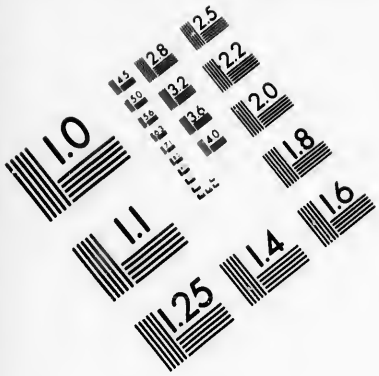

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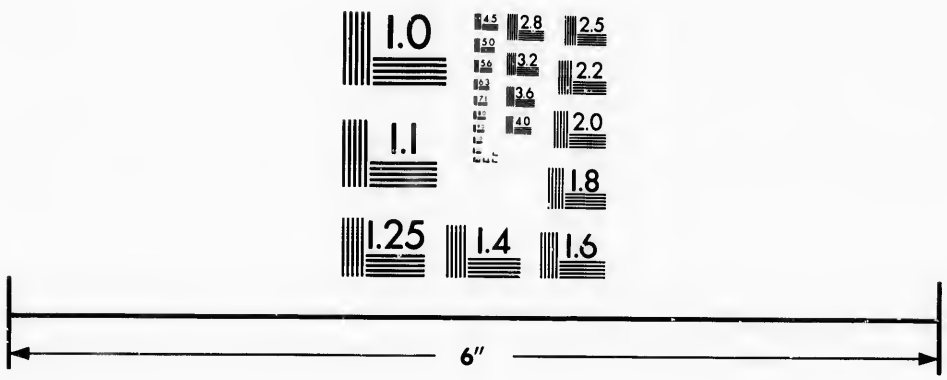

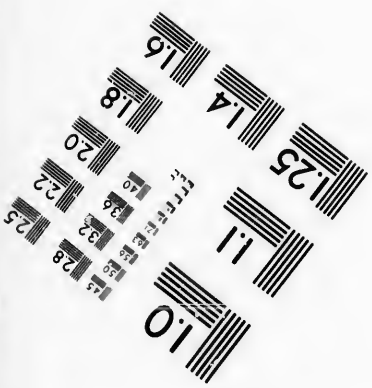

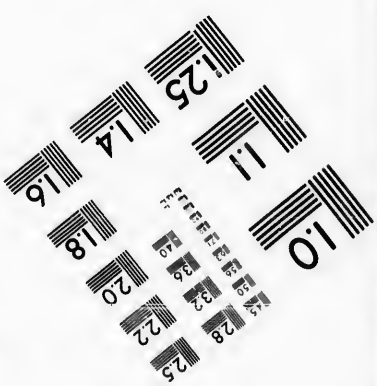

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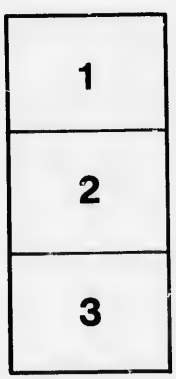

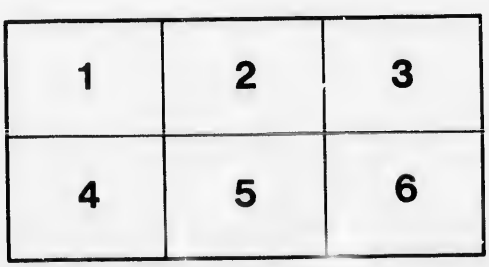

RELATIONS

OF

GEOLOGY TO AGRICULTURE

IN

NORTH-EASTERN AMERICA.

By JAMES F. W. JOHNSTON, F.R.S. L. & E.;

HONORARY MEMBER OF THE ROYAL AGRICULTURAL SOCIETY.

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THERE are two ways in which the relations of geology to agriculture can be viewed and considered: either broadly and generally, in regard to the agricultural character and capabilities of entire geological formations or groups of rocks; or locally, in regard to the connexion of the kind of fertility exhibited by this or that limited district or single spot with the kind of rock on which the surface rests. Of these two modes, the first or broadest is the most attractive, the most interesting in its conclusions, and the most satisfactory in the relations it establishes between agriculture and geology. The second is less simple, clear, and satisfactory. It is far more laborious to follow out also, and requires more knowledge of details in the investigator; but, at the same time, it leads to results which are directly practical and of immediate application.

In the present paper I propose to illustrate both, but especially the first, of these methods, by illustrations drawn from North-Eastern America.

A. GENERAL RELATIONS OF AGRICULTURAL CAPABILITY TO GEOLOGICAL STRUCTURE.

I. *On the Atlantic Sea-board.*—My first illustration I shall take from the Atlantic sea-board of the more western States of the Union.

If from the coast-line in any of the States west of the river Potomac—from the sea-shore of Virginia, for example, of either of the Carolinas, of Georgia, or of Alabama—a traveller proceeds inland till he reaches the first slopes of the Alleghany Mountains, he will pass over four regions which, even to the unprac-

tised eye, are most clearly distinct in the character of their soils and in the nature of their vegetable productions, whether natural or cultivated.

First. Rich muddy flats line the shore, intersected in some places by creeks and swampy hollows. To these low lands the negroes repair at the proper season of the year, and put in, tend, or reap the sea-island cotton and the rice, which here yield great returns. The white masters, or superintendents, visit them as rarely as possible, the climate in the hot season being rife with fevers fatal to the constitution of the white man. When these swampy flats are still in a state of nature, the swamp willow, the cypress, the swamp hickory, the green palmetto—the proud badge of North Carolina—the tall magnolia, the red maple, and the cotton-wood, form a distinguishing natural vegetation, rich and beautiful to the eye, but reminding the practised observer at once of a soil full of natural fruitfulness and of an atmosphere prolific in shivering ague and in depressing and rapidly wasting fever.

A few miles inland brings him to higher ground. The alluvial plain gradually rises a few feet above the sea-level, and dry, rich soils support a natural growth of hickory, oak, beech, magnolia, walnut and tulip trees, and of holly. Tobacco and sugar are the staple marketable crops, which the cultivator raises on these drier soils, where generations of exhausting culture have not already worn them out. They yield also large crops of Indian corn—the main food of the coloured labourers—to which the warmth of the climate is as propitious as the soil.

