

have arisen and been rendered auriferous solely from their proximity to invisible or now superficial granites.¹

(2). The newer, or Dioritic, outburst I have called Post-oolitic as the veins containing gold, and which proceed from its centres, cut through strata containing fossils of decided Post-oolitic forms, and possibly may be as late as early Cretaceous. These strata are frequently much altered and metamorphosed by the contact of the igneous Diorite, and, at such points, often become auriferous, or are cut by auriferous veins proceeding from the Diorite head mass. Although the results of an extended examination of these deposits in Chile, Bolivia, and Peru, occupying me from 1857 to 1863, are extremely interesting, I have only had time to publish comparatively few of the observations made. Since my return to Europe, however, I have been able to collect sufficient data to show me that this occurrence of gold is not at all confined to South America, as I had at first imagined, but appears also to be common to all the other quarters of the world. I have seen auriferous Diorites from Italy, and some auriferous rocks of this class are known to occur in the Ural; and, as before-mentioned, I have specimens from California, and I some time back received very similar specimens, through Lieutenant Aytoun, from the gold districts of India; and, lastly, within a few days, I have had the opportunity of examining a fine series sent over to the Jermyn Street Museum by Mr. Aveline, the head of the Geological Survey in Victoria, which are all strikingly similar to those examined by myself in various parts of South America.

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II.—RESULTS OF OBSERVATIONS ON THE CLIFFS, GORGES, AND VALLEYS OF WALES.

By D. MACKINTOSH, F.G.S.

[PLATE XV.]

THIS article will be devoted to the consideration of the indications of marine and fluviatile denudation furnished by the cliffs, gorges, valleys, and other phenomena, of some parts of Central and North Wales. With the view of collecting facts, the author, during April and May of the present year, resided successively at Bwlth, Rhayader, Aberystwyth, Dolgelley, Newtown, and Llangollen, so as to have opportunities for repeated observations; and the following notes refer chiefly to the neighbourhood of these towns and the intervening districts.

Abereddw Cliffs.—On entering the narrow part of the valley of the Wye beyond Three Cocks Junction, I began to be struck with the dim outlines of terraces at a considerable elevation above the river, until the romantic tiers of cliffs near Abereddw suddenly came into sight. They are the culminating point of what, in their absence,

¹ See Forbes on Peru and Bolivia, *Quart. Journ. Geol. Soc.*, vol. xvii.

might be regarded as unsatisfactory indications of raised coast-lines, situated chiefly, though not exclusively, on the east or Radnorshire side of the Wye. Whatever amount of erosion the river may possibly have accomplished in pre-glacial times, these cliffs, and sub-jacent drifts, render it certain that it has not flowed above the level of its gravel banks since the occupation of the valley by the sea. But before proceeding to describe the cliffs in detail, it may be well to try to dispose of an apparent objection to the idea of their being in reality old sea-margins. Generally speaking (not always) the platforms coincide in inclination with the outcrop of the strata which here mainly dip at a small angle to the N.N.W., or *contrary* to the fall of the river-channel. This fact (which, coupled with others, furnishes a strong presumption that neither the river nor a valley glacier could have had any share in the formation of the cliffs) can, I think, be sufficiently explained by the very probable supposition that the original correspondence between the horizontality of the outcrop of the strata and the sea-level may have been the reason why here and elsewhere such a succession of regular terraces should have been formed, while, under less favourable conditions, the sea failed to carve out very distinct coast-lines. But if these rocks can be shown to be sea-cliffs by a strict application of that analogical induction on which the whole superstructure of geology as a science is founded, then such seeming difficulties as the above may be left out of consideration.

