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THE CHEESEWRING, CORNWALL, AND ITS TEACHINGS. By Professor EDWARD HULL, LL.D., F.R.S., F.G.S. (*Secretary*).

DEVON and Cornwall are remarkable for the number and variety of objects of nature and art which are presented, at intervals, to the notice of the observer both along the coast and in the interior. In the former case, we have grand examples of cliffs and precipices hewn by the ceaseless waves from the Atlantic out of the hardest rocks, either plutonic or stratified, these latter being often contorted, folded and faulted, or pierced by caves and gullies; in the latter, we have numerous examples of prehistoric art in the form of stone circles and dolmens, such as the Trevethy Cromlech near Liskeard (Fig. 1),* and of early Christian art in the cases of stone-crosses, churches, castles, and fortresses, of which Tintagel, the traditional stronghold of King Arthur and his "Knights of the Table Round," immortalized by Tennyson,† is the most interesting example.

But our task here is to deal only with a work of nature, long antecedent to the oldest of these monuments of bygone art, so

* I use the general term "prehistoric" for the stone circles, but it must be remembered that Fergusson maintains that there is no evidence of their existence either in England or France in the days of the Roman occupation. *Rude Stone Monuments*, p. 20 (1872).

† "The Coming of Arthur" (*Idylls of the King*).

remarkable in form and outline as at first sight it might be regarded as the work of man, a monument erected over the grave of some prehistoric giant by his brother "giants of those days" who have left their monuments in the stone circles and dolmens of Britain and Western Europe. But a closer inspection dispels this illusion; and we ultimately recognize

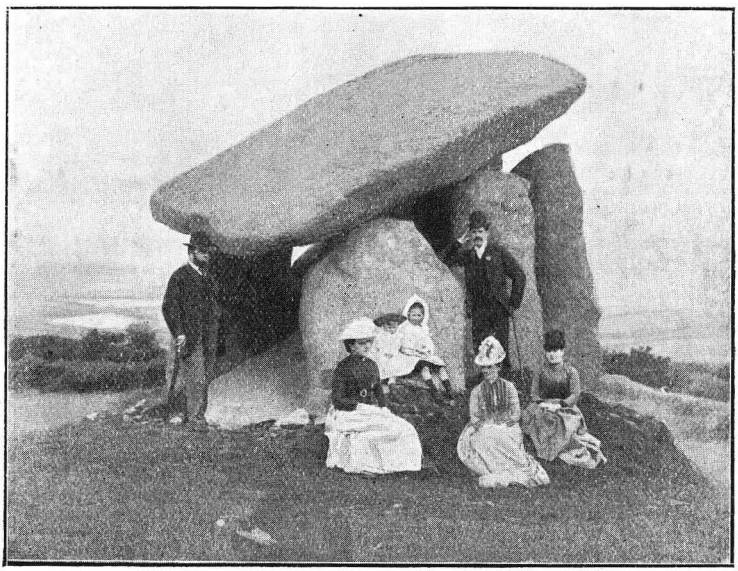

FIG. 1.—THE TREVETHY CROMLECH, NEAR LISKEARD.

that in the granitic pile of the Cheesewring and its companions around of lesser size we have noble specimens of natural monoliths the origin and mode of formation of which offer subjects worthy of the investigation of geologists and students of nature.*

The Cheesewring.—Rising from the granitic moorland about seven miles north of Liskeard in the centre of Cornwall, is the

* The Cheesewring is figured and described by the Rev. W. Borlase, F.R.S., under the name of "The Wringcheese," and he gives its height as 32 feet from the ground. He appears to have considered it as partly of druidical origin. (*Cornwall*, vol. ii, p. 165.) The Cheesewring is also figured (Fig. 190) and briefly described by Lord Avebury, *Scenery of England* (1902).

remarkable pile of rock known by this name. It is the largest of several tors of similar granitic material, standing upon a platform about 20 feet above the general surface of the