Second. Pursuing his journey towards the hills, after twenty miles or thereby—a breadth which varies in different parts of the coast—he reaches the edge of the drier alluvial plain, and ascends a low escarpment of yellowish sand. He now finds himself in the midst of forests of unmixed natural pine, covering a belt of barren sand generally unfit for cultivation, and which for hundreds of miles girdles in the lower plain of rich land he has already crossed. The worthlessness of this pine region for the purposes of the cultivator is illustrated by the history of that portion of the belt which runs through the State of Georgia. After the settlement of the boundary line between Georgia and Florida, the State Legislature of Georgia passed an Act ordering all the unsold lands of the State, after being surveyed, to be divided by lot among the resident population. The cost of surveying and other expenses imposed a charge of two cents an acre on these lands, which fell to be paid by the allottees. But a great many of those who drew the pine barren lots refused to take out their grants, thinking them not worth the two cents an acre they had to pay for them. The State Legislature, therefore, subsequently

ordered that all the land of this kind which was unclaimed after a certain period should be sold at four cents an acre to whoever would buy it. Large speculations were in consequence made by individuals and companies, chiefly with a view to cut down and sell the timber. The lumber merchants from the north-eastern States were conspicuous among these speculators; and I had the fortune to travel for some distance with a gentleman who, among other information, told me he was one of a small party who had bought no less than 190,000 acres of this Georgian barren in one locality, with the confident expectation of making much money by the sale of the lumber.

The species of pine with which this barren is covered changes as we proceed towards the south and west—probably from the change of climate and exposure. In North Carolina it bears principally the Pitch pine (*Pinus rigida*), which yields large supplies of turpentine. This and the timber are shipped from the port of Wilmington in that State. In Georgia, again, the prevailing tree is the Yellow pine (*Pinus mitis*), which yields a harder and more valuable timber than the Pitch pine. The chief difference, as I was informed, is that the sap or soft heart-wood in the Yellow pine is much less in diameter than in the Pitch pine, and thus the proportion of hard resinous wood in trees of the same size is much greater in the former than in the latter.

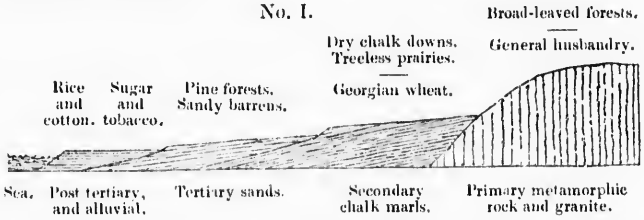
Third. Farther inland the traveller ascends another terrace, and at once escapes from the forest into the open treeless prairie, where, far as the eye carries him over the flat, only natural grasses wave in the wind, unless where settlements have been made, and the arts of husbandry have introduced a new vegetation. The thin soils of this attractive plain rest upon a rotten chalk or chalky marl, and, like the soils of our chalk downs, are absorbent of moisture and naturally dry. They produce a sweet herbage, grateful to the cattle, and yield fair crops of wheat while still in a virgin condition. The variety known in the market by the name of Georgian wheat is grown on these chalky prairies. They are attractive to the settler because they can be converted into farms without cost. There is no forest to fell. As much land as can be skimmed with the plough may be sown with grain year after year by the first settler, and the aid of a reaping machine makes him almost independent of labour when the time of harvesting comes. It is upon plains like these—so easy to till and so bare of trees—that in published accounts of some of the States we read of single fields of wheat containing from 400 to 700 acres of waving grain,* and from which a crop of ten or

* I have never myself seen any of these large fields, probably because I was never upon any of these prairies where they were to be seen. I was told by a

twelve bushels an acre leaves a profit upon the labour and capital expended. But the thin black virgin soils which cover them soon deteriorate. Deeper ploughing does not permanently restore them, and the knowing cultivator now sells his *improved* lot to a new comer, and betakes himself to another virgin tract which the tide of emigrant population is only beginning to reach.

Fourth. Crossing the prairie or chalk down, he comes again to a sudden rise in the country, over which cheerful forests of *broad-leaved* trees extend—of oaks, hickory, &c., and a scattered admixture of pines. He is now on the older rocky formations, of which the first slopes of the Alleghanies consist. Mica-slate, gneiss, and granite, here mingle their débris to form a characteristic red, clayey, but friable soil, which crumbles readily, and, from the nature of the climate, admits of a husbandry approaching more to that of our English farmers.

The marked features of soil and vegetation which our traveller thus perceives entirely coincide with as distinctly marked geological features. This is seen in the following section of the coast-line in question, from the sea to the mountains. The letterpress below the section indicates the geological formations—that placed above it indicates the natural vegetation and the crops which grow best upon each.



In this section a close general relation is seen between the changes in geological and agricultural character which appear on the several successive terraces or flats of land across which the traveller proceeds on his way from the shores of the Atlantic to the slopes of the Alleghany Mountains. Where the most recent or alluvial loams and rich clays end, there the tobacco, Indian corn, and even wheat culture, for the time, ends also. The tertiary sands belong to a more ancient epoch, and to them are limited, by a strictly defined boundary on each side, the dark pine forests which are so striking a feature of the country. On the older chalk, again, the treeless prairie and flinty wheat country is as distinctly limited by the formations on either hand; and

Michigan farmer who invited me to visit him, that he had 400 acres under wheat, and reaped with a machine. The average produce of the whole of this State of Michigan is only 10½ bushels of wheat per acre.

beyond this, again, the changed forests and cultivation of the higher country are determined by the change in nature and in age which the rocks of this region exhibit.

It is only necessary to observe further that the width of these several belts of land varies in different parts of the long Atlantic coast-line. The alluvial border is broadest in the southern States and along the Gulf of Mexico, the pine belt probably in Georgia, and the chalk marl in Alabama and Mississippi. The latter also—the chalk—is by no means continuous. It forms only a narrow belt in New Jersey and Maryland—almost disappears in the Carolinas—is known only in patches in Georgia, but becomes again broad and continuous in Alabama. Still, wherever, along this great distance, any of these formations occur, and of whatever extent they may at that place be, they always exhibit the same general characters of soil, of natural vegetation, and of agricultural capability, in so far as the climate of the place permits.

