usual genial current of thought—as Mendelssohn always was. Latterly a love of gain, the utter absence of which had been so remarkable in the youth and the man when struggling against penury and precarious fortune, became a strong feature in his character. For this last weakness the great artist is touchingly excused by his son. This abnormal state of mind, urges M. de Weber, was only superinduced by the strong and natural desire of the husband and father to provide as bountifully as possible for his family, when he felt that the hand of death was surely on him.

M. de Weber ascribes the indifference and the slights which so frequently fell to the artist's share in the world to his father's mean and insignificant appearance; it is a point which he presses frequently on his reader, more especially when writing of the want of all regard to him on the part of the English aristocracy. No doubt there was nothing imposing in the small, narrow-shouldered, thin, spare frame, with a limping gait occasioned by some early injury. The composer himself was accustomed to turn his own appearance into ridicule when he put on the hideous uniform of Saxon Court etiquette, and to declare that he was fit only for a wax-figure show. But he certainly must have derived some great charm of manner and expression from nature. He was evidently regarded in early life with more than complacency by the softer sex. He had a fine expressive head, although too large and too long to be in proportion with his slight stature, and somewhat encumbered by too marked and powerful a nose; his eyes were full of deep meaning, by turns benevolent, animated, and flashing, even through the disfigurement of his spectacles; his smile had the power of winning all hearts. When he appeared in England, it is true, long and wearing illness had bowed his form and crushed his genial spirit. But it is to his morbid susceptibility, mixed with a certain degree of shyness and reserve, rather than to his frail uncomely form, that his want of success in society must be attributed. A man of greater vigour of character and intellect would have found in the inconceivable popularity which some of his works enjoyed at that time amongst all classes of the people of England, an ample compensation for the imaginary slights which may have afflicted him in May-Fair.

With such elements of romance as those which the life of Carl Maria von Weber affords, it has been impossible for his biographer, in spite of all his efforts not to be 'zu nouvellistisch,' to prevent the interest of his book from being in a great measure that produced by a work of fiction, and we are indebted to Mr. Palgrave Simpson for an English translation and reconstruction of these volumes, which are in more respects than one an improvement on the original.

Art. V.—1. *Frost and Fire. Natural Engines, Tool-marks, and Chips, with Sketches taken at Home and Abroad by a Traveller.* By J. F. Campbell. Two volumes, 8vo. Edinburgh: 1865.

2. *Ice Caves of France and Switzerland, a Narrative of Subterranean Exploration.* By the Rev. G. F. Browne, M.A., Fellow and Assistant Tutor of St. Catherine's College, Cambridge; Member of the Alpine Club. London: 1865.

It is an ungracious task to criticise a book that has on the whole given us so much pleasure as 'Frost and Fire:' the author's hobby-horses are so handsome in their careless vivacity, as they canter about the easy green fields of science, bound with astonishing leaps over moderate difficulties, and shy with a lissom swerve at familiar sign-posts, it seems unreasonable to have them led up for examination, to estimate their soundness and real worth, by the rules that apply to common horseflesh. But old experience teaches wariness. Imperfect sight is a very frequent cause of shying among hobby-horses and horses in general; high jumps over low hurdles show a miscalculation of difficulties, due to inexperience in the hunting-field; and unsoundness in the legs is a cogent reason for avoiding a steady-going trot on the hard highway. We must be careful lest we unguardedly put our faith in a noble-looking steed, with a flowing mane and tail, and wonderful action, who is capable of a great deal but who, nevertheless, is not sufficiently sound to carry us over the heavy stage for which he is about to be harnessed.

There are two methods of treating topics such as those that form the subject of 'Frost and Fire.' One is the scientific method, the other is the popular. They are almost the antipodes of one another. The author who writes a really scientific treatise confines himself to phraseology that is rigorously exact, and handles his subject with a firm and comprehensive grasp. He avoids uncertainties of expression to the utmost of his power; and he shows an abhorrence of doubtful, dark corners of thought. He

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states clearly what he knows, and he draws with a firm line the boundary where his knowledge ends and the obscure and the unknown begins. The model scientific writer endeavours to be concise without baldness. He trusts that his readers will be sufficiently intelligent and studious, to succeed in realising to their imaginations the ideas which he has justly, though unrhetorically, set forth.

But the writer of a so-called 'popular' treatise on science works on quite another principle. He is as careless of precision as he is regardless of thoroughness and comprehensiveness. He endeavours at one and the same time to convey new ideas, and to stimulate a torpid curiosity in his reader. He tries to do so by selecting portions of old and familiar modes of thought, expressing them rhetorically and arranging them in new combinations. He therefore deals copiously in metaphors that are partially applicable, and in allegories that have to be strained in order to be understood. His method of treatment is approximative and confused, not clear and rigorous: it is partial, not comprehensive. However ingeniously or poetically the author of a merely popular book, on any branch of science, may acquit himself, the result is necessarily imperfect; for ideas that are really new are not to be extracted, ready made, from old ones.

'Frost and Fire,' notwithstanding its great and substantial merits, on which it will shortly be our pleasure to enlarge, is in its treatment a popular book; and is therefore crammed full of the faults that necessarily attach themselves to this style of writing. It is impossible to read the work without constant fret and vexation, that it should be so inadequate to its pretensions as a whole, and yet so excellent in many of its parts. It is literally a Kosmos in design, treating of primeval forces, from their application to molten planets and the constitution of the sun, down to the latest geological changes on our earth. Beginning and ending with Kosmic theories of questionable value, the middle of it is occupied with the author's careful geological observations in north-western Europe and America. He shows that it is probable an Arctic current from the North-polar seas swept, in ancient days, right over an almost wholly submerged Scandinavia and Britain, carrying fleets of icebergs, that scored the now elevated lands into their present configuration. This part of the work leaves little to be desired except condensation. We have also greatly to commend the author's experiments to illustrate the action of geological forces on a miniature scale, though it will be seen that we limit the professed range of their application, before we can consent to adopt them as substitutes for theory and calculation.

'Frost and Fire' is by no means a book to be skimmed or lightly dealt with. It consists of two thick volumes, with plenty of matter in them. They require steady reading, more than once, before the limits of the author's meaning can be apprehended; and it is hard work to read them, for the style is quaint and the course of argument exceedingly circuitous. The reader has to travel through all the Kosmic matter to which we take exception; and when, at last, he is fairly settled down into the more valuable part of its contents, he finds himself interrupted, over and over again, by pages and chapters of narrative or digression. These interludes are thoroughly interesting in their way, but they are superfluous; yet they cannot be skipped without risk. Every here and there the reader is liable to stumble on some remark, necessary for the development of the author's views, which seems as much out of its natural place where it lies, as some erratic block of granite perched on a hill of slate.

