Dr. Voelcker states that these phosphatic nodules vary much in composition, and that the average examples which he analysed are not so valuable as those in the Upper Green-sand at Cambridge, which generally contain 58 to 61 per cent. of phosphate of lime; but it is possible that some bands at Sandy may turn out to be much richer than others, and, hence, by careful separation, the percentage may be increased in the bulk to 54 or 56 per cent. The top beds are richer than those worked at the depth of six feet. The phosphatic matter contains a great deal of iron, derived, no doubt, from the formation in which they are embedded, and which does not necessarily belong to them, and many of them have a red tinge from this cause. It may be observed, in conclusion, that this new locality at Sandy has only been known for about two years, and has not long been worked.

III.—THE SEA AGAINST RIVERS: OR THE ORIGIN OF VALLEYS.

By D. MACKINTOSH, F.G.S.

IN a former article¹ I endeavoured to show that the more abrupt inequalities of the earth's surface, so far as they consist of escarpments with their associated phenomena, are chiefly due to the former action of the sea. Before proceeding to consider the origin of Valleys, I find it necessary to refer to a statement I made in the last article about Raised Beaches (page 69). My object was merely to show that the preservation of numerous terraces in the Cretaceous districts of Wilts and Dorset furnished an evidence of limited subaërial denudation since these terraces were formed. The terraces to which I alluded, principally occur at comparatively low levels; and that they are raised beaches can, I think, be clearly proved. But this is not necessary, so far as the *present controversy* is concerned; for the preservation of terraces in *gravel* (more easily worn away than chalk, according to the subaërialists), which all admit are either raised sea-beaches, or glacial-lake-beaches (such as those of Glenroy), afford an equally convincing proof of the impotence of rain as a denuding agent.²

Additional Remarks on the Denudation of the Weald.—Dr. Foster and Mr. Topley, in their very learned paper already referred to,³ admit that the gravel terraces of the basin of the Medway, some of which are "*well marked*," consist of "loose and incoherent deposits," which the sea, had it been there, would surely have swept away.

¹ GEOL. MAG., vol. iii., No. 2, Feb., 1866.

² Mr. Codrington, F.G.S., informs me that he has found *made ground* on the brows of several terraces of the class locally called *Linchets*, near Warminster. That the Belgæ or other races may have increased the transverse horizontality of some of these terraces, or may even have formed whole terraces, is easily conceivable; but that the thousands of terraces in the chalk districts of England were all fundamentally of human workmanship, is, I think, a theory involving such a series of improbabilities as to render it credible only to those who assign a most unwarrantable degree of stability to the relative levels of land and sea.

³ Quar. Jour. Geol. Soc., vol. xxi., No. 84, Nov., 1865.

But if these terraces have resisted the action of rain to so great an extent during the immense period required by the river to deepen its bed 300 feet, is it consistent to attribute to rains the power of eating out "the Gault valley," in the neighbourhood, to a depth of 120 feet, and breadth of $1\frac{1}{4}$ mile? Dr. Foster and Mr. Topley dispose of the marine theory in a very summary manner. But I cannot see the force of their objections. (1) The want of corresponding level, all round the Weald, of the foot of the Chalk escarpment, *can* be explained by unequal elevation, especially if several upheavals are admitted; and the fact of rivers flowing in the lowest parts is quite reconcileable with the idea of these parts having been scooped out by the sea, and does not necessarily imply that they were mainly excavated by rivers. (2) With regard to the assertion that the escarpments follow the *strike of the beds*, changing their direction as the strike changes, this remark cannot apply to the smaller bays and combs of the South Downs, the side-cliffs of which often run at right angles to the strike. That the British Isles do not furnish an example of long lines of cliff following the general direction of the strike is no more remarkable than it is that they do not supply an instance of the sea denuding the fractured summit of a series of formations *anticlinally* arranged like those of the Weald district of Sussex and Kent. (3) The absence of shingle or ordinary marine deposits at the foot of the escarpments can be satisfactorily explained, by supposing that they were removed soon after they were formed, as the land rose above the sea; or washed away during a second submergence, if not by the ordinary action of the sea, at least by a debacle, or series of debacles, occasioned by violent upheavals or depressions. The Woolhope valley of elevation in Herefordshire has been denuded without leaving any trace of the denuding agent, and very few would venture to assert that its concentric system of valleys, with only one effective outlet, could ever have been worn down and swept out by rains and brooks¹. (4) As it is quite certain that many changes of level have occurred in the Wealden area since the process of denudation commenced at the *summit* of the Chalk ranges, if not at a greater altitude, any objections to the marine theory founded on the present relative levels of different parts, cannot be regarded as possessed of much force, more especially when they come from subaërialists, whose theory of river-action involves a succession of local elevations.