It is, indeed, very remarkable how uniform in this respect the same geological formation is sometimes found to be, not only in the same country, but in different countries at great distances from each other. I have already alluded, for example, to the natural dryness of this chalk belt on the Atlantic border of the United States. The scarcity of water experienced by those who reside upon it is often great. Every one knows that the same of our own chalk region in England—that in very wells are sunk through it with the view of reaching that in London great depths are gone to, and at a vast ough the London clay and the chalk, before water can be . In the Paris basin the chalk is equally dry, and there are y few who have not read of the remarkably deep well at Grenelle in the neighbourhood of Paris, which, like the less profound London wells, has been sunk to the sands below the chalk, and with similar success.

So, in Alabama, on this formation water is only to be obtained by sinking through the chalk. Three years ago there were already about 500 wells in that State, sunk to a depth of from 400 to 600 feet, there being one generally upon each plantation. And thus, while the climate there, as elsewhere, determines the general character of the vegetable produce, what kind of plants under the meteorological conditions can arrive at perfection, and also the race of men by whom that labour can be best performed,* yet the geological structure determines whether or not any crops shall be able to grow at all, and, of the kind of plants suitable to the climate, which can be profitably cultivated upon its actual

* Cotton is the staple market crop of Alabama. The State contains by the last census (1852) a population of 779,000, of whom 344,000 are slaves.

surface. But in the present case the reader will perceive that the geological structure determines more. In such a climate, and with a soil so naturally arid, abundant water is indispensable; but this can only be obtained by deep boring performed at a great expense. The geological conditions, therefore, confine the possibility of cultivation to men of large means, and, in present circumstances at least, necessarily exclude all petty farming and the subdivision of the land into small holdings. They determine, in other words, the social condition of the people. This single illustration is enough of itself to satisfy any impartial person of the close general relation which exists between the geological character and the agricultural capability of a country, and of the broad general deductions in regard to its possible future prosperity—in a rural sense—which may be drawn from a knowledge of its geology. I believe it is partly under the influence of this conviction that the Senate and Congress of the United States have so often and so cordially voted large sums of money for the purpose of investigating and mapping the main geological features of the new States and territories which from time to time have been admitted into the Union.

II. *Relations of Geological structure to Agricultural capability in Western New York.*—I take my second illustration from Western New York, partly because this has long been celebrated as a rich wheat-growing district; partly because the relations we are studying are here really very interesting; and partly because this locality will give me the opportunity of showing, by a more detailed example, the intimate connexion which subsists between the economical value of a region in the agricultural, and the composition of its rocks in a geological, sense.

The section of the country along the Atlantic border, which formed the subject of the preceding illustration, terminated inland with the primary rocks of which the first slopes of the Alleghanies consist, and which, by their crumbling, form red friable soils, clothed with mixed, chiefly broad-leaved, trees.

The primary stratified rocks are there generally tilted up, squeezed together, as it were, and standing on edge. They thus occupy but little space, so that a mixed soil of a common character, derived from their intermingled fragments, overspreads them all.

But Western New York presents us with a most favourable opportunity of studying the special agricultural influence, in detail, of each individual member of whole groups of rocks. That subdivision of the primary rocks, distinguished among European geologists by the name of Silurian, is there flattened and spread out over a large extent of country; and the several beds of this

subdivision—partially overlapping and rising above each other in a succession of small but distinct terraces of greater or less breadth—plainly exhibit to the eye of the observer the chemical characters of each, the kind of soil which in crumbling it naturally produces, and the special effect it has on the agricultural capability of the surface that rests upon it.

The country to which I here refer extends along the southern shores of Lake Ontario, from beyond Buffalo, at the foot of Lake Erie, on the west, to Oswego, near the foot of Lake Ontario, on the east. Its length is about 180 miles, and its mean breadth from Lake Ontario towards the south about 30 miles. The district rises as we proceed southward from the Lake, sometimes by sudden starts over rocky escarpments, but generally in a gradual manner, till it attains a height of 600 or 700 feet above the Ontario. Farther south, towards the Pennsylvanian border, the high land attains an elevation in some places of nearly 2000 feet. The woodcut (p. 8) exhibits an outline of its geographical position and geological structure.

This outline map shows the relative position of the Lakes Erie and Ontario, the discharge of the waters of the former into the latter by the Niagara river, and the drainage of the high southern country towards the borders of Pennsylvania by the Genessee river, which falls into Lake Ontario below Rochester. The lines which run from east to west indicate the boundaries of the several rocky formations of which the country consists; all, except that marked 8 and 9, belonging to what is called in Europe the Silurian system of rocks. The area or strip of country covered by each formation is represented by the numbers 1, 2, 3, &c., in the ascending order of their superposition. They form, as I have above stated, a succession of strips, belts, or terraces, of greater or less breadth, from the lowest (No. 1), on the banks of the Lake, to the highest (No. 9), which covers the interior of the country. The names given by the New York geologists to these several rocks are as follows:—

No. 1. The Medina sandstone; No. 2. The Clinton group; No. 3. The Niagara group; No. 4. The Onondaga salt-group; Nos. 5 and 6. The Helderberg group; No. 7. The Hamilton group; Nos. 8 and 9. The Portage and Chemung groups.

The broadest belts, as will be seen from the map, rest upon the Medina sandstone and on the Onondaga salt-groups. Of course I do not compare any of these belts in area with the extended surface occupied by Nos. 8 and 9, which bound on the south the low and fertile region to which my observations will chiefly apply. The mineralogical character of these several groups of rocks, viewed in connexion with the nature of the soils

L. ONTARIO
L. ERIE
Toronto
Lockport
Rochester
Batavia
Attica
Buffalo
Niagara Falls
Auburn
L. Cayuga
L. Seneca
Ithaca
Geneva
N
S
1
2
3
4
5 & 6
7
8 & 9

they form, afford the illustration to which I am desirous of drawing the attention of my readers.