We will commence by showing cause for these objections, that we may be at liberty to dismiss that unpleasant part of our duty, and afterwards to follow with less interruption some of the many clues of inquiry that Mr. Campbell's volumes suggest.

First of all, we object to the title. The author treats 'Frost and Fire,' both there and throughout his work, as antagonistic entities. Frost does this, and fire does that. 'Hot particles repel, cold ones attract, each other' (vol. i. p. 14). But what is heat and cold? what are frost and fire? Does he mean by frost a temperature at which pure *water* freezes; and by fire a temperature at which *lava* melts? Or what substances does he take as his standards? Melted lava freezes into stone at a hotter temperature than that of burning coal. There are plenty of fires that burn at still lower temperatures. Gun-cotton explodes in the hand without singeing it. The fundamental motive power is *difference of temperature.* Ice and molten lava are specific results of this difference. But the author seems never at home with abstract ideas, and prefers to express himself by concrete ones, even when they are insufficient for his wants.

Again, his fundamental and favourite axiom, 'where light shines, there force radiates,' is still unproven. So far as experiment has yet taught us, mere light has not much to do with force. Obscure heat seems just as potent as that which is luminous. The author devotes a large part of his work

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to heat, and enters minutely into its meterological influences; yet so imperfectly does he grapple with the subject he attempts to explain, that we have been unable to find the term 'latent' heat anywhere in his pages, and the very idea of it seems pointedly ignored. Phrases like the following show a curious misapprehension of the nature of heat in its meteorological aspect:—'Air in high regions is pressed by less weight. It is colder than air near the earth; but like a sponge relieved from pressure, it is better able to hold water the lighter it is. There is more room in it, so to speak . . .' (Vol. i. p. 82.) 'When damp air has cooled and contracted to a certain point, it lays its load of water on any cold substance which takes in part of the charge of heat which expanded air. Vapour is condensed. It follows the heat out of the warm air to the cold substance, and if it cannot get in, it stops on the surface and gathers in round drops.' (Vol. i. p. 70.) He asserts here, if we comprehend him aright, that the charge of moisture air can carry depends on its state of condensation, rather than upon its temperature, which is wholly erroneous. We may mention that he nowhere makes any allusion to the specific heat of air at different degrees of condensation.

He is constantly speaking of 'ray-force,' by which he means much more than mere radiation. He says (vol. ii. p. 355), 'The subject (ray-power) is too large for unskilful hands and minds to grasp. It is dangerous even to step on such untried ground.' When he applies the term 'ray-force' to heat, he uses it in a more recondite sense than that of conduction or convection. These would undoubtedly be results of ray-force in the sense of force radiating in all directions equally, from every particle; but then he considers the *results* of ray-force as usually acting in the direction of rays; which they certainly do not. Thus the trade winds blow at right angles to the surface of the earth, whose equatorial warmth and polar cold set them in motion. The movements of machinery, moved originally by ray-force, are still more various. It is with considerable regret that we have, here and elsewhere, to express inability to understand the author's meaning, owing to his want of precision. The following passage is one out of many that could be quoted, which are to be met with in various parts of his book, alluding to ray-force. They are all of the same tissue. There is not one of them that puts his meaning into an intelligible form. The italics here, and further on, are our own:—

'In hunting ice-marks, and in hunting heat, all tracks followed backwards lead to centres from which force radiates: in the one case to the pole, and to pure centrifugal force; in the other to the earth's centre, where centrifugal force and heat must both act outwards, but not in the same directions. Pure centrifugal force tends to move bodies away from an axis of rotation, in a plane at right angles to the axis. Terrestrial heat *radiates* in all directions; two large volcanoes are active near the South Pole, Spitzbergen is rising in the north, and volcanoes abound in low latitudes. There is a faint glimmer of earth-light in this underground darkness, and some profit may be got out of this mine, even though digging into it may be hard labour. The object aimed at was to show that where *light shines*, there also force radiates, and there also forms result from movements caused by ray-force. The forms of volcanic mountains, and movements during eruptions, when carried round the whole shell, aim, like the rest of the forms mentioned, back at *a centre of radiant force;* and when it acts with sufficient power, rays shine out like rays from a hidden light'. (*Preface*, p. xx.) [A symbol is appended to this, of a star in the middle of a circle.]

Again, he seems (we still are obliged to doubt) to lean to the view that heat is an antagonistic power to gravitation. Thus, 'The action of solar heat is directly opposed to that of weight at the earth's surface' (vol. i. p. 65); and, 'Gravitation seems to be a law which applies to all visible material things [why *visible?* Does not air gravitate?]; if visible light [why not obscure heat?] be an *opposing force of like general application*, these two may have shaped worlds. . . .' (Vol. ii. p. 355.)

As to the value of his speculations on the action of Gravitation, the following passage speaks for itself:—'The same force of gravitation makes rain fall, *stops* a wagging pendulum, &c.' (Vol. ii. p. 229.)

He is not more successful in his notions of Refraction. He says, 'Warm moist equatorial winds which sweep over the plains of India come loaded with transparent vapour. While thus expanded, the vapour only serves to intensify the heat by refracting the sun's rays *like a lens*. . . .' (Vol. ii. p. 257.) We cannot conceive any way in which the analogy of a lens can apply, even in the most remote degree, to the case he describes.

It is not our object or desire to pick out more inaccuracies in the work, or more laxities of statement, than are sufficient to absolve us from the charge of doing scant justice to the scope of Mr. Campbell's design, if we decline to adopt his quaint phraseology, and to follow him throughout the obscure mazes of his argument. When his generalisations of our forces and first prin-

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ciples are expressed in ordinary language, they will be found, whenever they are accurate, to be chiefly made up of scientific truisms, and therefore to contain little or nothing of value that is not perfectly familiar to most followers of science. His originality consists in surveying the field of Kosmic relations from low points of view, and in showing that a number of very interesting glimpses may be obtained even from them. But we would say to the student, as we would say to a geographer who wanted to make out the lay of a new country, 'Do not waste time in wandering among the bases of the hills, but walk at once to the summits of two or three of them; it is a little more effort at the time, but it is not nearly so tedious, and it is the only satisfactory course of proceeding in the end.'

