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THE

CIRCULATION OF THE WATERS

ON THE

SURFACE OF THE EARTH

BY

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We live on the boundaries between two oceans; above the liquid expanse of the watery main, and at the bottom of the blue deeps of air. It is impossible for us to reach the surface of the latter, for our highest mountains pierce but its shallows, the azure waves rolling far over their summits. Of the former, only the surface is known to us; the secrets of its depths are hidden from our ken. Thus the greatest part of the firm crust of the earth is withdrawn from our investigation. Mighty masses of earth, it is true, rise up out of the ocean, making the proportion of the firm bottom of the sea of air to the liquid one as 51 to 146. But the idea that, could we succeed in draining the ocean dry, those masses that tower over the level of the ocean would serve to fill up the gaps, is long ago renounced as being incorrect. Humboldt fixed the mean height of the continents at about a thousand feet above the level of the ocean. While Bache calculated the mean depth of the Pacific at 14,190 feet, from the time needed by the wave of the earthquake (Dec. 23. 1859, when the Russian frigate Diana was lost), which rose thirty feet above the usual level, in the harbour of Simoda in Japan, to cross the Pacific to San Francisco and San Diego in California — rate = $6,_1$ league per minute, by 217 miles breadth of wave. Still this ratio is greatly exceeded in the deepest places; for Ross at a southern latitude of 15^0 3′, and a western longitude of 23^0 14′, found no bottom at a depth of 27,600 feet. Denham in the Herald, found soundings in the South Atlantic Ocean, but at 46,000 feet, while Parker in the Congress, and much about the same spot, failed to find bottom at 50,000. Brooke let down a plumb-line measuring 42,240 feet in the Indian Ocean, a sea in which the ancient merchants used to point out a spot at the mouth of the Hoogly in the Bay of Bengal, which they believed to be unfathomable, and therefore called "the bottomless pit". Let us however, imagine our supposition carried into effect, viz., all the seas drained, all the rivers run dry, we should be very much at fault, were we to imagine we had now arrived at the region of rigidity, of freezing. For the heat which increases rapidly inwards, aids us in coming to the conclusion that, at a comparatively inconsiderable depth, that which on the surface is firm, will liquefy in the heat of the central fire; that the hard crust which surrounds this liquid heart does not bear the same proportion to it as the egg-shell does to the contents of the egg; nay, is so fragile that recently the opinion was expressed, this shell of earth was incapable of supporting such a mighty load as the Himalayas, and that this mountain range floated in the central liquid ocean like an iceberg in the waters. And no contemptible one methinks, for this range towers five miles above the level of the external ocean. Judging by this, it is not hard to suppose that since even now the liquid so far exceeds the solid, the difference at an early period has been very much greater, perhaps indeed that the whole earth was once liquid.

The fundamental character of a fluid is the extreme mobility of its parts, which yield to every force that sets it in motion. If no external power, but their mutual attraction, operates on the fluid, the separate parts have nothing left to hold them together. They naturally assume the form of a globule, for the spheroid is that form which admits of the closest approach of all the several parts. If water falls, gravity can exercise no fashioning influence on it, as all the parts of a falling body move with equal rapidity; we here then perceive the spherical form at once assuming the figure of a drop.

This may be demonstrated in a still more striking manner by pouring oil, which swims on the surface in water, but sinks in spirits of wine, first into alcohol, and then adding so much water till this mixture, of heavier water and lighter alcohol, attains the exact density of the oil. The oil then rolls itself into the form of a perfect ball or globe which floats about in the transparent mixture, as does our earth in space. Now if a piece of wire, furnished at the lower end with a vertical metal plate, is thrust through the cork of the square glass-vessel containing the mixture, it is easy to attract the globe of oil to this circular disk in such a manner as to cause it to completely encompass it. This done, turn the wire slowly round; the revolving of the inner-plate sets the oil in motion, which gradually assumes the spheroidal form; that is, it becomes flattened at the poles. Increase the rapidity of the motion, and the oil will detach itself and turn like a ring round its rotatory axis. As in the second experiment we behold as it were, Saturn's rings forming under our eyes, so the first offers us the key to the riddle how the earth first assumed its spheroidal form, and how the ocean exhibits this form best, the irregularities of the land preventing it being so distinctly visible. Calculating our motions in reference to the centre of the earth, the nearer then we approach the equator, the farther we go from that centre; and indeed the mouth of the Mississippi is farther removed from the centre of the earth than its source. Those who delight in quaint expressions, can therefore say, if it so please them, that this mighty stream flows up-hill. But in order to judge of the fall of a river, its superficies must be fixed at every point of its geographical latitude according to its distance from the level of the ocean; that is, according to the position which its waters along with those at its mouth, would take in a state of repose.

We have compared the earth to a falling drop. It is however, less a comparison than the real fact, only in this case it is a drop falling towards the sun. I here employ the word "fall" in the same sense as Newton, viz., that gravity has the same effect on the moving body as on the stationary. If standing on a frozen lake, I fire a ball from a gun held scrupulously horizontal, and the same second, drop another out of my hand, they will both touch the surface of the ice at one and the same instant. Rapidly then, as the powder propels the ball, it still cannot escape the law of gravity: it falls exactly as the ball not acted on by the powder. The earth is such a ball hurled into space; and once set in motion, it would but for the sun, fly straight on, only the sun will not suffer that. He compels the earth to deviate from her straight course, and to fall towards him. Thus instead of a rectilinear path, she strikes into the circular one. All the effects of the forces however, diminuish with increased distance. That spot of the still liquid earth which is turned to the sun, falls farthest from the rectilinear point of contact, the centre less, and the side altogether averted, least of all. Thus both poles diverging from the centre, impart to the liquid earth an elongated spheroidal form, its longer axis turned towards the sun. Such a change of form can naturally not take place in solid earth, as the closer adhesion of the parts necessarily prevent any displacement. All its parts therefore move in like manner as the centre-point, namely all those *before* this same centre-point, hurrying it on in the same degree, as those behind drag it back. Now our earth being neither all solid nor all liquid, the liquid water will form its spheroid on the unvarying solid globe, that is, it will accumulate at the two ends turned to and from the sun, and flow off from the sides to both places. If the earth did not revolve on her axis, then the ocean would once for all be deeper at the two former points, at the latter, shallower. But the earth revolving, the heavenly body which influences the flood, changes its position, before the spheroid he has been trying to form in the liquid covering of the earth, has been completed. In this manner, a wave is produced which follows the heavenly body in its apparent course round the earth. The liquid spheroid then hangs over the solid globe which revolves under it; each place in this way coming twice during the day, at noon and at midnight, to the spot of the deepening ocean, and twice, at six o'clock in the morning and in the evening, to the shallow spots. This phenomenon is known as ebb and flood.