The Abereddw cliffs consist of Ludlow rocks of varying compactness, the hardest often forming their base. They run along the side of the valley for at least half-a-mile. There are four principal lines of cliff, with several subordinate ones, the latter apparently worn back at intervals so as to merge into the principal. At their northern termination they are separated from a single lofty cliff by a dry inlet, the sides of which present cliffs of the same form as those fronting the valley. The existence of this inlet, the floor of which rises up obliquely to the planes of stratification, is, at the very outset, a fatal objection to the theory that the cliffs have been formed by the atmosphere, and it is equally inexplicable by river-action. On the north-side of this inlet there are several pillars which present a smoothed outline very distinct from any shape communicated to the rocks by weathering (see Plate XV. Fig. 2). Beyond the upper termination of this inlet the left-hand line of cliff is continued, and here and there its base exhibits small caves, beautifully smoothed and rounded in a way that streams of fresh water (supposing them ever to have been here) could never have accomplished. At the base of the lowest main line of cliff, and at perhaps fifty feet above the railway, there are several caves with arched entrances. In one cave two lateral openings communicate with the main entrance; and on one side of the latter a pier only a few inches in diameter supports the superincumbent fabric. The interior of this cave is here and there rounded and smoothed in a way as much resembling modern marine architecture as a ripple-marked slab of sandstone is like ripple-marked sand on the sea-coast. If the first is not the work of the sea, neither is the

latter. Further to the north there are several detached or nearly detached square pillars of rock, one of which is represented in Plate XV. Fig. 1. At this spot the rocks show no sign of weathering; but in most places weathering has proceeded to a very considerable extent. Its effect, however, is to *ruin the cliffs*, and most assuredly not to *form* them. It is precisely undoing what the sea has accomplished. The line of demarcation between the rough, splintered faces of rock invaded by weathering, and the smoothed and sculptured faces left by the sea, and preserved in sheltered situations, is often clearly defined. On the broad level platforms at the bases of the lines of cliff there are here and there a few very large blocks which could no more have fallen from the cliffs than from the moon. One of these blocks, between twelve and fifteen feet long, rests on the outer edge of a wide platform, and might easily be mistaken for a *bloc perché*. It appears, however, to be simply an unscathed mass of mudstone, nearly *in situ*, excepting that on one side the enlargement of a joint has allowed it to slip down (See Plate XV. Fig. 3).

The Abereddw cliffs vary in height from a few feet to twenty. The platforms vary in breadth from a few yards to 150, and are generally covered with silt or loam. The third platform, reckoning upwards, inclines 3° transversely and 5° longitudinally. In several places a line of cliffs turns round at nearly right angles, similar to what may be observed on modern sea-coasts, and beyond the abrupt corners the rocks are frequently the most smoothed and rounded. No agent *passing by* could possibly have given rise to such phenomena. But they are precisely such as the face-to-face action of the sea produces on lines of cliff, irrespective of their direction. The mossy covering on the above smooth and unweathered faces of rock is often quite one-eighth of an inch thick.

Marks left by the Sea.—The most convincing marks left by the sea on many parts of these cliffs consist of smooth curvilinear grooves, and finely-graduated shallow pits, which have been formed independently of any peculiarity of structure in the rock. The most perfect fac-similes of the grooves may be seen on the sea-coast at Aberystwyth. The pits are likewise there represented, but not so much on the vertical faces of the cliffs as on the rocks lying under high water. Both are apparently the result of the motion of small stones wielded by the waves as instruments of abrasion (See Plate XV. Figs. 4, 5, the first representing pits and the second grooves on the Abereddw cliffs).

Between the Abereddw cliffs and Builth a large terrace extends for some distance along the eastern side of the valley at a considerable height above the river, and, farther on, the remains of successive terraces may now and then be traced. At Builth the comparatively narrow gorge, through which the Wye has hitherto flowed, opens into an irregular basin, fringed with cwms, which merges into the great plain of Central Wales.

Valleys excavated by Streams.—On travelling along the above plain towards Newbridge Station, I was finally led to admit what I had previously suspected, namely, the probability of streams having mainly excavated the uniformly-continuous V-shaped valleys that

furrow the south-eastern side of the hilly desert of Central Wales, which at one time must have been a comparatively level table-land. To assert, however, that the same agency could have levelled down the plain would be to attribute to rivers a power of performing the most contradictory feats. To be consistent, subaërialists must admit that there is a tendency in brooks and rivers to *persist* in the channels they have selected, and to wear these channels *downward* as long as there is a sufficient inclination to give excavating power. A river when it enters a plain may wander over its surface to any extent; but a plain even approximately level, or a wide smooth valley or basin, must be the result of a wide-spread denuding action. That the sea, under certain conditions, planes down the land all must admit; but it is likewise, under other conditions, capable of producing inequalities. Rivers (apart from deposition during floods) can only produce the latter.

