

**XVI.—Observations on the Geological structure of Cornwall, with a view to trace its connexion with, and influence upon its Agricultural Economy, and to establish a rational system of Improvement by the scientific application of Mineral Manure.**

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**T**HE fabulous and romantic age of geology may be said to have passed away; its disciples, no longer engaged in the support of whimsical theories, direct all their attention to the discovery of facts, and to their application to purposes of extensive utility. The present æra of geology may therefore, with much truth, be compared to that of its kindred pursuit, chemistry, when in the dawn of the sixteenth century it escaped for ever the trammels of alchemy, and assumed the rank and importance of an inductive science. The parallel

may be carried still farther ; for it must be confessed, that the benefits incidentally derived by chemistry from the visionary researches of the alchemists, and those which have been conferred upon the science of geology by the zealous but mistaken pursuits of its earlier disciples, are equally numerous, and alike important ; the happy allusion of Lord Bacon to the fable of *Æsop*, respecting the former, may, with much truth and force, be applied to the latter. “ They are like those husbandmen, who, in searching for a treasure supposed to be hidden in their land, have, by turning úp and pulverizing the soil, rendered it fertile.”

Amongst the number of useful facts which have been thus brought to light, few perhaps, in the science of geology are more striking, none undoubtedly more useful, than those connected with the discovery of a certain regular order in the occurrence and association of the different mineral beds and strata, which form the surface of the globe, and whose disintegration and decomposition have given rise to the loose covering or soil, from which vegetation springs, and by which it is nourished, supported, and perpetuated.

There is certainly no district in the British Empire where the natural relations between the varieties of soil and the subjacent rocks can be more easily discovered and traced, or more effectually investigated, than the county of

Cornwall; and no where can the information, which such an enquiry can afford, be more immediately and successfully applied for the improvement of waste lands, and the general advancement of agricultural science.

As we advance from a primitive to an alluvial district, the relations to which I have alluded, become gradually less distinct and apparent, and are ultimately lost in the confused complication of the soil itself, and in that general obscurity which necessarily envelopes every object in a state of decomposition: we can, therefore, only hope to succeed in such an investigation by a patient and laborious examination of a primitive country, after which we may be enabled to extend our enquiries with advantage through those districts which are more completely covered with soil, and obscured by luxuriant vegetation; as the eye gazing upon a beautiful statue, traces the outline of the limbs, and the swelling contour of its form, through the flowing draperies which invest it.

The construction of a geological map of a county like Cornwall, if viewed only as it regards the subject of this memoir, must be anticipated with considerable interest; and should the labours of this Society terminate with the completion of this great desideratum, it will have to boast that it has presented one of the greatest gifts which agriculture can receive from science. It would not only point out the

connexion between the varieties of soil and the subjacent rocks, but it would explain the local circumstances which might be friendly or hostile to their improvement, and direct the agriculturist to the different mineral substances associated together in their vicinity, and which might contain principles capable of extending their fertility, or of correcting and modifying the causes upon which their poverty or barrenness may depend.

The county of Cornwall may be said to consist of four primary rocks, each of which, by decomposition, gives origin to a peculiar soil, distinct in its nature and characters, and requiring an appropriate system of cultivation and improvement. They all however agree in one essential particular—their earthy combinations are few and simple; the great object of art is therefore to extend and multiply them, and thereby to encrease and diversify their chemical and mechanical agencies. In alluvial districts the very contrary obtains, for nature has already mixed and compounded the different particles of rocks in every proportion and in every manner, and has therefore left but little to be effected by the suggestions of science, or the resources of art.

The principal rocks of which the county of Cornwall consists, are granite, schist, hornblende rocks, and serpentine. Beds of limestone, dykes of porphyry, veins of quartz, and those of other minerals, will also claim a por-

tion of our attention, inasmuch as they effect an influence upon the soils beneath which they occur.

Granite forms the skeleton of the county, upon which all the other formations repose. The soil to which its disintegration gives origin, is provincially termed a *growan soil*; it occupies a very considerable area of the peninsula of Cornwall, constituting no less than three hundred thousand acres, one half of which is unenclosed waste land, affording a scanty pasturage for a miserable breed of sheep and goats; but which, by drainage, and judicious cultivation, might, without doubt, be much improved. The other portion of *growan* land is endowed with various degrees of fertility, and capability of improvement, in different districts, or even in different spots in the same district; a fact which seems to have an intimate connexion with the nature of the granitic substratum, and consequently to admit of elucidation from the enquiries of geology.