Hitherto we have only taken the sun into consideration, and not mentioned that mute companion of our earth, the moon, to whom the earth takes the same place as the sun to us. The attraction however, is mutual, the moon not only inclining to the earth, but likewise the earth to the moon, i. e. the former moves more rapidly when the latter stands on her path before her, more slowly when behind her; and she inclines sideways out of her path when the moon does the same. The same reasons which are at work to cause the sun to produce a flood, operate likewise on the moon and with a similar effect. When all three bodies are standing in a straight line, as at full moon and new moon, the solar flood falls to the same spot as the flood caused by the moon; therefore the water rises here for two reasons, higher than usual. When the three bodies form a right angle, which happens in the first and third quarter, at the same spot where the moon raises the tide, the sun causes an ebb, and we have therefore the difference of two effects. The former floods known as the spring-tides are considerably higher than the latter to whichwe give the name of the neap-tides. But as the moon rises each day well-nigh an hour later than the preceeding, exact time fifty minutes,—so if both tides meet to-day at noon, the lunar tide will set in to-morrow at one o'clock, while the solar tide unchanged will make at noon; the following day the former will take place at two o'clock, and so on. Thus in a week the lunar flood and solar ebb will happen together, while in a fortnight the flood will again set in as at the beginning of this term.

Now we might believe, that the small near moon in the place where it hangs in the heavens has, by a hundred and sixty times, a weaker power than the big far-off sun, the lunar tide would be comparatively less. And so it should, if the whole powers of attraction of the heavenly bodies were spent in the producing of the tides. But we have seen their power of producing tides is only the difference of their effects on the surface, and on the centre of the earth. The half of the earth's diameter nearer or more removed, is a much more considerable matter than with the sun; for the latter is distant from us 12,000 times the length of the earth's diameter, the former only thirty times. Hence a thirtieth of the lunar power is to the twelve thousandth part of the solar power, as 5 to 2 (more exact as 50 to 18). Wherefore the sea rises two feet under the influence of the sun, but five under that of the moon, for the difference between two small numbers can be much greater than that between two large ones. At the spring-tides the water rises 5+2, therefore seven feet; and at the neap-tides 5—2, that is, it rises three feet.

But what is the nature of the motion of the waters at their ebb and flow? Progressive or oscillating? The water of a river flows, that is, the following particles take the place of those gone before, as we can clearly see by any body floating on the surface. The case alters with the billowy ocean. A vessel does not float along on the crest of the wave, it rises on it, but then sinks down again into the watery-valley without any change of position. When the wind sweeps along a field of corn, every blade bends before the pressure to rise again afterwards. The wave that skims along the surface is formed by a continuity of blades; in the same manner the water rises and falls in succession at different places, and this succession appears to us like a lateral progress. The motion of the sea is exactly like that of the little wooden pegs in the inside of a piano, when we pass our hand rapidly over the keys. The undulatory motion of the sea is to the flowing stream what the transmission of sound is to the wind. It is easy to understand therefore, why the tumultuous ocean can as little drive a mill-wheel, as a canonade can set a wind-mill in motion. The wave and the sound are vibratory motions, with this difference, that in the sound the atmospheric particles rather hold off from the sound-producing body, and afterwards return to their places; while the water takes a perpendicular motion in the direction of the progressive wave. This latter motion, produced by a rising and falling, is hence termed a transverse or oblique vibration; the former caused by a swaying backwards and forwards, a longitudinal vibration. What has just been said of the water, merely applies to those short chopping waves raised by the wind, the height of which is considerable as compared with the transverse section, and not of those tidal waves, which are very low in comparison with their immense cross section. In the latter, the perpendicular motion is not rectilinear, but the preponderating vertical direction accompanied by a little lateral push, which we detect in the shock of the beating wave. This produces an elliptical motion of the watery particles, the long axis of those ellipses being almost vertical having only a slight inclination, and the short one horizontal. The tidal wave therefore, in its motion, more resembles that of the atmospheric particles, than the drops in a watery wave agitated by the wind. The oscillatory motion of the water at high tide may hence be termed progressive longitudinal, the height of the tide, which represents ebb and flood being inconsiderable in comparison with the lateral motion.

The reasons of the origin of this lateral motion are not difficult to explain. Let *a*, *b*, *c*, *d* stand for the points of the transverse section of two successive meridians perpendicular to the equator; the sun on the days it crosses the equinox stands within the four and twenty hours vertically over these four points in succession in the following manner — taking *m* as centre:

a. b. c. d.	*a. b. c. d.*	*a. b. c. d.*	*a. b. c. d.*
m	*m*	*m*	*m*

In the first case, *d* will show the strongest inclination to approach; *c* less. If *c* is liquid, it will try to move in the direction *cm*; but if solid, then it can only move parallel with the motion of the centre-point of the earth, or in other words, parallel with *dm*. A lateral motion towards *d* is thereby imparted to a liquid body resting over *c*. In the second case, a solid and a liquid *c* move in the direction *cm*, but with different degrees of velocity. The fluid is raised, but accepts no lateral motion. In the third, *b* moves towards *m*, a liquid *c* in the direction *cm*, a solid, in that parallel to *bm*. Again we have a lateral motion, but, opposed to that in the first case, namely towards *b*. This also holds good for that half of the earth turned from us. We see therefore that on both sides of the meridian over which stands the celestial body to which we are indebted for the flood, the water flows towards it; consequently two ebbs bound laterally the two flood-masses; and so on either side the water makes a lateral oscillating movement.