The Great Denudation Puzzle.—One of the best districts for studying denudation in South Britain may be found between Newbridge and Marteg Bridge. On following the course of the Wye from Newbridge northwards, you pass through a narrow gorge, and soon find yourself in the open valley of Doldowld. You see on your left a transverse gorge running into the bosom of the hills and suddenly terminated by a cliff. You can scarcely resist the idea that this is an old inlet of the sea scooped out backwards, and not excavated by any descending stream. Still following the Wye, you again pass through a narrow gorge, and suddenly arrive in the irregular plain of Rhayader. Within the space traversed you have had a sufficient example of what may be called the Great Denudation Puzzle—the problem to be grappled with before any real progress can be made in determining the relative claims of the sea and rivers, namely, the *cause* of the narrow gorges which connect comparatively wide and level areas—gorges which cut through ridges, escarpments, and sometimes table-lands. Two theories have been advanced by the subaërial school of geologists to account for these gorges.

Professor Ramsay's Theory.—The following explanation is given by that formerly able advocate of marine denudation, Professor Ramsay:—"It is a trick that rivers have; they will cut through escarpments in what seems an unnatural fashion" (*Physical Geology of Great Britain*, p. 145).¹ But the very *abrupt commencement* of the gorges under consideration would seem to be inconsistent with the idea of their having been worn through by any *obliquely-directed* aqueous action, or an action which must have had a vent along the base of the escarpment while the cutting-through process was going on.²

Professor Jukes' Theory.—Professor Jukes has lately advocated the

¹ Professor Ramsay says of the estuary of the Humber (*op. cit.* p. 147), "*The sea effected a breach in the rocks. Then suppose these lands to have been heaved up, . . . the river then ran through it.*" Prof. Ramsay says *much more* in proof that he *does not deny* the efficacy of marine denudation, but we have not space to quote it here.—EDIT.

² Many of the gorges are so narrow that a river could not have found room to bend round and return during the progress of the supposed excavation.

theory that a narrow connecting gorge is the expression of an original river-channel, as its waters flowed transversely off a table land, and that the longitudinal vales or plains were worn down by the river and its tributary streams in easily denuded rocks during the time that the river alone was gnawing out a narrow passage or outlet in a zone of tough rocks which eventually become a ridge or strip of elevated ground. It is admitted that this explanation will only hold good where the rocks of the wide depression are of a kind more easily eroded than those composing the ridge: that is, supposing a gorge one-sixth of a mile in width, and a vale three miles in width, the materials of the vale must have been eighteen times more easily washed away than those in which the gorge was excavated. I do not think that the assumed correspondence between the atmospheric denudability of the rocks of the respective areas has been proved as regards many if not most of the districts where the denudation puzzle is exhibited. It would require an extensive series of observations and experiments to determine which rocks most readily give way to atmospheric, fluvial, and oceanic action. Rivers affect rocks, as regards their relative composition and structure, much in the same way as oceanic currents, though they do not give rise to precisely the same form of effects. The atmosphere, apart from running water charged with abrading matter, as I have already shown, accomplishes its task chiefly by chipping or splintering, which, strictly speaking, does not come under the denomination of denudation until the fragments are carried away by streams. Mere rain has so little influence on hard rocks that, in considerations of this kind, it may be left out of the question.¹