That the texture of granite, and the proportion of its component parts, had a considerable influence upon the degree of fertility of the superincumbent soil, I was led to believe by a bare inspection of specimens brought from fertile and barren districts. Mr. Tyacke, of Godolphin, has, at my request, furnished the Society with some striking specimens in confirmation of this fact, and I have had an oppor-

tunity of adding others. Mr. E. Giddy has likewise contributed to the collection in farther illustration of the views which are offered in this memoir. It is hardly necessary to remark, that granite consists of three substances in the state of mechanical admixture, viz. *felspar*, *mica*, and *quartz*, the first and last of which being essentially different in chemical composition, are necessarily so in their agricultural influence. *Felspar* is capable of being, in part, resolved into aluminous earth, and includes, moreover, several elements which have been discovered by experience to be highly congenial to the process of vegetation: quartz, on the contrary, has a powerful tendency to resist disintegration, and even when it is decomposed, it is reduced only into siliceous particles. The nature of felspar varies also very considerably in different kinds of granite; it occurs sometimes in an earthy form, is easily pulverized, and emits, when breathed upon, a strong smell of aluminous earth; at other times it is met with in a hard, compact, and less earthy state, not easily yielding to the action of air and moisture. In some felspar the proportion of its siliceous greatly exceeds that of its aluminous elements, and in others again magnesia forms a constituent part.

The relative proportion of mica appears also to have some influence, and where this ingredient occurs in granite in very considerable

abundance, it is generally indicative of a light and poor soil. I have detected the presence of magnesia in several of such soils, but I should rather attribute their barrenness to the circumstance of a large proportion of mica being frequently associated with a considerable quantity of quartz in the granite of Cornwall. There are, besides, incidental ingredients in granite, which must be taken into account, such, for instance, as iron, whose presence not only disposes the rock to a rapid decomposition, but it may subsequently become a useful element in the soil itself.

It would appear from these views that the value of a *growan soil* will bear a relation to the proportion of felspar in the subjacent granite: it is therefore a circumstance which should be always examined by the scientific agriculturist, who wishes to form a correct estimate of the capabilities of any *growan* district. Upon an investigation of many of the more fertile parts of Cornwall, this fact is very strikingly illustrated; it will be found that in such districts the quantity of felspar in the granite varies from 70 to 90 per cent, and that it possesses also the earthy texture which so greatly accelerates its decomposition; this is one of the mineralogical circumstances which will explain the unusual fertility of the *growan* soils in the parishes of Saint Burian, Seunen, and Saint Leven, and which are let, upon an average, at

the rent of £4 per acre;\* on the other hand, let the geologist, in passing over the dreary and barren moors which occupy the centre of the county, collect specimens of its granite, and they will be found to offer a striking contrast to those of more fruitful districts; many other instances might be mentioned, but the geologist will have no difficulty in multiplying them. The Islands of Scilly are very fertile, a circumstance depending upon the large proportion of felspar and iron, which enters into the composition of the granite, and the consequent rapidity with which its decomposition proceeds. Guernsey consists of *gneiss* abounding in felspar, its soil is accordingly fertile; whereas the granitic parts of Norway are distinguished for the abundance of quartz, and we therefore find that their superincumbent soils are sterile. Von Buch confirms the truth of this report; he observes, in his travels through that country, that "in the fruitful clay-slate the ground yields twelve times the amount of the seed, whereas on the rocky granite soil it hardly repays the diligence and pains bestowed on its cultivation."

\* These soils produce large crops of corn of every kind, of red wheat from 40 to 45 Winchester bushels per acre, of prime barley from 45 to 60, 70, and even 90 have been produced; in these estimates, collected by Mr. Worgan in his agricultural survey, it must be remembered that the Cornish exceeds the statute acre nearly in the ratio of six to five.



