plants, and mostly in the foliage leaves, so that creeping insects satisfy here their need of food, and do not trouble themselves about reaching the flowers higher up, and thus these remain protected from their visits.

"From the foregoing obervations," says M. Kerner, "it will sufficiently appear that the relations of plant-form to that of animals living at the expense of plants are far more manifold than has hitherto been supposed, and that especially numerous formations in foliage-leaves and stem are so far of biological significance that by them protection is afforded to the flowers against the prejudicial visits of certain animals. Where the attacking animals are absent this defence is also, naturally, useless, and therefore all these formations are properly to be regarded as means of protection only for those plant-stocks which occur in their original region—in the region where the species to which they belong has arisen. In another place they are perhaps not means of defence; indeed they may even be of disadvantage, or their formation there is at least something superfluous, not in the economy of the plant, and as a matter of course, these disadvantageous, because not economically organised plants, when they come under conditions which are not in harmony with their form, are driven out of the field by competitors that are more advantageously organised.

"If, for example, a plant species comes, in course of its migrations, into a region in which it is exposed to other attacks, or if the external relations in the place where the species arose (and with which it was formerly in agreement) are altered, it may become more and more rare, and gradually quite die out. Among these changes of external relations, however, are to be understood not merely changes of climate; a not less important part is played by the changes which occur in the animal world in a particular region. Apart altogether from changes in the extent of distribution of animals, the animals vary as well as the plants, and individual varieties, which occur with new characters that are advantageous relatively to given external conditions, may become the starting point of new species. What is of advantage, however, to the animals which attack the plants, constitutes, as a rule, a disadvantage for the attacked plant, and it is therefore not only possible, but in course of time it has actually often happened that in consequence of the multiplication of an advantageously organised animal form in a certain region, some plants in this same region having their flowering function destroyed, and their formation of seeds hindered, have disappeared gradually from the scene.

"While, on the one hand, the dying out of certain species with altered external relations, is at once explained by changes in the attacks of animals, the same relations, on the other hand, afford an explanation of the phenomenon, that under similar external conditions, plant species, which, with reference to other characters, are classed under the most different genera and families, do yet in certain formations agree with each other. Only the advantageous forms can maintain themselves, and only those individual varieties which appear with characters that are advantageous with reference to the conditions presented by the locality and position become the starting-points of new species. Since, however, the creation of new species in this way may occur in the most different plant-families, it is explicable that we find, *e.g.*, in one floral region, very many species of the most different stocks guarded with prickles, in another floral region such species furnished pre-eminently with flowers very rich in nectar, and that often even the character of the whole vegetation is determined by the preponderance of plants with like formations. Owing to the fact that the variety of the means of protection, as well as of the means of attraction is very great, and that through formations of the most different kind the same result can be reached, this conformity is again, of course, greatly limited. Indeed, precisely by this circumstance that, against the same prejudicial attacks, very different formations may serve as equally good means of defence, is the phenomenon explained that frequently several species of a family occur beside one another, without entering into competition in this relation, because the species, each after its own fashion, possess equal advantages."

THE ACTION OF THE WINDS IN DETERMINING THE FORM OF THE EARTH[1]

IN view of the most recent discoveries in the region of physics, especially with regard to the nature and properties of forces, it became necessary *eo ipso* for dynamical geology to give up as unsatisfactory the division of geological forces into "igneous" and "aqueous," and to substitute a division of them into "primary" and "secondary"; of which the former explain all the motions which we observe on and in the earth, according to their origin and nature; while the others—one might call them "agencies" to distinguish them from the first—would teach us what and how great changes in the figure of the earth's surface are produced by the bodies so moved, through reciprocal action on each other. Sensible of this inevitable reform in dynamic geology, the author of an essay entitled "The Action of the Winds on the Configuration of the Earth," sought to call attention to the gaps hitherto existing in physical geography, and especially to show what a mighty and yet hitherto very little observed agent the wind is, considered as one of these secondary geological forces. In the following paper the author offers to the readers of NATURE a *résumé* of his memoir.

It is at once evident and conformable to nature that the winds are to be regarded, in the first instance, as a proof of the unequal insolation at different points of the earth's surface, but, in their direction and variation, they are immediately influenced now by the position of the sun, now by the earth's rotation and the distribution of the solid and the liquid; that the winds are, on the one hand, a product of these geophysical actions, and, on the other, become a special factor, of which not only the meteorologist, but also, in front rank, the geologist, is called on to take account. Since, that is to say, it is purely the winds which determine the condition of moisture of the atmosphere, and have to perform the *rôle* of distribution of rain over the entire surface of the earth, but at the same time, in their constant circulation from the equator to the poles and from the poles to the equator, represent an imposing motive force, it is obvious that to be able to prove and establish more fully their geological *rôle*, one must consider them in this twofold relation; on the one hand as a climatic-meteoric, on the other as a mechanical agent. Accordingly the essay referred to treats, in its first part, of the climatic-meteoric, in the second, of the mechanical action of the winds; while the third part comprehends those actions of the winds which they perform indirectly either in meteorological or in mechanical relation.