¹ This I have endeavoured to prove as regards millstone grit and other rocks (see article on Brimham Rocks—*GEOL. MAG.* April, 1865). But I think it can be shown that limestone is more or less exempt from any process of dissolution caused by the atmosphere apart from the grinding action of streams. Many limestone cliffs would appear to be both rain-proof and air-proof, as they still retain the smooth grooves and undercuts imprinted on them by the sea. These marks may be distinctly traced on those parts of the Eglwyseg rocks, in Denbighshire, which are not undergoing fragmentary dilapidation. The most striking proofs, however, of the resistance offered by Carboniferous Limestone to mere rain may be seen on a table land to the north-west of Minera, and about eight miles from Llangollen. A number of nearly square flags of limestone, separated by a very regular system of joints, lie flat on the surface. From a distance they look like a vast assemblage of grave-stones. Here and there whole flags or ranges of flags have been carried bodily away, without leaving the slightest trace of their existence, and that, most assuredly, by no kind of atmospheric action. Nearly every remaining stone presents a series of peculiar marks, consisting of smooth, semicircular grooves, from an inch to eight or nine inches in depth. These grooves are generally straight, but sometimes winding, and generally, though not always, roughly parallel; they often turn round at nearly right angles, and run into each other or vanish at the border of the flag. They sometimes terminate in circular perforations. No one would say that glaciers could have formed such a number of deep and complicated grooves. Rain is out of the question, its effect being evidently, as one may see on the spot, to roughen, and that to no very great extent, the smooth curvilinear outlines of the grooves. There is no appearance of any former river-channel, and rivers, had they been here, could not have given rise to such indentations. There is only one explanation left, and it may be seen exemplified on the sea-coast of Wales—(I have seen this at Aberystwyth)—namely, the backward and forward motion of pebbles driven by the advancing and receding waves of the sea. Similar wave-worn flags may be seen farther to the south, and I have no doubt in other localities. Their position must be at least 1000 feet above the present level of the sea.

Gorges and Open Areas not simultaneously Denuded.—The more the forms of the hollows of Central Wales become imprinted on the memory, the more one is led to the conclusion that the longitudinal vales and transverse gorges were not excavated at the same time. The vales and surrounding slopes, with the exception of occasional rocky projections and cliffs, are either level, gently undulating, or smooth and continuous in their outline. The gorges commence most unexpectedly on the sloping side of a ridge, and run right through, with steep, rough, and bare rocky cliffs. (See Plate XV. Fig. 6, which represents the commencement of a gorge to the south of Rhayader.) That rivers often flow through them, and not longitudinally along the open country, does not necessarily imply that they were excavated by rivers. These gorges would naturally become deeper and more cleared of gravel than the open area, supposing them to have been formed along the course of a previous slight depression, by a swift oceanic current, as the land was rising; and rivers would afterwards find their way more easily through them than along the adjacent drift-encumbered vales.¹ I can at present see no theory so little beset with objections as that which would regard these gorges as deep sea-straits formed after the general outline was given to the neighbouring country; and this view is confirmed by the fact, that on the sides of some of these gorges the rocks appear to be sea-worn rather than river-worn. It is likewise favoured by the fact that river-drifts, or traces of river-drifts, suddenly terminate at a small elevation above the present river channel, as may be observed in the neighbourhood of Rhayader.² With regard to the excavation of the plain on which Rhayader stands, there are proofs of sea-action on the rocks beneath the drift deposits, consisting of grooves, hollows, and smoothed projections, which are distinct in form from those now observable in the bed of the neighbouring river,³ and equally distinct from ice marks.

Cwms and Deep Basins near Rhayader.—In the neighbourhood of Rhayader there are phenomena adjacent to, or associated with, the above gorges, which show that the power to which the gorges owe their present form, was sufficient to effect the greater part of their excavation. I allude to the cwms and deep rocky basins, which no river-action or glacial-action will explain. Towards the left of the area represented by Plate XV. Fig. 7, there is a shallow valley descending from the table-land, which, in all probability, was at one time uniformly continuous with the valley in the foreground. Superimposed on this valley, and apparently formed at a later period, there is a remarkable cwm, with Gwyn-llyn⁴ at its bottom, which must have been scooped out by an agent assailing the land backwards. This cwm is identical in form with many hollows on

¹ It is a remarkable fact, that narrow gorges are generally very free from accumulations of drift.

² The best example of this may be seen about two miles to the north of Rhayader, on the left hand side, near to where the railway crosses the Wye.

³ Mr. Randall, F.G.S., tells me there are similar marks on the rocks under the marine drift near Coalbrookdale.

