of Loch Tay runs along the top of an anticlinal arch. Hence that which in geological structure is a depression, has by denudation become a great mountain, while what is an elevation has been turned into a deep valley." Mr. Whitaker informs me that detached hills in the London Tertiary country have very commonly this inward dip; so too have the Tertiary hills west of Canterbury.

I venture to call the attention of geologists to this generally *basined* or synclinal forms of detached hills. There is no reason, if hills and valleys are due to marine action, why the hills should be synclinals and the valleys sometimes anticlinals, since the sea where we now see it at work pays no regard to dip and strike.

Postscript.—Although not immediately bearing upon the district described in the foregoing paper, I should like to call attention to a work by Mr. William Wallace,[1] in which the structure of the Alston Moor district, and the Tyne valley generally, is described. The author clearly recognises the power of rain and rivers in excavating valleys, and also that marine action had previously, and during the upheaval of the country, largely denuded the beds. I subjoin a few passages from this interesting work (pp. 45, 48): "It is difficult to resist the inference that the bed of the Tyne river above Alston must have been some 200 feet higher than at present." "There are less clear indications of its having occupied still higher positions." "As the river deepened its channel, and the sides of the hills were decomposed and carried away by pluvial agency, all marks of ancient river beds must have been destroyed." ". . . . the sheets of strata, which once stretched from the more elevated sides of the mountain across the valleys far above the bed of the present stream, were gradually removed by the action of the waves and currents of the sea; and further, that previously the strata had been thrown out of their original horizontal position, the erosion being regulated by those portions which were most elevated, as the range of the Pennine mountains, and by the anticlinal axis stretching from the summit of Cross Fell to the sources of the Tyne, and from there north-eastwards to Kilhope Law. The exact point, however, where breaker action ended, and the erosive action of the streams now flowing in the country began, is not, perhaps, determinable."

III.—Notes on the Comparative Structure of Surfaces produced by Subaërial and Marine Denudation.

By George Maw, F.G.S., etc.

The article by Mr. Mackintosh on "The Cliffs, Gorges, and Valleys of Wales," in the September number of the Geological Magazine, raises so many questions in opposition to the views I endeavoured to support in the previous number, that I venture to offer

[1] "The Laws which regulate the deposition of Lead Ore in Veins." 8vo. 1861 Chap. ii. "Elevation of the Strata and Denudation of the country."

a few further observations on some of the more salient points in which Mr. Mackintosh differs from the advocates of subaërial denudation. Let me, however, in the first place, admit with him the full belief by subaërialists in the existence of numerous evidences of the coast action of the sea over the land surface. The most superficial observer must at once detect in the drift-covered surface and terraced outlines of much of the dry land, the existence of former progressive coast lines of sea erosion over almost the entire surface; indeed, it is this very palpable evidence of the tooth of the sea on the land and its strongly marked character, by which the advocates of subaërial denudation believe they can distinguish between the work of the sea and the denudation performed by rains and rivers, and that the surface erosion performed by the sea has been so trifling as to scarcely interfere with the general structure of surface brought about by subaërial agency.

Valley Excavation produced by Marine Currents directly assailing the Coast (?).—The assumption that coast indentations and valleys may be the result of marine currents directly assailing the coast, though easily disprovable in principle, is also capable of being tested by the facts of the cases brought forward in illustration. The advocates of subaërial denudation hold that marine inlets and valleys running up from the coast are the result of the submergence of land previously moulded by rain and river action, and believe that small local currents, having the power to perform the work attributed to them, and the persistency to perform it on a particular spot, could never have existed. In long narrow channels, such as the fjords of Norway, it is not unusual to find two narrow inlets opening out of the main channel exactly opposite each other, implying on the marine theory of excavation, the existence of currents striking from the same point in exactly opposite directions. A glance at the map will at once show that the Norwegian inlets are merely the seaward prolongation of valleys that have their origin close to the Scandinavian watershed. If, as I shall presently endeavour to show, the sea does no material work below the tidal range, and that the excavation must therefore have been done on its coast outline, how are we to account for the persistency of points of resistance and points of erosion (and these quite independent of the structure of the rock) on the line of the fjords and their valley prolongations through such an immense range of altitude? Is it not obvious that the complete change of coast outline involved in such an oscillation of level must have repeatedly changed and disarranged the course of such assumed local currents? It is a very suggestive fact that this singularly indented coast is now undergoing a change of level—may it not be recovering itself from a submergence which caused the sea to run up the valleys that were cut out by subaërial action on a land surface of greater elevation than the present?