More particularly the *First Part* is concerned with the characteristics of the two principal wind systems, the polar and equatorial currents, and with their reaction on those continents and mountain-chains, by which, in their typical course—as is manifest on oceans and neighbouring coasts, especially west coasts, of continents—they are variously disturbed. The equatorial currents here appear as properly the distributors of precipitation, and therefore as the principal factors by which the transporting power of flowing water, or generally the levelling action of water on the earth's surface, is produced. The polar currents, on the other hand, discover a tendency to act contrary to the work of the equatorial currents, that is, to restore the precipitated water in vapour form to the atmosphere, and generally to further evaporation. In view, however, of the fact that not all the water, which by action of the winds is precipitated on the solid land, returns to the ocean or the atmosphere, these two air-currents together appear to be similarly empowered to empty entirely, some time, the immense water-basin of the earth from which they continually procure anew their freight of water, and meanwhile to continuously lower the sea-level, through by a very small quantity, and therefore to take a prominent part in the so-called secular elevation of continents.

These two air-currents, indeed, are not everywhere and always true to the character just given. On the contrary, when they have to accomplish a great work, and especially when a polar current has to rise over a lofty mountain, or an equatorial current

[1] Abstract, by Dr. Francis Czerny, of a memoir of his in the 48th supplementary number of Petermann's *Mittheilungen*.

has to traverse an extended surface of dry land, the former, as a rule, even appears as a rainy wind, while the latter, if its course have been *long* enough, appears as a dry wind; and if the mountain range be high enough, which the latter is required to rise over, this may, when it has reached the other side, even stream down as a hot, withering wind, the föhn of Continental writers, on the thirsty regions. If, then, we find in coast districts a greater yearly rainfall than further inwards, or if, on the wind side of the hills, we find lower snow-lines and further-reaching terminal moraines of the glaciers than on the lee side; or lastly, if we find successively regions of forests, of steppes, and of wastes, we may easily recognise therein each time an expression of the power of the winds, which, according as they are abundantly or poorly laden with aqueous vapour, or even quite dry, call forth this variety of geophysical phenomena.

The ever-moving atmosphere has therefore the most heterogeneous actions. While it feeds the glaciers and rivers, it causes at the same time a backward prolongation of these to the common source of the water—to the ocean, so as, with its moist breath, to produce everywhere simultaneously a formation of humus, and awake all into life; and again, where it is otherwise—where it appears as by nature a dry wind, or has been deprived of its freight of water, it brings with it drought and death. In the deserts the flora and fauna, then, have an extremely poor existence; the rivers no longer flow in a regular course; they have already been long in retreat, or are still only intermittent in their flow; the lakes also, when they are to be found in deserts, continually lose, through the constant evaporation, an abundance of water, although they may long have ceased to have an outlet to the neighbouring sea. In many deserts you do not meet with a single brook or pond; instead of such, you find only dried-up wadis and depressions, while the extensive stretches of waste, covered with salt incrustations and efflorescences, as also the scattered remains of dead animal species of past times, give evidence that these waste and withered regions formerly wore quite a different physiognomy; indeed, as the fossils and deposits of gypsum and salt testify, must even have been flooded with enormous inland seas. Now, probably (next to solar heat), it was above all, the winds, especially the dry winds, which, acting for a long period of time in the earth's history, dissolved these seas into aqueous vapour, carried them away, and so transformed the former lake bottom, now laid bare, into a waste.

Second Part.—But the winds are not only an expression for the general circulation of the air and aqueous vapour of the ocean; they are also a moving agent *quand même* not to be underestimated, since, in their progress, they communicate their own motion to all bodies which are not heavy enough to withstand them. Now, according as, in this way, solid or liquid bodies (especially the waters of the ocean) are put in motion, the mechanical action of the winds is to be considered from two distinct standpoints; first, its action on the solid land, and second, on the water, and through this again upon the solid land.

In the first case, it is the conditions of the strata that are continually altered under the action of the winds. It is at one time the snow, at another the salt-dust, at another the vegetable and animal remains, the ashes thrown out in volcanic eruptions, masses of dust and *débris*, or lastly, sand, that are whirled about, raised, carried miles away, and again deposited. The so-called wind-bedding characterises in every case the formations so produced, or in course of production. We shall cite here only two of the most remarkable examples of this kind of power in winds. One is the extensive Chinese Loess formation, which, according to von Richthofen's researches, appears to be quite a wind-formation; the other is the progressive dune-formation and dune-shifting on flat sandy coasts. Closer investigations (in this connection) of the conditions under which dunes are generally formed, examinations of their form, slope, and strike, and further, some materials furnished in the narratives of travel of Rohlfs and Dr. Tietze, have enabled the author to form a new theory as to the origin of sandy wastes, but especially to show that, as a rule, they are simply dune-formations on the shores of the former inland lake which has disappeared through evaporation. Some examples of sand scratches, sand cuttings, and the devastations wrought by hurricanes, illustrate the further mechanical action of the winds on the dry land.