In granitic countries, the frequent recurrence of rain is likewise a powerful cause of fertility, and in this respect the climate of Cornwall is certainly highly congenial; there is a popular adage, well known to the members of the Society, that "*the land of Cornwall will bear a shower every week day, and two upon a Sunday.*" This, like most of our popular sayings, is founded in valuable observation and experience, and serves to record an opinion sanctioned by the universal consent of successive generations; the philosophical explanation of the fact is, that the shallowness of the soil, and the large proportion of siliceous matter entering into its composition, together with the nature of its rocky substratum, render a constant supply of moisture indispensable for its fertility. This is one of the numerous instances of intelligence and design which nature displays in connecting the wants and necessities of the different parts of creation, with the power and means of supplying them; thus in primitive countries like Cornwall, the soil necessarily requires moisture, and we perceive that the cause which occasions, at the same time, supplies this want; for the rocks, elevated above the surface, solicit a tribute from every passing cloud, whilst in alluvial and flat districts, where the soil is rich, deep, and retentive of moisture, the clouds float undisturbed over the plains, and the country frequently enjoys that long and uninterrupted series of dry weather, which

is so congenial and necessary to its fertility. Linnæus observes, that the plants which chiefly grow upon the summits of mountains, are rarely found in any other situation, except in marshes, because the clouds, arrested in their progress by such elevations, keep the air in a state of perpetual moisture, somewhat resembling that of the fogs in meadows and marshes; in exemplification of this fact, the locality of *parnassia palustris* immediately suggests itself to our notice.

As a general rule, it may be stated that in order to obtain the greatest fertility, the proportion of siliceous matter in a soil ought to be increased according to the quantity of rain that falls, or rather perhaps to the frequency of its recurrence; for it is evident that one of the principal effects of this element is, to diminish in the soil its capacity for moisture; we accordingly find that in the rainy climate of Turin, the most prolific soil has from 77 to 80 per cent. of siliceous earth, and from 9 to 14 of calcareous, whereas in the neighbourhood of Paris, where there is much less rain, the silex bears only the proportion of from 26 to 50 per cent. in the most fertile parts.

Let the agriculturists of Cornwall, if there be any who regret the frequent recurrence of rain, hail with gladness the golden showers that fill their granaries with corn, and clothe the pastures with perpetual verdure.

“ Not such as wintry storms on mortals shed,  
Oppressing life, but lovely, gentle, kind,  
And full of every hope, and every joy,  
The wish of Nature.”——

To return from this digression, I would observe that the essential character of a *growan soil* may be stated to be a peculiar unsusceptibility to all external agents, and an inaptitude in its internal composition, to those chemical changes with which fertility seems to be connected: I have examined a great number of such soils, and have rarely met with much soluble matter in their composition. These observations, however, apply with different degrees of force to different districts, according to the value of the soil, and to the extent of judicious improvement which it may have undergone. As a rule for the amelioration of a *growan soil*, it may be recommended, as a general principle, to encrease the number of its elements, and consequently to extend their affinities. The Cornish code of agricultural improvement may be very shortly expressed, **MIX, COMBINE, and MULTIPEY MANURES.** In the treatment of a *growan soil*, in particular, the manures cannot be too complicated, and those of an animal and vegetable nature should be always previously mixed with clay, decomposed slate, or other argillaceous substances, with which they may contract an intimate union, and by such means be more securely

preserved in the land to which they are applied.

My friend, John Scobell, Esq. of Nancealverne, who has a considerable estate in the western part of Cornwall, communicated to me a singular practice which the farmers in his neighbourhood pursue with evident advantage, which is that of actually dressing their incorrigible land with the comminuted fragments of decomposing granite. Strange and enigmatical as this may appear to the agriculturist who has not studied the subject of mineral manures, to the mineralogist it is a fact, capable of easy and satisfactory explanation: the *growan*, or decomposed granite, contains, as I have before stated, large quantities of felspar, and therefore of alumina, with small quantities of alkali. I have made several experiments in order to detect the presence of an alkaline element; and, by treating the pulverized substance with sulphuric acid, I have succeeded in producing a crop of alum crystals. Upon the same principle the application of decomposing slate proves a valuable manure for *growan* lands, since it contains alumina in very great quantities, and is therefore capable of imparting to them that tenacity of which siliceous soils are destitute. This intermixture of soils, or of decomposing rocks capable of producing them, where one kind of earth is either redundant or deficient, has been most successfully practised in other counties. Mr. Bakewell, in his