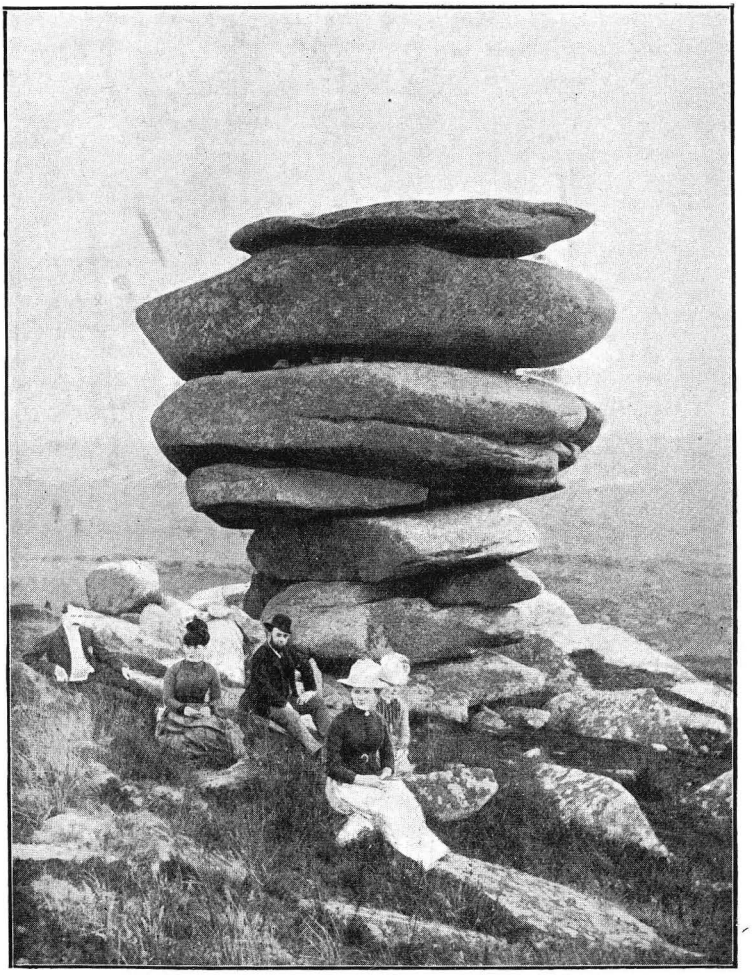

FIG. 2.—THE CHEESEWRING, NEAR LISKEARD, CORNWALL.
From a photograph by Mr. W. H. Huddy, Liskeard.

moorland, and owing to its form and position has given rise to much speculation regarding its origin and mode of formation.

It is mentioned in Woodward's *Geology of England and Wales* as one of the tors near the granite quarry from which the stone used in the construction of the London Docks and Westminster and Waterloo Bridges was obtained.*

To turn from the geological to the popular idea of the nature and origin of the Cheesewring, we have only to quote the views of the late Mr. Wilkie Collins in his entertaining narrative of *Rambles beyond Railways*, written half a century ago,† which is amusing and instructive as indicating the crude ideas which prevailed on such subjects at that time. Discarding the druidical theory advanced by "certain learned men," to wit, I presume, Borlase and those who adopt his views, he proceeds to give what he considers to be the correct geological explanation of the origin and mode of formation of this natural monument. According to his view of the subject it is assumed that the Cheesewring and all the adjacent upstanding masses of stone "were once covered, or nearly covered, by earth, and were thus supported in an upright position; that the wear and tear of storms gradually washed away into the valleys all the earth from between the rocks, and then left such heaps of stones as were accidentally perfect in their balance on each other to stand erect, and such as were not, to fall flat on the surface of the hill in all the various positions in which they now appear." In this account of the formation of the Cheesewring and similar tors we seem to have an illustration of the proverb "*ne sutor ultra crepidam.*" Mr. Collins was a writer and novelist, but not, I fear, a geologist; and hence the amusing attempt to explain on geological principles the origin of the Cheesewring and similar Cornish tors. In fact, it will be observed that he starts with the assumption that these isolated rocks were in existence before being "covered with earth"; but their origin still remains to be explained. Mr. Collins, however, deserved credit for recognizing that the Cheesewring is a natural monolith, and not to be classed with the dolmens, or cromlechs, such as that of Trevethy, which has been erected at a short distance to the southward, near St. Clair's Well.

