Fifth, Pentecost Island.—On this island the marks are not so clear, when seen from seaward, but on landing they are noticeable; it has also old coral rock at a great elevation.

The absence of barrier reefs round these islands is a remarkable characteristic; is it due to the gradual upheaval?

The islands have generally a short fringe reef surrounding them. If the above theory is correct, these will, in course of time, form another step of the elevation. The black volcanic rock that shows out from the limestone cliffs at various heights seems to uphold this idea, as this rock must form the base upon which the coral has grown.

NOTICES OF MEMOIRS.

The Drifting Power of Tidal Currents versus that of Wind-waves. By G. H. Kinahan, M.R.I.A., etc.

[Abstract of a paper read before the British Association, Bristol, August, 1875, and before the Royal Irish Academy, Dec. 1875.]

IT might have been supposed that the exhaustive Report on Waves by J. Scott Russell, F.R.S., etc.,[1] should have decided the relative effectiveness of the tidal currents and wind-waves with regard to their drifting powers. This, however, seems not to be the case, if we may judge from the recent paper on The Chesil Beach, Dorsetshire, read by Professor Prestwich before the Institution of Civil Engineers, Feb. 2nd, 1875, and the discussion which followed.

In the Report above mentioned, Scott Russell divides waves into four orders:—To the first of these or *waves of translation* belongs the great tidal wave, while wind-waves, according to that observer, (with a certain limitation) belong to the second order; this limitation being that those wind-waves in the act of breaking on a beach change into waves of the first order. Indirectly, however, the wind forms a different order of waves; for if water is piled up in a "narrow" by the wind, the waves induced are "waves of translation."

Scott Russell also proves that a wave of the second order has little or no carrying power; consequently wind-waves can have little of this, except when running up the beach, they become waves of translation, and even then their action is limited to quite a narrow line. In a tideless sea, wind-waves breaking on the coast-line form considerable and permanent banks, as in the Mediterranean, where the detritus brought down by the Rhone is piled during storms on the neighbouring shores, forming banks and lagoons. Considerable wind-wave action also will be found in fresh-water lakes and in brackish-water lagoons, if in the latter the cross-tides counteract one another; but as far as my experience goes in the seas round Ireland, the wind-waves do very little permanent work if unaided by the tidal currents. If wind-waves did effect permanent driftage, it ought to be apparent on the coast-lines; the direction of its movement corresponding with that of the prevailing winds resolved along

[1] Report on Waves, Brit. Assoc. Report, vol. xiii. 1844, p. 311.

the trend of the coasts. The direction of prevailing winds is always registered by the lean of the trees on a coast-line, Fig. 1; while the course of the driftage is marked by the sand ridges on banks forming the knee-shaped "invers" or mouths of the streams, Fig. 2; the "inver" being shifted laterally in the direction in which the driftage tends. But the lean of the trees and the driftage of the beach are often in opposite directions.

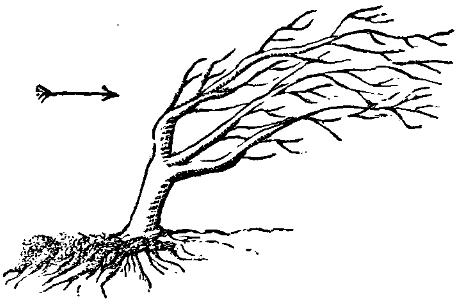

FIG. 1.—Tree bent and growing in the direction of the prevailing wind.

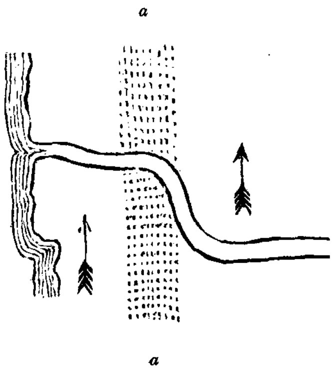

FIG. 2.—Knee-shaped 'invers' at mouth of river, showing the set of the prevailing current.
a. a. Travelling Shingle-beach.