“Introduction to Geology,” observes, that part of Lancashire is situated on the *red sand rock*, which being principally composed of siliceous earth and the oxyd of iron, forms of itself very unproductive land; but that, fortunately, in many situations, it contains detached beds of calcareous marle, by the application of which it is converted into a most fertile soil. Mr. Brande has also observed in the General Remarks upon the Soils of Great Britain, which are appended to his descriptive catalogue of the minerals of the Royal Institution, that experience and science have greatly improved the advantages to be derived from the proximity of different soils to each other; and that there can be no better illustration of the utility of an intimate acquaintance with the relation of the different strata, than the amelioration of the Suffolk sands, which, by the proper application of a substratum of a shelly marle, provincially termed “*crag*,” have been changed from a parched and useless heath to arable and productive land. A most interesting illustration of these views seems to be presented in the extraordinary fact which I have discovered in the county of Cornwall, respecting the increased fertility which characterizes soils that are superincumbent upon the junctions of rocks. The most superficial observer may easily satisfy himself of the truth of this fact; indeed the line of junction between the granite and slate formations, may, in many

parts, be traced by the eye alone through tracts of cultivation, from the remarkable fertility which attends it. It may be defined a *zone of fertility*, since both the *growan* and *slaty* soils become mutually enriched as they approach each other: numerous are the examples which might be adduced in confirmation of this fact; the following, however, as being readily accessible to investigation, are particularly noticed. The most valuable part of the estate of Trengwainton, the seat of Sir Rose Price, lies upon the junction of slate and granite; this line may be traced to Madron church, and from thence round the Mount's Bay, in the direction of which we shall invariably find the superincumbent soil distinguished for its superior fertility. It is probably worth notice, that all the villas around this beautiful bay are placed upon the junction of rocks. Where the *hornblende formation* intrudes itself, the fertility of the land is still farther increased, as may be seen on the valuable estates of Castle Horneck, and Trereiffe, as I shall hereafter have occasion to notice, when I treat of *hornblende* soils. The zone of fertility may be also seen well characterized on the line of junction between granite and slate at Penrhyn, and on that extending from Chyoon on the acclivity of Paul-hill, to Mousehole, in the Mount's Bay; this latter instance attracted the attention of Mr. Worgan, who, in his general view of the agriculture of Cornwall,

notices this district as one highly fertile, and as being famous for producing two crops of potatoes in one year. On Saint Michael's Mount the geologist will also discover an example of the fertilizing influence which the junction of slate and granite exerts upon the superincumbent soil; the beautiful carpet of herbage covering the south-eastern base of this singular spot, is a feature which instantly strikes the attention of the stranger. To these examples I may add another, which I have very lately discovered: I was requested by my friend Mr. Pendarves, to examine whether any geological arrangements could explain the cause of a particular line in his estate of Pendarves, being more fertile than the neighbouring lands; upon tracing the direction of the granite and slate formations, we soon discovered that this line of superior fertility, was superincumbent upon the junction of these rocks. In making a tour through the county of Cornwall, you will frequently hear the farmer speaking of a vein of rich land; I have generally found upon enquiry, that this is no other than the *zone of fertility* superincumbent on a junction. During the summer of 1816, I made a geological excursion around the peninsula of the Lizard, and farther opportunities were thus afforded me of confirming my opinions upon many points connected with the objects of this memoir, and of collecting illustrations from a district highly interesting,

and, but little explored. In proceeding from the church of Constantine\* to Mawnan, I was fortunately accompanied by a very intelligent farmer of that district, who informed me that in the former parish the *killas* and *growan* lands as they came together were much improved in quality, and that they were mutually increased as much as one third in value; he also stated that the crops upon this "rich vein" were much earlier. Some time since I mentioned these results of my enquiry to Mr. Whidby, the ingenious and scientific director of the "Breakwater" in Plymouth Sound, and he informed me that the same encrease of fertility, as far at least as he had noticed, was certainly evident upon the different junctions in the neighbourhood of Plymouth. I have not had any opportunities of extending the enquiry into other counties, but I should hope that the publication of these short and imperfect notices may awaken the attention of more able and diligent geologists, and that a mass of facts may be ultimately collected which will lead to a full and satisfactory explanation of this interesting phenomenon; at present, I confess I feel much difficulty in accomplishing it. That

\* This spot deserves the attention of the geologist, for in a quarry may be seen the best, and, perhaps, the only well defined *gneiss*, in the county of Cornwall; it was pointed out to me by a zealous member of our Society, the Rev. John Rogers, of Mawnan.



the intermixture of the decomposed parts of these different rocks, is one grand cause to which we are to look for explanation I am willing to admit, but I cannot help suspecting that future enquiries will also discover that there are other equally important causes involved in the explanation; bold as the conjecture may appear, it is by no means unphilosophical to suppose that some galvanic influence may exert a powerful agency, perhaps by accelerating decompositions, and promoting in the elements of the superincumbent soils those various changes which are essential to luxuriant vegetation.

