

15th March 1877.

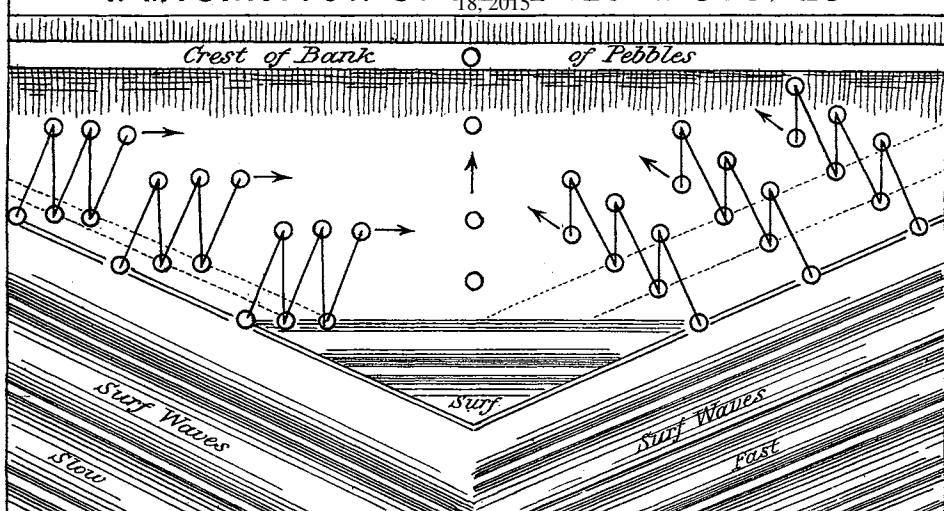
D. MILNE HOME, Esq., LL.D., *President*, in the Chair.

The following Communications were read:—

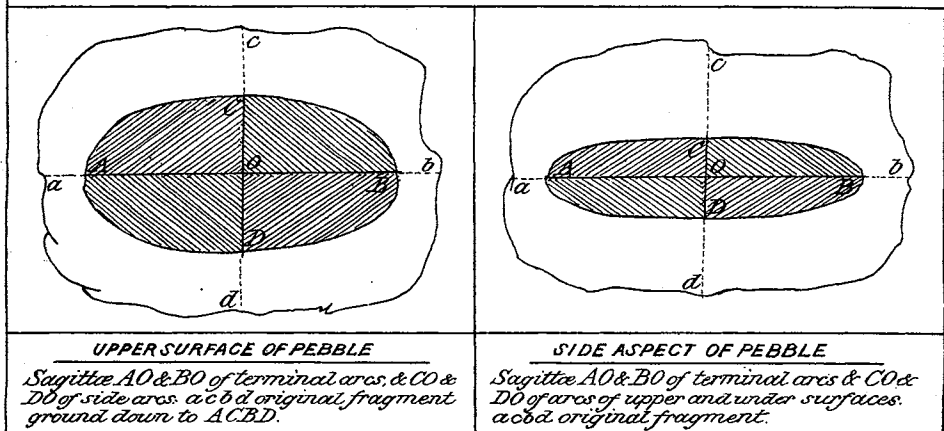
*On Rolled Pebbles from the Beach at Dunbar.* By Dr W. T. BLACK.

Several banks of corroded pebbles and stones were thrown up on the beaches on the east side of Dunbar, facing the Links, by the late winter gales, brought there probably from more distant localities to the east, and from the greater depths of the sea reached by the waves. These illustrate the beginnings of the formation of larger pebble banks as those of Chesil, and Northam Burrows, by the occurrence of an obstruction to the surge of the wave by the perpendicular face of the bank of turf of the Links, causing a bed of pebbles to be deposited at the base in front, and again on its summit behind. The pebbles seem as if their rounded ovoid shape were due to like actions as produce the ovoid shape of a cake of soap after much use, viz., a sliding motion in the palm of the hand, and with an occasional rolling of the mass round. Similarly these pebbles are first rolled up the slope of the bank by the impact of the surge towards the crest, whence again they descend by sliding within amongst themselves, influenced chiefly by the action of gravity, and lubricated by the return wash. The ovoid shape seems to be taken by all sorts of stones, from the soft sandstone to the hard quartzite, and may therefore be independent of mineral composition, or relative hardness of the stone. The sagittæ of the chords of the rounded surfaces may be assumed to be inversely proportionate to the amount of friction employed in shaping them respectively, i.e. when the sagitta is short greater friction would have been exerted than on that face where the sagitta is longer. Sandy layers are to be seen at the bottom and base of these newly formed pebble banks, as well as on the old ones at Chesil, and Northam, and may be taken to represent the *debris* of the friction of the stones amongst each other in the mass above. The larger stones are to be found on the top and off sides of the bank, and the smaller ones on the front slope and nearer the base on the sandy layer. This distribution may be supposed to be due to the difference of force exercised by the fresh impact of the surf going upwards, and its exhausted power when the water travels back, under the influence of gravity alone, when again the larger stones are left behind, and the smaller ones and sand are carried down the slope. The surf wave on the above idea is supposed to strike the bank perpendicularly in front, but should it move against it obliquely, either on one side or other of the perpendicular, then the pebbles will be driven obliquely up the bank towards the