No. 1, *the Medina Sandstone*, consists of layers of brownish or red sandstone, intermixed with layers of reddish shaly or shivery clay. These yield the red soils of the low flat belt which skirts the southern shore of Lake Ontario. At its eastern extremity this rock contains few partings of clay, and produces therefore poor sandy soils of comparatively little value. Over much of these poor sands natural pine forests still extend, as the traveller sees when he steams along the Lake from Rochester to Oswego. But, as is occasionally the case with other sandstones, the partings of clay increase in number and thickness towards the west, producing first sandy loams, and finally rich clay loams well adapted to the growth of wheat. Hence this same formation, which at the east end of the Lake affords only poor hungry soils, yields between the mouths of the Genessee and the Niagara rivers some of the richest wheat-lands in the State.

No. 2, *the Clinton Group*, forms a very narrow zone, which is nearly concealed by the débris of the rocks which lie immediately above and below it. This group consists of green and blue shales with limestone intermingled, altogether from 60 to 80 feet in thickness. They are soft and thin, and have therefore been washed away by the ancient sea nearly to the edge of the hard thick limestone of No. 3 which lies above it. The admixture of the fragments of this Clinton formation has produced a surface of excellent wheat-soil. It forms a very narrow terrace of calcareous clay, sloping with a gentle inclination towards the lake. The dotted line N S in the map represents the line of the cross-section (No. III.) given in page 18. A glance at the map will show that along the line of this section the zone of the Clinton group is broader than it is anywhere towards the west, reaches a breadth in fact about equal to that of the Medina sandstone below, or of the Niagara limestone above it. It is necessary to notice this fact, otherwise this cross section would appear to be inconsistent with the general indications of the map, in which the Clinton group forms usually a very narrow strip indeed.

No. 3, *the Niagara Group*, consists of an enormous thickness of limestone above, resting upon a great thickness of dark blue crumbling shales below. At Niagara, where the river falls, the limestone has a thickness of 130, and the shale of about 80 feet. The shale alone, where it comes to day, produces stiff blue clays, which, from the sloping nature of the surface, are generally dry and susceptible of culture. Like many of our own still untouched clays at home, however, they are to be hereafter rendered greatly more valuable by the introduction of our British system of thorough drainage. This mode of improvement is

beginning now to attract a considerable degree of attention among intelligent and well-educated farmers in the older States of the Union, and nowhere more, I believe, than among those who cultivate this naturally favoured region of Western New York. Where the débris of this Niagara shale is mixed up with those of the Medina sandstone and Clinton groups—which is frequently the case along the lines of junction—the admixtures are said to produce soils of "unequalled fertility." This fact illustrates the observation of all agricultural geologists in every country, that the economical value of the land almost invariably increases along the line of junction of two geological formations; provided that coverings of far-transported drift do not prevent the subjacent rocks from exercising their legitimate influence upon the nature of the soils that cover them. The overlying Niagara limestone, where it is uncovered with drift, has crumbled down into thin open soils which produce wheat, but are better adapted for Indian corn, or for the turnip husbandry, should this region ever become familiarized to it. The surface of the limestone, however, is generally overspread with fragments of the underlying more crumbling shale which have been drifted over it, and thus the belt No. 3 is, for the most part, overspread with deeper and richer soils than would have resulted from the decay of the lime-rock alone.

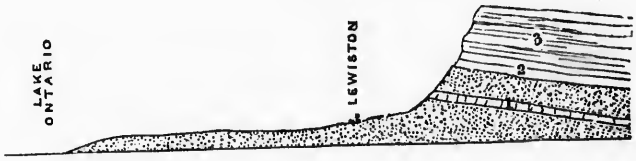
It will be seen in the cross-section (No. III.) given in page 18, that the rise from No. 2 to No. 3 is by a sudden step or cliff. This cliff is comparatively low towards the east, where the section is taken, but increases in height towards the west. This is owing to the circumstance that the bed of limestone increases in thickness in proceeding from the east towards the west. In Wayne county, where the section is taken, it is only 30 or 40 feet thick; while on the Niagara river, above the rapids, it is 164 feet, and it still increases in thickness as we proceed farther towards the west, along the northern shores of Lake Erie. This is owing, most probably, to the increasing depth in that direction of the ancient sea in which this limestone was deposited.

This increasing thickness exercises an influence upon the agricultural character of the country occupied by the Niagara group in its western range, but its most sensible and striking effect in Western New York is on the physical features of the district. The outcrop of the limestone forms a long cliff or escarpment, which skirts the whole southern edge of the lake, and presents to the traveller most beautiful and extensive views of the flat country below and far over the waters of the lake beyond. From the Genessee to the Niagara rivers this cliff is a characteristic feature of the country, and is familiarly known by the name of the "mountain-ridge." Over this escarpment of

the limestone the Genessee and the Niagara, among other rivers, precipitate themselves, producing those magnificent falls which have given celebrity to Niagara, and an unlimited water-power and most rapid rise to the city of Rochester.

The following section will give an idea of the appearance of the mountain-ridge in the steepest and boldest parts of its course, and will show how it overlooks the flat plain of the Medina sandstone and the waters of Lake Ontario.

No. II.



In this section the dotted mass above and below No. 1 is the Medina sandstone, No. 2 is the Niagara shale, and No. 3 the overlying thick-bedded limestone. It is taken behind the town of Lewiston, at the mouth of the Niagara river, on what is called the American side. The view which the spectator enjoys from the top of the escarpment at this spot is worth going a long way to see. Sheer down one looks over the scattered town of Lewiston, upon the broad flat forest-lands stretching many miles back from the lake, and eastward along its shores farther than the eye can reach. Here and there only, at the time of my visit, in all this distance a clearing appeared upon this often marshy flat. Right in front lay the endless lake and its occasionally bolder shores beyond, with now and then a straggling sail or a distant steamer's smoke, all mellowed and blended by a four o'clock sun. I was much struck both with the extent and with the unsubdued wildness of the prospect, when I unexpectedly reached the cliff on my way from the falls; and I could not help thinking how some two centuries hence, when all this low plain before me shall have been cleared, drained, and cultivated—when smiling villages and cheerful homesteads, and scattered flocks and herds overspread its surface, and the blue smoke may be seen dying away from many chimneys as the Sabbath bell draws the gathering people towards the frequent house of worship—how many in those days for broad pictures of natural beauty, intense with countless little episodes of still life, will yet frequent this mountain ridge when the noise of the neighbouring cataract has wearied them, and softer scenes are wished for to calm and compose their fevered spirits.