Denudation of the Malvern Hills.—The Malvern Hills form perhaps the driest mountain ridge in England; and yet this ridge is much indented on its eastern side by valleys and hollows of denudation. Some account of these may perhaps prepare us for forming

¹ Have any geologists yet particularly noticed what the sea is now doing under the chalk cliffs of the Isle of Wight? From some statements in Mr. Whitaker's paper (Quar. Jour. Geol. Soc., vol. xxi, Nov., 1865) I should infer that in many places no deposit is allowed to accumulate under the cliffs, and that the "hard Chalk-marl and harder Upper Green-sand stretch out as a foreshore for some way westward of their outcrop in the cliff," so free from detritus, as to allow their even bedding to be clearly perceived.

a more correct estimate of the limited extent of fluviatile action in valleys traversed by rivers. The smaller valleys of the Malvern Hills were referred to during a discussion at the last British Association Meeting; and a hint was then thrown out that they may have been formed by streams arising from melting snows towards the close of the Glacial period. But that they could only have been formed by the sea will, I think, appear from the following considerations:—Their lower entrance is in general narrow, and they widen out very smoothly upwards, until they either graduate into the slope of the nearest summit, or into a shallow pass or col. They sometimes open at the very summit of the ridge, where no stream from the melting snow could possibly have originated; and between the highest ground and the lowest of these valleys there is not sufficient space for a stream to have formed. They are of the same shape with the deeper valleys or passes which at intervals divide the hills

COVES ON THE WESTERN COAST OF THE MALVERN STRAITS.

(such as the valley terminating in a combe behind North Malvern, and the pass leading from Great to West Malvern), only differing from them in extent; and no one would assert that the latter could have been excavated by any torrent of water derived from the very narrow saddle-shaped ridge of the Malverns. Both passes and shallow valleys present clear indications of their having been scooped out by an agency assailing the hills from without, and operating in an inward and upward direction. That the sea was the denuding agent becomes more apparent when we trace the connection between these hollows and the very decided combes which may be seen farther to the south behind Malvern Wells. These smooth hollows have been scooped out in hard Gneissic rocks, composed of Hornblende, Mica, Felspar, and Quartz, and cannot be explained by the waste of softer materials, for here the Trappean protrusions, which, farther to the north, have guided the excavating agent, are nearly if not entirely absent. Of the three combes represented in the accompanying woodcut, one, I believe, is quite

dry. All the water coming from another finds its way through a small spout on the roadside; and although the stream from the third may not make so great a display of its denudating power, in the shape of an artificial cascade, it may be quite as large, and, in the eyes of subaërialists, perhaps as able to scoop out a combe as the last-mentioned. But these "dismal hollows"¹ cannot by any straining of the subaërial hypothesis be satisfactorily explained. All the facts are against rain, frost, and streams. The slopes are protected by a thick and varied covering of vegetation. Their dryness is quite remarkable; and to appeal to the very few small springs, scattered at long intervals along the base of the hills, as denudating agents, would be out of the question. I do not see how the conclusion can be evaded, that these deep hollows point out some of those parts of the western shore of the Malvern Straits which were most exposed to the fury of storms, or the sweeping action of currents. As the geologist surveys these hollows, he may at the same time look across the old bed of the Severn Sea; and recognize in the distant Cotswold escarpment the counterpart of the coast-line on which he stands, with headlands on the one side corresponding in form to headlands on the other, and combe answering to combe, where once "deep called unto deep."

Denudation of the Longmynd Valleys.—From the dry valleys of the Malvern Hills we may find an easy transition to the deep "gulleys" of the Longmynd, in Shropshire. I am not aware of any spot in South Britain to which the subaërialist might more readily lay claim; but even here I think it can be shown that the streams were originally usurpers of the valleys, or that the valleys made the streams, and not the streams the valleys. From the high and comparatively level plateau of the Portway, the main valleys in their general course cut across the strike of the nearly perpendicular strata, towards the pass of Church Stretton, which bounds the mountain on the east. Their directions could not, therefore, have been determined by comparatively yielding strata. The valleys in many parts are very winding, and they could not, therefore, have been excavated by a stream running down so steep an inclination as would have been necessary to give sufficient excavating power; for in proportion to the slope in the bed of a stream, must be its tendency to flow in a straight line.² In the Longmynd, the smaller streams run in nearly all directions, irrespective of hard and soft rocks, and the hollows they traverse are often continuations of intervening cols. Many hollows are dry, or are moistened by a rill so choked with vegetation as to render it scarcely visible. Several streams flow down into the deep valleys along a general inclined plane, without any depression, beyond a few inches, to mark their course; and these are as large as streams which in other places traverse comparatively deep and wide gulleys. The upper ends of some valleys (Oakham Dingle for instance) are large and combe-

¹ Camden long ago called a hollow in this neighbourhood the Dismal Hollow.