We also find that such a floating body as a ship at anchor always swings with the tide, except in a very excessive gale; and fishermen's nets when they break loose always drift with the tides. So also floating timber drifts with the tide unless it comes so near the shore as to be under the influence of wind-waves, after they have become "waves of translation."

The study of the tidal currents on the coasts of Ireland teaches us that they have little or no driftage power when the tide is on the ebb, even when confined in narrow channels; to this, however, there are exceptions, as the quantity of water flowing out through a channel may be considerably increased by land drainage, thus causing the efflux to be longer in duration than the influx; and in some places the tide runs out of an estuary for hours longer than it flows into it, the efflux being augmented by floods of rivers and the like. It appears also that the driftage is greater during spring- than neap-tides; and that the maximum driftage occurs when the direction of the incoming tidal current is the same as that of the prevailing winds. We also learn that the "set" of the tidal current inshore depends very much on the shape of the coast-line. If the coast-line is straight, the set of the tide along the shore and outside in the deep water will probably be similar; but if it is indented, or islands lie off the coast, back or "counter-currents" and cross-tides will be induced—which form off-shore banks, and thus lead to various complications. Large rivers may also form counter-currents and off-shore banks.

In illustration of these points the author exhibited a series of diagrams to show the way in which, when two headlands project about equal distances from the general coast-line, the secondary currents branching from the main tidal current decrease in power from the headland first touched, while it is not unusual for a half-tide counter-current to set backwards along the shore from the second headland. Also that when one headland projects much further than the other, if the coast-line is formed of soft materials, off-shore shoals usually are originated, and the secondary currents increase in power from the first headland, if it be the longest.

If, however, the longest headland is the second one, and a strait occurs at the end of it, as in the English Channel between Portland Bill and Cape La Hague,[1] the secondary currents increase in intensity towards the strait,—a condition which may account for the peculiar sorting of the pebbles on the Chesil Bank, from Bridport to Portland.

Races formed by the meeting of counter-currents with the main tidal current are always connected with the tail end of an off-shore bank; but whether the bank is due to these causes, or the currents to the bank, it is hard to determine.

An island off a headland seems always to have secondary currents passing it on each side, between which a bank grows from the mainland, the counter-currents much resembling those which would have occurred were the island connected with the shore.

The flow of a large river generally forms a bank or shoal off its mouth at the junction of the river current with that of the tidal current. About this bank the currents run in various complicated directions; at different heights of the spring- and neap- tides—high-water spring-tide currents often running right across it.

In a muddy estuary the affluents of the main channel are nearly invariably deflected up stream, showing that the arrangement of the detritus is influenced more by the incoming tidal current than by the efflux. Such tidal accumulations, however, are greatly modified by the river floods, as a strong freshet will effect considerable denudation while the tide is out. Denudation may also be effected by artificial means, as in the estuary of the Boyne, where, by judicious arrangements, the tidal waters have been made to assume the functions of river freshets.

Scott Russell has shown that at the centre a wave of translation is higher, stronger, and swifter, than at its margins. Somewhat in the same way the driftage of the incoming tidal wave is usually much stronger offshore than it is inshore. This is well known to fishermen, who often neglect outlying fishing grounds on account of the additional labour connected with them arising from the augmented velocity of the tides.

On a steeply sloping beach the driftage solely due to the tidal wave current is conspicuous when there are no waves formed by the wind. Under these conditions some particles of the beach may be

[1] The effect here is also augmented by the increased current in the sea between these two headlands due to the "nodal point" of the tide in the English Channel at Swanage.

observed to travel upwards in oblique lines, formed of a series of curves, while others move in curving lines along the beach.

The following is the usual arrangement in a steeply-sloping beach formed of mixed detritus. The highest spring-tide limits are usually indicated by an accumulation of coarse gravel and shingle. A similar band of coarser shingle in greater quantity being also found near the low-water line of neap-tides. This lower band usually travels along its own level, but some of its pebbles may travel upwards obliquely to the spring-tide line, where they remain until disturbed by extraordinary tides or storms.