Along the indented west coast of Ireland it is well known that currents do not directly assail the coast, but that the Gulf Stream here takes a grand sweep to the N.E. almost parallel with it.

In the case of the Aber valley, cited by Mr. Mackintosh as an example of marine excavation, the eroding current must have been perfectly constant in its exact location and direction during a range of coast elevation or depression of at least 1200 feet, and you must assume that there were five or six such independent currents within as many miles to form the other similar indentations along the neighbouring coast. In connection with this locality another grave difficulty presents itself: you are not in the open sea, but the valleys opening into the coast deböuch into the mouth of the Menai Straits, up and down which a strong tidal current is constantly running transversely. The Isle of Anglesea rises opposite within a few miles to a height of more than three hundred feet, and must always have formed a barrier against the sea directly assailing the point now occupied by the Aber valley, to, at least, the extent of its present height. Now, even if the possibility is admitted of a current assailing the coast at Aber, when Anglesea was beneath the sea, how are we to account for the excavation of the valley to the extent of two or three hundred feet below the level of the top of the opposite island-barrier? These are only a few of the many local instances in which the theory of marine currents is easily shown to be inapplicable, but the whole assumption that currents, whether of wind or water, can move up and take effect at the extremity of a *cul de sac* is fallacious; you may as consistently assume a power to make the smoke pass up a chimney with the top closed; *there can be no motion without a thoroughfare.* This may be familiarly illustrated by the impotence of the wind to enter an open window when the door of the room is closed, but only make an outlet for the wind and its power through the room is at once asserted.

On the Diversion of Watershed Lines and River Channels.—In connection with the existence of transverse gorges, and the passage of river channels through high land and mountain chains, it is important to bear in mind the *extreme antiquity of the general structure of the present hill and valley system;* on the first emergence of a sedimentary deposit from the sea under which it was formed, the subaërial waterflow begins to take up a definite position, and this may in the first place be determined by the most trifling inequalities of surface. The slightest elevation will throw off the rain, and river channels will begin to be formed in the faintest depressions; the water *must* find an escape and it will leave the higher and find the lower ground, however trifling the difference in height may be. We must thus look for the initiation of the present watershed and waterflow systems in the very earliest history of the emergence of the new-made land, and when once formed they will maintain, under uniform circumstances, their original positions.

The want of correspondence between river channels and the general valley contour of a country, although not unfrequent, must be looked upon as purely exceptional, and attributable to special circumstances that have supervened since the land surface received its first impress of watershed and valley systems. Among the causes tending to the diversion of river channels may be enumerated, fracture or the opening of rents, drift accumulations, damming up valleys and diverting the waterflow, and the alteration of the lie of the ground through local dislocations, upheavals, and depressions, the whole of the causes may have been going on in every variety of degree, working in unison or conflict, ever since the land surface received its first impress of hill and valley contour, and may have produced a variety of exceptions to that regularly graduated contour resulting from the accumulative waterflow over the land surface. May not also some connecting gorges and transverse valleys possibly be the fragmentary remnants of sets of watersheds and valleys that were first initiated on other surfaces than that on which the prevailing hill and valley system had its origin?

It is impossible to limit the persistency of a set of valleys and watersheds that have never been interrupted by the diverting causes before referred to, or that have not been covered up by superincumbent formations; let us, however, consider the case of an old land surface diversified with watershed ranges and river valleys buried beneath an overlying deposit. The deeper depressions of the buried surface would, as shown in Figure 1, to a certain extent reproduce

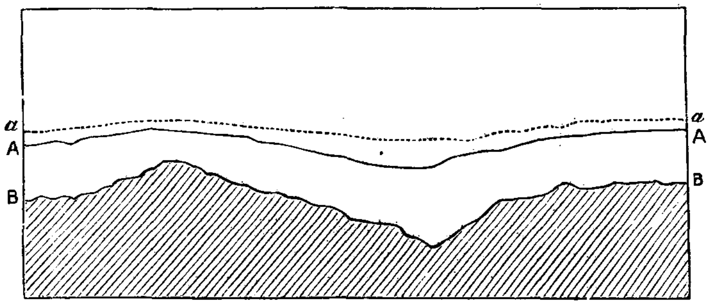

Fig. 1.—Exhibiting partial conformity of New Deposit to the subjacent Ancient Contour.