Were the surface of the earth everywhere covered with an equally deep sea, a very broad double-wave would go round the earth from east to west within twenty-five hours, it being highest at the equator, and sloping quite away at the poles. Something resembling this is to be seen in the South Seas where the land retreats almost wholly. The phenomenon however, shows an essentially different aspect in the Pacific, Indian, and Atlantic Oceans. In each of those waters a new tidal-wave always arises at the east coast, which is reflected on the west coast before a second primary wave has time to form. If you pass a violin-bow over the sounding board, the bow sweeping down calls forth on the margin of this elastic board inflections which progress over it like waves, and return reflected from the margin. The more equal the intervals are, which are set in motion by the bow, the more regular will be the meeting of the wavelets in their passage hither and thither; the progressive vibrations are soon changed into standing ones, when all the parts of the sounding-board vibrate simultaneously round their centre of gravity. Let us now compare the sun and moon, the bodies which influence our tides, with the light bow, and those vast ocean hollows or basins with the elastic sounding-board. Now it is not improbable that a broad arm of the sea be made to oscillate like the water in a glass, when pushed rapidly backwards and forwards on the table, with your hand. Just as this oscillating water rises and falls most at the edges, and changes its position least in the centre, just so will the ebb and flood be stronger at the coasts than at an island in the middle of the sea. After having long asked how it would be with the ebb and flood in an ocean equally deep everywhere, and surrounding the whole earth, in the answer, of course only a theoretic one, a new step forwards has recently been made, by seeking to determine by experimental observations, what aspect the phenomenon exhibits on the actual oceans of the earth. The result then has confirmed the fact, that the flood in America indeed comes from the east, but in Africa and Europa from the west. If the tidal wave enters a narrowing bay, it is heaved higher, but if it flows round a larger island, it may possibly be delayed so long on its way, as to come rolling in, when the other part of the wave is already on the turn. Just as on a sounding-board, when a water-mountain and a water-valley meet, there occur lines of rest. In the German Ocean there is a spot where the waves pressing through the Canal, meeting that branch of the great Atlantic tidal-wave coming down from Scotland, completely absorbs the flood. The grandest accumulation is to be seen in America n the Bay of Fundy, in the rear of which, there is sometimes a difference of a hundred feet in the level. If the Baltic had such a flood, Berlin would at certain times be a maritime town, for the pavement of Dorotheen Street near the old Observatory, lies exactly a hundred feet above the zero of the water-mark in Swinemunde. But the Baltic is so perfectly enclosed by Denmark, that not till a few years ago did the Mecklenburgers succeed in proving that it *has* a flood, though to be sure but of a few inches. How grand on the other hand are the appearances on the west coasts of Europe. We can scarcely believe the testimony of our eyes, when we behold children in Ostend playing at the Digue on the dry strand, building their fortresses of sand, where but six hours later the bathers are disporting in the waters; or when from the cliffs at Bristol at the ebb, you see a dog running through the stream at that place where the omnibuses are already stopping to pick up the passengers from the steamers; when on the line from Chester to Anglesea, the wide bay of the Dee is drained, where six houres later returning from the Britannia Bridge, you see proud vessels a float; or when at the ebb you can walk round Heligoland dryshod, where at high-tide, the surge breaks on the rocks with the din of thunder. The Scandinavian coast dips so abruptly into the sea, that its cross-valleys filling with its waters, form the fiords. The water that the high-tide has carried up, rushes back at low-tide with such violence, that it has been said, though with much exaggeration, that Norway is a country where the ocean forms cataracts. If they are not cataracts, they are at least dangerous whirlpools of which the Maelstrom is the best known.

And what is the final result of this ceaseless, restless tossing? The effect is the most visible in the polar sea, in the unceasing breaking-up of the masses of ice, the enormous pressure of which the strongest vessels are often unable to withstand; the beneficial result, however, is that passages are opened up into territories which would otherwise be locked in by an impenetrable wall of ice. The result of this thousand years' friction on our own coasts, is likewise visible in our sandy sea-beach. If we try to calculate the value of the labour requisite to grind down solid blocks of rock to such minute grains, what company of shareholders would undertake to produce even the moderate quantity of sand on which Berlin is built? The reason of the great mechanical power lies herein, that the waves raised by the wind being only superficial, penetrate but little below the surface, while the force which produces the flood, acts on the whole body of water. A tidal-wave which rises three feet at the equator, and slopes away regularly towards the poles, bears 200 cubic miles of water from one quarter of the earth to the other, and in six hours. If this volume seems trifling to the aggregate body of water on the earth, which Herschel computed at the 1786th part of the bulk of the earth, still the force necessary to move such a volume over such a space is not despicable, when we remember that one cubic foot of water weighs sixty-six lbs. Prussian, (half a kilogram). But how high must the tides have been when the whole earth was in a liquid state! If the first clods which solidified, united to form a connected crust, then the tides must have beat them more wildly together than now in the polar seas. Is it to be wondered at, if there are everywhere traces to be found in the crystalline primitive rocks, of vast havock and destruction, even there where they have not pushed their way into the shattered covering which holds the strata bound together. Such traces must be most distinctly visible in the equatorial regions, because there the vertical action of the heavenly bodies must have been much greater on the flood of a still quite liquid earth.

The knowledge whether the internal liquid ocean of fire is fluid, or whether more over viscous, is hidden from us. Like the visible wave on the shore, perhaps it works its way, pushing and destroying at the firm crust, on which we can often clearly trace the marks of those progressive waves which we call earthquakes. This crust is certainly plastic and pliable. Does not Sweden rise before our eyes out of the sea, which incessantly retreats from its coasts, while on the Pomeranian shores no such change is visible? In other places does not the land sink, as for instance in Istria, where Roman pavements are to be found below the present level of the ocean? Have we not through Darwin almost attained the certainty that the report of a sunk Atlantis is realised in the main idea, in the Pacific Ocean; where the great Australian coral-reef, that no doubt once touched the coast, though now cut off from it by many a mile between, repeats the line of the coast in a great curve of some five hundred miles in extent, and where hundreds of coral-rings, — a lagoon in the middle,— still mark out the expanse covered by the islands long ago engulfed; while the corallines are labouring unweariedly on the yielding bottom, to keep up a connection with the surface of the ocean? Their activity will not come to an end, nor the whole colony become a dead rocky mass, till the bottom of the sea rises up high and dry as so many of our mountain-ranges, which under the names of Mount Jura and the Rauhe Alp, stretch like a wall of fortification, from the South West frontier of Switzerland, away into the region of Bayreuth.