We therefore shall consider 'Frost and Fire' not as a continuous whole, but as a miscellany of observation, experiment, and theory, which from their value, diversity, and number, have a just claim upon a critic's attention.

The leading idea of the work may be expressed as follows:—All the movements of inorganic nature may be compared to those of several series of different sorts of machines. One series of the machines is that of aerial currents; another of oceanic currents; another of rivers; another of glaciers; another of volcanic eruption; and so on. Yet although each series of these machines produces very different effects, they are all worked by the single power of heat. In this they resemble the vast collection of 'machinery in motion' shown at the International Exhibition, where a series of looms and spinning machinery, centrifugal pumps, magnetic lights and freezing apparatuses, were all put into simultaneous action by the revolving shaft of a single engine. Again, every cutting-wheel of every machine leaves characteristic marks on the material it works upon. Both the article that is being manufactured, and the chips that the machine cuts out of it, bear marks of the particular tool with which it has been worked. For instance, the stump of a felled tree, on the one hand, and the chips or sawdust lying by its side on the other, both betray that an axe or a saw, as the case may be, has been employed to cut it down. This quaint imagery, indulged in to a degree that confuses the reader, pervades Mr. Campbell's book. Mountain forms are considered as tool-marks of the terrestrial engines; igneous and sedimentary rocks as their chips; and it is held to be the business of philosophers to identify the particular engine that made them, from inspection of the tool-marks and chips. But how are philosophers to learn the marks of engines that worked with mighty power in ancient days but are torpid now? How are they to familiarise themselves with the conception of processes going on in molten planets; under enormous glaciers; within sedimentary depositions that have required ages to complete themselves; and in oceanic currents, under different geographical conditions to those we now find in existence?

Calculators cannot grapple with complex problems of fluid motion, and it is almost interminable labour to work out the results of any large system of simple mechanical actions, such as coexist in most of the problems with which geologists have to deal. Mr. Campbell shows two ways by which a geologist may learn these things. The first is to go to Iceland, a sail of a week, and there to study glaciers and volcanoes in full operation, shaping a country as large as Ireland. Secondly, he advocates what we may call parlour geology. He contrives a dozen or more ingenious experiments, with mud and ice, sealing-wax, plaster of Paris, and spirit lamps, which show currents, and deposition of strata, and volcanoes, and geysers, and ice action, all within the compass of a glass tank, such as people keep little fish in. It is clear enough that the constants of the problems he endeavours to solve are not equally reduced in this miniature geology, but the effects of the actions that take place in his models are generally so similar to those that have taken place in nature, that we are *primâ facie* induced to believe the variations in the conditions of the problem of no material importance. To this question we shall recur. Next, in the midst of his elementary teaching, he dashes off on a line of original research. He finds that no effect, except ice, is sufficient to account for the configuration of the countries he knows, namely Iceland, Scandinavia, Western and Southern Europe, and part of North America. He therefore hunts the ice-tracts wherever he lights upon them, following their spoor with the zeal of a sportsman. He discovers, in addition to tracks radiating from high mountains, and therefore clearly made by ordinary glaciers, a set of marks that sweep over even considerable hill-tops, from NE. to SW. in grand curves, varied only by occasional eddies. These particular ice-marks are his 'great game,' the elephants of his chase, which he pursues from Lapland, over Sweden and Norway, Scotland, England, and not forgetting the Isle of Man, to Ireland, and then over the Atlantic to America. Hence arises his theory of a North-polar

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current, which drifted icebergs in ancient days over what is now the head of the Gulf of Bothnia, and brought Greenland weather to an archipelago of small islands, where the tops of Snowdon, Scawfell, Ben Lomond, and other mountains in the countries we have named, formed the principal peaks. They were then covered with glaciers, and were almost as arctic in appearance as is Spitzbergen at the present time. Lastly, he analyses volcanic phenomena, and offers, by help of his miniature geology, a vivid example of the way in which molten planetary globes may be presumed to harden on cooling, and his views on the state of their interior, when the thorough solidification of the mass is incomplete. This is a general outline of Mr. Campbell's work, in which lengthened and highly interesting narratives of enterprise in the far North are also included.

Before entering into particulars, let us premise in a few words the qualifications that Mr. Campbell appears to possess for executing his task. We have stated his defects, now let us do justice to his merits. Every chapter of his book proves that he is a joyous traveller, a keen and adventurous sportsman, an energetic and truth-seeking observer. He is endowed with the eye and the hand of an artist, and the pen of a painter in words, for he is a powerful, eloquent, and ready writer. He is also gifted with singular mechanical ingenuity, that lends unusual value to the experiments with which he illustrates his theories. Many of them will, no doubt, be hereafter employed in geological lectures. The sketches and other contrivances that form the illustrations to his work, are very numerous. All of them are original, many are quaint, none are ineffective. We will take only two instances of his ready adaptation to circumstances in these matters. He wishes to picture the structure of a stone of lava, that had been projected as a molten drop, and had sufficiently cooled to retain its shape before it fell to the ground. It is one of the illustrations to which we have just referred, of the interior of the earth, such as he considers it to be, chambered and tubular, with, it might be, hot lava still partially filling the chambers and tubes. He cannot make a satisfactory drawing of the section of the lava drop—its minute anatomy is too intricate. So the idea seizes him of compelling the lava to print its own likeness. He saws the fragment into a slice, of a thickness that corresponds to the depth of type, and he hands it over to the printer, in the place of an ordinary woodcut. This piece of nature-printing is all that could be desired. So again, he uses certain letters in black type, to stand as symbols of particular geological incidents; **O** is a crater, **Δ** is a river delta, and so on. We will quote a passage in which these letters are employed, where it will be remarked that their use gives precision and vividness to the idea he wishes to convey :—

'Distance does not affect the test by outward form. . . . If there were a large delta or river-bed upon the moon's surface, it could be recognised there as easily as upon the earth, for it has a conspicuous shape. It is a tool-mark. No **Δ** is to be seen in the moon; no forks and meanderings; no **V**, no **Y**, no **S**. There are no clouds there from which rain can fall. There can neither be river nor tree, like earthly trees and rivers, on the moon's surface, because familiar water and air forms are absent. But fixed, solid forms are there. It is known how similar forms are produced in this world. So it is fair to conclude that these lunar shapes, these **O** craters, also resulted from a combined action of heat, cold, and weight, which did their work, and have now ceased to work on that surface, though still active here.' (Vol. i. p. 20.)