⁴ Sometimes erroneously called Llyn Gwyn.

our present sea-coasts. To the right there is a basin with three outlets. The Wye enters on the right hand behind Ganallt Hill, and escapes by the valley in the foreground. In the background there is a basin with lofty cliffs, one side of which is skirted by the Wye, and into this basin a small brook enters from the west by a series of cascades, or rather water-slides (the latter not represented in the sketch). The sides of the basin look very unlike any cliffs the river is now forming, and no trace of river-drift can be found at an elevation of more than a few yards above the river. A very powerful current must here have entered a previous hollow, or series of hollows, and by a gyratory movement scooped out the basin.

On arriving at Marteg Bridge the Wye is joined by the Marteg River. As we proceed along the banks of the latter by railway, we see the most extraordinary complication of gorges, some with streams, some dry, but generally speaking the size of the stream is *not* proportioned to the size of the gorge. During the journey to Llanidloes many short Y-shaped gorges on the sides of hills or table-lands, may be seen, some with, and some without streams.

Action of the Sea at Aberystwyth.—A whole article might be written on the gorges, cwms, and precipices to the south of Llanbrynmair station, but I must hasten to the sea-coast. At Aberystwyth the subaërial geologist will find himself in comfortable quarters. Here the sea is forming a plane of denudation, and cutting with equal facility along the sides, and across the ends of ridges and valleys, without producing indendations beyond a small cwm. Were the floor of the sea to be elevated, we should here have a land plain bounded on the eastern side by an escarpment, with rivers debouching on the plain where they now enter the sea. But are we to conclude from this that the sea produces nothing but planes of denudation, and that it can only originate land surfaces in the form of plains with bounding escarpments? It is a remarkable fact that in channels, and on comparatively protected coasts, the sea generally forms approximately straight lines of cliff; but what do we find on the western shores of Ireland,¹ Scotland, and Norway, where the land is directly confronted by the sea, and exposed to the full fury of storms, and the undeflected force of currents? If some of the sea-lochs and fiords can be shown to be submerged land-valleys, this argument will not apply to all deeply indented sea-coasts, for the following reasons :—*At any given time the greater part of the earth's surface must be covered by the sea; during the gradual or intermittent submergence and re-emergence of the land, every part of it in succession must figure as a sea-coast; the average time² required for a submergence and re-emergence must be sufficient to allow the sea to efface*

¹ Why is not the sea cutting across ridges and valleys on the west coast of Ireland? Because in Ireland it is *now* forming ridges and valleys as it *anciently* did in Wales. On any given coast the sea must be either *destroying* or *producing* inequalities.

² Any given area of the earth's surface must, during a given lapse of time, be longer below than above the sea-level, otherwise the proportions of land and sea could not be maintained.

all the inequalities produced by subaërial denudation; the majority of the inequalities below the sea-level must, therefore, at any given time, be the result of marine denudation.¹

Remarks on Cader Idris.—From the sea on the west, and the valley of the Mawddach on the north, a succession of cliffs and plateaus, in some places regular, in others very much interrupted, rises up to the summit of the narrow table-land of Cader Idris. The northern rocky escarpment of this mountain looks more like an old line of sea-cliffs than any form with which subaërial agents are capable of investing rocks. On this and other escarpments of the mountain there are extraordinary cwms or semicircular indentations. One of these is occupied by Llyn-y-Gader. Its excavation must have been accomplished in a very wholesale fashion, if we are to judge from the immense number of stones choking up its entrance and distributed towards the west—stones which merge into, but in their immediate derivation are distinct from, the debris of the adjacent cliffs. Lyn-Cae, on the other side of the peak, is situated in a still more striking cwm. Ice may have had a share in the excavation of both; but to attribute to land ice any *great* amount of denudation in this district would be inconsistent with its surface-configuration, which could never have admitted of an ice-shed worthy of the name. There are several cwms towards the northern end of Cader Idris (two of them represented in Plate XV. Fig. 8) which appear in very unlikely situations to have been excavated by streams of either ice or water. From the summit of Pen-y-Gader peak (the highest point of the mountain) many cwms, quite distinct in form from any possible modification of a river channel, may be described. Not a few of them would seem to have been hollowed out in the gable-ends of old headlands. The beholder may see a cwm of this kind, at a high altitude, staring him in the face, as he looks towards the northern side of the valley of the Mawddach.