Let us now pass from the attracting power of the sun and moon, to another impetus or force which they possess, namely, their heat. And as we above designated the former power as immeasurably small with the planets, so now in the latter case, we may omit all mention whatever, of the moon, which, though it does not generate cold as used to be thought, still its heat is so inconsiderable, that only very recently it has been positivey proved to possess any. In treating this latter point then, that of heat, the only body deserving of notice is the sun, whose heat is so great that in one year it could dissolve a crust of ice hundred feet thick enveloping the whole earth. With every degree of heat, the water, the sea, too, on the surface, is changed into an aeriform invisible body, which we call vapour, and which remains hidden from our view, till it again returns condensed as fog, or a cloud. This evaporation increases with an increased extent of surface and a higher degree of heat; it is therefore greatest in the torrid zone. Incorporated with the air, the vapour ascending from thence towards the poles to the height of the atmosphere, becomes dense according to the degree of cooling, turning to rain, or snow, or dew, or hoar frost on the ground. To this process we apply the terms distillation, and sublimation. As in the evaporation of water, it leaves behind it all the substances which it dissolved while in contact with its firm bottom, so rain-water being distilled water, is pure. If by an artificial extending of the superficies we increase the volume of evaporation, as they do in the south of France to gain the sea-salt, we can closely inspect this uninterrupted chemical analysis. The atmosphere is then, as its name shows, a great steam-apparatus, whose reservoir is the ocean, its furnace the sun, and whose condensing vessels are the higher geographical latitudes. If the rain falls immediately back into the sea again, it diminishes the pungency of the saline ingredients, which evaporation has intensified, and old sailors tell us, that this is the case in the rainy season in so marked a degree, that in a calm, drinking-water may be skimmed from the surface of the sea. For this reason the sea is less salt in the vicinity of the equator, in the region of calms, than in that of the rainless tradewinds; it diminishes again in the tropics, when the sinking tradewind induces new falls, the so-called subtropic rains. But, if on the other hand the rain falls on the land, if the soil is porous, it penetrates; or, should the soil be rocky, or clayey and impervious to water, it flows off to a lower-lying level.

Now the surface of the earth is composed of strata lying one upon the other, till down into the deepest depths; those on the plain are disposed horizontally, while on the other hand, those on the mountains take an inclined or sloping position. The gaping edges of those layers, the so-called strata-heads, can be seen best on the summits of the mountains, as if in the heaving of the great bulk, the outer covering of the strata had been disturbed, and the bursting mass had hardened into the form of the crystalline rocks. The water-tight and the porous strata alternating, the former fill with water, when the rain falls on the exposed formations. The French have a good expression for such a spongy stratum, and call it *une nappe d'eau.* You can make the whole arrangement pretty clear to yourselves by a very simple contrivance. Take a pile of alternating sheets of dry writing-paper, and well-soaked blotting-paper, and then bend up the whole upper part of the book thus formed, out of its horizontal position. You thus gain not a bad idea of how the strata look at the top of a mountain.

Farther; if you join two vessels at the bottom by a cross-pipe, and pour water into the one, the water in the other will rise as high as in the first, no matter how it may differ in size and in capacity, nor how long the pipe is. If you lead a pipe through a dike by the sea-shore, and curve it round, the water will rise to the sea-level, even though the pipe should end in a quill. Add one drop, and the whole ocean rises, naturally in proportion to its expanse. This is called the law of communication of tubes; of such tubes the U-shaped offers the simplest illustration. This law of course holds good for any number of vessels connected by tubes. Such are the Suterazi of the Turks, who, when they desire to conduct water from the one hill to the other, carry a pipe down the one hill, right across the valley, and up the ascent of the second. Had the Romans been acquainted with this principle, they would not have reared their splendidly-arched aqueducts which bear a more brilliant testimony to their feeling for art, than for their knowledge of physics.

The arrangement for providing all larger towns with water, is only an imitation of these Suterazi. A main reservoir is almost filled up with water, the connecting pipes branch off as required under the street-pavement, and from these the communicating pipes are conducted into the houses, and carried to a height which of course does not exceed the level of the main reservoir. The effort to rise is everywhere equal, and the upper wall of the horizontal part of the pipes therefore, has to withstand a pressure from below upwards. If it cannot withstand the pressure, the water oozes out, and a source is formed. For indeed, what else are those nappes d'eau, but the water in those pipes, the walls of which are formed by the water-tight layers? Hence the springs ooze out at the foot of the mountains exactly where the upper covering has cracked, in making a bend round. But the spring is often to be found at a greater distance from the base, where for example, the stratum comes to an end in the plain, or has been burst at some point. If the strata are disposed horizontally on either side of a so-called erosion-valley, the water issuing thence can have no ascending power, unless the layers assume an inclined position at a greater distance. Those valleys lined with sloping layers fall into three divisions, viz., into concave or basin-shaped, in which the strata of both walls dip towards the valley; divergent valleys, where this is the case only on one side, which presents a succession of strata sloping gently downwards, and the other a steep descent laying bare the headsof the layers; and lastly chasms, in which the heads of the strata are turned to both sides of the valley and slope off to the outside. From this, it is to be expected that springs may be found on both sides in the basin-shaped valleys; in the divergent valleys only on the sloping side, and in the chasm not at all; as the rain falling on the heads of the strata would simply feed the springs of a neighbouring valley.— But nature has frequently neglected to make the opening for the spring to bubble forth, and man must come to her aid, by breaking through the upper stratum with a ground-auger, and in this manner get a well, an Artesian well, so-called from the province of Artois, where they were first introduced into Europe, in the year 1126. The ascending power of the water naturally depends on how high the curve of the layer is filled with water. As long as the auger is boring in the upper stratum, it remains dry, but immediately fills with water as soon as the last wall is pierced, just like those pipes laid in our houses as a protection against fire, which being left empty in winter to prevent freezing, fill instantly the obstruction is removed. If the nappe d'eau has no side bent upwards, i. e., if it is filled merely by lateral infiltration, then on reaching the water we get only a well, to obtain the water out of which, it has to be drawn, or pumped to the surface. If the spring has been bored in a high-lying region, it is possible the water does not rise to the surface at all, but remains at a certain depth corresponding to the point of issue of the stratum in the mountains. If the water-tight layer over the porous one were quite wanting, the water if it possessed any force to ascend, would do so of itself. In this case it would be useless to add a new bore to the many already made.

The irrigation of the deeper-lying oases in Sahara seems from the most ancient times to have been effected by means of Artesian wells. Shaw says of Wad-reag, — a collection of villages at the entrance of the Sahara, — that these villages have no springs, the inhabitants procuring water in a peculiar manner. They dig wells, a hundred, or even two hundred fathoms deep, till they find under the sand a stone resembling slate, under which the Bahar taht el erd, that is, the water is found under the earth. This stone is not difficult to pierce, which on being done, the water bursts forth so suddenly, and in such abundance, that the men who have been let down, frequently perish, though drawn up as quickly as possible. Olympiodor tells of the digging of such deep wells in the great oasis. They are called Bahr in the erosions of the lower plateau; on the plateau itself, Schreia.