It is possible that geological writers may imitate Mr. Campbell, and that the letters he employs may become as generally assigned to the same purposes, as the letters used by mathematicians to express the constants of mechanics, optics, and the rest, or as the x, y, and z of simple algebra. He uses them frequently, and always with good effect.

In analysing the work, we shall be obliged to travel over old roads. We must crave the reader's indulgence when we do so. There is no help for it, for though the contents of 'Frost and Fire' are thoroughly original in phraseology and tone of thought, yet they describe a good deal of well-known matter, and have obviously been written with imperfect knowledge of the labours of others. Indeed a chief part of its charm is due to its eloquent enunciation of familiar ideas in new language and under new associations. We feel something of the same interest in reading it, that we should feel in the perusal of a work having a similar scope, written by a highly intelligent gentleman of another race and hemisphere: say by a Japanese, who, knowing intimately the volcanic districts of his own remarkable land, and being irregularly acquainted with European science, had thought out a great deal for himself and expressed all he thought, from a Japanese point of view.

It will be convenient if we consider the natural engines that mould or hew the forms of the earth's surface, as being aerial,

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liquid, and solid. The same material may successively present itself in each of the three conditions. Thus water, for instance, may rise as vapour, descend on the hill tops as snow, crush downwards as a glacier, stream from it as water, and then recommence the cycle. It is all one great system of circulation, but the phases of it are subjects of separate inquiry. First, as regards the aerial.

The motion of currents of air in a room is an old and favourite topic of the author. It was the subject of a great deal of experiment on his part, the results of which appeared in a parliamentary 'Report on Warming and Ventilation of Dwellings,' 1857. He contrived to fix a large number of delicate silk vanes in an ordinary room, an anemometer was placed over the fireplace, and a series of thermometers were attached to a pole that reached from the floor to the ceiling. When all was in steady action, he mapped what had taken place. Lines were drawn with a bold hand to follow the directions indicated by the vanes. All the eddies and draughts were recorded by curves drawn from nature, after they had been made manifest by the vanes and also by moving fumes. In short, an excellent physical chart of the air currents of that particular room was incorporated in the Parliamentary report, and is reproduced on a smaller scale in the present work. It is a highly ingenious diagram, and shows how architects ought to experimentalise before they can hope to understand the art of judicious ventilation. Air is so sensitive to warmth, that we are informed the heat given off from the body of a man, in a still room, will cause perceptible currents at a distance of thirty feet from him in the space of two minutes. That is the rate at which the smell of a cigar is found to travel. It is the warmth of burrowing animals that ventilates their holes, and enables them to breathe. Mr. Campbell makes very forcible remarks on the different ventilation of different mines. He evidently speaks with a thorough knowledge of the subject, and his observations are worthy of attentive consideration. He describes the excellent currents of air maintained in a Northen coal-pit by the careful establishment of separate currents, of ascending hot and used air, displaced by descending cold and fresh draughts, and he contrasts with this a deep cold metal mine, where a few narrow pits all open about the same level, and stagnation is the rule:—

'The only air engine found working in one big mine was a piston in a rough deal box; a panting, short-armed little boy pulled and pushed at the cross handle. The air was close where he worked, and the squirt and its pipes leaked. A long way off, at the "end," a very faint puff, which gently bent the flame of a candle for a moment, was the sole result of each violent effort. . . . Men at work in bad places pant and seem to breathe painfully; their faces are red or purple; their veins swelled; their brows wet, and begrimed with soot. They seem to labour hard, though their work is not harder than quarrying stones elsewhere. In such places candles flicker and sometimes go out altogether; no puffing or drawing will light a pipe or keep it lighted. There is no laughter, no fun; no busy cheering clatter of active labour at close ends; there is silent toil; the carbonic acid is not laughing gas. . . . The death rates between certain ages were as follows:—

Ages.	Cornish people above ground	Northern colliers	Cornish men under ground	
35 to 45	10	10	14	per 1,000.'
45 to 55	15	17	34	
55 to 65	24	24	63	

(Vol. i. pp. 55–57.)

It seems to us that every instance of a frightful rate of mortality like this, is a just subject for legislative interference. Whenever evidence is adduced that the death-rate among workmen employed in any private undertaking, habitually exceeds a certain maximum, which the legislature would have no real difficulty in fixing, thanks to the minute returns of the Registrar-General, we think it is reasonable to demand that every such undertaking should *ipso facto* be held illegal, after fair notice and opportunity of amendment.

The general nature of currents of air in a room and those in a mine are shared by the winds, and are betrayed by the objects they act on. Foremost among these are clouds, whose shapes can be copied with marvellous fidelity by the following pretty arrangement by the author. A glass aquarium is half filled with water: a piece of ice is dropped in to float upon it, at one end of the tank, and a bit of smouldering tinder is laid on the ice. A plate of glass forms a roof to the whole:—

'Cooled air streams down upon the floating ice, and drives grey smoke rapidly before it, drifting along the water towards the warm end, like a cold sea-fog before a north-easter. At the warm end, the mist lifts, like a sea-fog when it nears a warm shore. The smoke rises to the glass roof, spreads there and returns along the top towards the ice; whirling, streaming out, and taking the forms of fleecy summer clouds, which float high in the air above the Atlantic in fine weather. "Stratus," "cumulus," "cirrus," "cirro-cumulus," "comoid cirrus," and the rest of the learned tribe; "mackerel sky," "mare-tails," "Noah's arks," and vulgar popular clouds of their class; nameless cloud forms which are the joy of an artist, and his despair

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when he tries to copy them; all appear drifting with streams, which various degrees of weight [? specific gravity] and heat cause to flow in air and water, shut up within a cubic foot of space.' (Vol. i. p. 70.)

This little illustration, ingenious as it is, can only approximate to the truth. A characteristic feature of clouds is that they are never constant in bulk. They are always either evaporating into invisible vapour, or increasing in size by the condensation of invisible vapour. Moreover, clouds have a movement that is due to another cause than the simple drifts of aerial currents. When they evaporate, the vapour, which is far lighter than air, is partly entangled in their substance, especially at their edges. It lifts them and causes them to work and to seethe with a proper motion of their own; that is to say with one that is not due to the winds and currents of dry and cloudless air. On the other hand, when a cloud is increasing, it subsides. Again, clouds often form at the plane of junction of two strata of air, of unequal temperature; they dissolve from below and form from above. None of these effects can be illustrated by smoke in a glass tank. Nevertheless, the experiment shows a great deal, and well deserves repetition in lecture rooms, with suitable explanations.