themselves on the contour of the new deposit *a a*, and the consolidation and subsidence[1] (represented by the space between the line A A and the dotted line *a a*) of the thicker parts of the new deposit being greater than that in the thinner parts over the higher ground, would still further cause the contour of the ancient surface to be

[1] From observations I have made on the contraction of clays and other materials in drying, it appears probable that strata newly deposited passing from the degree of wetness whilst submerged to a comparative state of dryness on emergence, would contract about as follows:—

Clayey strata from 8 to 10 per cent. of original bulk;
Sandy „ 3 to 6 „ „

Even supposing that the new superimposed deposit was completed with a perfectly level surface, and did not follow in any degree the irregularities of the subjacent contour, the thicker parts over the deep valleys would have a greater amount of contraction than the shallow parts over the higher ground, and thus tend to the reproduction of the general form of the old ground (though with less strongly marked irregularities of outline), and the principal lines of old waterflow and watershed on the new surface.

roughly reproduced on the surface of the overlying deposit. This following of the irregular basement line, in superimposed beds, is well shown in Figure 2, representing a section on the Bristol and

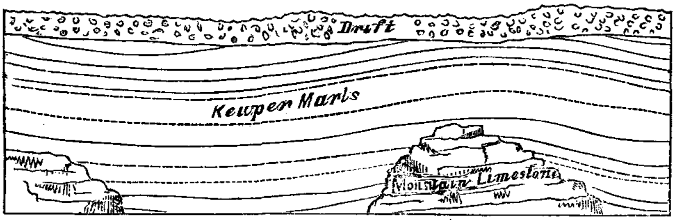

FIG. 2.—SECTION NEAR THE BOURTON STATION ON THE BRISTOL AND EXETER RAILWAY.

Exeter Railway, near the Bourton station, six miles from Bristol, where the Keuper Marls dip away in each direction at an angle of from 4° to 6° from the bosses of Mountain Limestone over which they were deposited. It seems probable that the main valleys and lines of waterflow of the ancient buried surface would impress their outline through a considerable thickness of superincumbent deposits and thus determine the direction of the principal watercourses on the new surface; occasionally the new watercourses would be diverted from the ancient buried lines of waterflow by adventitious irregularities of surface, especially in the case of the shallower valleys, *and it is in these that many of the cross cut valleys and transverse gorges appear to have been initiated.*

Referring to Figures 3, 4, and 5, representing a series of valleys

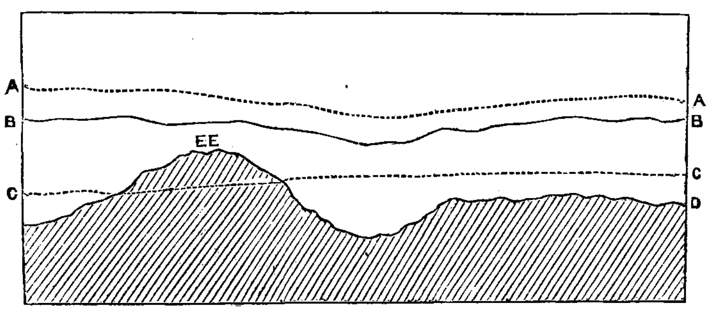

FIG. 3.—TRANSVERSE SECTION OF ANCIENT VALLEY SYSTEM. LONGITUDINAL SECTION OF SUPERIMPOSED SYSTEM.

superimposed *in part uncomformably* over an ancient buried series, let us suppose the superincumbent deposit A A to be gradually denuded by subaërial agency, the main lines of waterflow will simply re-excavate and perhaps somewhat alter the old buried valleys over which they are conformable, ***but wherever the upper system of valleys*** C C ***runs transversely*** (as in Fig. 3) to the buried system the separating ridges, as at EE, Fig. 3, or CC, Fig. 4, will be cut through; denudation may proceed over ridge and valley, and gradually lower the entire surface to F F, after having removed the whole of the newer deposit, *and will impress on the old deposit a contour partaking of that of both*