No. 4, *the Onondaga Salt Group*, derives its name from the brine-springs which issue from it in various parts of this western

region. Salt is largely manufactured from the water of these springs, especially at Syracuse, where the annual produce amounts to 125,000 tons, about a fourth of the whole annual consumption of the United States.

This group of rocks consists in descending order of,—

a. Green calcareous shales and shaly limestone, rich in magnesia.

b. Calcareous shales and impure limestones, containing deposits of gypsum.

c. Green marls and shales, and shaly limestones.

d. Green marls, with bands of red marls.

The formation as a whole is crumbling, friable, and rich in calcareous matter. The soils it produces are consequently rich, free, and easily worked. It has an average thickness of about 1200 feet, and forms a belt of generally level but undulating land, with a gentle inclination towards the lake. It runs east for upwards of 100 miles beyond the line of section N S in the map, and westward across the Niagara river, round Lake Ontario, and far into Western Canada. An inspection of the map will show that this belt occupies a large proportion of the whole area of the district. Its average breadth is 10 or 12 miles, the latter being its breadth on the Niagara river. In the line of section N S, its breadth suddenly expands to between 20 and 30 miles. Towards the east it narrows off, and disappears as we approach Schnectady and the Hudson river, while in Western Canada it expands to a maximum breadth of about 80 miles.* In this western region, therefore, the Onondaga salt group forms a large area of rich land, profitable in Indian corn, but especially in wheat.

During a stay of a few days at Syracuse, I visited the farm of the Hon. Mr. Geddes, a member of the State senate, and, under his guidance, had the satisfaction of surveying a considerable extent of this formation, so very interesting in its geological, agricultural, and economical relations. This gentleman is the owner of 300 acres of the best quality of land which occurs on this formation, and, like nearly all the owners in this country, lives upon and farms his land himself. The soil I found to be a light-coloured calcareous clay, which crumbles readily and never bakes. It is generally shallow, and rests on one of the green shaly rocks above mentioned. This shale crumbles readily in the air, and, by exposure, becomes paler in colour, forming the light-coloured soil of which the farm consists.

This neighbourhood, in its general aspect, appeared to me more like a part of Old England than of a newly cleared or settled country. Of Mr. Geddes's 300 acres, 270 were in arable

* See some additional remarks on this point in the concluding paragraphs of the present paper.

culture, and comfortable houses and good buildings of other kinds were seen on most of the farms I passed. The size of farms is here generally from 100 to 300 acres, and these, with the buildings upon them, usually sell at 50 to 60 dollars an acre. At this price Mr. Geddes expressed to me his opinion that it was the cheapest land in the States *for those who have capital to buy it.* By those, of course, whose whole wealth consists in their bodily strength and industrious habits, the wilderness land of the more western regions is alone attainable.

I give, as an illustration of the capability of this very best land, the following statement of the produce per acre, as furnished to me by Mr. Geddes. This soil is of a very useful kind, producing all sorts of grain crops, though not of equal quality. The yield per acre is,—

Wheat	. .	18 to 35 bushels,	of 60 lbs.
Barley	. .	20 to 55 ,,	48 lbs.
Oats	. . .	40 to 100 ,,	32 lbs.
Indian corn	. .	50 to 80 ,,	56 to 60 lbs.
Potatoes	. .	100 to 300 bushels.	

It is least adapted, he said, to the growth of potatoes—which is more probably owing to the climate and the great summer heats than to any defect in the soil. Turnips are as yet but little grown, and the feeding of stock is not much attended to.* An average weight of 32 lbs. a bushel does not indicate a climate well suited to the oat crop. As a general rule indeed the climate which ripens Indian corn well rarely produces a crop of heavy oats.

The fact that this land has been ploughed for fifty successive years without receiving any manure will give the reader an idea of its innate richness. I walked with Mr. Geddes over two fields which have never been manured during the fifty years which have elapsed since his father first cleared them, and he thinks the land as good as ever it was. It yields from 50 to 60 bushels of Indian corn, and in 1848 it gave 30 bushels an acre of wheat. The soil consists, for the most part, of crumbling fragments of the green shale. When the older land appears to become exhausted the plough is put in a little deeper, so as to bring up a little of the crumbling rock (green shale). It is then said to produce wheat as abundantly as before.

The most sceptical as to the influence of geological structure upon agricultural capability can scarcely doubt after such an illustration as this.

The rotation on this farm was—1. Indian corn after lea, with

* When the necessity for manure becomes more urgent to the land, the feeding of stock will no doubt take in American the same place it occupies in English agriculture.

manure, if any is applied; 2. Oats; 3. Barley or Pease; 4. Winter Wheat with seeds in spring; 5. Grass, cut twice for hay; 6. Grass pastured with sheep and milch cows.

If the land be foul, it is now summer fallowed and sown with wheat, followed by seeds as before, after which Indian corn comes in again. If it is not foul, the rotation commences with Indian corn immediately after the two years' grass.

On soils derived from this extraordinary green shale, such severe—what we should call scourging treatment—may be continued a great many years with apparent impunity; although it is seen even here to tell very soon on land of inferior quality. But in this naturally rich land also its effects become visible at last. Hence it is that this celebrated wheat region of eastern New York AS A WHOLE is gradually approaching the exhausted condition to which the more easterly wheat growing, naturally poorer districts, had earlier arrived. Of course where the subsoil or subjacent rock is so full of natural fertility as this green shale is said to be, the exhaustion can only be superficial, and fertility may again be restored to the surface soil. But to do this will require both a more skilful and a more expensive system of husbandry—conditions which manifestly imply that crops can never again be raised so easily or so cheaply as during the early and virgin freshness of this deservedly lauded district.

