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The Evolution of the Hastings Coastline: Discussion
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of the Forest Ridge. Headlands have been eroded, and embayments silted behind shingle banks. A regularized coastline such as this presents none of the variety of deposition forms which it possessed at one time, and which still exists in regions where each inlet or pronounced bend in the coastline gives rise to spits and bars, not yet obliterated by silting of the inlet or blunting of the projection. Here are found no such examples of growing, stable, and eroded shingle spits as occur, for example, on the south coast west of Beachy Head. The shingle foreland of Dungeness has, however, not yet reached a state of equilibrium. It is still extending its point seawards, while Langney Point has ceased to grow, and is now retreating before the attack of the waves.

A study of the evolution of a submerged and transverse coastline like that of the eastern Wealden area affords an excellent preparation for the consideration of coastlines whose topography does not admit of so symmetrical a course of development. Submitted nearly everywhere to a somewhat similar movement of depression at the same period as the Kent and Sussex coasts, the shores of England and Wales have responded in ways as various as their structure and topography to the moulding action of the waves. Certain resistent lengths remain relatively unchanged; some few regions have attained a stage apparently further advanced than that reached by the transverse Wealden coast. Generally the state of development is rather behind that of this region. Each type of coastline presents its own problems—problems which are the more easily solved since lengths in almost every stage of development are available for comparison. The author is at present engaged upon a book, now nearing completion, in which the subject of coastal evolution is considered as applied to the shores of England and Wales.

Before the paper the PRESIDENT said: I have now to introduce Miss Ward, who was a student of geography at the Liverpool University under Prof. Roxby, and a tutor in geography at Liverpool for three years. She has made a special study of coast erosion, and she is going to give us this evening a lecture on coast erosion near Hastings. She is, I think, very shortly bringing out a book upon this subject which will be of great value and interest to us.

Miss Ward then read the paper printed above, and a discussion followed.

Dr. J. S. OWENS: It is with great pleasure that I listened to Miss Ward's paper, as it is very unusual to meet a lady who takes such an interest in this subject and deals with it in such a capable manner. There were a few points on which I should like to touch. One is the projection seaward of the cliffs at the commencement of the present cycle of erosion. I gathered that Miss Ward based her calculations upon a period of about 3500 to 4000 years and a rate of erosion of about 3 feet per annum; this gives about 2 miles projection. I think it probable that the rate of erosion at the present day is very much slower than it was in the period immediately following the commencement of the present cycle. First of all, as Miss Ward has pointed out, the erosion of a headland is much more rapid when there is some place for the material to go to. When the bays were there and unfilled, all the material

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washed away from the headlands was easily disposed of. Again, one of the greatest protections against the advance of the sea is the accumulated débris from the broken-down shore cliffs. The cliffs did not exist in the beginning of the present cycle, but were formed by erosion, and as the erosion pushed them back the volume of material to be moved increased very quickly with the increase in height. It is from that material that the protection comes, and the rate of erosion must bear some inverse relation to the volume of material to be removed per unit of advance. If a high cliff falls there is an enormous amount of material to be moved by the sea before the toe is again exposed. In the case of a low cliff the period is much shorter, all of which means that the rate of erosion is inversely related to the height of the land. I conclude therefore that the rate of erosion at the beginning of the present cycle was was much more rapid than at present, perhaps three or four times as rapid, so that if we take a rate of 6 feet per annum, which I think would be nearer to it than 3, we should double the projection seaward. Miss Ward mentioned a current exceeding 3 knots being uncommon in the Straits of Dover. A current of 2 knots, the velocity she refers to on the bottom, means nearly $2\frac{1}{2}$ feet per second, which is a fairly powerful current when it comes to moving material. I think it is very dangerous to regard any current which is capable of moving material continuously as negligible, because of the enormous periods which are available for transport. It has been shown—I have done so myself by experiments (British Association, 1912)—that the volume of material transported in ripples by a current along the bottom varies approximately as the sixth power of the velocity. The capacity of a current to move material therefore rises very rapidly with increase of velocity. The ripple formation ceases and ripples are swept away at about $2\frac{1}{2}$ feet per second; but even if this current were negligible alone, when the depth of water is such that the waves begin to touch bottom, you have a combination of wave and current action combined. A tidal current which is unable to move a piece of the bottom alone may move it when a wave is rolling past. A current of $3\frac{1}{2}$ feet per second is capable of moving stones and sweeping sand rapidly along without forming ripples. Reference was made in several parts of the paper to the prevailing drift along the south coast being from west to east. A point not always kept in mind in this connection is the fact that when slack water occurs at about mean sea-level the part of the foreshore from that level to high-water mark is exposed only to the flood current. As the water rises, the direction of the current changes at, say, about mean sea-level and continues to flow in the direction of the flood while the level rises to high water and falls again. There is thus a part of the foreshore never exposed to the ebb current, and consequently the ebb could never produce drift on that part. That is one reason why the drift is from west to east on the south coast; another is the direction of the prevailing wind. I think we may take it that erosion of the coast is the normal condition, and that accumulation is abnormal. If you consider a coast, newly formed or otherwise, it always presupposes a gradient seaward, and if there is any movement of the water on such a gradient it will tend to cause a slipping down the slope of the material forming the land; and that is, I suggest, the natural condition. You therefore always have a natural tendency towards erosion, which in exceptional cases is modified by accumulation, such as when headlands are wearing down and being deposited in bays. Generally speaking, I quite agree with Miss Ward's deductions, but there is one point on which I differ somewhat. There is a reference to "inertia" in the growth of a shingle bank across an estuary.