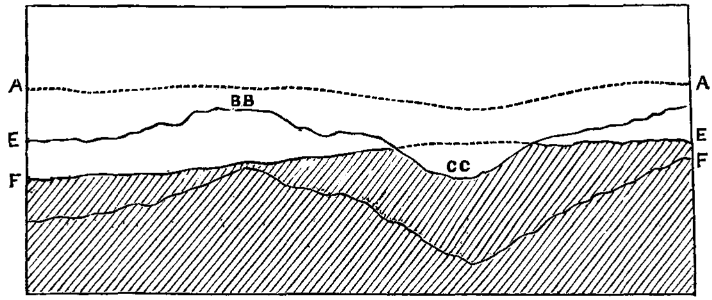

FIG. 4.—LONGITUDINAL SECTION OF ANCIENT VALLEY SYSTEM. TRANSVERSE SECTION OF SUPERIMPOSED SYSTEM.

the old and new surfaces, the association of the general system of valleys with transverse gorges having had their origin on different surfaces and which could not be accounted for on any single simple system of waterflow.

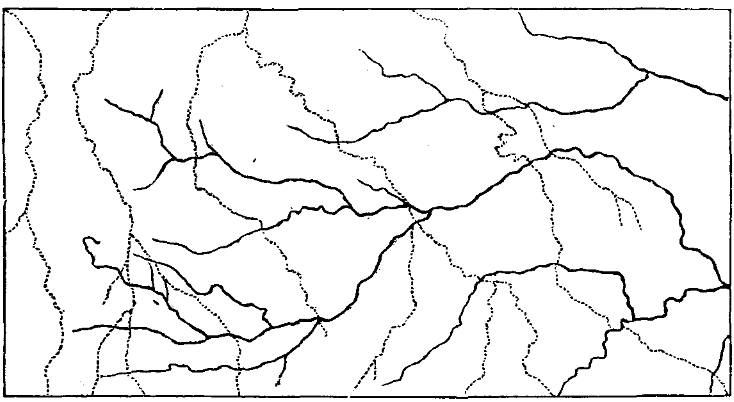

FIG. 5.—The dotted line represents the ancient buried Watercourses, and the dark lines those on the new overlying surface.

The unequal resistance of old and new deposits may also introduce complicated systems of contour; for instance, in the case of the valleys in the softer upper deposit (CC, Figs. 4) running transversely to the ridges of the older underlying formation, the transverse ridges would be gradually cut through, and, as the level of the older valleys was approached, an outlet would be formed for the progressive excavation of the softer deposit filling them up, and the old valleys would be restored, connected by the transverse gorge which played so important a part in their re-excavation. If a progressive series of land contours superimposed on new surfaces of deposit are enabled to faintly transmit, *in part*, their structure upwards (see Figs. 1 and 2) to succeeding surfaces, each surface differing in its details from that which precedes it, a complex structure of surface would be gradually accumulated, the individual changes of surface being lost in the denudation of surface through the superimposed strata, and the accumulated result impressed on the single fresh denuded surface (F F), of the older formation.

"V"-*shaped Gullies and Vertical Gorges.*—The sudden transition that frequently takes place between the form of the immediate water channel and that of the main valley containing it, is I think capable of a satisfactory explanation compatible with a common cause. In

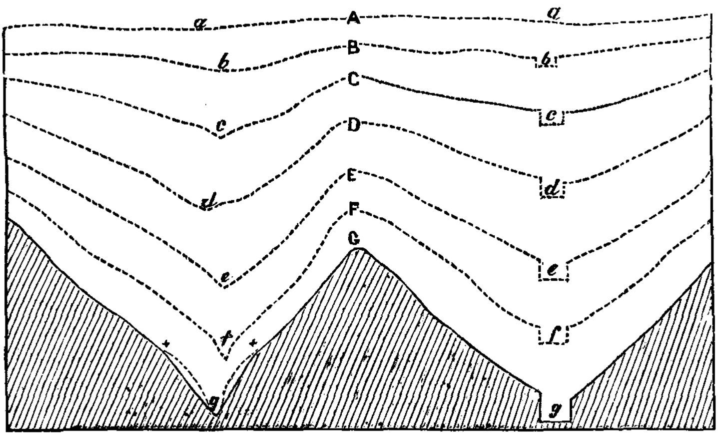

Fig. 6.