It is now time that I should proceed to describe the Cheesewring, and discuss its origin and mode of formation—a task by no means easy, and which cannot be done without taking a

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* 2nd Edit. (1887), p. 575. De la Beche has omitted reference to it in his standard work, *The Geology of Cornwall, Devon, and Somerset* (1839).

† R. Bentley (1851).

rather distant retrospect into past geological times. And first as to its form and composition. In form it consists of five disconnected, or partially connected, slabs of tabular granite, large and massive in the upper part, while supported below as on a pedestal by slabs of much smaller dimensions. The total height from the base is, as stated by Borlase, 32 feet, and it rises from a granitic platform, or flattened dome, elevated about 20 feet above the general surface of the moorland. At its base lie large blocks and slabs of granite, and at short distances, several similar monoliths of smaller dimensions. Thus the Cheesewring is conspicuous from a considerable distance over the moorland to the south; and just under the south side of the tor is the large granite quarry to which reference has been made above. In this country of remarkable works of ancient art, such as standing-stones, old crosses, druidical circles, and dolmens, the Cheesewring rises pre-eminent as a conspicuous work of nature.

Composition and Mode of Formation.—In the endeavour to arrive at some theory regarding the mode of formation of the Cheesewring and similar isolated granitic masses, we get some assistance from a view of the face of the quarry which has been opened near its base.

The whole mass consists of largely crystalline grey granite; and on observing the wall of rock which has been cut back almost perilously near to the base of the Cheesewring, it becomes clear that the rock belongs, as regards its structure, to that variety known as "tabular granite." In the upper part of the wall distinctly horizontal "planes of cooling" are seen to have been developed, giving the mass a stratified, or bedded, appearance. Granite with similar tabular structure is not uncommon. I have seen it myself in the Mourne Mountains in Ireland; but the planes of division are sometimes inclined to the horizon. De la Beche and Dr. Boase have recognized the structure in other parts of Cornwall and Devon, and have pointed out how this structure gives rise to the formation of tors or carns as on Dartmoor.* Lord Avebury has also pointed to this structure in the Logan Rock on the Cornish Coast.†

Planes of Cooling in the Granite.—We have now to inquire, what do we mean by "planes of cooling and solidification in

* Report, p. 163. Similar tors have been developed on Kinder Scout in the massive beds of millstone grit, which have a composition similar to that of granite, though of course of entirely different origin.

† *Scenery of England*, p. 432.

granite"? Numerous observations amongst rocks of igneous origin have shown that when such planes have been developed they assume a position parallel to the outer surface of the mass, whether this has been the atmosphere, or an envelope of previously existing rocks into which the molten mass has been intruded. In the case of Devon and Cornwall the granite has undoubtedly been intruded amongst rocks of Devonian and Silurian age, and may not originally have reached the surface of the ground; or only at rare intervals. This is a point on which we cannot speak with certainty; but of this there can be no doubt, that such a rock as granite, coarsely crystalline in structure, could only have been consolidated from a molten state with extreme slowness; which would be the case if it was overlain by large masses of previously existing stratified rocks, or by outer portions of its own mass which have been removed from off its surface by denudation. Molten masses which have been extruded at the surface of the ground cool and consolidate with comparative rapidity, and are consequently vitreous, micro-crystalline, or granular in structure, although of similar chemical composition to granite itself. Of such we have examples in the "dolomite" of the Puy de Dôme and other volcanic hills in Central France. This rock has cooled and consolidated at the surface of the ground; and as a result it is micro-crystalline or granular, though containing small crystals of mica and other minerals. But it is owing to an original envelope, or covering, of solid material, whether of stratified rocks or of part of the granitic mass itself, that the structure of the granites of Cornwall and Devon is coarsely crystalline, the crystals of felspar, mica, and quartz being well developed; the quartz, however, generally occurs as the paste in which the other minerals are enclosed.

