vancing wave-sections (vertical), causing the whole of the wave-crest to curl over against the shore, and forcing it to break over and form breakers. In this latter case it is therefore the increased friction between two different layers of water that gives rise to the pouring over of the crest of the wave. I several times observed the same thing in the Tarim: for instance, when the river was flowing towards the east and the wind was blowing from the same quarter, there arose small waves, with steep transverse crests, which broke over and, even when the wind was not very strong, were tipped with white spray. In consequence of the current these waves were however almost stationary. But breaker waves occurred also even when there was no wind, for instance where two branches of the river met, each flowing with a swift current.

Since then increased friction, that is to say the arrest of the under side of the water, when taken in vertical section, in waves of any and every height gives rise to breaker crests, we have precisely the same phenomenon that we find in drift-sand. In this the friction between two layers of sand is always immensely greater, and consequently even the smallest dune-wave is forced to pour over, because the sand rolls down its leeward side, exactly as the water does. In the sand however no bottom current is needed, and the depth of the 'sand-sea' is immaterial; for friction is under all circumstances present, and an under layer of sand, even though lying close beneath the surface of the dune, always performs the same function that the bottom of the sea does for the wave. Sand-waves therefore always form breakers and rollers, so that the only thing with which dune-formations can properly be compared are the breakers of the sea, or generally over-pouring wave-crests. It is therefore improper to compare them with ideal wave-movement and its orbital paths. The orbital paths of breakers are as little cycloidal as are those of the sand, and in their case a water-particle, swinging in a vertical plane, does not return to its point of departure, but, like the sand-particle, simultaneously advances a short distance in the direction of the impelling force.

Both in water and in sand a similar transportation of material takes place under yet another form. Theoretically the effect of a constant wind blowing upon a sand-field is to sweep it away down to the very last particle of sand; and this would also follow practically, were it not that fresh sand, produced by disintegration, is constantly being brought up by the wind. In this process of the forcible removal of the sand-field the formation of dunes constitutes one phase, or a phenomenon that is intimately related to mass-transportation, because the agency that effects the removal of the sand is just this of the periodical revolution of the sand. How plainly the same phenomenon is repeated in the ocean! Krümmel says upon this: »Es ist daran festzuhalten, dass die Triftgeschwindigkeit jedenfalls bei starken Winden grösser wird, als bei schwächeren, trotz der Wellenbewegung, die ja schon bei sehr geringer Windstärke sich einstellt. — Aus den Beobachtungen der Seefahrer ergiebt sich sogar, dass die 'turbulenten' Bewegungen an der Meeresoberfläche bei gleichbleibender Windstärke nur eine vorübergehende Durchgangsphase der Wellenbildung vorstellen, dass vielmehr bei 'ausgewachsener' See das Überfallen der Kämme sich vermindert oder gar aufhört. Dann aber dürfte jedenfalls die Trifterscheinung sich ganz normal vollziehen.»*

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* *Op. cit.*, p. 349.