Passing to the mechanical action of winds on water, we have, above all, to consider drift-currents (wind-drifts) and the motion of wind-waves. But while the former manifest themselves as powerful factors of transport, the wind-waves are besides characterised by a not unimportant effect in the direction of depth, but more especially by their now land-forming, now land-shattering surge. In this way the waters appear also as the most powerful medium through which the action of the winds is exerted on the solid land. In fact it is the capricious wind-wave that destroys and carries away whole stretches of coast in order to raise somewhere else and lay dry whole areas out of the oceanic depths (sand bars, sandbanks, flat coasts, delta formations, &c.). It is the wind-wave that ever renders active the principle of constant transformation in opposition to that of stability, and seeks to alter the contours of the dry land. Not without reason, then, does El. Reclus remark:—"It is by the movement of the atmosphere that we have to explain the form of continents." (*C'est par les mouvements de l'atmosphere, qu'il faut expliquer la forme des continents.*)

Third Part.—The winds, finally, produce, in an indirect way, many geological phenomena. According as they influence and determine the air-pressure, they cause now a perceptible swelling out, now a sinking of some large water surface, as has been observed on the oceans as well as on the North American and the Swiss lakes. Through this influence of air-pressure the winds further appear to affect volcanoes now favourably, now preventively—since also the lava masses in the crater (according to P. Scrope's representation) must be sensitive to atmospheric pressure; in high pressure finding a greater resistance, and in low pressure rising and breaking out more easily. The firedamp explosions also appear to be favoured by barometric depression. Similarly a certain connection can be demonstrated between the air-pressure and earthquakes.

Still more evidently are winds seen to exert an influence on earthquakes and volcanic phenomena, when regarded as rain-winds. With a large access of atmospheric water are connected both subterranean deluges and overturnings, and an abundant formation of steam in the heart of volcanoes; these circumstances immediately give rise to earth-tremblings, or violent volcanic outbursts and exhalations of steam.

If the hypothesis of T. R. Mayer, that the trade-winds are the principal cause of terrestrial magnetism, be correct, we must also, finally, ascribe to the winds an important part in the production of electricity. Lyon, Duveyrier, and Rohlfs have observed that the dry desert wind is uncommonly rich in electricity.

The author, indeed, has, in the course of his researches, given attention especially to the action of the winds in the most recent geological periods, and must in the meantime leave to specialists the more definite answering of the question how far the traces of action of winds also in the older periods of the earth's history can be followed. It is certain, however, that since in historical geology we have to do with a land flora and fauna, and with the (wrongly) so-called ocean precipitate, and so with the building up of sedimentary layers, we have so many undoubted proofs of the existence of rain and rivers, and accordingly of that of winds. Even when the earth was still a ball of glowing gas—and consequently a sort of sun to the moon's inhabitants, we can conceive the wind already acting as a geological agent—with the proviso, indeed, that the theory (of Faye and Reye) which regards the sun-spots as cyclone-like phenomena, or Secchi's view that the temperature of the sun at the sun's equator is higher than beyond the 30th degree of latitude, be verified.

UNDERGROUND TEMPERATURE[1]

A REMARKABLE series of observations have recently been taken in a boring at Sperenberg, near Berlin. The bore was carried to the depth of 4,052 Rhenish (or 4,172 English) feet, and was entirely in rock salt with the exception of the first 283 feet, which were in gypsum with some anhydrite. The observations were taken under the direction of Herr Eduard Dunker, of Halle-an-der-Saale, and are described by him in a paper occupying thirty-two closely printed quarto pages (206-238) of the *Zeitschrift für Berg-Hütten-und-Salinen-Wesen* (xx. Band, 2 und 3 Lieferung, Berlin, 1872).

[1] Ninth Report of the British Association Committee, consisting of Prof. Everett, Sir W Thomson, F.R.S, Prof. J. Clerk Maxwell, F.R.S., G. J. Symons, F.M.S., Prof. Ramsay, F.R.S., Prof. A. Geikie, F.R.S., James Glaisher, F.R.S., George Maw, F.G.S., W. Pengelly, F.R.S, Prof. Hull, F.R.S., Prof. Ansted, F.R.S., Prof. Prestwich, F.R.S., Dr. C. Le Neve Foster, Prof. A. S. Herschel, G. A. Lebour, F.G.S., and A. B. Wynne, appointed for the purpose of investigating the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land, and under Water. Drawn up by Prof. Everett, Secretary.