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When a shingle bank grows across an estuary it is due to a continuous supply of fresh material moved along by the operation of oblique waves and currents, and "inertia" applied to such action seems to me somewhat misleading. With reference to the widening of the shingle banks at Hastings, in my experience a widening of a shingle bank always presupposes some obstruction to littoral drift such as may be caused by a headland or groyne. In conclusion, I should like to thank Miss Ward for her excellent paper.

The PRESIDENT: Dr. Evans was not able to be present here owing to illness, but has sent a letter about this lecture which I will ask the secretary to read.

Letter from Dr. J. W. EVANS: I have had the opportunity of seeing a proof of Miss Ward's interesting communication on the Hastings coastline. She contends, I understand, that after the Neolithic depression the coastline of the south-east of England showed numerous bays and promontories determined by the surface contours previously existing in the neighbourhood of the sea, and that these features, whether on a large or small scale, have been subsequently to a large extent obliterated by marine action. She has, I think, amply proved her case by means of a wealth of historical detail, but I doubt whether we can regard the changes that have taken place on this part of the coast as quite typical of those that may be expected to follow such a depression in other cases. The circumstances have been somewhat special. On the one hand, the rocks are comparatively soft and easily broken up; and on the other, the strongest winds, those from the south-west, and the waves to which they give rise, strike the shore at a very oblique angle and carry the beach material rapidly from west to east. In this they are assisted by the flood tidal current that has the same direction parallel to the shore. The fact that the ebb current tends to diminish the effect of the waves is less important, for, as the author points out, it is only present when the tidal level is low. It must be remembered, too, that the destructive and transporting action of water increases rapidly with the velocity, and a short period of violent movement produces far greater results than a longer period of moderate activity. All the evidence shows that it is in periods of high seas and strong tides that the greater portion of marine erosion is effected, and this is nowhere more conspicuously the case than on the south-east coast of England. The work of marine currents must not be despised because they have little action on the sea-bottom under conditions of calm. When the sea is rough and as a result of wave disturbance a considerable amount of material is in a state of continuous or intermittent suspension, a quite appreciable amount of transport will result from even slow-moving currents, and the author very rightly does not leave out of account the eastward drift, due directly and indirectly to the prevailing winds.

Mr. HINKS: I should like to know how it is that the shingle which is being so prominently deposited upon Dungeness manages to escape altogether the Camber sands by Rye, just between Dungeness and Hastings. It always struck me as being very curious that there is a beach of shingle at Winchilsea and a beach of shingle at Romney, and midway between the two is a beach of the very finest sand to be seen anywhere.

Miss WARD: I will reply briefly to one or two of the points raised. As to the suggestion that erosion is nowadays rather slower than it was, I think this is probably perfectly true. I was really more strongly influenced in my conclusion that the headlands cannot have projected very far by the fact that the very small local streams flow out at sea-level, and in the immediate past it is probable the cliffs receded rather more slowly than to-day. Before Hastings

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Corporation constructed its present system of groynes there was a continuous shingle beach from Beachy Head as far as Dungeness Point. Recession is thus probably quicker than in the immediate past, but I quite agree that in earlier days still recession took place more rapidly than now. However, I cannot personally accept the view that the headlands projected anything like 6 or 7 miles as has been suggested by Gulliver, because I cannot imagine what can have happened in this case along the lower courses of the streams. As regards the importance of transport by currents, I am quite convinced of that in my own mind if I rather minimized their importance while speaking. With regard to the eastward drift at Hastings, I think the beach is often only exposed to the current of the flood tide which moves towards the east while the tide is rising and sinking above half-tide level. I have found it a little difficult to follow exactly what occurs inshore, but that is not always what takes place. Sometimes you have the flood current coming from the east and flowing towards the west for an appreciable time. As regards inertia of 'longshore drift, I think I got that idea from the Americans. They gave examples from their own coast which bear out their conclusions that it does possess a certain amount of inertia. With regard to the widening of shingle beaches, every one will quite agree with Dr. Owens in his explanation of this phenomenon. One must, I think, also admit that the widening of the beach may occur simply by the alteration of the direction of shore drift by changes in the coastline immediately to the windward.

I admit I have chosen in south-east England a case giving one of the best examples of working out the development of coastlines. Nevertheless, even on coastlines where conditions are less symmetrical you do get an orderly succession of changes which can as a general rule be followed, and there does exist a fairly thoroughly worked-out scheme by which you can foretell the development of most types of coastline from their original condition to what they may be when some considerable way at least through their period of development.

Referring to the shingle which comes across Rye Bay towards Dungeness from Hastings, you get no shingle until opposite Romney Marsh. You have shingle to the west of Rye Harbour. Beyond that you have a beach of pure sand until you come out to Dungeness Point. The only explanation is that the shingle passes through deep water to the point across the bay. I think no one has ever been able to suggest any other explanation. It must pass through the deeper water and across the bay up to the point.

The PRESIDENT: In this Society we usually go so far afield and treat geography on so large a scale that it is of unusual interest to us this evening to listen to the geography of our own island and hear of it in detail. The point which struck me most was the importance of that increasingly effective geological agent—man. We saw what man has been doing on this coast, and in future centuries of course man will be of ever-increasing importance as a geological agent on the coast of these islands. Men are flocking down to the seaside. We are erecting every kind of barrier along the sea-coast—piers and groynes which must in the course of years very seriously affect the drift of the gravel along the coast. That is a very important agency, and perhaps Miss Ward in her book will look a little into the future. We have to thank her for having put before us so very clearly this interesting subject, and shall look forward with special interest to this book which is about to be published. I am sure you would like me to thank her on your behalf for this most interesting lecture.

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