When in the year 1854 after the battle at Meggarin, General Desvaux was encamped in the oasis Sidi Rasched, he remarked that on one side of it the palm-trees looked poor and shabby, while they were sound and flourishing on the other. On enquiring into the cause of this peculiar appearance, he was informed that there was a scarcity of water, the chief well having fallen in, and as they possessed no means of digging a new one, they were awaiting the day when their palms would cease to bear fruit, and they should all die of hunger. It was Allah's will. The general on his own responsibility concluded to send to France for a boring apparatus; an engineer from the house of Degousée in Paris was summoned. He found the matter practicable, and the following winter after a division of Spahis had worked for four days, a spring bubbled forth out of the deserted shaft bringing 4300 litres of water a minute. The inhabitants rushed in crowds to the blessed spring bathing their children in it. Now came petitions from all the other oases for similar favours, and since then some fifty wells have been brought into use without visibly diminishing the volume of water in those already dug. The love of exaggeration now prevalent, has led many to express a hope, that in the above manner, the desert would in course of time, be changed into a lovely garden.

The abundance of water in a spring may be exceedingly embarrassing. A considerable number of years ago, an Italian proprietor had an Artesian well dug in his grounds, but it proved to be so powerful, that it inundated his own and his neighbour's estates. All endeavours to stop the spring were unsuccessful; and the law-suit for damages in which this involved him, completed his ruin. The story of Gœthe's Zauberlehrling was realised on him to his misfortune. Frequently the water-tight stratum runs away over the tops of the mountains and the heads of the porous layers which are then prevented from filling with water. This was the case in Marseilles, where the fruitful soil of the vineyards was often entirely washed away by the thunder-plumps. It struck the vintagers to bore deep holes through the upper stratum of clay, and to construct channels into which to carry the rain-water, and since that time springs about the circumference of a man's arm, which were unknown before, have formed at the harbour. In the year 1831 the fountain in the Cathedral Square in Tours cast up branches and shells from a depth of 335 feet.

Can we still doubt in the face of those facts, that the water, which oozes forth in natural springs, is originally Tagewasser (daylight-water; the water which penetrates into a mine from the upper strata) as the miners call it. And who knows it better than they, they who keep up an unceasing struggle to get it under, who construct channels over the pits and mines in order to prevent it breaking in, by carrying it off rapidly; and who after a heavy shower of rain see it appear first in the lower, and afterwards in the lowest depths. How many sources dry up after long drought, many so frequently as to get the name of "hunger-springs" by way of contrast with those in Switzerland in spring, and which on the first dissolving of the snow burst forth everywhere. And yet there are still to be found adherents of the so-called capillary system. We know it is true, that in a narrow tube the water with a curved concave surface, stands higher than in a wide vessel, into which the tubes are introduced; but the water can be higher only as long as the surface is hollow; if it has run out, the surface must first be equalized; that however, can never be, because then the condition of standing higher no longer exists. You see in dipping a bit of sugar into your coffee, it imbibes the coffee, but no coffee spring will ever bubble forth out of it.

But we are told that, in the hot Summer of 1822, the water collected in unusual quantities at the bottom of the mines in the Harz Forest, while on the surface all the springs ran dry. How easy it was to explain this by saying, that the earth, loosened and cracked by the heightened temperature, its natural capillary tubes were so much widened that they could no longer raise the water to the surface, hence it was compelled to collect at the bottom! This explanation is certainly simple, but simpler still the following. That as those waters were raised by means of mill-works driven by springs, on the drying up of those springs, the works stood still and could not raise the waters!

As frequently several strata containing water lie one above the other, — in digging for coals in St. Nicolas d'Allierment near Dieppe, seven with considerable ascending force were discovered, the last a thousand feet below the level, — if the upper one does not yield water enough, the borer is sent down deeper, though not always with a happy result. It has happened thrice in Würtemberg that the water thus obtained disappeared, for instead of a new layer, a cavity had been pierced, into which the water disappeared.

As a rule, the water in the stratum thus pierced, is stagnant, but sometimes also flowing, in which case the plummet drops suddenly deeper, and begins to swing hither and thither, as in Paris at the Barrière of Fontainebleau, where it fell twenty-three feet. At the Gare Sain Ouen, of five springs bored, the third had so strong a flow that the stones which the borer had brought up out of the deeper shaft, were carried away; this obviated the necessity of expediting them up to the top opening; they were raised no higher than to the third. How do such subterranean rivers originate? This may be observed in the Carse in Carniola. There a younger firmer limestone formation lies on the top of another quick-crumbling one. If the substrata is destroyed, the upper sheath falls in. In hundreds of examples cavities formed in this manner are to be seen on the line of the railway between Vienna and Triest. If a river falls into such an opening, it disappears; re-appearing again afterwards at a great distance. Enquiring my way at the nearest post-house to the Perte du Rhône, the official said to me: "You don't need to go there, You can see something much more remarkable in the garden at the back of my house." And indeed the sight was worth looking at. I found myself suddenly at the side of a perpendicular, deep-cut, perfectly dry channel, the rocky bottom of which was perforated like a sponge. Now when the water of the subterranean river rises, it oozes out of these apertures, filling the whole bed. And did not Livingstone see the mighty waterfall of the Zambesi disappear into a deep cleft? Something similar has likewise been observed in plains, as for instance in the case of the Guadiana, which for a time is lost in a great meadow, so that, when the Spaniards are told of the great bridges in England, they answer proudly; in Estremadura there is one on which a hundred thousand oxen can graze together. Sometimes those subterranean rivers only flow periodically, the explanation of which phenomenon is to be found in Greece.