Evidences of Denudation.—The evidence that denudation has taken place to an enormous extent over the Devono-Cornish area meets us at every step along the coast, and especially the north coast of this great promontory. Wherever we examine the coast-cliffs along the western shore fronting the Atlantic, we observe the strata rising from the waters, generally at high angles, or contorted and folded in a remarkable manner, as at Boscastle, Bude Bay, and Clovelly. But whatever may be their position, they invariably terminate upwards along a nearly horizontal or slightly inclined plane extending inland from the coast, and when viewed from a distance, looking almost like a horizontal line against the horizon. This upward truncation of the strata, bed over bed, means, of course, that they were once

continued into what is now the air; these vanished masses having been planed off the surface by the waves of an ocean which once swept over the existing land when at a lower level than at present, leaving an inclined plane surface known as "a plain of marine denudation."* This term was first proposed by its author to the surface of the Silurian district of Cardiganshire, which, though consisting of alternating hills and valleys formed of inclined Silurian slates and grits like those of Cornwall, terminate upwards along an *imaginary* plain surface, sloping gently from the interior to the sea-coast. (Fig. 3, p. 147.) To this subject we may well give our attention for a short time, as it is one of great physical interest.

Plains of Marine Denudation.—Everywhere in the south and west of England and Wales we are confronted by plains of marine denudation, a term first employed by Sir Andrew Ramsay.† Let me illustrate what I mean by this term. Supposing the British Isles and Western Europe to be elevated from 100 to 200 fathoms above their present level as determined by the surface of the ocean, they would be found to have a fringe of varying breadth consisting of a gradually sloping surface bounded inland by the coast cliffs and breaking off in the direction of the ocean, by an abrupt declivity (or escarpment) leading down to the abyssal regions. This gently sloping fringe, sometimes 20 to 100 miles in breadth, would, therefore, constitute a plain, and as it was formed by the ocean waves and currents, ever wearing back the coast, breaking down the rocks and reducing the surface of the land to that of the surface of the ocean, it would constitute a plain of marine denudation.‡ This plain would at intervals be crossed by river-valleys descending from the interior lands into the abyssal ocean below. Such plains are also represented on the land, wherever the land has been, at whatever period, below the

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* The name proposed by the late Sir A. C. Ramsay in his work, *The Physical Geology and Geography of Great Britain*, 5 Edit., p. 497 (1875).

† *Ibid.*, p. 497. This term in the abstract might be written "planes of marine denudation"; but in the concrete as applied to special features of the landscape the term appears the more correct.

‡ The process of formation of this plain, constituting as it does the land margin of the Great Continental Platform, is admirably illustrated in the picture of Widemouth Bay, Bude, in Cornwall, given by Lord Avebury in his *Scenery of England* (p. 126), where the highly tilted and contorted strata of Devonian age, as seen in the coast cliffs, are planed down by wave action to a general surface sloping gently seaward, and laid bare at ebb tide.

surface of the sea; and, as, I have said, there are frequent examples of these once-submerged plains, as, for instance, in Cardiganshire, of which the accompanying figure taken from Sir A. C. Ramsay's work is a representation (Fig. 3). What

FIG. 3.—SECTION TO ILLUSTRATE STRUCTURE OF A PLAIN OF MARINE DENUDATION.

Generalized Section across the Silurian Strata of Cardiganshire (after Ramsay).

Phys. Geo. and Geog. of Great Britain, 5 *Edit.*, *p.* 497.

is specially remarkable is the fact that the plains are quite independent of the nature and position of the rocks; they are carried across hard rocks and soft, highly inclined or contorted as well as nearly horizontal strata; though of course the harder rocks have withstood the marine action better than the softer. Thus in the valley of the Avon at Bristol we see the solid beds of Carboniferous limestone rising in succession from below each other, but terminating abruptly at the sky-line in a flat surface or plateau, through which the river-valley has been eroded by the action of the river itself in the course of ages. The Carboniferous, Devonian, and Silurian formations of South Wales, generally highly inclined, terminate along a nearly level sky-line as seen from the Gorge of the Avon to the north. Further to the east we have the remarkable table-land of the Cotteswold Hills of Gloucester and Somerset, breaking off towards the west in an elevated escarpment rising above the vale of the Severn. Finally, when we come to Cornwall itself, the subject of more immediate interest, we find that the surface of the country resolves itself into a gently sloping table-land commencing in the coast cliffs, penetrated by numerous valleys descending into the sea, and composed of various strata of Carboniferous or Devonian age, which have been highly tilted, or thrown into numerous folds and flexures, but which break off along the sky-line, the once continuous portions having been as completely swept away as if they had never existed. But we have only to attempt to restore the vanished strata along the lines of dip and flexure to become convinced that thousands of feet have been denuded from off the existing surface of the country.