The winds leave their marks on sandy tracts, as is well known, by their power of raising dunes. We may here remark that some of those in the Sahara, according to Dr. Barth, and of central Arabia, according to Mr. Palgrave, seem very remarkable and deserving of study. They are said not to travel, but to remain stationary for years. Wells are dug near the foot of them; villages spring up, and palm-trees grow. If all this be as it is stated, we must look for the cause of it in their occupying the permanent *locus* of some regular aerial eddy.

Another effect of wind is shown in the forms of vegetation. The trees, in exposed places, stream away from the prevalent wind which, in the British Isles, is south-westerly.

'Every exposed Welsh tree bends towards the dawn. Every exposed tree on the west coast of Scotland seems to be driven by a furious wind on the calmest day. . . . At Dalwhinny there is something almost ludicrous in the stormy look of a whole wood of fir trees, which point their fingers down Strathspey, and bend their trunks as if yielding to a furious gale.' (Vol. i. p. 31.)

Mr. Campbell suggests very truly that if we mapped the direction in which the trees, exposed in open windy places, are bent, we might add another Physical Chart to those we already possess, showing the prevalent winds all over the earth. He lays considerable stress on this phenomenon of bent trees, and he gives us two drawings of them. One, at least, is a careful study; for we have ourselves taken the volume to Little Ormes' Head to compare it with the original tree, which grows in a park near there. He continually speaks of them as trees 'bent by the wind;' and appears to think they have been curved by the simple pressure of the wind, in the way that they might have been forced out of shape by the continued pull of a rope that had been lashed to them and kept on the strain. If this be his view—and he certainly suggests no other—we have not the least hesitation in saying it is almost wholly erroneous. The influence that mainly shapes the tree is of quite another nature, and one that has constantly struck us as being a most beautiful illustration of Darwin's great law of Natural Selection. Mr. Campbell's drawing of the tree near Little Ormes' Head is a vigorous artistic rendering of the original, and a perfectly just one from his mental point of view; but it omits some small details of much significance, which a photograph would have represented; and others which a drawing of the tree down to its foot, five feet below the top of the wall, which forms the bottom of his sketch, would have included. The trunk is represented in his drawing as having a perfectly smooth stem; one that, if left to itself, would have been the central, upright axis of the tree. A closer examination of the original shows that its present trunk would, under no circumstances, have been so. There are faint marks left to indicate, that while the tree was growing, whenever it pushed out buds, those that were situated to the leeward of the stem were favoured by their position and lived; those that faced the wind were nipped and perished. Their remains bear witness to efforts of growth in a direction that would have maintained the axis of the tree in a vertical position; but these efforts have proved abortive. Low down, under the partial shelter of the wall, the growth to windward is considerable, though stunted, and the stem is upright; but higher up, as the exposure is greater, the windward growth almost wholly disappears, and the tree becomes curved. The whole life and development of the tree has, under these circumstances, been restricted to a leeward branch, and subsequently to successive leeward subdivisions of that branch, until it has acquired the shape that is best calculated to escape the force of the wind. These views are simply corroborated by observation of numerous specimens of

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these forms of vegetation under various degrees of exposure and in different stages of their growth. The favoured development of those branches of weeping trees that happen to grow towards the rising damp, to the prejudice of the others, is a fact of a similar nature. It is one cause, though we do not go so far as to say it is the only cause, that moulds the shapes of weeping trees.

The currents and eddies of water have a considerable resemblance to those of air. The two may be compared with advantage in that very glass tank we have already described. The author sinks a black stone in the water, to catch the heat of the sun, which he allows to shine on the apparatus. He puts it in the opposite corner to the floating ice, and he pours a little milk upon the ice.

'Heavy cold streams pour down from the ice at the cold end, and flow along the bottom toward the stone, driving milk vesicles like drops of water in a grey mist. Light warm fountains flow up from the stone at the warm end, and flow along the surface toward the ice, driving milk-like wreaths of mist rolling up into a summer sky from a mountain side. The water is circulating.' (Vol. i. p. 69.)

Currents in the very bed of a river, or beneath the surface of the sea, may be watched, as Mr. Campbell informs us, by an arrangement that smugglers used in the old days. They sank their contraband cargo when there was an alarm, and they searched for it again by the help of a so-called marine telescope. It was nothing more than a cask with a plate of strong glass at the bottom. The man plunged the closed end a few inches below the surface, and put his head into the other end, and then he saw clearly into the water. The glare and confused reflections and refractions from and through the rippled surface of the sea, were entirely shut out by this contrivance. Seal-hunters still use it. With this simple apparatus the stirring life of the sea bottom can be watched at leisure and with great distinctness.

'So far as this contrivance enables men to see the land under the waves, movements under water closely resemble movements under air. Sea weeds, like plants, bend before the gale; fish, like birds, keep their head to the stream, and hang poised on their fins; mud-clouds take the shape of water-clouds in air; impede light, cast shadows, and take shapes which point out the directions in which currents flow. It is strange, at first, to hang over a boat's side peering into a new world, and the interest grows. There is excitement in watching big fish swoop like hawks out of their sea-weed forests after a white fly sunk to the tree tops to tempt them, and the fight which follows is better fun when plainly seen.' (Vol. i. p. 67.)

Mr. Campbell suggests plate-glass windows in the bottom of a boat; it would bring men and fish face to face; and the habits of the latter could be leisurely watched. He regrets that a diver cannot see clearly under water; objects seem blurred and indistinct; his eyes were not made for seeing under water. We have heard bathers regret this before; but we think they might remedy the difficulty. This very subject has been the topic of a paper, read last month at the British Association, by Mr. Galton, in which he investigates the cause of this indistinctness, as well as the curvature of the spectacle-lenses, that might be used to obviate it. His theory is simple and may be stated as follows. When the seal-hunter looks through the flat glass bottom of his marine telescope he sees things with equal sharpness of outline, whether they are in air or in the water. Now, suppose he takes out the flat glass and replaces it by a curved one, like a huge watch-glass, what would be the result? He would still see things distinctly in air, just as distinctly as we may see them through the curved front window of a brougham; but he would see nothing when he plunged his instrument into the water. The convex outer surface of the glass would have indented a corresponding concavity in the water and, consequently, a concavo-plane water-lens would have been interpolated between the seal-hunter's eye and the interior of the water. This is precisely the action of the cornea of the eye of a diver. Moreover, the radius of the cornea being very small, only 0·31 of an inch, the concave water-lens that it creates is one of very considerable power. What, then, is the power of that double convex lens, say of flint-glass, which, when plunged into the water, shall exactly neutralise the concave water-lens? The calculation is perfectly simple. We may conceive the lenses to form part of a detached apparatus, so well compensated in all its parts that the eye can see just as well in air and, through air, into water, whether the apparatus be in front of it or not. The conditions of this apparatus are, 1. that it shall be of water (conceive it, if you will, of ice) hollowed above with a concavity, the radius of whose curvature is 0·31 of an inch. 2. That it shall be flat below. 3. That a double convex lens of flint-glass shall be imbedded in it. From these data, it is required to find the radius of curvature of each of the two surfaces of the lens. Calculation shows it must be 0·47 of an inch; its focal distance being consequently only

