

the crest, where they at once plunge over and disappear on the leeward side. But that they do increase Cornish has proved experimentally. »In a few minutes the surface became rippled, and the ripples grew in height, in wave-length, and in regularity, under the constant blast.»\* Supan also says, and rightly: Sobald das Sandhäufchen kaum 1 cm. hoch ist, nimmt die Leeseite die natürliche Böschung an; die Luvseite ist stets sanfter geneigt, an ihr bewegen sich die Sandkörnchen aufwärts, um auf der Leeseite hinabzufallen.»\*\*

The annexed cuts (p. 429) reproduce examples of ripple-marks from the dunes of the western Desert of Lop. They are of divers patterns, depending upon the shape and slope of the dunes, and upon the angles at which the wind impinges, as also upon the magnitude of the sand particles. There exist also limits to the origination of ripple-marks, dictated by the size of the particles. Fine gravel, being too heavy for the wind, forms no dunes, nor fine dust either, for the reason that it is too light to adhere to the surface in a hard wind. The ripple-marks are on the leeward slope long and straight (see fig. 188), and the difference between their two slopes is often in this respect very slight. But a closer examination of the ripple-marks on the windward slope will often reveal the fact, that some of them reproduce to some extent the crescentic shape of the individual dunes, although it is seldom that that formation is found, because these embryonic dunes, the ripple-marks, seldom have an opportunity to develop individually, but are always associated in long rows like the chains of dunes; that is to say their wings coalesce with those of their neighbours. Yet two things there are distinctly noticeable in the ripple-marks that are formed on the windward side of dunes, namely they have themselves a gently ascending windward face and a steep leeward face.

A very soft breeze is unable to make the rufflings of a water surface swell into waves, because friction and the moment of inertia of the water are greater than the force of the wind; and it is only when the wind has succeeded in overcoming the resistance implicit in the water that the rufflings do succeed in growing as big as waves. At first a sudden and violent squall gives rise only to the same sort of fine ruffling of the water; but if the wind continues, these rufflings rapidly assume the dimensions of waves; so that waves thus express the summation of the work the wind has accomplished during a certain period. Dunes also are an expression for the accumulated labour of the wind acting during a certain period; while ripple-marks, on the other hand, may originate and be totally changed in the course of one or two seconds. Any one who has been on the windward side of a dune when the wind has been blowing cannot have helped noticing, how the ripple-marks, especially in squally weather, keep continually changing their shape and character in accordance with the steepness of the dunes and their position relatively to the wind. They put one in mind of the delicate wrinklins of the skin on the inner side of the hand or at the tips of the fingers. Some of the patterns they assume are shown on Plate 51 of vol. I. When the surface of a dune is studied in absolutely calm weather, its surface is always found to be covered with ripple-marks. From them one is able to read directly, as upon a self-registering instrument, from which direction the wind

\* Already quoted on p. 410 above.

\*\* *Op. cit.*, p. 505.