Monroe county is in the centre of this district. The Genessee river runs through it, the city of Rochester stands in it, it embraces a large portion of the richest land in the Genessee valley and on the Onondaga salt group, and the corn averages of this county, as published by the New York State Society, are higher than those of any other county in the State. It may be supposed therefore at the present moment to be the most fertile. Now the averages per acre of Monroe county are as follows:—

Wheat . .	19½ bushels	Indian corn .	30 bushels.
Barley . .	19 ,,	Potatoes .	110 ,,
Oats . .	32 ,,		

For a highly and deservedly lauded, fertile, wheat-growing district, the pride of the State of New York, the happy home to which the longing eyes of British and Irish agriculturists have long been directed, these are but low averages. Either the land is not so good as it has been called, or it is, and has been, badly treated. The general treatment has certainly been bad, but as surely large portions of the land are naturally very good, and may still be made very productive. But if they can, it must be, as with us at home, by the application of more skill and by a more prudent husbanding of the natural riches which the soil contains. The trouble of preparing, collecting, and applying manures must not henceforth be thought too great for a free and independent

North American farmer. This is well understood now by the leading promoters of agricultural improvement both in the United States and in the British Colonies. But in this district of Western New York they feel the influence upon local prices of the great importations of wheat and flour from the new States west of Lake Erie. The tide of this commerce in grain has now turned in direction. Instead of sending westward from Buffalo its thousands of barrels of flour, as it did in former years, New York now yearly receives from the west, through the same port, its hundreds of thousands of casks of flour and of bushels of wheat. So that, besides the improvements which the advance of knowledge suggests, self-interest is now urging the farmer of New York to the adoption of wiser and better modes of culture. "What," said the President of the Oswego Agricultural Society, in his address at the close of 1850—"What, I ask, is to meet this competition of the west, but greater skill and care in the mode of agriculture?" This is precisely the language which speakers and writers in our own country have of late years been almost daily addressing to British farmers.*

Nos. 5 and 6. *The Helderberg Limestones and Sandstones* (5), rise immediately behind the Onondaga salt group. Where I drove along the edge of this limestone with Mr. Geddes it formed a high escarpment, from which the view of the flat lands below, and of the country towards the lake, was beautiful and extensive. Though far from what it was half a century ago, this great stretch of undulating plain still seemed strange and savage to an eye accustomed to the finished and artificially picturesque appearance of an English landscape. Swamps and lakes, and rude natural forests, with intervening tracts of land under waving corn, remind the spectator how much nature yet rules, how long human industry must patiently labour still before the asperities of a new country can be rubbed off, how many generations of the enterprising men who now possess it must still toil and adorn this fine land before it will smile at their feet like that which their forefathers left.

At this limestone the natural richness of the country as a wheat region begins to fall off. The soil upon the limestone itself, and upon its subordinate sandstone, is often thin, resting on a hard rock, but, where it happens to be deep, it is full of fragments of limestone, and is of excellent wheat-growing quality.

The Marcellus Shale (6), which overlies the Helderberg limestone, is thin, varying from a few feet in thickness to a maximum

* Those who are interested in the wheat-producing capabilities of the United States generally, and in their future relations to our own wheat markets, will find the subject discussed at some length in the 13th and 25th chapters of the author's '*Notes on North America*.'

of 60 or 80 feet. Its effects on the surface of the district therefore are chiefly to improve the soils of the limestone at the points of junction, and to form occasional narrow stripes and patches of stiff clay, richly calcareous, and productive in wheat. When the escarpment of the Helderberg limestone is less bold than where I visited it, near Syracuse, its surface is generally overspread with the débris of the softer rocks which adjoin it on either side. It is so in the line of the cross section N S (Section, No. III.), and there the soils which cover it form a prolongation of the rich land, fertile in wheat, which covers the plains below.

In the accompanying outline map it will be seen that the belt formed by these rocks (5 and 6) is very narrow in Western New York. Farther to the west however it expands, and along the north shore of Lake Erie it forms a wide and valuable tract of land in the fast filling-up and fertile region of Western Canada.

No. 7, *the Hamilton Group*, consists of olive and dark-blue shale, which, when alone, forms stiff dark-coloured clays far less rich in calcareous matter than the Onondaga soils. They are therefore less open and friable, and in consequence more difficult and expensive to work. Still they are capable of producing excellent wheat under favourable circumstances, or when properly prepared. The celebrated Genessee valley rests on this formation, but the natural soil of the Hamilton shales is there modified, or altogether covered by drifted fragments of the Niagara limestone and other more northern formations, which have been washed up the valley. Hence the quality of the Genessee soils is not that which is natural to those of the Hamilton group.

This group is of great thickness, and, as is shown in the map, forms a belt of land 10 or 12 miles in breadth. Where the shales are rich in lime they are submitted to arable culture. They are everywhere however difficult to keep clean, and are especially infested with corn gromwell (Lithospermum arvense), called here pigeon-weed. They are for the most part, therefore, like our own stiff clays of the lias and other formations, left to perpetual grass, which they produce of excellent quality. Here, therefore, the grazing and dairy country of Western New York commences.

Nos. 8 and 9. *The Genessee Slate* (No. 8), which is separately distinguished in the cross section (No. III.), is too thin to form an important agricultural feature of the country. It crumbles more slowly than the Hamilton shales; but where its fragments mix with those of the Tully and other thin limestones and calcareous shales beneath it—also represented in the section—it forms good soils.

The Portage and Chemung Groups (No. 9) consist of alternations of shales, poor in lime below, with flagstones and massive sandstones. They are of enormous thickness, and extend south-

wards beyond the borders of Pennsylvania, where in the line of section they reach a height of 1000 feet above Lake Ontario.* These rocks belong to the Devonian series of English geologists, and lie immediately under the old red sandstone, which begins to cover them beyond the Pennsylvanian border—further towards the south than the map or section extends.

The district occupied by these groups of rocks presents a complete contrast to the wheat-region—a contrast rich in evidence of the close relation between geological structure and agricultural capabilities. When first cleared the virgin surface produces crops of wheat, but after the first crops—as is the case in many parts of New Brunswick, which rest upon similar rocks—winter wheat becomes uncertain, and spring grain only can be sown. Being thus found naturally poorer, it is less cleared and cultivated than the more favoured land in the plains which border the lakes. Like poor land among ourselves also—I may say like poor land in all countries—it is occupied for the most part by a poorer race of cultivators, who direct their chief attention to the rearing of stock and to dairy husbandry.

The cross section, taken along the line N S in the map (p. ~~18~~), exhibits at a glance the relations—physical, geological, and agricultural—of this interesting district. It commences from Lake Ontario on the north, and is continued nearly to the Pennsylvanian border on the south.