In alluding to the silent, secret, and corrosive agency of the galvanic influence, I cannot resist the opportunity of directing the attention of the Society to an interesting illustration of its effects, which has been lately afforded by the rapid, and for awhile inexplicable, decay of the flood gates in the port of Hayle, a circumstance which has been discovered to depend entirely upon the contact of iron and copper bolts and braces, introduced into the different parts of the frame work.

SLATY SOILS, or those produced by the decomposition of *slate* or *schistus*, are, generally speaking, much more productive than the *growan* soils which I have described, although, like the latter, they vary considerably in their degree of fertility; a fact which depends upon a number of circumstances, amongst which may

be noticed, the inclination, or dip of the strata.—the chemical composition of the rock—the number and size of the quartzose veins that intersect it, &c. Where the schistose strata have a considerable underlie, the superincumbent soils are usually light, hungry, and ungrateful; the soluble ingredients are washed away, and the manure which is applied, passes off through the fissures of the strata, and consequently produces only a transient benefit to the land. That the composition and texture of the slate rock exerts also an influence upon the fertility of the superincumbent soil, is a fact equally evident; where, for instance, its fracture is siliceous, and its texture resists disintegration, we may be generally led to the inference, that such a district is inferior in fertility. I have seen well marked examples of the relative value of slaty soils depending upon such a circumstance; for instance, on the north-eastern side of Godolphin Hill, the schistose soil exceeds in value at least one-third that upon the northern side; upon examining the slaty substratum, it will appear that the former is friable, and almost earthy, whereas the latter is siliceous and brittle. I have generally observed, that where the slate has a disposition to shiver into thin laminæ, the superincumbent soil is poor. The improvement of such districts is to be effected by the application of the same principles as those

recommended for the amelioration of *growan* lands.

The next soil which presents itself to our notice, is that superincumbent upon the varieties of hornblende rocks; these, of course, vary as much as the nature of the rock which produces them; they all, however, exhibit the same characteristic peculiarities. I shall, therefore, for the sake of perspicuity, comprehend them under the general name of *hornblende soil*.

All the varieties of this soil are more complicated in their composition than those which have been already described, and they universally constitute the richest and most fertile parts of the county; if, upon taking an estate, the farmer discovers any blocks of this rock, which is known by the provincial name of *dun* or *iron-stone*, he may congratulate himself upon the circumstance, for it is generally an omen of the land's fertility, or, at least, of its capability of improvement. Notwithstanding the density and hardness of this rock, it decomposes most rapidly, apparently in consequence of the disposition which its ferruginous elements possess, to combine with oxygen; this fact is seen in the ochreous appearance of the different faces of the stone, and which has bestowed upon it the popular name of *iron-stone*: experience has also at length taught the inhabitants a fact which theory could easily have anticipated, that this stone, notwithstanding its hardness, is

by no means a durable material for the repair of public roads. The colour of this soil has a reddish hue from the presence of iron ; it contains in its composition a considerable portion of aluminous earth, and more vegetable matter than in the other soils ; this depends upon a greater disposition in the earthy elements to combine with it ; I have also found many saline compounds ; indeed, it would seem that the internal changes which take place in these soils, are more numerous and rapid than in the others before mentioned : the iron, no doubt, contributes essentially to these changes. I have already in my paper upon the "Recent Sandstone of Cornwall," alluded to the important agencies of this mineral body, and the present enquiry is capable of affording a farther illustration of its extensive influence in the œconomy of the earth's surface ; amongst the saline bodies which abound in hornblende soils, is *sulphate of lime*, probably the result of a play of affinities between the calcareous sand with which it is manured, and the salts of iron which are derived from the decomposition of the *pyrites* with which hornblende rocks so universally abound. *Nitrate of potass* is also a salt, which very frequently occurs in abundance ; in the fertile lands at Alverton, near Penzance, it may, in dry weather, be collected in great quantities, in a state of efflorescence ; how far the presence of this substance influences the fertility of the soil, I am not

prepared to say, but Dr. Clarke has an observation in his travels in Russia, which is well worthy of notice. "The earth is strongly impregnated with nitrate of potass in all the environs of Woronetz, and it is to the presence of this mineral that the extraordinary fertility of the Ukraine has been attributed. The whole country, south of Tula, abounds with it; insomuch that it sometimes effloresces on the soil, and several fabrics for extracting it have been established."