0·39 of an inch. This is a high power and necessitates a very bulging glass, even though it be made of a much smaller diameter than ordinary spectacle-lenses. Opticians do not keep such glasses, they must be ground on purpose. We learn from Mr. Galton's paper that he has used combinations of lenses for seeing under water with complete or almost complete success, and that he is still engaged in perfecting his glasses. Such spectacles would be of real use to divers for pearl and sponges, and for sailors who had to examine the bottom of their ship. They might also afford great amusement to bathers generally, and, we dare say, to Mr. Campbell in particular. They give to the diver, as was stated in Mr. Galton's paper, the privilege of intelligent entrance into a new element. Persons in diving-bells or in diving helmets do not require these lenses, for their eyes never come into contact with the water. Their case is similar to that of the seal-hunter with his marine telescope. It follows from this theory, that extremely short-sighted persons whose imperfection of sight is due, as is commonly the case, to malformation of the crystalline lens, and not to a smaller radius of curvature of the cornea, ought to see much better in water than ordinary persons. On land they use concave spectacles; they take them off when they bathe, and they indent a concave water-lens of the same power as other people. Therefore, everything else being the same, they view things under the water *minus* strong concave glasses, which is exactly the same thing as viewing them *plus*, or through strong convex ones.

The 'tool-marks' of water upon geological forms are of course considerably deeper than those of air, yet they are absolutely insignificant compared to the marks either of ice or of heat. Water flowing over a stone wears it very slowly, excepting always limestone, which it dissolves away, by the help of the free carbonic acid that most water contains. The mark left by a stream on a rock is, as the author says, like the polish which a carpenter gives with his hand to what he had cut into shape and nearly finished with rougher tools. Where a stream runs rapidly down a slope, it cuts a gorge, whose section is V, or a U, or it may be Y. Hence ancient mountains that have been warred against by rain for ages are deeply furrowed on every side. A cone is grooved and fluted into steep peaks and ridges. It is weathered. The outline, which may be symbolized by Λ, is a tool-mark of rain, and of the other atmospheric influences which come under the category of weathering. The chief of these is the percolation of water into the crevices of rock, followed by its freezing, and the consequent quarrying of the peak, layer after layer, through the sudden expansion of the water as it turns into ice. Mr. Campbell continually designates this as an 'ice-wedge;' a most inaccurate metaphor. The word wedge calls up four ideas; a certain shape, easy insinuation, a blow to drive it in, and a rending effect of great power. Only two of these, namely the second and the last, are shared by his 'ice-wedge.' Why then confuse a very simple idea by the gratuitous use of inappropriate metaphor? It is bungling to no purpose. An A has two strokes in common with a V, and an E has three strokes in common with an F; but if we were to use these letters indifferently, it would be hard to decipher our spelling. Pray let us call a spade a 'spade,' and a wedge a 'wedge' and nothing else.

The well-known plan of a river, as it runs through a plain, receiving tributaries, making S meanderings, and finally forming a Δ, is reproduced on every occasion. It is to be seen in every gutter, and may be experimentally varied on the smallest scale of parlour geology.

The exceedingly feeble erosive action of water, on rocks, limestone excepted, is ably shown by Mr. Campbell in several striking instances. One is the Oxerá in Iceland, a rivulet the size of a mill-stream. It flows over a plain of lava, in which it has cut a channel of two feet deep and three or four wide. There is ample evidence that the Oxerá has never changed its bed, that its action has been uniform ever since the first; and finally, that it began to run, as soon as the lava of the plain had cooled, and was cracked in the way we now find it to be. The streamlet plunges into one of these cracks, and there is no water-mark on the opposite side, showing that Mr. Campbell's conclusions must be correct. Now the Icelandic Parliament has held its meetings on this lava plain for 800 years; and there is historical mention of the Oxerá, with minute details, of very ancient date. Hence we know that the *minimum* period during which the Oxerá has been running is 800 years, during which time it has only cut a channel of two feet deep, or at the rate of one foot in 400 years. Little as this is, the air and rain have done far less; for the curl on the surface of the lava is almost as fresh as if the molten plain had cooled only yesterday; not one quarter of an inch of surface has as yet been weathered away. The most that any river can do in a glen, is to nick a mere trench down the middle of it.

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River action is wholly inefficient to scour out the glens themselves; much less is it able to give the rounded shapes of mountain bases. As the author says, an artist might as well try to sculpture a bust with a hand-saw. The tool-marks of water are different to what we find on the hills, and these betray the action of a far more powerful engine.

Terraces and beaches are another tool-mark of water. The author illustrates their formation by the help of a model. Plaster of Paris is poured from a funnel into a deep vessel where it takes the shape of a cone, like the sand recently fallen into the bottom half of an hour-glass. Then he adds water till the whole of the plaster of Paris is covered, when the cone will be found to become more obtuse. Next he contrives that the water shall run off slowly, while its surface is kept agitated. After the water has run away, the cone will appear terraced with contour lines. The plaster sets, and the model is permanent. It will be found to have a strong generic resemblance to many islands; for instance, to the Isle of Man, which is similarly terraced. Mr. Campbell writes at some length to explain the way in which these terraces are made, and gives numerous instances, on many scales, in which they can be observed in nature, as by the side of shrinking pools and river beds; but his explanations are none of them directed to meet the real difficulty. How is it that a continuous action (a *steady* sinking of the water-level) produces an *intermittent* result? The answer is, that the intermittence is due to the cliffs falling in masses and at intervals. The water continuously undermines their bases, but they do not fall continuously; the undermining proceeds until the amount of unsupported weight on the cliff face, exceeds the cohesive power of the material of which it is made, and then, and not till then, is there a downfall, to be succeeded by a period of repose. Again, of the three processes in which the water is employed—of undermining, of levelling the fallen earth, and of washing it wholly out of the way into the deep sea—the two first are usually far more quickly effected than the last. Terraces and beaches are therefore created more rapidly than they are washed away, and their form is durable. Mr. Campbell symbolises this 'tool-mark' of water by L; an upright cliff, and an horizontal, or, at all events, an only slightly inclined foot.