It is clear from what has been said that this erosive action has been effected by some agent acting horizontally, breaking down and carrying away the materials which once overspread

the existing surface; and when we ask ourselves—what agent in nature is capable of such powerful action, we can only reply, the waves of the Atlantic Ocean, impelled chiefly by westerly winds, acting on a gradually subsiding land area, aided by the tidal and other currents which take up the fragmental matter and carry it away to the outer depths of the ocean to form new strata.

Now, the granitic areas of Devon and Cornwall have, like those formed of stratified materials, been subjected to the agency of denudation, so that the present surface of these areas is altogether different from the original surface after consolidation. Much material has been eroded and carried away since consolidation at former periods, chiefly at the close of the Palæozoic or Primary period. During the cooling and crystallizing process there may have been portions of the mass protruding into the overlying rock further than others, or they may have been of firmer consistency, and such portions would (*cæteris paribus*) resist denudation to a greater extent, and remain conspicuous above the adjoining areas. All this is conceivable; but I do not pretend to precision in a matter so enveloped in difficulties and obscurity. It is permissible, however, to suppose that on the retiring of the sea by reason of the elevation of the land, such more solid masses would be left as isolated pillars, or sea-stacks, to the action of the atmospheric agents, whether frost, rain or wind; disintegration would ensue, and decomposition along the joint planes. In the case of such granitic tors as the Cheesewring, where, as we have seen, there is a tendency to split along horizontal planes, the ultimate result would be to produce such natural monuments as the Cheesewring itself, and its companions of less elevation.

Such is the explanation which I venture to offer for the formation of this fine granitic tor. Some of the points in the reasoning are inferential; others are capable of demonstration, such as the extent to which denudation has acted over the surface of the country, removing perhaps thousands of feet of strata and rock which once were superimposed on those now forming the surface. Of this denudation we may say, when standing on the surface of the moorland in sight of the Cheesewring, "*Si monumentum quæris, circumspice.*" Of its kind, few more noble monuments can be found in England.

Discussion.

Dr. Logan Jack, F.G.S.—Professor Hull has given us a most interesting and suggestive explanation of this remarkable natural

monument. He has interpreted it to us by means of one of those "sermons in stones" of which we constantly hear, but of which we do not very often understand the language. Professor Hull is, however, an adept in that language, and his explanation, I need hardly say, is singularly clear and explicit. The great lesson which has been taught to us undoubtedly is that of "denudation."

Shakespeare's great mind, I believe, grasped the whole subject of sub-aerial denudation when he wrote, "Time makes mountains level, and the continent, weary of solid firmness, melts itself into the sea." He saw the whole process going on—how a plain, subject to sub-aerial denudation, might become carved out and utterly worn away till the whole mass would be reduced, as it ultimately might be reduced, to the level of the sea, unless there were some compensating elevation.

Very much has been said about the dependence of features of scenery upon geological structure, and no doubt those features do depend, in a remarkable degree, on geological structure; but one of the most forcible lessons brought before us by this "sermon in stones," which has been interpreted to us to-night, is, if I may say so, how independent scenery can sometimes be of geological structure. You would naturally suppose that these contorted strata (as drawn on the blackboard) would form, when they were bent into a saddle, a valley, and when they were bent into anticlinal axes, a hill; but there is a good example in the lower part of this small diagram of the reverse being the case, where a little valley is carved out on the top of the anticlinal axis. That exemplifies the *independence* of the scenery to some extent. At the same time there may be a deeper meaning in it, and there may really be dependence. For instance, it is well known that the tops of anticlinal axes are more or less shortened, like the reefs of Bendigo and some of the Australian fields. These shortened anticlinal axes may have given direction to the forces which eroded the valley in that instance, though the contrary appears to be the case.

Then, again, in the section of the Avon drawn on the board it is seen how the valley is carved out of the escarpment at right angles to the strike of the strata and the level summit of the cliffs which is made by the truncated ends of the strata of limestone.