Sea-worn Summits of Hills.—On Mynydd Gader, between Cader Idris and Dolgelley, the hard, rocky surface has retained the peculiar characteristics of an ocean-floor. The general form of certain parts is more or less rounded, but in detail the surface is very uneven. Both hollows and projections, however, are here and there smoothed in a way indicative of the backward and forward motion of stones in water. Indeed they present fac-similes, only a little roughened by rain, of rock-surfaces now under high-water on the neighbouring Welsh coast. The granular disintegration of rocks is here almost unknown. The mountain streams, after long-continued rains, are as clear as crystal, excepting when they flow through an exceptional superficial deposit of clay or mud. The river Mawddach itself, at Dolgelley bridge, I observed to be quite transparent during and after heavy rains. We have no *à priori* reason therefore to attribute the inequalities of the rocky hill-summits to rain. The ridges of the

¹ The shores of the intricate channels and inlets on the Pacific coast of British North America, if elevated from the sea, would present but slight difference from sides of the narrow valleys in the Rocky Mountains at an altitude of 3,500 feet.—Dr. Hector, Quart. Journ. Geol. Soc., Vol. xvii. part 1.

hills between Cader Idris and the river Mawddach are generally very serrated (see Plate XV. Fig. 11, which represents one of these ridges as seen from near Dolgelley); and the inequalities in detail present a more or less sea-worn configuration. Before quitting the Cader district, I may remark that I saw one striking instance of what I have occasionally noticed elsewhere, namely, a stream flowing very nearly along the summit of a rocky ridge, and apparently possessed of as much denuding power as streams in the neighbouring hollows. It may be seen about halfway between Llyn Guernan and Llyn Gafr.

Torrent-ruts on the Kerry Hills.—The previous remarks may prepare the tourist for understanding how the grass-covered escarpments he may see on his right hand on travelling from Llanidloes to Newtown, should present no signs of mere pluvial action. At considerable intervals, however, the otherwise smooth and continuous outline of these escarpments is broken by temporary or permanent torrent-ruts, and occasionally good-sized gulleys. Kerry Hill, to the south of Newtown, presents the best example I have yet seen of the relative effects of subaërial and marine denudation. The northern slope is wonderfully smooth and continuous. The ruts and narrow gulleys caused by rain water collecting at intervals, and by a few small streams, are evidently *disfiguring* and not forming the inclined plane of marine denudation represented in Plate XV. Fig. 9. Farther towards the east, in the direction of Bishop's Castle, the hills are deeply indented by gorges and large Y-shaped hollows, which I had not time to examine.

Retrogressive Excavation by Waterfalls (?).—About a mile and a half to the south of Newtown there is a short deep gorge terminated by a high cliff with a picturesque waterfall. But the latter cannot be credited with having excavated the gorge backwards for the following reasons: the breadth of the stream and of its channel above is not equal to the extent of the cliff, and the continuity of the face of the cliff has not been broken or indented by the waterfall, but presents the appearance of the inner precipice of a previously scooped out hollow. The same remark applies to many of the waterfalls of Wales, which are merely falls or slides over transversely-continuous cliffs. The waterfall near Aber furnishes a striking instance of a stream tumbling over a long and continuous cliff of hard rock, which forms the inner boundary of a valley containing marine drift. At the bottom of this valley, and distinct from its general outline, the stream flows along a clearly defined channel. A similar channel may be seen above the fall; both are the work of the stream, but the falling over the cliff is merely an accident in its history.¹

¹ To the west of Aber, the channel excavated by the Ogwen may be traced from the sea to Llyn Ogwen as a depression distinct from the outline of the wide area over which it flows in the lower part of its course, and equally distinct from the great gorge of Nant Francon, which, with the precipice of Ben Glog, must have existed before the supplementary action of the river commenced. Fig. 10, Plate XV., is a view (from a photograph) of all that a considerable-sized tributary of the Ogwen has been able to effect in modifying the outline of Nant Francon.