This travelling of beaches accounts for the accumulation of shingle on that side of an artificial groin against which the current sets, the larger fragments ascending a beach where the groins are near together, being prevented descending by the groin, while the smaller fragments are withdrawn by the back wash of the waves of translation.

Should two groins be far apart, the materials will be sorted by offshoots from the on-shore waves, so that the large fragments will lie against the second groin, while the finer materials will be deposited behind the first.

Many natural groins produce similar results; but as some of these extend into deep water beyond the margin of the beach, the effects will be different. A beach travelling with the general tidal current will be drawn out into deep water to be carried in obliquely into the next bay. If, however, the bay is long, narrow, and regularly formed, the wash will be directly in and out, and at the heads of such bays larger beaches generally accumulate than in more open ones.

If there are a succession of bays, and the headlands between them are formed of hard rocks, from which shingle is not easily derived, the materials of the beaches will decrease in size from wear and tear till they are eventually composed of fine sand, in the last bays of a series, furthest from the source of the tidal current. This refers solely to the driftage immediately along a coast-line, for there might be a deep-sea driftage of coarse materials striking obliquely on the coast, which would modify the above-mentioned results.

So far the driftage considered was that of the tidal currents. The action of these, however, could be modified or augmented by wind-waves.

Wind-waves, as shown by Scott Russell, have usually no driftage power, but locally they may be waves of translation. Incoming tidal waves augmented by wind-waves proceeding in the same direction are capable of performing the maximum amount of driftage on a coast-line; while if the wind opposes the incoming tidal current, it modifies the operation of the tidal waves or may temporarily arrest it altogether.

Tidal-waves and wind-waves when opposed to each other pile the gravel and sand in ridges on the beach. The axes of these ridges and intervening hollows are at right angles to the direction of the opposing currents, when these have equal force and assume an obliquity when one or the other current has a predominant strength.

If the wind and tidal actions are proceeding in contrary directions, the maximum power of the wind-waves seems to be exerted during the ebb of the tide—especially that of spring-tide—when portions of the bottom are rooted up at depths which are ordinarily undisturbed.

Should continuous heavy gales blow from a direction oblique to the tidal-wave, accumulations of detritus due to the wind-waves will form at one side of bays, while other accumulations, due to the tidal driftage, will be formed at the opposite side.

All these accumulations are of slow growth, taking weeks to form. A gale, however, of forty-eight hours' duration—especially during spring-tides—from a direction coinciding with, or obliquely coinciding, with that of the tidal current, will sweep them all away.

One point, however, calls for notice here, namely, that the accumulations due to the wind waves cannot be dissipated until those due to the tidal current are first removed—the latter replenishing the former as fast as they are removed.

In support of these conclusions, detailed observations on the South-east Coast of Ireland were given at too great a length to be reproduced here, and the author concluded by making the following deductions:—

First. That the driftage due to the incoming tidal currents is always going on in deep water, and also more or less in shallow water.

Second. The driftage due to wind-waves only occurs during gales, and even then is only due to the waves that break on the shores.

Third. That the wind-wave driftage might be prevented from damaging a harbour if a *floating* breakwater were made to cross the direction from which storms proceed, for a fixed one would most likely tend to cause the harbour to become silted up.

REVIEWS.

Bristol and its Environs—Historical and Scientific. 8vo. pp. 475. London and Bristol, 1875. Published under the Sanction of the Local Executive Committee of the British Association.

If the British Association in its annual visits to our larger cities and towns has much to answer for in the diffusion of what some would term Scepticism, and others a spirit of rational inquiry, it is certainly instrumental in bringing before the public a number of facts, and in creating an interest and wholesome stimulus in scientific work.

The book entitled "Bristol and its Environs" is a praiseworthy example of what may result from such stimulus, and if other local executive committees follow the example, we may have in time a valuable series of hand-books.

The geological chapters in this work have been written by Messrs. E. B. Tawney, W. W. Stoddart, and R. Tate, each of whom, apart from other work, has done good service in adding to our knowledge of the local geology. Few districts have indeed been the subject of so many contributions to geological literature as the country around Bristol; and no city can be prouder of one who devoted so much of