The South of Europe shares the subtropical rains which fall heaviest in Autumn, continue throughout the winter on to spring, when they reach a second maximum, while in summer there fall none. In the Morca, a part of those waters flow from the mountain steeps right into the sea; the others collect, forming a lake in the deep ravines of the interior. The side walls of these ravines are cracked and rifted, and form natural drain-pipes to the lakes, which are called Katavothra, when in the rainy season the level of the lake rises to, or above the mouth. The issues of these canals are called Kephalovrysi, i. e., river-heads. In this manner the waters of the lake of Stymphalos form the Erasinas; those of the plain of Argos at Mantinea, the Anavolo; those of lake Phenia, the sources of the Ladon. Drama Aly the last Bey of Corinth, in order to prevent the stopping up of those issues, had an iron grating put over three of them at the lake of Phenia. At the outbreak of the Greek war of liberty they were removed, and a rich plain was thereby turned into a lake of 150 feet deep, and 20,000 of mean breadth. It is almost the same case with the lake of Copaiva in Beotia between Helicon, Chlomo and Ptoon. At the end of the summer, in August, this lake was transformed into a plain, with the exception of a little pond at Topolia. By here widening the Katavothra, man had aided nature; nay, in antiquity two artificial tributaries had already been contrived. If these subterranean canals open into the sea, sweet-water springs are originated as in Anavolo, Artros, and many other points of the rugged coast of Argolis, Laconia and Achaia. Such places in the days of antiquity were regarded as sacred spots, whence the ruins of temples are so often to be found in their vicinity. But as a proof of how far those water-tight strata can run out into the sea, an English convoy-ship came upon a vast sweet-water spring, bubbling up at a distance of a hundred nautical miles from the nearest point of the Indian coast. This can never occur in the shattered primitive rocks, which lie everywhere scattered about. Therefore in a granit vale, we find many, but only small springs, which hidden away under the stones, betray their presence by their murmuring. What a contrast between such springs and those of the Vauclouse, which in one minute, even when their flow is scantiest, yield 1200 cubic feet of water, and threefold the quantity at other times.

Those springs which originate in glaciers, form a class by themselves. They are born of the water melting from the surface of the glacier, penetrate between the rifts, then flow on under the ice, till at last they issue forth, very frequently out of a splendid ice-grotto. The finest instance of this is the source of the Ganges, which breaks out as a stream of one hundred and twenty feet broad, from a perpendicular wall of ice in the vicinity of the temple of Gangatri. All those glacier-rivulets known by their white soapy-looking watcr, have a fuller flow during the day than at night; and the higher the temperature of the air, the more abundant are their waters. We have one remarkable proof of their flowing under the glacier-ice. In the year 1790 Cristian Borer, the landlord of the Grindelwald, tumbled into one of those rifts in the ice, while driving his flock down from Bœniseck. When he came to himself, he discovered he was lying in flowing water, and began to make the best of his way out again with his broken arm, coming to light at the gate of Lütschine, having crept for hours through icey flowing water.

The fruitful soil of our lowlands generally lies on a subsoil of sand, and is protected by dams from the inundations of the river. If on the breaking up of the ice, the water rises considerably, the inhabitants seek to stem the tide by raising the dike; but the combined exertions of the inhabitants of the villages are often not sufficient to avert the danger by reason of another circumstance. The embankment thrown up, itself composed of firm soil and girded with solid wicker work, would be quite able to resist the lateral pressure of the rising waters, not so the sand-stratum however, on which it is erected. While all are busied on the top raising it, then suddenly there bursts out behind it a well-ground, that is the ground is covered with springs that bubble up with increasing force, bringing quantities of sand with them; the undermined embankment falls in with an awful crash, and the lowlands are covered with water. It is an incorrect conception of the matter to say, the sand which after such a catastrophe covers the fruitful soil, is the sand from the river. We should much rather say, that in the turmoil of waters the fruitful top-layer is carried away, laying bare the sandy subsoil. The white stripes therefore like the foot-path on a meadow, lie deeper than the green sward. Berlin has unfortunately well-ground; accordingly when the Spree is at high water, the cellars are filled. Von Oesfeld has published a chart of the most considerable of those inundations.

The difference between the coldest and the warmest month in the year, for the surface of the ground in Berlin amounts to 13. 64 degrees; at one foot below the surface, to 12. 95; at two feet, to 10. 69; at three feet, to 9. 14; at four, to 8. 51, and at five, to 7. 95. According to this rapid decrease, we can calculate that at a depth of twenty-four feet below the surface, there will be but half a degree of heat, and at, from sixty to seventy feet, there will be scarcely any traces of it left. The so-called variable stratum has according to this not even 100′ of power. Springs show therefore, that the deeper the horizontal part of the nappe d'eau is imbedded in this variable stratum, the more equal is its heat. Thus it comes that adjacent springs often differ considerably in this respect. At Marienberg near Boppard, Hallmann's minute and careful observations have proved a yearly difference in the heat of the atmosphere, of 15. 72 degrees; at Michael's Spring, of 7. 73; at Hassborn 4. 77; at the Mühlthalquelle 2. 99; the Hirschkoppquelle 2. 62; the Salzbrunnen 2. 14, and at the Louisenquelle 0. 96; while the chief source (Quelle), that one, which feeds the whole bathing establishment, the Orgelborn, only of 30. 54 degrees. And this variability is not simply observable in mountain springs, but also in those of the plain. In Conitz, after many years' observation, the difference between the coldest and warmest month amounted in the one spring to 3. 06, in another to only 0. 46, while the atmosphere showed 17. 22 degrees of heat. The Gesundbrunnen, in the Oranienburg suburb of Berlin, varies only $\frac{3}{10}$ of a degree within a year. The skater is therefore not a little astonished when he finds the same spot in the pond bubbling up through the ice, that in summer, while bathing, he had avoided on account of the cold. In the torrid zone, where the heat is equal throughout the year, and the difference between day and night greater than between summer and winter, the above is an everyday appearance. Lucretius, for instance, tells of a source near the temple of Jupiter Ammon in the oasis, which was colder in the day, and warmer at night. The earth, adds he, is like a folded hand; in the cold it doubles itself up to prevent the internal warmth from streaming forth; in external heat it opens, and the earth cools because the internal warmth escapes. What a graceful explanation this is! It is a pity however, that it is perfectly false, for the thermometer shows us, that what is here explained, viz., the variation in the temperature of a spring, does not exist at all.

The best spring in the Tropics can afford little refreshment, as the mean differs but little from the heat in the hottest months. While with us everything grows fresher and stronger around them, in Lapland and Iceland they are a curse for vegetation by bringing their icey cold into the short hot summer. A source in Cumana = + 20°, differs from the hottest month = 23. 3, only about 3. 3; in Cairo about 5. 9; in Strasbourg 7°; in Upsala about 8. 3. But even here nature avoids the extremes permitted her, for while in Basle the temperature of the springs is equal to the mean heat of the atmosphere, in the tropical regions they are below the mean, while in the frigid zone they exceed the temperature of the ground by several degrees. It is hardly necessary to add, that the rainy season above all other causes, exercises an influence on those varying conditions. But even supposing an equal division of the quantum of rain within the annual period, there are manifold reasons for the temperature of the springs being higher, in higher degrees of latitude, than the atmosphere. In the severe cold of winter for instance, the water is prevented penetrating the frozen ground till a thaw sets in; in other words, till the degree of warmth is higher. Hence the mean heat of the water which feeds the springs, must of necessity be higher than the mean heat of the athmosphere. If we penetrate through the variable stratum, deeper into the ground, the degree of heat, it is true, remains unchanged throughout the whole year, but rises the deeper we go. While our springs on the surface have 8° of heat, the water in the bore at Rüdersdorff, 700 feet below the level of the Baltic, has 18. 2; in the bore at Rehme near the Porta Westphalica, 2144 feet deep, 18. 5; and on boring the well of Grenelle in Paris, it rose from eight degrees and a half to 22. 2, when at a depth of 1683 feet, at length penetrating the chalk bed and reaching the greensand, which slopes off at Tours, they came upon a water-bed, the ascending power of which was so great, that in Grenelle, people used to climb up a high mast in order to see at the top of it, the water flowing out in the shape of a shell.