There is no part of the county where the superior fertility of hornblende soils may not be witnessed: in the Mount's Bay, the fact is most striking. The shores of this beautiful bay, in the vicinity of Penzance, consist principally of hornblende rock and slate, and their fertility is not exceeded in any part of the kingdom; a belt of land around this town, consisting of one thousand acres, produces a rent of £10,000 per annum! All hornblende soils, however, are not equally fertile, as I have before stated, a fact which depends upon the structure of the rock, and seems to offer another point of analogy between hornblende rocks and basalt, and lava. M. Cordier\* has lately examined this last substance, with a view to explain why some currents of lava remain always sterile, while others are speedily covered

\* In a memoir read before the Royal Institute of France on the origin of basalt and wacke rocks.

with the finest vegetation ; and he found that this difference depended upon the degree of vitrification which the lava had undergone.

Where the hornblende rock has a considerable proportion of felspar in its composition, its fertilizing influence is further increased, as is seen in the sienitic formation of St. Keverne. The lands between the church of this parish and Coverac Cove, constitute one of the most extraordinary districts in the kingdom, presenting a rare combination of rudeness and fertility ; gigantic boulders, and fragments of sienite, lie scattered in all directions, and yet, in point of luxuriant fruitfulness, this country may be denominated the Garden of Cornwall.

Decomposed sienite, as may be seen in the vicinity of Menacchan, especially in passing from this village to Tregonwell Mill, is extensively applied as a manure to slate lands in that district, and, as I understood, with evident advantage. In the parish of Mullyan, a decomposing greenstone is very extensively applied as a manure.

The last soil which I have to mention is that superincumbent upon serpentine ; this, in comparison with the foregoing ones, is limited in extent, occurring only in the peninsula of the Lizard, and in a circumscribed spot near Liskeard. If we consider the "*Lizard peninsula*" to consist of the lands south of a line drawn from the Helford Harbour to the Loe Bar, it will be found that the serpentine soil

will just occupy one-third of its area. This soil, although inferior in fertility to that of many districts in Cornwall, is by no means so sterile as we should have expected from the abundance of magnesian earth in its composition. In France we have an example of a large chalk district rendered barren by the presence of magnesian earth.\* No opportunity has been afforded me of examining in detail the peculiar characters and relations of serpentine soil; I hope that some other member of the Society will prosecute the enquiry. To the botanist this district is well known as the habitat of the *erica vagans*. This elegant heath seems to find a magnesian soil not only congenial, but essential to its existence, for notwithstanding its profusion on Goonhilly Downs, not a single specimen is to be found beyond the line which defines the boundary of the serpentine formation. The botanist will be glad to learn that I have gathered it in the vicinity of Clickertorr, near Liskeard, where the serpentine formation again betrays itself, accompanied with an evident deterioration of soil in its immediate vicinity.

When it is considered how constantly the rocks of Cornwall are intersected by metallic and other veins, carrying every species of mineral matter, it cannot be deemed extraordinary, if we occasionally find some rare salts in

\* Trans. Geol. Society of London. vol. ii. p. 175.

its soils. The Rev. William Gregor found in a schistose soil near Creed, and also in the vicinity of Helston, several uncommon substances, amongst which was a *muriate of manganese*. In the vicinity of Redruth I detected a considerable proportion of *sulphate of iron*; the soil which contained it had not been manured, as I was informed, by *calcareous sand*, or it might probably have been converted into *gypsum*. Veins of iron appear to improve the country through which they pass. I have seen an example of this fact in the parish of St. Mewan.

In the view which has been just taken of the geological structure of Cornwall, in reference to its agricultural economy, it would appear that the fertility is much greater than that which usually occurs in a country composed of primitive rocks. This peculiarity, however, is not greater than that which distinguishes its geological character; granitic countries usually present a bold and varied outline, whereas the aspect of Cornwall is tame and uniform. "I went into Cornwall," said a geologist of well known celebrity, "to see an example of a primitive country, but instead of an example, I found an exception."