As to the Cheesewring, it is a very remarkable and picturesque example. There are many such, but in England there are, perhaps,

few that are more remarkable than this. The origin of them is always mysterious, but this explanation given by Professor Hull seems to be very reasonable and feasible. In general, though, I have observed, and it has been my business to observe, in Australia and the East a good many mining operations, and in those frequently tunnels are driven and shafts are sunk in the decomposed granite. Invariably it is found to be the case that decomposed granite always contains some harder portions which are met with in a way which I am quite unable to explain.

I should like, before I sit down, to ask Professor Hull about the Logan Rock mentioned in his paper. My acquaintance with England is somewhat old, and I have forgotten some of the things I have read; but my impression is that the Logan Rock was, for a long time, understood to be an artificial monument—that it was a rocking stone, in fact, balanced finely upon a point, and that it was dislodged from that point by some mischievous persons a good many years ago. I would like to ask Professor Hull if the Logan Rock to which he refers is the one of which I have a vague recollection.

Mr. DAVID HOWARD.—I think that everyone who knows Devon and Cornwall will appreciate the extreme interest of this paper, not merely from the question of the particular Cheesewring it deals with, but the light that it throws on the whole geology of those counties, or, to use that dreadful expression, their "physical geography." Nothing strikes me so much as the dulness or flatness of the upper level of Cornwall, and the wonderful beauty of the valleys cut out in the lower portion at a much later period. Denudation has been at work in two such totally different ways, a contrast which I think of great importance, because very often, without a special knowledge of geology (and a little knowledge of this branch of science, like others, is a dangerous thing), it leads one to suppose that we must look only for denudation which is at work at the present day. In Devon and Cornwall, and especially in Cornwall, there is an old sea-bottom, so to speak, and you see the rocks standing up by themselves, leaving a comparatively flat floor, and in the lower portion you see the effects of the rapid running water flowing down from a higher level and eroding the valleys on its way to the sea.

As to why granites are sometimes harder and sometimes softer, we are met with the great problem how granite came to be granite at all. The construction of its crystals is due not only to cooling,

but, I think I am right in saying, the presence of the vapour of water. It evidently must have been brought about under pressure, or it would not have been granite at all.

Rev. F. A. WALKER, D.D.—On one page of the paper the learned lecturer states, "More solid masses would be left as isolated pillars, or sea-stacks, to the action of the atmospheric agents, whether frost, rain or wind." I suppose we have plenty of examples in the Scilly Isles and portions of Land's End of those pillars as the result of centuries of atmospheric action and corrosion, and I would ask Professor Hull if he regards the brine as a potent agent in the decomposition of granite; because I know in very distant ages we have an old authority as to the decomposition of granite by brine. It occurs in Herodotus—ἅλμην ἐπανθέουσαν ὥστε καὶ τὰς πυραμίδας δηλέεσθαι. Herodotus, Euterpe, Lib. II, chap. 12, "efflorescence of brine causing the very pyramids themselves to be corroded,"—and he refers to the variegated Ethiopian stone (red granite) which forms a portion of the casing of the second and the whole of that of the third pyramid. I would say that I noticed some curious effects of that corrosion by brine in several objects I brought with me from Upper and Lower Egypt years after. The saltpetre crops up, and in the specimens I have brought this saltpetre was at work for a long time after, rendering the labels illegible and reducing the trays in which the geological specimens are placed to pulp, and it is indicated in this ancient massive monument by the Father of History.

A VISITOR.—May I ask if there is any law or regulation for the preservation of geological relics like these at all?

Professor HULL.—I should hope that the local County Council will have the preservation of the natural and artificial monuments under their care. That is all I can say. Of course we know that Stonehenge has now, after many centuries of neglect, been put into a state of safety.

The CHAIRMAN.—Before calling on Professor Hull to answer these questions, may I ask a question myself? May I ask whether a stone is made of exactly the same material as the ground underneath —*i.e.*, as to a stone not brought from a distance—and are the planes of cooling in the Cheesewring parallel with those in the granite rock beneath it?

[The Chairman illustrated his meaning on the blackboard.]