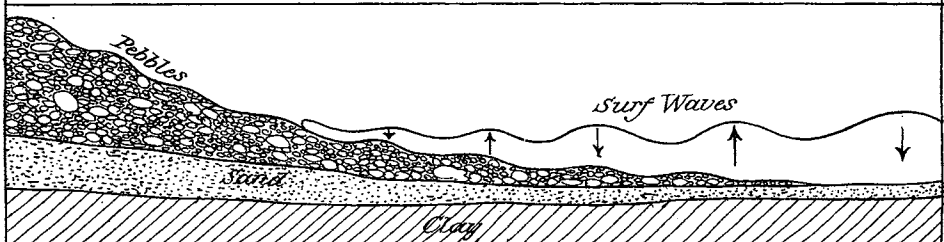
# I. MIGRATION OF PEBBLES & STONES



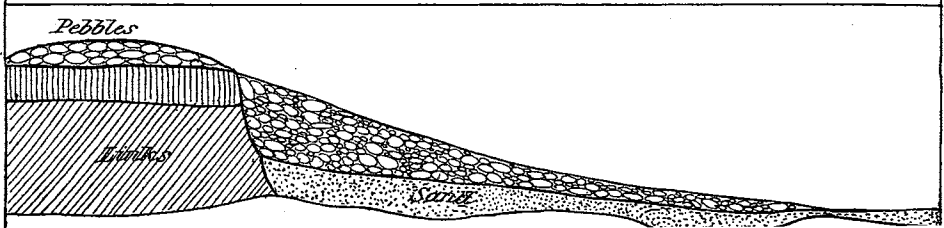
## II. ESTIMATION OF FRICTION ON STONES



## III. ACTION OF SURF ON PEBBLE BEACH



## IV. SECTION OF BEACH AT LINKS OF DUNBAR



crest, but they will probably slide down again so far only, perpendicularly, by action of gravity to a different spot. The difference of longitude of this spot from the place the pebble originally started, may be assumed to represent the distance of its migration along the bank, and the difference of latitude of this spot from the one below may be taken to represent the distance the pebble travelled upwards. As regards the action of the surf on the shore, it may be observed that sea waves in general may be considered to be direct up and down oscillations of the superficial layer of water 6-9 feet deep, reciprocating with each other, as the beam of a balance, so the last wave nearest the shore will plunge its whole weight downwards on the beach. It may be observed that pebble beaches are wavy or terraced on their front slopes, whereas sandy beaches are smooth or of uniform slope, so that it may be supposed that the plunge of the surf digs out a hollow trench of pebbles each time, and launches the *debris* up the slope with its forward surge, and leaves it there. A different effect would take place with the sand, for on it the downward plunge of the surf would have but little effect in dislocating it; but the return wash, on the other hand, would bring it down with it to the sea. Hence sand-hills become levelled downwards by the action of the sea waves, but pebble banks, on the other hand, are elevated by the same means. These rolled pebbles may provisionally be selected, into three types,—(a) oblong ellipsoids, varying from oblong spheroids at an early stage, and due to the rolling action chiefly; (b) flat ellipsoids, varying from flat spheroids, and due to sliding action chiefly; and (c) oval ellipsoids, combining the two former shapes, and due to more prolonged attrition of both rolling and sliding. Measurements of stones—(1.) An oblong ellipsoid of sandstone was found to have its long diameter 4.36 in., middle, 2.88 in., and short 2.77 in., contents 15. cub. in., surface 32.10 sq. in. (2.) A flat ellipsoid of sandstone was found to have its long dia. 3.60 in., middle, 3.00 in., and short 1.18 in., and contents 6.116 cub. in., surface 22.53 sq. in. (3.) An oval ellipsoid of trap was found to have its long dia. 3.55 in., middle 2.57 in., and short 1.55 in., and contents 7.413 cub. in., surface 22.10. sq. in. (4.) An oblong ellipsoid of sandstone had its long dia. 3.46 in., middle dia. 2.28 in., short dia. 1.77 in., and contents 7.31 cub. in., and surface 19.55 sq. in. Therefore the oblong ellipsoids contain relatively the more contents in proportion to their surface, and the flat ellipsoids the less contents than the other forms.

The tendency to these two forms may probably be owing to the original masses having been of a prismatic or tabular shape. The oval ellipsoid would seem to be the form resulting from the longest continued attrition, as it was also assumed by harder stones of porphyry and quartzite. This also may be inferred from the greater likelihood that these stones were of some amorphous shape at first than those of sandstones or other stratified rocks.