The same observation would apply to the agricultural character of the county. In general, primitive formations disintegrate into rugged piles, whose acclivities are too steep to allow any accumulation of soil, and conse-



quently they but rarely constitute the fertile parts of the globe. As far as the imperfect state of our knowledge will allow us to generalize, it would appear that PRIMITIVE rocks are accumulated towards the poles, and that the great mass of SECONDARY formations is found to occupy the middle and southern latitudes, which constitute a portion of the globe eminently calculated for the abode of man, and of the animals which are subservient to his wants, or indispensable to his comfort. This observation, however, must be regarded only as a loose and vague conjecture; nor should I have introduced it into this memoir, had it not coincided with the result of the extensive and laborious researches of a celebrated geologist, who has traversed the continents of Europe and America, with the view of examining their geological structure and relations; I need not state that I allude to Mr. Maclure, of Philadelphia, a name well known to our Society from the splendid map of the United States of America, and the suite of specimens illustrative of their geology, which have been lately presented by that gentleman.

By an arrangement of rocks similar to that which I have stated, nature is continually heaping, in the middle and southern latitudes, the matter consolidated by the action of animal and vegetable life, and might, therefore, as Mr. Maclure ingeniously observed, tend to augment the diameter of the globe in those places, and

of course to give the appearance of flatness to the poles.

I shall conclude these notes on the soils of Cornwall, with a few observations upon the different kinds of mineral manure which are applied for their cultivation and improvement.

SEA SAND is very generally used for this purpose, but as this substance is various in its composition, it is obvious that its operation must be very different in different parts of the country; its mechanical action, however, in dividing the particles of the soil, applies equally to every kind; it moreover may be said generally to impart a small quantity of sea salt to the soil.

CALCAREOUS SAND, consisting of comminuted shells, is the species more generally employed; and the quantity which is every season carried away from different parts of the coast for the purpose of manure, almost exceeds belief. From Bude, in the parish of Stratton, it has been ascertained that in one day as many as four thousand horse loads have been taken; and from the harbour of Padstow, it has been computed, that fifty-four thousand cart loads are annually carried. The expense of land carriage for sand, used in the county, has been considered as amounting, at least, to thirty thousand pounds annually.

With respect to the composition of "shelly sand," it will be found to vary with the state of the tide, and the direction of the wind,

circumstances which the farmer ought always to notice; for when the wind is blowing off land, the lighter particles of the sand are thrown upon the beach, and it is more calcareous in its composition. On examining samples of the sand usually employed, I have found it generally to contain from 60 to 64 per cent. of carbonate of lime. That its beneficial operation depends upon the presence of calcareous matter there cannot be any doubt, but at the same time, we are borne out by unequivocal facts in believing, that the sea salt, with which it is impregnated, contributes materially to its fertilizing powers. This opinion I have lately stated before a Committee of the House of Commons, appointed to enquire into the laws respecting the Salt Duties, and I am anxious to record such an opinion in this memoir. Amongst the facts to which I allude, as bearing strong testimony to the truth of this opinion, is the striking circumstance of the farmers sending several miles to the harbour of Padstow for the very sand which is drifted to their lands, and might, therefore, be obtained with little trouble, and no expense.

The calcareous matter of the sand would seem to undergo different changes, and to be disposed of more or less readily, in the different kinds of soils to which it is applied; its conversion into *gypsum*, or sulphate of lime, as I have already mentioned, appears occasionally to take place. In *growan* soils it undergoes the

least change. I examined several of these soils, that had not received a sanding for a considerable length of time, and I found them to contain about five per cent. of carbonate of lime, two-thirds of which were in the form of an impalpable powder, and the remaining one-third in that of fine sand. A series of comparative experiments made with different soils, would furnish interesting and important results. On the supposition that the action of this sand was purely chemical, our worthy President suggested the probability of gaining some advantage by previously grinding it so as to reduce it to an impalpable powder. Mr. Bucestow, an intelligent farmer, accordingly made the experiment, and he states that the result was favourable; no conclusion however can be drawn from one experiment; numerous and repeated trials are necessary to establish the utility of any practice, in an art so obscure as that of applying with success the different species of mineral manure.

How far the presence of gypsum in any of the soils of Cornwall may contribute to their fertility, is a subject well worthy of farther investigation. I have already shewn that it might be easily produced by the admixture of calcareous sand and decomposing pyrites: examples in which the elements of these bodies, when presented to each other under circumstances favourable to chemical action, enter into new combinations, and produce gypsum,

are familiar, and I have already dwelt upon the subject in a former paper. I might now remind the mineralogist of many more instances, amongst which are the well known specimens of oyster shells studded with crystals of selenite from Shotover, evidently produced by the action of sulphate of iron upon their calcareous elements. The same theory will also explain the generation of alum, from *aluminous shale*, at the Hurlet Mine, near Glasgow.