There is therefore no difficulty in understanding the origin of hot-springs both as concerns the height of their temperature, and their variability, which a comparison between the observations of Carrère in the year 1764, and those of Anglada in 1819, clearly proves, though at first Anglada fancied the results, he had obtained were opposed to those of Carrère, not having remarked the thermometer the latter had used was divided differently from his own. In Mont Dore people now bathe in a hot-spring with 30. 7 degrees of heat; this same spring was used in the days of Julius Cæsar without its first undergoing a cooling process. Now as one can stand the hot bath at Roussillon (40°) for only three minutes, and in water of 36°, about eight minutes, the springs must have retained their degrees of heat since the days of the Romans, unless indeed they all had skins like the Turk, whom Marshal Marmont saw tarrying for a long time in a bath with 60 degrees It no longer strikes us as extraordinary, that the hot springs appear just where the cuttings in the primitive rocks are deepest; or that their temperature generally rises, the nearer we come to the granit-axis of the mountain; as there, that which once formed the interior having been forced to the surface, the deeper the water can penetrate, the more probable it appears. Thus it becomes clear that, while the springs in

Roussillon at Olette show 70°, those of Dax in Foix only 60° of heat; those of Bagnères de Luchon farther west 50°, those of Barèges 40°, the eaux bonnes, and les eaux chaudes in the valley of Ossan 30°, and lastly those of Cambo, not far from Bayonne, and farthest from the chief mass of granit in the Pyrenees, only seventeen degrees. That the hot mineral waters owe their heat to their springing from a great depth, is corroborated by the chance discovery of a spring with forty degrees of heat, in a copper-mine, 1350 feet deep, at Wheal-Cliffort near Redruth in Cornwall, the temperature of which almost entirely agrees with that of the Bath-wells.

It is no contradiction to the above, to say that springs sometimes change their degrees of temperature considerably in consequence of earthquakes, for by such displacement of the ro cks, their connection with deeper-lying strata may either be cut off, or opened up. After the great earthquake at Lisbon in 1755, the Source de la Reine in the springs of Bagnères de Luchon, rose forty degrees, thus being transformed from a cold, into a hot spring, while the reverse took place in a spring in Bagnères of Vigorre, in consequence of a great earthquake in the year 1660. When on September 29. 1759, the Jorullo in the municipality of Valladolid, rose at a distance of thirty-six miles from the coast, and forty-two from any other active vulcano, the rivers Cuitimba and San Pedro near the Cerro de St. Ines, were lost. Their clear waters had once irrigated the sugar-cane fields of the adjacent Hacienda. At a distance of six hundred feet off, there broke out in their place, two rivers from the clay-vault of the Hornitos, in whose waters Humboldt saw the thermometer rise to forty-two degrees.

On its long subterranean path, the water generally comes in contact with substances which it has power to melt. Even common spring-water is, for this reason not so chemically pure as rain-water; and although it holds but a very small quantity of carbonate of lime in solution, it is still sufficient to form, inconjunction with soap, a flaky lime-soap, while in rain and river water the soap dissolves equally; and it prevents pease and beans becoming soft in boiling, for the lime adheres to the shells, and in this manner excludes the entrance of the water. Therefore we call spring water hard, in contrast with the soft river water. A spring becomes a mineral spring, when the ingredients which it holds in solution, exist in greater quantities.

Pliny has given us the key so to say, to the fabrication of mineral springs; it is as follows. The waters partake of the nature of the country through which they flow. Starting from this dictum, Struve investigated the basalts, phonolite and porphyry in the vicinity of Bilin, Teplitz, Marienbad, Carlsbad and Eger. After having discovered all the solid ingredients of the neighbouring chalybeate springs, he proceeded to imitate them artificially, by bringing the pounded rocks in contact with carbonic acid gas and water, under the pressure of a pump. The brilliant results of these experiments are the artificial mineral waters, a blessing indeed more especially for those regions remote from the healing springs. Those waters have been objected to on the score, that in the natural waters, there were possibly unknown ingredients, an assertion which has been confirmed since the discovey of Cæsium and Rubidium in the waters of Baden-Baden and Türkheim, by means of Bunsen's spectral-analysis. But further, you have to consider that, along with the healing substances beneficial for a certain form of disease, the natual mineral waters frequently contain such as promote indigestion, to omit which is surely better than to fabricate a slavish imitation. The assertion that hot mineral waters in cooling, follow other laws than artificially heated waters, is a fiction, probably devised to throw discredit on the artificial mineral waters.

If from the point of view of science, I mean to ascribe the same effect to the artificial waters as to the natural, still it is by no means said, that a course of waters taken at home, have the same beneficial effect, as when drunk on the spot. One invalid amongst the healthy is always isolated; he is merely endured. How different in a watering-place, where every body is sick! Where you may see plainly written in the face of every visitor he belongs to the majority, looking like a parliamentary deputy who, seeing his party has the upper hand has laid aside the resigned opposition air, which but a short while ago, so strangely contrasted with the aplomb which so peculiarly marks out the props of government from among the other creatures of this earth. Added to all that, there is the prescribed diet which, it being in the interest of the landlord, is much more strictly adhered to, than at home; and lastly, the infinite healing power in *idling*; not alone for those who at home are overwhelmed with business, but also for those who are accustomed to it, because for once at least, their hearts are filled with a proud satisfaction in the fulfilment of their duty! In short every one comes out in a new character. You meet bankers who, in the reading-room are more eager to have a first peep of the lists of new-comers, than of the exchange-list; lawyers, who for once all agreed on some case submitted to them; councillors, who have laid aside the severe official air which might lead us to suppose, that there was some real reason for the mysterious expression of their countenances; military men, disguised in the apparel of ordinary human beings; and by way of contrast, people putting on a negative incognito, being nothing, and wanting to make you believe they are something. What invalid would not recover under those circumstances, when disease itself assumes a graceful form; for how often do you see faces which suggest the wondering question, what can be the matter with him or her! If such then is the case even in a small watering-place, what a superabundance of attractions does not a large one offer! This confusion of tongues, this wondrous mixture of bonne société and demi-monde, both brilliant and still so different; like a jewel and its imitation! What fine shades in the mutual bow and in the manner of conversation; from the highest grade, when questions are addressed but no replies waited for, to the very lowest step of going thoroughly into a matter. And now when you step out of those gaily-decorated, fairylike halls, into one of those sequestered vales, and you cast yourself down near the source that babbles on heedless of listeners, you behold below, a brook meandering through the fresh meadow, near by, a mill, high above, a castle clothed with ivy, and overlooking the dark-green of the woods, can any one be surprised, that in the marriage contract of a Parisian lady the words, "et la saison à Bade", dare not be omitted?

