing the mouth of the Missouri, I reached the city of St. Louis, in the State of Missouri.

From this place the geology of the country south to Red river, and southeast to the Atlantic, has been already sketched out in my report of 1835.

I have the honor to remain,

Very respectfully, sir,

Your obedient servant,

G. W. FEATHERSTONHAUGH,

U. S. Geologist.

REFERENCES FOR THE DIAGRAMS.

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18 Section from Georgetown, D. C. to Green Bay.

19 Section from Green Bay to Prairie du Chien.

20 Section from Prairie du Chien to Coteau de Prairie.

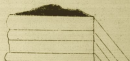
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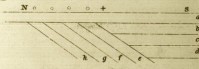
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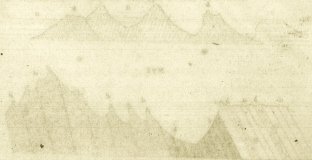




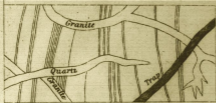
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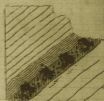
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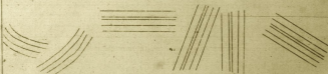
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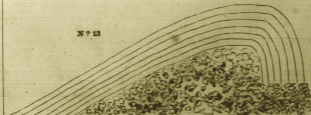
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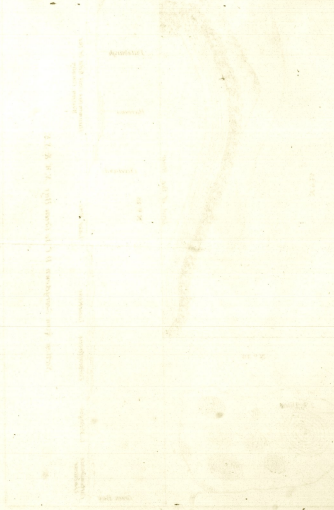
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Level of Wills Creek

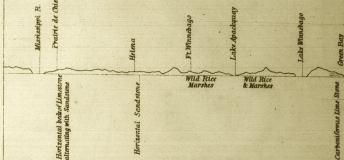


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Sec. from Green Bay & Prairie de Chien W.S.W. E.N.E.

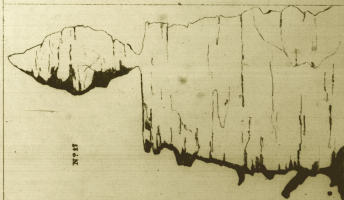


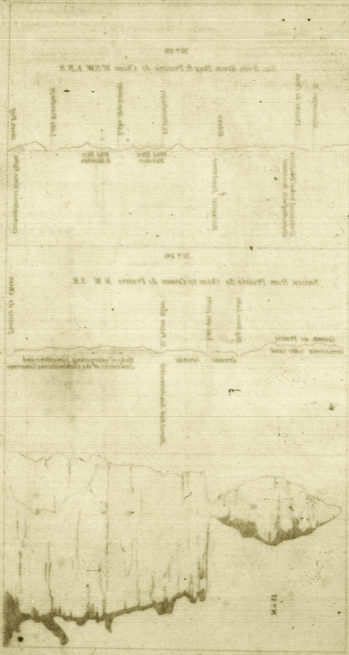
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Section from Prairie de Chien to Coteau de Prairie N.W. S.E.



N° 17





Explanation of some Geological Terms used in this Report.

- Anticlinal**—where the beds dip contrariwise, like slates on the opposite sides of the roof of a house.
- Brachiopoda**—molluscous animals inhabiting certain shells, with spiral arms, serving the purpose of locomotion.
- Conformable**—beds whose planes or faces conform in parallelism to each other.
- Conglomerate**—rocks formed of fragments of older rocks, usually rounded into the pebble form by the action of water.
- Cleavage**—lines in slates and other rocks which resemble the lines of stratification, but which run in a different direction. The intervention of a siliceous seam, or sometimes the position of fossils, will determine doubtful cases.
- Formation**—a bed or group of beds, deposited at an epoch independent of that during which the beds it lies between were deposited.
- Goniatites**—a chambered shell, with a siphuncle, spirally striated, resembling the ammonite and nautilus.
- Ichthyodorulites**—defensive fin bones of an extinct shark-like species of fish.
- Ignigenous**—rocks having their origin from fire, in contradistinction to those having their origin from water.
- Lignites**—carbonated fossil wood.
- Mural escarpment**—perpendicular cliffs, presenting a section of beds like a wall.
- Naere**—the brilliant iridescent appearance on the surface of some shells.
- Out-lier**—A mass of rock detached from the general formation of which it once formed a part.
- Radiaria**—animals including echinites, encrinites, &c.
- Rock**—all beds, whether hard or soft, are, in geology, included in this term.
- Section**—when the edges of a series of beds show themselves on the banks of a river, or in any escarpment, as if the formation had been cut through, this is a natural section. Rivers cut through their beds usually by retrocession.
- Seam**—a thin parting between thicker deposits.

Sedimentary rocks—Deposited from water.

Septaria—calcareous concretions, divided by irregular lines of carbonate of lime into septa or chambers.

Siphuncle—A tube passing through the septa of concamerated shells, to enable the animals to rise and sink in the water.

Stratum—a bed or deposit distinct from another bed.

Stratified—deposits formed by beds lying upon and usually parallel to each other.

Strike—the direction of the edges of beds at right angles to their dip, as we say to *strike off* in any given direction.

Synclinal—where the beds converge towards each other in concave lines.

Talus—a slope at the foot of an escarpment, formed of the fallen materials.

Unconformable—beds whose planes do not conform in parallelism to each other.

Unstratified—amorphous masses, without any appearance of stratification.

Zoophytes—animals producing coral rocks.

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