One of the prettiest parlour illustrations of geological action in the work, is the arrangement by which the deposition of silt may be narrowly watched in progress, both from above and in section. The drawing that accompanies the description aids in the explanation; but even without that advantage, Mr. Campbell's account will be fully intelligible. It deserves careful consideration:—

'A glass tank with flat sides was half filled with Thames water, as supplied in London. A glass funnel was placed in a retort stand, so that the end of the funnel touched the water near one end of the tank. Through this channel finely divided materials of various colours and specific gravities were poured, in the following order:—1. "Silver sand;" 2. Coarse granite sand from the Scilly Isles; 3. Fine pipeclay mud, squeezed in with a sponge; 4. coarse yellow sand; 5. silver sand; 6. yellow sand; 7. very fine dark river mud, part of a ball in which a mud-fish was brought home from the river Zambesi, in Africa; 8. silver sand; 9. Zambesi mud; 10. silver sand; 11. Zambesi mud; 12. silver sand; 13. pipeclay, to make a white surface. In spreading from the channel through which they fell, these materials formed themselves into a conical mound; but the base of the heap could not spread beyond the glass walls, and the edges of the forming layers were seen through them. Four vertical sections of a stratified mound were seen forming at different distances from the channel by which the materials entered, and they varied in shape, colour, and material. No one of them presented thirteen flat layers arranged in the order in which the materials were poured; instead of thirteen beds there were nearly thirty. . . .To imitate nature, bits of ice were floated at one end, N., and sunlight was allowed to shine on the other, S. This arrangement of temperature moved the miniature engine, and it worked accordingly. The water about the ice cleared, and a thin layer of clean cold water floated, because that water was about 33°, but columns of cold water (about 37°) sank down from the ice, and the falling streams carried suspended mud rapidly downwards. Wherever an iceberg is melting the same thing must happen on a larger scale. . . The curves of temperature were shown within by clouds of mud, as curves of temperature are shown by clouds in the air. As these mud-clouds fell, layers began to fall on the uneven surface below, and these followed every curve, which had resulted from the method of pouring in the heavier and coarser materials. Horizontal layers of falling silt formed in the water, and sank gradually, settling upon each other, but varying in shape as the currents of cold water moved them from N. to S. below, while warmer currents moved them from S. to N. above. Wave-marks and ripple-marks were formed on the surface of the mud, and fresh layers were seen to form against the glass. The heavier particles forced their way through the falling shower, and these beds in forming slowly assumed a very complicated structure. White clay and brown mud separated and mingled, and took strange branching tree-like shapes, like those which occur in mottled sand stones. These are called "dendritic concre-

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tions," and have been ascribed to electrical action; in the tank they resulted from mechanical action alone. The bed of silt in gathering weight squeezed out the water, and the water in rising displaced and pushed up the lightest particles of mud. Through a lens the operation was seen; some grains were falling slowly, as snow falls in still air, others were rising in jets and fountains of water squeezed out by the growing weight above; others, again, were drifting before the currents, as snow and clouds drift before the wind. When the water cleared the surface of the mud was a white surface of deposition with current-marks, the sides of the mound a section of a small geological formation; and the whole operation had been seen from beginning to end. Temperature and gravitation had been set to work a small engine, and it packed silt as the sea does.' (Vol. i. pp. 304–6.)

Mr. Campbell justly remarks that geological writers often improperly assume that strata are deposited flat. It was not so in the model, where they followed pretty closely the curves of the interior currents. Neither can they lie horizontally when they are deposited on sloping surfaces. Mr. Campbell illustrates this by a drawing of snow, fallen upon the irregularities of a mountain side, but we shall see that the analogy is not appropriate, and had better be dismissed.

There is no doubt that deposits under water tend to obliterate hollows, but their particles follow the law of equilibrium of sand and of talus heaps, not that of fluids; still less that of snow, whose behaviour under the pressure of its own weight, introduces a wholly new element. A blunt-angled cone of sand, in still water, would be as perfectly in equilibrium as a more acute-angled cone of the same material in air. The presence of water enables the grains of sand to move more freely among one another than they did before; but it does not endow them with absolute freedom of that kind of motion. Equilibrium among the particles of the heap is maintained so long as the inclination of its sides does not exceed a certain moderate angle, which is constant for each description of material.

We have thus far spoken of what takes place in still water; but we must recollect that a very moderate current, washing to and fro, materially modifies the result; it gradually wastes the cones. The grains of silt are exceedingly minute objects; consequently the ratio of the surface of any one of them to its weight, is enormously greater than the same ratio in pebbles or boulders. Since the extent of the surface of any solid is as the square of its diameter, and the weight of it as its cube, it follows that the ratio of which we have been speaking is inversely as the simple diameter. Now the effort of a given current of water, to move a solid particle, may be considered proportional to its surface, and the resistance of the particle to the power of the current as its weight; therefore the effective balance of power of the current over the particle is inversely as its diameter. From these considerations it is clear that though a feeble current may be powerless to stir a single grain of a heap of sand, it may perfectly control the movements of silt, the diameter of whose particles (supposed to be of similar shape and specific gravity) is ten or a hundred times smaller. Hence a very slight current washing to and fro is sufficient to level any cones or other inequalities in a deposit of silt.

We now turn to the consideration of more powerful engines than those of water or air, in the great machinery of nature. Water rises insensibly as vapour, but it falls on the cold hill tops, and on the comparatively sunless polar regions, in the form of solid flakes of snow, which speedily are crushed together by their own weight into hard, huge, toppling or sliding masses. Air or vapour may pass in a thin swift current, against moderately hard rock, until in the course of a few days many hundred tons weight have impinged upon it. But as at no time was the disintegrating tendency of the impact greater than the cohesive strength of the mass, the continuance of the effort will not have prejudiced its stability. So again, and for the same reason, the same number of tons of water, heavier in specific gravity and more sluggish in movement, may eddy against the same object during the same period, with equal absence of result. But let these tons of vapour or of water be converted into a single block of ice that has been accumulating during the days of which we have spoken, and let it then float like an iceberg, with the velocity due to those currents of water that by themselves were so harmless, and strike against the rock, the result will be enormously greater. There has been a concentration of energy upon a single effort which, in the case we have supposed, would certainly exceed the cohesive power either of ice or rock. When the concussion takes place, both ice and rock would probably suffer, and the former more than the latter, owing to its inferior hardness. But in estimating the effect that may practically take place, we must recollect that glaciers on land, or floating in the forms of bergs at sea, commonly enclose large stones, and the impact is frequently between rock and rock, and not be-

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tween ice and rock. A watchmaker's steel graving tool is set in a wooden handle, by which the pressure on its point is spread innocuously over a large surface, where the tongue of the tool is in contact with the handle; so are the stones set in the ice. When ice, armed with these implements, grinds against rocks, we need not regard the weakness of the material of the ice handle, any more than we need regard the weakness of the wooden handle in the watchmaker's tool.