nearly all the mountainous valleys of Wales the immediate water-channels are bounded by either vertical cliff-sides (as in the Aber valley, and by the way, here you have a fine example of cliffs produced by river action) or by steep sides having a regular and uniform slope, and in both cases joining into the general contour of the valley by a hard and well-defined outline. It must be borne in mind that on the theory of subaërial denudation as illustrated in Fig. 6, not only the amount, but the rate of excavation is greater towards the bottom, than the confines of a valley towards the watershed; near the watershed you have nothing but the rain that falls on the spot, but as you proceed downwards a progressive concentration of water and consequent power of excavation takes place, and in the actual water-channel at its base there is a kind of force in its erosive intensity which is unlike in its effect that of water distributed over the surface. The progressive modification of the contour will be represented by the succession of dotted lines in Fig. 6. The waterflow depression being lowered at a greater rate than the watershed, the tendency towards the vertical will first commence at its very bottom.

Now nearly all materials have what is called an angle of repose, and will fracture or slip off as soon as their inclination attains to within a given number of degrees of the perpendicular. Some very solid rocks will we know stand with almost vertical sides, and in such rocks running water will scoop out a vertical trough as indicated on the right hand side of Fig. 6, and of this structure examples occur on the Rhone a few miles below Geneva, on the Rhine in its passage through the Via Mala, and on a smaller scale in the Aber valley; but in the great majority of cases softer strata and rocks abounding in a variety of lines of jointing, cleavage, and bedding will find an angle of repose like any loose material, though at a steeper pitch; *the sides at the very bottom of the valley, especially where there is quick running water, will first exceed in their slope the angle of repose of the rock,* and the result will be the breaking down and sliding off of the sides up to a hard angle, as at * on the left hand side of Fig. 6. At first this may be to no great extent, but as the stream deepens its course downwards the confines of the slipping sides will proportionably recede upwards, and a large V-shaped valley be produced, having apparently no harmony or community of origin with the more rounded outline of the valley in which it is placed. The mountains of Wales afford an almost endless number of illustrations of the variety of effect produced by the different degrees of concentration of the waterflow, and the various combinations of the several kinds of outline brought about by subaërial denudation. In some localities the V-shaped gully is but a subordinate feature in the general rounded outline of the valley. In other places the angle of repose will run up to the crest of the watershed, producing a steep gorge with straight sloping sides, and here and there the vertical cliff will, from variation in the structure of the rock, boldly stand out from the straight slope of repose.

The Aber Valley.—In the earlier part of the article I have endeavoured to point out the difficulties that the *position* of this steep valley present to its having been excavated by a marine current directly assailing the coast, and there are certain points in its structure that also militate against the possibility of its marine origin, the most obvious being that it is a complete *cul de sac* affording no thoroughfare for the passage of a current. At about three-quarters of a mile from its mouth the valley splits up, and on the face of the headland separating the two divergent branches which above all other parts would have received the full force of the sea, there is no appearance of any escapement, indeed the sides of the valley throughout, except at its very end, exhibit that graduated contour which appears to be characteristic of subaërial denudation. At the extremity of the left hand fork of the right hand branch below the waterfall a delta like mass of drift occurs, partly filling up the valley; it is evident that its deposition could not have been contemporaneous with the excavation of the valley, as denudation and deposition cannot go on simultaneously on the same spot. The general disposition of the mass appears as though it was deposited when the valley was partly submerged, the debris having been brought down by the stream above the waterfall, and through this delta-like heap the stream has cut a deep winding channel since the emergence of the land. At the end of this main branch of the valley, a little below the waterfall, the stream divides, each of the branches of which flow from a short *cul de sac*, the main branch to the left over a boss of Porphyry with a steep cliff-like front; it is, however, not a true cliff produced from below, but a very steep sloping mass resisting the cutting power of the stream, the level of which above and below it represent the relative rate of degradations of the Porphyry and Silurian rocks, the Porphyry appears to be metamorphic, and graduates into the slates and shales, with which gradation of material the relative steepness of the valley sides exactly correspond, the portion bounded by the Porphyry being the steeper of the two; the small branch of the valley on the right hand side just misses the Porphyry and here the cliff-like form is lost, and the little *cul de sac* graduates upwards to the watershed like the remainder of the valley. Now if the cliff-like contour of the left hand branch had been produced from below by the erosive action of the sea, would not the softer Silurian strata have been the more easily assailed? and why has not the whole valley that cliff-girt outline which we know the sea produces? There is nothing in the nature of the rock to prevent it standing in the form of a cliff, for the immediate channel of the stream consists of a gorge with vertical sides from 30 to 50 feet deep, the whole valley (except the immediate river channel), although rather steep in its conformation, has a graduated sloping contour, and there is no reason why the sea should have singled out high up the valley a little spot to leave its characteristic mark upon, whilst the more salient parts were left untouched.