Valleys and Cliffs near Llangollen.—On entering the old bay of the Murchisonian, or Severn Sea, now called the Vale of Llangollen, the river trick, or denudation puzzle, again presents itself, and is repeated as far up as Corwen.¹ But in whatever way the directly or obliquely-transverse valleys, and their connecting gorges, may have been formed, it is very obvious that the sea must have been here at no very distant period, geologically speaking. There is a true marine strait, or mountain pass, at a considerable altitude behind Barber's Hill.² The footpath from Llangollen to Try-Carreg Farm leads through it. At both ends the ground rapidly declines, and no freshwater stream could ever have traversed it. The rocks on the south side present indications of sea-action. It may have been formed, or, at least, modified, during the glacial submergence. The Eglwyseg range of cliffs on the opposite side of the irregular Vale of Llangollen are, in some parts, a fac-simile of cliffs now or lately washed by the waves at Llandudno. There are seven rounded promontories, with six intervening inlets. Of the latter, four are dry, and two are traversed by insignificant streams. It would be going too far to assert that the successive terraces mark as many pauses during the rise of the land above the sea. But that they have been carved out by a great body of water appears evident not only from the general configuration, but from features already referred to (page 391).³

Remarkable Assemblage of Raised Beaches.—To the south-west of Llangollen I met with the most extensive and perfect series of raised beaches I have yet seen in South Britain. They commence on the side of a hill about a mile to the South of Llantysilio railway station; and the stream which falls into the Dee, close to the station, interrupts their continuity in the upper part of its course. They consist of main and subsidiary terraces; and as many as nine can easily be distinguished. The lower and more striking terraces, near Try-Carreg Farm, are not now under cultivation, and from the circumstance of several erratic boulders of trap lying on the platforms, one would suppose they have never been cultivated. The upper terraces have evidently been much effaced by the action of the plough. The cliffs of the lower terraces are more or less rocky, and appearances justify the belief that they have been undermined by the sea. The breadth of the platform C (Plate XV. Fig. 13, which roughly represents a part of these terraces as seen from a distance) I found to be about 150.

¹ Between Llangollen and Corwen, on the left hand side of the road, streams with cascades may be seen descending from the Berwyn Mountains, with little or no channel to mark their course. Behind Corwen a powerful stream has, in some places, excavated no channel at all, in other places a miniature gorge. The excavating power of this stream is assisted by a steeply-inclined course, and numerous cascades; and the gorge may, with the greatest safety, be regarded as the measure of its denuding capabilities, as the ground on each side rather falls away from it than towards it.

² Fig. 12, Plate XV., is a distant view of this pass. In most of the wet passes of Wales and the Lake District, with which I am acquainted, the streams which flow away from the cols could have had no share in the formation of the cols themselves, which indicate an agency cutting straight through a ridge, and cannot be referred to an improbable linear coincidence in the original sources of the streams.

³ See Mr. Kinahan's able article on raised beaches in Ireland, in *GEOL. MAG.*, Aug., 1866.

feet, and the height of the escarpment below from 40 to 50 feet; and this may be regarded as about the average size of the main terraces. The platform C, where I examined it, was very nearly level, both longitudinally and transversely. It was covered to a considerable depth with clay and loam, mixed with well-rounded, semi-rounded, and angular small stones. The platform B is covered with similar silt, and is here and there more or less swampy. These terraces, which are probably the most elevated of any yet discovered in Great Britain, furnish a proof of numerous and long-continued pauses, and a consequent presumption in favour of considerable denudation, during the intermittent rise of the land above the glacial sea. But the advocate of marine denudation is not necessarily limited to the glacial period of submergence. The *general* form communicated by the sea to the rocky surface of any particular area, may be capable of resisting atmospheric denudation for an indefinite period.¹ The style of architecture may remain after the details of the structure have been laid in ruins; but during a secondary submergence of the land, the sea may be able to repair the havoc committed by the powers of the air, and re-impress its seal on the blanched and shattered monuments of its primeval sway.