The above section sufficiently explains itself. It exhibits in brief what in the preceding pages it has been necessary to state verbally a little more in detail. The points it is intended chiefly to illustrate are—

a. The physical and geographical position of this celebrated wheat-region in reference to Lake Ontario.

b. The special agricultural relations of the several groups of rocks which in this district form the Silurian system of English geologists.

c. The sudden and striking change of produce and capability which manifests itself when we ascend from the calcareous soils of the lower region, to the stiff clays of the more elevated Hamilton group of rocks. The wheat region, par excellence, is then entirely left behind, and a dairy country commences. And

d. The still further contrast presented by what in our island would be the heathy hills and moors of the Portage and Chemung groups—destined, like our own poorer hills and highlands, to rear the hardier breeds of stock.

On all these points I have already dwelt probably in sufficient detail.

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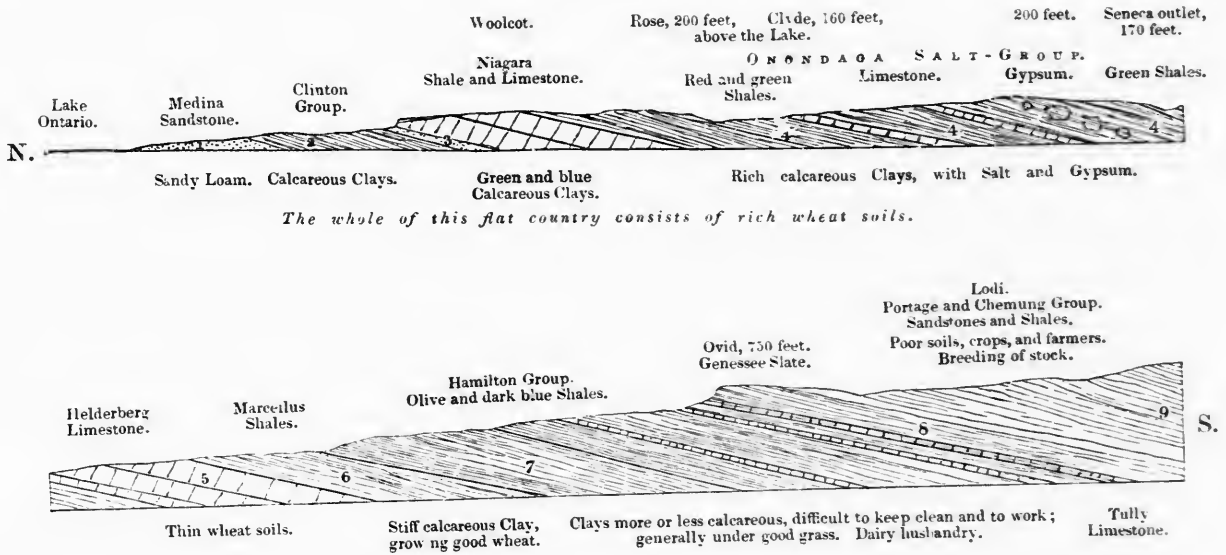
* Ontario itself is 231 feet above tide-level.

No. III.


Woolcot.
Rose, 200 feet, above the Lake.
Clyde, 160 feet,
200 feet.
Seneca outlet, 170 feet.
Niagara Shale and Limestone.
Onondaga Salt-Group.
Red and green Shales.
Limestone.
Gypsum.
Green Shales.
Lake Ontario.
Medina Sandstone.
Clinton Group.
N.
Sandy Loam.
Calcareous Clays.
Green and blue Calcareous Clays.
Rich calcareous Clays, with Salt and Gypsum.
The whole of this flat country consists of rich wheat soils.
Lodi.
Portage and Chemung Group.
Sandstones and Shales.
Poor soils, crops, and farmers.
Breeding of stock.
Ovid, 750 feet.
Genessee Slate.
Hamilton Group.
Olive and dark blue Shales.
Helderberg Limestone.
Marcellus Shales.
S.
Thin wheat soils.
Stiff calcareous Clay, grow ng good wheat.
Clays more or less calcareous, difficult to keep clean and to work; generally under good grass. Dairy husbandry.
Tully Limestone.

There are two additional observations however which I will venture to introduce as likely to interest the general reader. They are both in substance somewhat scientific, yet both entirely practical in their bearing.

First. In speaking of the soils which rest upon the Marcellus shales represented in the above section, I have alluded to the difficulty experienced in keeping them clean, and to their being especially infested with the corn gromwell (Lithospermum arvense), known in North America by the various names of pigeon-weed, red-root, steen-crout, stony-seed, and wheat-thief. In Yates County, in Western New York, a little to the west of the line of section N S, the pigeon-weed is described to be so abundant in some places as almost to have become the lord of the soil. It was unknown there—as it is said to have been in all this lake country, and on the river flats of the St. Lawrence—thirty years ago. It is supposed to have been an importation from Europe, probably in samples of unclean seed-corn from England, France, or Germany. Now "hundreds of bushels of the seed are purchased at the Yates County oil-mill, and, if it were worth 8*s.* instead of 1*s.* 6*d.* a bushel, these hundreds would be thousands."*

My readers will observe in the concluding words of this quotation how one evil leads to another. The purchase of this seed at the oil-mills must be mainly for the purpose of adulteration.† I have examined samples of American linseed cake, in which seeds were to be recognised that I could not name. They might, I then thought, be those of the dodder—a parasite which in this country infests the flax-plant in some localities—but they might also be other cheap seeds purposely mixed with the linseed. To persons who are in the habit of buying the cheaper varieties of American cake this point may not be unworthy of attention; and as oil-cakes are chiefly bought by farmers, some may regard it as a kind of poetical justice, that the idle farmers in one country should be the means of punishing the less discerning of their own class in another.

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* Transactions of the New York State Agricultural Society, 1846, p. 436.

† In the Transactions of the New York State Agricultural Society for 1850, p. 512, I find it stated that this seed yields two or three quarts of oil from a bushel of seed. As a gallon of such oil weighs about 7½ lbs., we may take *four pounds* as the average yield of this seed per bushel. But linseed of 52 lbs. a bushel yields 17 lbs. of oil; and the best rape of 56 lbs. yields 16 lbs. a bushel. Supposing the gromwell seed to be about 50 lbs. weight per bushel, 4 lbs. of oil would barely pay the cost of expressing, were it not for the value of the cake. English crushers reckon that, for an additional shilling in the price of linseed per quarter, about 3 lbs. more of oil should be yielded, so that in their reckoning, 1*s.* 6*d.*, the price of the gromwell seed, would require 4½ lbs. of oil to pay the cost of the seed alone. The value of the cake therefore, as I have said in the text, must be what the Yates County crushers mainly look to.