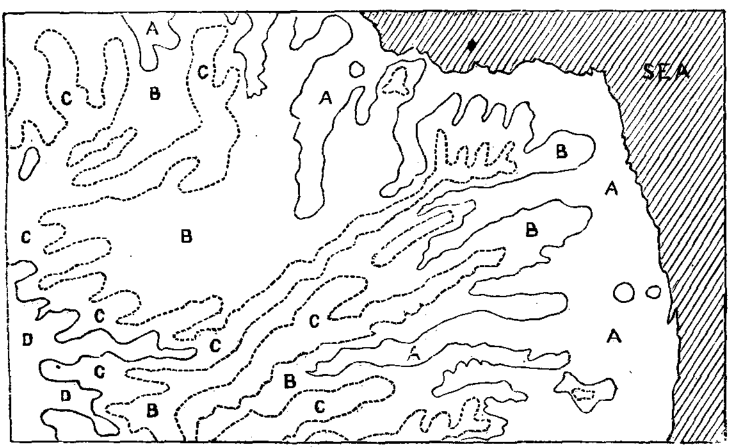

Fig. 7.—Part of the Coast of South America, showing the want of Correspondence between the Direction of the Coast-line and the Lines of equal height on the Land.

The tendency of Marine Coast to be straight.—In my former paper

I pointed out the general tendency of the eroding coast line to be straight, in contrast with the sinuous course of lines of equal height on the land surface. Fig. 7 represents part of the coast of South America, on which I have endeavoured to roughly show the disposition of the adjacent land-lines of equal height as indicated by the disposition of mountain chains and river courses. The belt of the land marked A may be taken to represent a range of altitude from the sea level to 200 feet, B from 200 to 400 feet, C from 400 to 600 feet, and D land over 600 feet in height. One of the most striking features here indicated is, that whilst the various land lines have a certain parallelism and concentric disposition with each other, they show no kind of relation to the direction of the coast line. If the prevailing land contour has been brought about by the same agency as the coast line, how is it that they do not exhibit some kind of affinity? Why should the sea have carved a particular kind of outline on the present coast and not have followed the same principle of erosion (as indicated in Fig. 8) when at a higher level on the present land surface? A comparison of Fig. 7 representing the *actual* land contour, and Fig. 8 representing the lines of equal

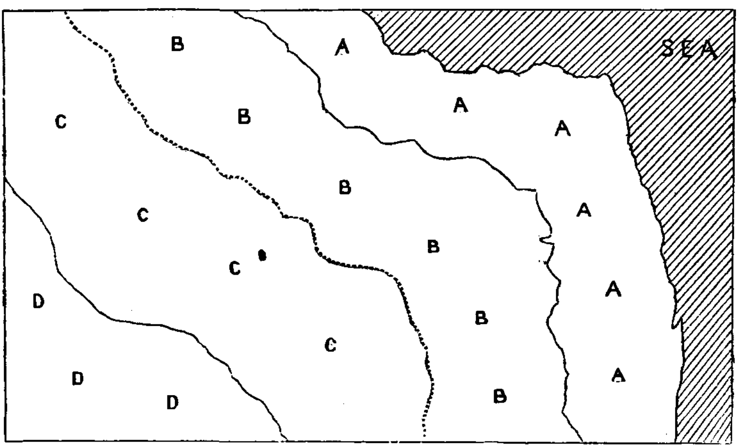

FIG. 8.—HYPOTHETICAL LAND CONTOUR ON THE PRINCIPLE OF COAST EROSION.

height, had the coast contour been applied to its surface, will readily exhibit the essential difference in structure between the result of subaërial denudation and marine erosion.