Of all the mineral springs, the saline are of the most importance. The theory of lixiviation has been most clearly and satisfactorily proved on them; science having succeeded in directly tracing the birth-place of their saline ingredients, to the enormous beds of rocksalt. This important discovery, to which Prussia owes Wilitschka in Stassfurt, was made by Herrn von Langsdorf, who with unwearied perseverance carried on his boring operations in Wimpfen in Würtemberg, from August 1812, on to the Spring of the year 1816; till at a depth of 475 feet, he at length reached a bed of rock-salt sixty feet in thickness. This success provoked imitatiou in North, and South Germany, and in France.

The carbonate of lime which so many springs hold in solution, leaves a firm deposit on the evaporation of the water. This evaporation produces in the lime stone caves, those wonderful stalactic formations we are all acquainted with. Just as icicles are formed in thaw-weather, so do lime stone drops form on the roofs of those caves, from the calcareous sediment left after evaporation. Those pendent formations are met by others rising from the ground, produced by the falling drops, till both meet in the shape of a sand-glass, but which the continual accumulation, changes in time into fine slender columns. A more rapid evaporation takes place at one waterfall, the Lapis Tiburtinus of the Ancients, now generally known in another form, as the Confetti di Tivoli.

The Carlsbad sprudelschale (thermal tuff), is a well-known example of the stalactites of hot-springs, every visitor bringing away with him at least one petrified souvenir. Here too, this deposit is a result of increased evaporation from the falling of the water. A fine instance is the Pambuk Kaleffi (the cotton-castle), so called from the picturesque shapes of the calcareous deposit, — the Hierapolis of the Ancients, of which Strabo tells us, its waters solidified so rapidly that canals were transformed into walls made of one solid piece. These springs take their rise in large numbers in a table-land; now as they themselves cast up ever new obstacles, they have to make their way in devious channels, till reaching a steep of three hundred feet, they fall over it for a reach of about half a mile. According to Tchichatschef, the enchantement of the scene,— the vista of stalactites, half dazzling white, half yellowish, which cover the wall, beggars description. — Something similar may be seen in the province of Auckland in New-Zealand,—in the Tetarata, on the North East coast of the Roto mahana. The hot bubbling water flows out of a snow-white basin covered with stalactites, eighty feet long and sixty broad, over self-formed terraces, hewn as if out of dazzling marble, into a series of deep-blue basins, such as the most refined luxury could not have devised better; from their gradual descent, a gradation of temperature takes place; and they are large enough for a man to swim about in comfortably.

It is therefore no fable, when the Greeks speak of bridge-building springs. Tchichatschef has made a very fine drawing of the one in Pambuk Kaleffi which, spanning the dry bed of the river, affords the traveller resting beneath, an agreeable coolness from the evaporation of the dropping water. On the way from Erzerum to Trapezunt, Ely Smith saw another. In this one the crust of the tufa had grown too heavy, broke, and having fallien into the river formed the pillar across to which this natural bridge is thrown. On the way from Algiers to Constantine, you meet with springs whose bubbling noise aud rising columns of vapour, are to be seen and heard from a great distance. An innumerable quantity of dazzlingly white calcareous pyramids, here assume the oddest rocky shapes. The Arabians tell about them, how a mighty chief had wedded against the laws of the Koran, and Allah, wroth with the Marabut who married them, transformed the bridal pair and all the marriage guests into stone; and the wicked boiler that contained the marriage-feast, was condemned for ever to boil and bubble. Hence the name Hamman el Meskhatin, the Cursed Springs.

Frequently the stalactites rise gradually tube-like, ending in a wide basin. The hot water running into this basin, has naturally a much higher temperature at the foot of this tube, than at its surface; the vapour-bubbles which form beneath, having to bear not only the pressure of the atmosphere, but the pressure besides of the column of water above them. Those above approach the boiling-point; but those waters, which from their cooling on the surface cannot reach that point, suddenly boil up, when brought by a stronger swell into chance contact with larger bubbles, sending up the water mixed with steam, with an enormous force, to a great height. The best-known of such hot springs are the Geysers, and the Strokker in Iceland. The temperature of the water of the former, at the bottom of a shaft of 59 feet deep, and nine broad, is a hundred degrees; hence twenty degrees warmer than the usual boiling-point; the temperature of the latter, ninety-two degrees at a depth of twenty-seven feet in the tunnel, which reaches forty feet down.

The usual height to which the projectile force of the latter carries the water, is one hundred and fifty feet, but on the removal of a possible obstruction at the lower opening, it may rise to one hundred and eighty.

The New-Zealanders say of the Tetarata, that sometimes the whole body of water is hurled out of the principal basin with an awful force; on these occasions one may look down thirty feet into the empty basin, which however, rapidly refills.

The crustatious deposits of cold springs, correspond to the thornstone of our drying-houses, while the incrustations of hot springs may find their analogy in the sediment which overlays our steam-engines, the removal of which remains a still unsolved problem.

The vastest mineral spring is the sea itself. But the balance in which its component parts are held, chiefly effected through evaporation, influx and other organic processes, can only then be understood, when we shall have traced the farther course of those waters which are so to say, born of the springs, viz., brooks, streams and rivers, — over the surface of the earth, the study of which would form a second part to our present train of reflections, and would be the immediate visible supplement to that Circulation of the Waters, the first processes of which from their taking place in the regions of the air, and under the ground, hence removed from our sight, have been so long misunderstood.

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