The physiological history of this Lithospermum teaches us both how necessary a certain amount of physiological knowledge, in reference especially to the plants of his own local flora, is to the practical farmer; and also how unexpectedly the careless farmer may be punished for a neglect of what may be called the very first rule of strong-land farming—that is, of keeping his land clean. On the flat clay lands of Lower Canada, opposite to Montreal, formerly celebrated for their wheat, I found the same weed spoken of as a universal pest, though as in New York State it was said to have been wholly unknown thirty years before. A constant repetition of wheat crops for a long series of years without cleaning had led to this result.

The peculiarities in the character and habit of this weed consist, *first*, in the hard shell with which its seed or nut is covered; *second*, in the time at which it comes up and ripens its seed; *third*, in the superficial way in which its roots spread. The hardness of its covering is such that "neither the gizzard of a fowl nor the stomach of an ox can destroy it." Thus it will be for years in the ground without perishing—ready to sprout when an opportunity of germinating occurs. It grows very little in spring, but it shoots up and ripens in autumn, and its roots spread through the surface soil only, and exhaust the food by which the young wheat should be nourished. A knowledge of these facts teaches us, *first*, that unless care be taken to exclude the seed from the farm, it will remain a troublesome weed for many years, even to the industrious, careful, and intelligent cultivator. It is said to be so prolific as to increase "more than 200 fold annually!" In the *second* place, that spring ploughing will do little good in the way of extirpating it, as at that season it has scarcely begun to grow. United spring and autumn ploughing is "the only reliable remedy." *Thirdly*—that raising wheat year after year allows it to grow and ripen with the wheat, and to seed the ground more thickly every successive crop. It is said that when it has once got into the land two or three successive crops of wheat will give it entire possession of the soil. It is not therefore the immediately exhausting effects of successive corn crops which have alone almost banished the wheat culture from large tracts of land in North America, especially on the river St. Lawrence. The indirect or attendant consequences of this mode of culture—the weeds it fosters, &c.—have had an important influence also.

These observations are not without their value at home. For although with us a continued succession of corn crops is rarely now seen upon any land, yet foul and weedy farms are unhappily still too frequent. And the more one studies the history and habits of the weeds, which almost every district can boast of as

peculiarly attached to itself, the more one becomes satisfied of the value of a familiar acquaintance with them, to the improvement of the art of culture, of the condition of those who practise it, and of the agricultural productiveness of a country. No one will readily accuse me of a desire to undervalue the usefulness of chemistry to agriculture, and yet I have often had occasion to regret the evil influence of opinions hastily expressed by ill-informed persons—as if this branch of knowledge alone were able to bring this most important and difficult of arts to speedy perfection. The longer a cautious and truth-seeking man lives, the wider will appear the range of knowledge, theoretical and practical—the more numerous the circumstances to be taken into consideration—before he can arrive at an accurate solution even of what some look upon as simple and superficial questions.

Second. The second observation I wish to add refers to the extension of the richest wheat-bearing formations of Western New York into the upper part of Canada West. The consequence of this extension is the reproduction in this new region of the great natural capabilities of the country I have been describing.

Bounded on the east by Lake Ontario, on the west by Lake Huron, on the south by Lake Erie, and on the north by Manatoulin Bay, stretches a wide peninsula, occupying an area three or four times as large as the wheat region of Western New York, and covered entirely by those rocky formations on which the fertility of the latter region mainly depends. Proceeding westward from the head of Lake Ontario, we pass in succession over the surface of the Medina sandstone, the Niagara limestone, the Onondaga salt group, and the Helderberg limestone and shales. On these, as the map and sections contained in this paper show, the principal wheat region in Western New York is situated. It will also be recollected that among these the Onondaga salt group is especially conspicuous for the natural fertility and friableness of its soils, and for the ease with which they can be worked and cultivated.

Now in this peninsular portion of Canada West, the Medina sandstone and Niagara limestone expand a little after they turn round the western end of Lake Ontario, and then run towards the north in belts somewhat broader than those which they form in Western New York. But the Onondaga salt group widens to such a degree as in a line due west from Toronto to be upwards of sixty miles across, and to occupy almost the whole breadth of the peninsula between the two lakes, Ontario and Huron. The natural capabilities of this new region, as a whole, may be inferred from what I have already said of the results of experience in the state of New York. So far as depends upon soil, it ought to be one of the richest agricultural regions in North America.

Towards the southern end of the peninsula again, and along the entire northern margin of Lake Erie, of the Lake and River St. Clair, and of Gratiot's Bay, in the southern part of Lake Huron, the Helderberg formation extends. It will be recollected that I have above described this rock, as it occurs in Western New York, to be in some places covered with thin soils productive of wheat; but that over it lie certain calcareous shales (Marcellus shales), which, when not entirely removed from the surface by the action of ancient waters, form a soil equal to almost any other in productive capability. The large portion of this Western Canadian peninsula, over which this Helderberg formation extends, must, therefore, like that occupied by the Onondaga group, contain many tracts of fertile land, and this, as well as its neighbourhood to the lake, is no doubt a cause of the rapidity with which it is in the process of settlement. Indeed, when we consider that nearly the whole of this peninsular region consists either of the Helderberg rocks or of those of the Onondaga group, we cannot help predicting both a rapid filling up and a great future, in many respects, to this most interesting portion of Canada.

Thus from the humbler task of explaining why certain regions have exhibited and still manifest a singular natural fertility, geology advances to the higher gift of prediction. United theory and observation enable it to point out where rich and desirable lands are sure to be found—to inform the statesman as to the true value of regions still wild and neglected—to direct the agricultural emigrant in the choice of new homes—and, looking far into the future, to specify the kind of population and the processes of industry which will hereafter prevail upon it—the comparative comfort, wealth, numbers, and even morality, of its future people.

A third illustration, not less interesting than the two already introduced, I had intended to draw from our own province of New Brunswick, but this I must reserve, with the remainder of my subject, for another article.

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