If we for the present pass over the case of irregular coast lines resulting from unequal power of resistance in the rocks, the general tendency to be straight seems easily capable of explanation. In the first place, the ordinary wave-action along a coast is tolerably equal, and there are no *primâ facie* reasons why, under similar circumstances, it should produce an irregular result, or why it should persist at one particular point in eroding at a greater rate than at another. The action of the waves within an inlet, be it ever so straight and exposed, must always be less than against a headland; a headland is more or less assailable from three quarters, whilst an inlet can only receive the first force of the direct waves. Waves running along the shore can take little effect upon its recesses; in short, the projections of a coast, be they from whatever cause, must always be more open to assault than its indentations, and in this a compensating equivalent exists for any exceptional tendency towards an irregular outline. With respect to the assumed erosive action of currents, even if any large proportion played directly against the coast, they would be unable to make a deep inlet, for motion cannot take place up a *cul de sac*—a "cushion of still water" would fill the recess, deflecting the current at its mouth, and thus neutralize its excavating power; furthermore, all the persistent currents of the ocean are on a scale altogether disproportionate to the details of coast outline, and for the most part take grand sweeps parallel with the coasts.

On the Levelling Action of the Sea.—If we examine the sea bed between high and low water mark, on any cliff-girt shore, it is impossible not to be struck with the singularly level disposition of the reef surfaces extending seaward, which once formed the foundations of the old cliffs. Their general height will be a trifle above that of low tide, and any irregularities of surface will not exceed one or two feet. This well-marked lower limit to the erosive action of the sea is not confined to hard rocky coasts, but will be found to hold good in the softest strata. The fragile Wealden Sandstones to the east of Hastings stretch out to seaward for many hundred feet as level reefs just appearing above low water; and even the soft London-clay spreads out on the Suffolk coast as a level plateau exposed at low tide. There can be no stronger evidence of the impotence of the sea to do much in the way of erosion below the tidal range; and if a uniform level of land is maintained, it seems practically impossible that anything but a level surface can be the result. In the case of a coast being emerged or submerged, the progressive action of the tidal range would, of course, produce a steep or gentle inclination of surface according to the relative rates of erosion and change of level; but such inequalities must tend to be parallel with the shore (as indicated in Fig. 8), and similar variations of surface, trending in an opposite direction, could only be produced by sea erosion from local differences in the oscillation of level; but these, we know, do not take place within the narrow limits of hill and valley undulations. Furthermore, although you might get a single *incline* parallel to the sea by its action, it is obvious this could not be repeated in reverse so as to produce an *undulation*, and still less possible would it be for the sea to produce that intricate series of undulations skirting river valleys opposed in their direction to the eroding sea line. It may be perfectly true that marine terraces occasionally follow the sinuosities of the land contours, but these are evidently the effect of sea erosion superadded on previous contours produced by subaërial denudation.

On the Formation of Plains.—In Mr. Mackintosh's paragraph, entitled "Valleys Excavated by Streams" (p. 389), he appears to consider himself at issue with subaërialists in attributing to the sea the planing down of flat table lands. The discussion commenced "On the Formation of Hills and Valleys," and there has been no point more strongly insisted on by those who attribute the sculpturing of the land to subaërial agency, than the contrast between the work of the sea, as expressed in the level surfaces of flat-topped ranges and elevated plains, and the work of rains and rivers in excavating the intersecting valleys. Professor Ramsay, in the concluding paragraph (p. 237) of his "Geology of North Wales," says—"To the eye of one who appreciates the physical features of a country there is, indeed, on ascending a height, nothing more striking than the average flatness of the tops of many of the hills, especially when the rocks composing them are of tolerably uniform texture—a flatness, be it remembered, not connected with anything like a horizontal position of the beds, for everywhere they are contorted and often stand on end. All Wales shows this feature from the Towey to the slaty hills that flank Cader Idris and the Arans on the south and east, and even in the mountain land, from Cader Idris to the Menai Straits, traces of a similar approximate uniformity in height are plain to the experienced eye,—showing the relics of an old form of ground in which deep valleys have been not rent but scooped out. In lower ground, the features of Denbighshire, east of the vale of Clwyd, in a remarkable manner agree with these principles. There, in an average table land, *the result of quiet marine denudation* of disturbed strata, innumerable valleys have been cut out of the solid mass, the accumulated draining of which forms streams of tolerable size, which, *from higher to lower levels*, have gradually cut through an unfaulted escarpment of Carboniferous Limestone on their way to join the Clwyd. Such principles, I am convinced, give, when well considered, the true key to the meaning of the present outlines of the country; and few subjects in physical geology would promise greater interest than a complete account of the denudations by which, after the disturbance of the strata, Wales assumed its present form."