The use of gypsum as a manure has been questioned by several intelligent farmers: various testimonies however in favour of its efficacy, have been presented to the Board of Agriculture by Mr. Smith; it must, nevertheless, be admitted, that in this kingdom it has never been employed with the signal success which marked its adoption in America, and which was so palpable and extraordinary, as to have at once ensured its universal introduction. Whenever any doubt or hesitation betrayed itself with respect to the extent of its fertilizing agency, it was only necessary to sprinkle a small quantity on a meadow, in order to produce entire conviction, and this was usually done in the form of letters, or characters, which in a few days became so much more luxuriant than the surrounding grass, as to be visible at a considerable distance: it is, I understand from Mr. Maclure, chiefly applied to grass lands as a *top dressing*, in the propor-

tion of one bushel, weighing 70 lbs. to an acre, and the Americans explain its operation by supposing it to depend upon its solubility in water, and its consequent absorption by the roots of the grass; they have accordingly found that by burning it, and thereby diminishing its solubility in water, fifty or sixty bushels are not so efficient as one, before it undergoes that operation.

When this substance was first introduced into America, which was about twenty-five years ago, it was imported from the quarries of Montmartre, and in such request was it, that a bushel of wheat was usually given for the same measure of gypsum; it is now obtained from Nova Scotia, not having been hitherto found within the States; and it may perhaps serve to convey some idea of the extent to which it is applied, when I state that Mr. Maclure assured me that not less than three hundred vessels are constantly employed in the traffic, and that in Philadelphia twenty merchants at least are solely engaged in supplying the demand for it. Its efficacy appears to be considerably increased by applying it in a minute state of division, and a want of attention to this circumstance may possibly have rendered its advantages less conspicuous in England. In America three or four hundred mills, of a peculiar construction, have been erected in different parts, with which it is ground to an impalpable powder. It appears,

however, never to answer so well within fifteen or twenty miles of the sea, nor in wet lands; this, perhaps, may have been another source of disappointment. We may infer, therefore, that the value of the application may vary with the character of the soil, especially as it regards its power of absorbing and retaining moisture; many valuable hints upon this point are to be found in Sir H. Davy's masterly system of agricultural chemistry.

It is undoubtedly necessary, before we can hope to apply any mineral manure with advantage, to understand the nature of its operation; I trust, therefore, that I may be excused for hazarding the following theory in explanation of the *modus operandi* of sulphate of lime. The solubility of this substance in water affords a great facility to its introduction into the circulating fluids of a plant, and hence whatever diminishes this property diminishes also its fertilizing powers; it is thus, therefore, enabled to penetrate and pervade the whole vegetable organization, and to enter into combination with its woody fibre, by which the density of its texture will be increased, and consequently the vascularity of the plant, and the evaporation from its leaves, in the same ratio, diminished: from these views it would appear that gypsum does not act by effecting any chemical change in the soil, but solely by diminishing the plant's evaporation; this idea seems to be fully borne out by the evidence

which is furnished by the different circumstances attending the operation of this manure: we find, for example, that succulent vegetables, planted on dry soils, are those which are principally benefited by its application, and that the various grasses so manured, retain their verdure in the driest season, and on the most arid lands; and at the same time we find that these crops, especially clover, acquire a proportionate encrease in the density of their fibres, that is to say, they become much more rank and stubborn, and often to such a degree, that in America, where its effects are best known, sheep frequently refuse feeding upon the stalks: by analysis, gypsum would most probably be discovered in their composition, but I have had no opportunity of submitting them to experiment. Upon the same principle we find that under circumstances, or in situations, where the evaporation from a plant is provided for by a constant supply of moisture, that such a check to it becomes unnecessary, and therefore that the effects of gypsum cease to be apparent.

It remains for me to conclude these notes upon the soils of Cornwall with an apology for their numberless imperfections, and for the abrupt and unsatisfactory way in which I have dismissed many of the more important points of the enquiry. The truth is, that with this memoir I abandon the study of geology. The pursuit of the science commenced with my



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residence in this interesting county, and it must terminate with it. I part with it, however, with the reluctance of an old friend, who has furnished me with much delight and amusement, during the exercise of a laborious and anxious profession. That I may not be seduced from my present resolution, although I have not, like Bishop Watson, in imitation of the idolaters of old, *burned my books*, yet I have taken a no less effectual step to wean myself from the pursuit—I have given away my mineralogical specimens.