NOTE.—Since the above was written, Mr. Maw's able article on *Watersheds* has appeared in this Magazine (August, 1866). I have only space to express my opinion that his observations on the graduated series of levels extending from watersheds to the sea are applicable only to certain areas where the sea may first have formed an inclined plane of denudation, and afterwards hollowed it out into valleys. I do not believe in the existence of *systems of valleys* as a general rule. In most districts large valleys run approximately parallel to the lines of watershed, and are only transversely connected at long and irregular intervals by narrow and apparently accidental gorges. It is through these gorges that rivers, after much wandering about and change of course, find their way to a lower level; and they often seem (the Severn for example) to have the greatest difficulty in reaching the sea at all. With regard to marine denudation, it ought to be remembered, that on many coasts the sea is not only running up previously-excavated valleys, but *forming fresh inlets*, frequently long and winding; and that its excavating power in these inlets is often increased rather than diminished. It is not true that the sea acts on the *principle* of making straight lines of coast, for we everywhere find it taking advantage of the slightest crevice or inequality in the composition of rocks as a commencement of indentations which are small in protected situations, but extensive beyond any assignable limit on coasts that are fully exposed. I believe that coast indentations increased by current action during gradual submergence, and current indentations in-

¹ Excepting at intermediate levels where streams have had space to acquire considerable volume, without descending so far as to lose sufficient inclination of channel. This may be called the *zone of maximum atmospheric denudation*—the higher and lower lands the *minimum zones*.

creased by coast-action during emergence, may assume forms identical with most of the valleys and gorges which diversify the surface of the land. (See some excellent observations on the marine origin of valleys in *Lyell's Elements*.)¹

III.—ON THE RELATION WHICH THE EAST ESSEX GRAVEL BEARS TO THE STRUCTURE OF THE WEALD VALLEY.

By SEARLES V. WOOD, JUN., F.G.S.

[Continued from the August Number, p. 354, which contains the Map and Sections referred to.]

IN the former paper² I adverted to the evidence which the Thames gravel afforded, that the channel in which it was deposited opened out over the Wealden area, and the corroborative evidence which the East Essex gravel furnished of a similar state of things.

The Map accompanying this paper (see the August number) shows the East Essex gravel running down from the NN.E., *across the mouths of the Thames and Crouch*, its course becoming as it nears the Weald parallel with the eastern edge of the Thames gravel. In consequence of the extent of marsh on the eastern side of the Medway, between Chatham and Sheerness, the extension of the gravel in this direction does not appear; but the southern termination of the great sheet at Hoo, near Rochester, is an abrupt one, extending along a line parallel with the Chalk escarpment of the Weald at that part.

In the Thames Valley paper, I showed (see Section 7 of that paper, p. 103 of Vol. III. of this MAGAZINE) that the Thames gravel was cut down by a sharp denudation *in the opposite direction to the river Thames, and in the direction of the Weald*, and that a newer gravel ($x5$) extending to the Chalk country, forming the north side of the Weald Valley, had been formed under the brow of the Thames gravel. Now the features exhibited by the East Essex gravel are similar in this respect; for the great sheet which thus terminates parallel with the contiguous chalk escarpment, is cut down in the most decided and abrupt manner towards that escarpment.

Owing to the dip imparted by the upheaval of the Weald country to this gravel near Rochester, it descends eastwards by a rapid slope to the Medway, and northwards more gradually towards the Nore; but a line drawn from the very high ground occupied by this gravel on Hoo Common, to the nearest scarp of the North Down, shows this cutting down very distinctly. (See Sec. 14 beside Map.)

In this Section the gravel ($x4^{17}$) is divided from the Chalk by a considerable thickness of London clay and Lower Tertiary sand, and the whole have been cut down together to the Chalk at Rochester, and a newer post-glacial bed ($x5^{17}$) has been formed at their foot.

¹ Answers to other parts of Mr. Maw's article will be found forestalled in the preceding pages.

² GEOLOGICAL MAGAZINE, Vol. III., pp. 57 and 99.