Striking examples of these level platforms also occur in the uniform outline of the surface of the Mountain Limestone, Durdham Down, near Bristol, at an average height of 280 feet above the sea, and the level top of the headland of Devonian Limestone bounding Babbicombe Bay, east of Torquay, given by Mr. Chambers in his "Ancient Sea Margins" (page 246) as 278 feet high. Of another similar platform on the south-west side of Tor Bay, Mr. Chambers remarks: "The one which forms the south side of Tor Bay dividing it from the valley of the Dart, has a remarkable appearance from Hope's-nose, the opposite promontory, for its flatness is like that which we should make in a drawing with a ruler, and it perseveres for many miles inland." The absolute identity of height between the Bristol platform, and that at Babbicombe Bay is remarkable; Berry Head, though supposed to be less by Mr. Chambers, is, I believe, identical in height, and it seems highly probable that these uniformly flat surfaces were all contemporaneously ploughed down by the sea.

The whole tendency of the sea appears to be to work on as straight a line as possible, whether it be on the vertical cliff face, the straight lines of coast, or the level surfaces of sea coast reefs. As regards vertical cliffs, the action of running water in river channels will occasionally produce similar results to the sea, but in all other respects the effect of subaërial denudation seems to be the production of a sinuous outline and a rounded undulating surface. Now as the straight element in the form of the ground is altogether subordinate to its rounded contour, it seems impossible to resist the conclusion, that rains and rivers have been the all powerful agents in modelling the land; indeed, the distinctive features of marine and subaërial denudation seem almost unconsciously recognized when the advocates of marine denudation point to the exceptional cases of terrace-structure in proof of the former action of the sea, and thus unwittingly admit some other agency to account for the almost universally rounded form of the land surface, and the sinuous disposition of its lines of equal height.

NOTE.—It has been suggested to me that in the paper "On Watersheds," in the GEOLOGICAL MAGAZINE of August, I used the term Watershed in rather too general a sense. I wish to explain that, in speaking of *watershed areas*, I merely referred to the individual tracts defined by the lines of watershed. I may also have inadvertently fallen into the use of the word as descriptive of an area, instead of a line, from the idea that was before me of the watershed line structure, branching *downwards* from the main line of watershed and ramifying over the whole area it includes, in the same sense that the ramifications of the waterflow branch *upwards* over the whole area to the watershed.

IV.—NOTE ON THE MIMOSA-DALE CHALYBEATE, UITENHAGE, SOUTH AFRICA.

By A. H. CHURCH, M.A., F.C.S., R. A. College, Cirencester.

A SMALL quantity of a highly ferruginous water was lately given to me for analysis by my friend and former colleague, Dr. John Bayldon. He had collected the sample himself at the spring in Mimosa-Dale, Uitenhage, South Africa, where also he had obtained specimens of the iron-salts which are freely deposited by the chalybeate waters.

The incrustation consisted of a crystalline ferrosoferric sulphate containing a good deal of water. In chemical and physical characters it approached Misy, but its occurrence as an abundant natural deposit covering the ground about the spring for a considerable space is of peculiar interest. Misy, it is well known, occurs in the waters of the Rammelsberg mine, near Goslar, in the Hartz, but neither in the abundance nor under the conditions of the Mimosa Dale deposit.

The water was found to contain 63.49 grains of solid matter per imperial gallon. It had a strong acid reaction, and a most decided styptic taste. By means of a direct iron determination, by the permanganate process, in the original water, together with an estimation of the total iron present in the water after it had been treated