² See Mr. Fergusson's Paper on the Ganges, in *Quart. Journ. Geol. Soc.*, vol. xix., Aug. 1863.

shaped, with an abrupt termination. The sides of the valleys graduate into the slopes of the hills, and are uninterruptedly continued around detached hills (Round Hill, for instance), in such a manner as to show that the denudation which spared the hills also excavated the valleys down nearly to their bottom. The level at which the action of the streams commenced may, in some of the larger valleys (Ash's valley for instance) be distinctly recognized, being indicated by a sudden and abrupt increase in the steepness of the declivity on both sides. In the lower parts of some of the valleys, the stream cuts through drift similar to that of the open country. In all instances where the streams debouche into the pass of Church Stretton, which is a continuation of the plain of Shropshire, they fail to cut a channel in comparatively incoherent gravel, though their waters (the Oakham brook for example) flow as swiftly as in some of the upper parts of their courses. While it is difficult, if not impossible, to reconcile all these facts with the hypothesis of subaërial aqueous agency, I think they can be at once accounted for by the undermining and indenting action of the ocean. The gulleys of the Longmynd are mainly winding and ramifying *voes* or creeks, excavated while the mountain, as an island, was gradually, or at intervals, suddenly rising above the sea.

Absence of Correspondence between River-courses and Valleys.—In tracing the courses of the larger streams and rivers of England and Wales, we find, in many instances, a much more striking proof of the pre-excitation of valleys than among the gulleys of the Longmynd. Generally speaking, there is a remarkable absence of correspondence between the size, form, and direction of valleys, and the size, velocity, and the course of the rivers by which they are traversed. A river debouches on a plain through a valley which is an arm or ramification of the plain—the line of escarpment that bounds the plain running up each side of the valley. This valley frequently extends far into the bosom of the hills, and is covered by a continuation of the marine drift that is scattered over the plain. After leaving the valley the river retains as much excavating power as before; but it fails, under equally favourable circumstances, to cut a channel in the plain beyond a few feet or yards in depth. Why, then, give the river credit for having worn down the valley? A river, after flowing through a plain without making much impression in the shape of a channel, suddenly enters a narrow gorge, through which it flows to the sea; or the gorge is merely a breach in a barrier, on the other side of which the river re-enters a plain, where, with unimpaired velocity, it flows only a few feet below the general level. On the supposition of its having formed the gorge, it must have commenced the work of excavation when the level of the plain was at least as high as that of the barrier, and the plain itself must have been worn down by the river. Many considerations prove that the plain could never have been worn down by the river, or its subaërial assistants but supposing this to have been the case, why should the river have made such a wide display of its denudating power on the area of the plain,

and done so little in the gorge? Many river-courses which do not embrace plains, consist of a succession of wide basins and narrow connecting gorges, where the rivers ought to have formed continuous valleys, supposing them to have been the excavating agents.¹ All these phenomena can be easily explained by supposing the plains to have been arms of the sea, the wide valleys or basins inland seas and bays, and the connecting narrow valleys or gorges, straits.

Fig. 1.

Fig. 2.

That rivers have not excavated large valleys of the form represented by Fig. 1 is, I think, evident, not only from the fact that they have done so little on plains, but likewise from the similar form of their *actual* channels in the valleys and on the plains. I cannot see why the channel A, Fig. 1, should not be regarded as the measure of fluviatile denudation as much as the channel B, Fig. 2.

Reserving for a future occasion some additional remarks on the river-courses of Wales, the Lake District, and other parts of England, I would conclude this article by again directing attention to the simplicity of the marine contrasted with the pluvial and fluvial theory of denudation. The latter, regarded as embracing only one period of emergence, requires such a combination of disintegrating and carrying agents, and such a correspondence between local elevatory movements and inclinations in river-channels, to keep its complicated machinery going, and prevent a glut of detritus, as to render it untenable without very strong evidence in its favour, consisting of an extensive collection of instances, and a wide indication of facts; and when we come to connect former with recent periods of emergence, the theory becomes still more entangled. The reiterated and locally-unequal movements, necessary to submerge and re-elevate a given area, accompanied by the increase or obliteration of pre-existing inequalities through the action of the sea, must be sufficient to derange the effects of any former system of subaërial denudation, so as to render a resumption of its operations impossible, and a fresh beginning necessary.

IV.—ON A SPECIES OF LICHAS, AND OTHER NEW FORMS FROM THE LLANDILO FLAGS.

By H. WYATT-EDGELL, 59th Regiment.

IT was publicly stated not long since² that of all the Silurian strata there were no two so closely connected as the Llandilo

¹ Examples of all the above phenomena may be found in the courses of the Ogwen, Dee, Severn, Teme, Lug, Derwent (Derbyshire), Wye, Usk, Avon (Somersetshire), Exe, Dart, etc.

² See Professor Ramsay's Address, 1863, Quart. Journ. Geol. Soc., vol. xix. p. 38.