Professor HULL.—Very much so, yes. I am much pleased with the discussion, and I am especially pleased that Dr. Jack is able to coincide with the views I have put forth.

What he says with regard to the dependence of natural physical features and independence is perfectly true, and it is sometimes very difficult to know why we have both. In such a case as the table-lands of Cornwall and Devon, the independence of the features is a matter which we know is very remarkable and originates from the enormously powerful action of the ancient ocean during the times of the subsiding and emergence of the land. On the other hand, we have features such as those of the Cotteswold Hills, not so very far off, in which the dependence of the features is capable of explanation by the character of the strata. For instance, in the case of the Cotteswold Hills, we have first the plain of Gloucester, and then it gradually rises in *this* way [*explaining on the blackboard*]. Beyond the escarpment of the Cotteswold Hills we have another plain, the upper plain being formed of Oolite limestone; the whole plain of Gloucester being formed of the Lias clay. So that the dependence of the escarpment of the Cotteswold Hills is clearly due to the superior hardness of this mass of limestone, which is about 250 feet and 300 feet in thickness, superimposed on the soft shales and other strata on which it rests. This limestone was originally covered over by newer strata to a height we do not know; but what remains of this table-land is the result of a horizontal denuding agency when exposed to the waves of the sea and subsequent subaërial erosion.

Then we have a second plain of marine denudation in this valley of the Severn and the plain of Gloucester, by which the strata of the Cotteswold Hills have been eroded back from their original margin. So in this case we have a repetition of the effect of the dependence of the conditions of the strata for their physical features and independence in such cases as those of Devon and Cornwall.

Now Dr. Jack does, I think, very clearly indicate the difference between denudation which produces a plain surface and denudation which produces valleys, and I have been endeavouring for many years to maintain that you cannot have a great plain of strata, more or less elevated, without bringing in the action of the ocean. On the other hand, the valleys, as everyone admits, are the result of the erosive action of running water. But there are geologists in the present day who will not admit that these islands were submerged

under the ocean at any recent period at all, and they refer all the escarpments and table-lands and plains to the agency of running water.

Lord Avebury, in his volume to which I have referred, and strongly recommend every one to read, goes very near holding the same opinions as myself; but he does not go quite so far, I think. He puts, perhaps, more stress on running water in forming escarpments than I am disposed to do; but at any rate we are very nearly in harmony on that subject.

Dr. Walker referred to the sea-stacks rising from the sea. Of course as we approach the coast of the British Isles from the outer ocean we can often, over the area formed by the Cortinental Platform, see these stacks. But sea-stacks and islands are really harder portions of the original strata which the sea had not had time to wash away. Ultimately, I suppose, the sea will level down most of the sea islands and sea-stacks that bound our coast; but it must be a matter of time.

Mr. Rouse and Colonel Alves referred to the existence of water in granite. I have examined under the microscope a good many sections of granite, principally from Ireland, and in almost all cases the silex or quartz of the granite was found to contain minute cavities filled with liquid. They are exceedingly small, and it is only in the quartz that these cavities occur, not in the felspar or in the mica. The explanation of this seems to be that the quartz is generally found to be non-crystalline in form. There is a crystalline structure (as it polarizes), but the form of crystal is not developed as in the case of mica and felspar; and the explanation is that the quartz was the last of the three minerals to consolidate. It had been kept in a pasty condition by the presence of water, and, no doubt, water containing carbonic acid, which must have been in a state of highly superheated steam at the time the granite was in the course of consolidation. Thus the crystals of mica and felspar had time to form and were embedded in this paste of quartz (with fluid cavities) which ultimately, as time went on, became solid.

That is the explanation I venture to offer for the remarkable phenomenon of the appearance of acid water in granite.

Dr. Jack put a question about the Logan Rock near Land's End. I have not myself been there, but the Logan Rock which is described by Wilkie Collins is a large monolith, so nicely balanced on its floor

as to be easily moved backwards and forwards. Some years ago a daring ship's-captain and his crew landed and displaced the block out of pure mischief, to the great indignation of the inhabitants, and the captain was obliged to replace the stone in its original position at his own expense, which was considerable.

I think, Mr. Chairman, I have now replied to the questions, as far as time and ability permit.

The Meeeting then adjourned.