Mr. Campbell's many chapters on the nature of glacier action are vigorously written, with his usual play of fancy, but they cannot be said to add materially to our real knowledge of it. Take, however, the following extract, not for its novelty, but as a specimen of his vigorous style. He describes the land glacier as a 'conglomerate of air, sand, mud, stones, and frozen water,' and says:—

'So in moving through a rock-groove, this heavy, flexible, viscous rasp grates and grinds, breaks and crushes, thrusts, rolls, and drags everything that comes in the way. If water flows round a sunken stone on a warm day, it becomes a vice at night; it clasps the stone, binds it to the moving mass, and grinds it against the rock, like an iron in a wooden plane. If the tool is not strong enough to crush a rock, it is flexible, and the weight behind pushes it over; if it is broken, it mends itself. Wherever it goes the ice-tool grinds; it works broken stones into polished boulders, boulders into mud, fractured rocks into roches moutonnées, and mountain-glens into rounded, polished, striated rock grooves.' . . . (Vol. i. p. 203.)

With equal power, and at greater length, he describes berg-ice. How each of the enormous glaciers of the North holds bergs on the 'slips,' like vessels that are being built, in a position to be launched into the sea, when their time comes. He renders us familiar with the miles of ice-floats, enclosing these bergs that drift to and fro with the tide, or sail off altogether with the current, scraping along the deep sea bottom as they go, and necessarily leaving enormous valleys of denudation in the wake of their habitual tracks. A land glacier moves only some four feet in the twenty-four hours; a berg drifting with the tide up and down the firths of an archipelago, will move five miles an hour, or 158,400 times four feet in the twenty-four hours. The land glacier can do much, but how enormously greater must be the tool-mark of floating ice!

Mr. Campbell says, by far too broadly, and in obvious ignorance of previous writers,

'Of the moving stream of ice-floats, many pictures have been drawn by able hands; but no one seems to have considered the system as one great denuding engine.'

Sir Roderick Murchison has already replied to this, in his own behalf, in his Anniversary Address to the Royal Geographical Society. In truth the idea has long been a familiar one, though not by any means so minutely worked up in all its bearings, or so prominently enforced, as in the present work.

The value of Mr. Campbell's volumes lies chiefly in his chapters on the ice-marks in Northern Europe, and in the conclusion he bases on them. We wish they had been written plainly, and not in a broken, ornate style; and as such had been submitted to discussion before geologists in the usual channel. The argument turns entirely upon matters of detail. Mr. Campbell states that in such and such places there are such and such ice-marks. There may be a conflict of evidence for aught we know about these; certainly Mr. Campbell occasionally finds marks which he reproaches geologists for having overlooked. However, we have strong cause to confide in the accuracy of our author's observation. Few sportsmen could track a deer better than he, and he has evidently given quite as much attention to the spoor of ice as the spoor of game, excellent sportsman though he be. We do not therefore feel we have a right to carp at his facts. We must accept them provisionally; and we describe them, at least in their general bearings, together with the theory he builds upon them. He has hunted his ground thoroughly. When the theory took hold of him, that a vast current had swept over Scandinavia and Britain in curves from the north down to the south and south-west, he set himself steadily to work to track its tool-marks. He takes up the track in Norway, and follows the direction of the ice grooves over hill and dale, without once dropping it. It leads him across the German Ocean, for it points to Scotland, and to Scotland he goes. Then he pursues the same line across Scotland and onwards to Ireland, and finally to America. Having mapped this line, he starts on a new one, a little to the south of it, and proceeds on precisely the same principle, and so again on another and another. All these lines give parallel curves in vast sweeps, coinciding with the course that an unimpeded polar current would necessarily follow, owing to the earth's rotation at the widening out of the meridian towards the equator. He visits the head of the Gulf of Bothnia and finds it scored with ice-

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marks, showing that once a sea passage lay right over it, and corroborates Von Buch's remark that a subsidence of 1,400 feet would be required to submerge it. Now other facts and reasonings come in. First, all these marks of sea ice, whose characteristic it is, that they have no reference to the watersheds of the mountains, but pass over or along them, always maintaining a south-westerly course, are at a lower level than 2,000 feet. Therefore the land was submerged up to 2,000 feet during the cold period; under which circumstances the sea passage to the Pole, in the direction of an Arctic current, would have been unobstructed by the head of the Gulf of Bothnia. Secondly, the author finds no terrace of glacial drift lower than 1,400 feet; and therefrom concludes that when the land was submerged only to that amount, the cold period closed. This, it will be observed, is the precise depression at which an Arctic current would first be obstructed. Thirdly, the universal parallelism of raised terraces and sea margins, with the present sea level, shows the emergence of Scandinavia and Britain to have been uniform, and therefore the foregoing arguments have additional weight.

It is quite unnecessary that we should follow the author's lengthy demonstrations, that an Arctic current would be capable of drifting an Arctic climate to these islands. It does so to almost the same parallels on the opposite side of the Atlantic, and there is no reason why Arctic and Equatorial climates should not have been even more strongly differentiated in the same latitudes in former times than they are at present. Mr. Campbell does not attempt to prove that the Greenland climate was mild when ours was glacial; nor why an Arctic current should elect (the phrase may pass) to sweep over Scandinavia and Britain, when these countries were submerged, rather than over any other course. This is a blank in his argument, but one that it is not essential to fill if all the rest can be maintained.

It is equally unnecessary we should follow his arguments about the course that an Arctic current would necessarily follow; we have already said something and shall have yet to say a few more words upon it. The general theory of ocean currents, as a corollary to that of the trade winds, is perfectly understood, though Mr. Campbell fails to grapple with it and master it. His conclusions are approximatively right, that its course would present the shape of a comma (,), and we need not waste more time here in pointing out inaccuracies in his processes. He refers to a motive power, driving icebergs south, which we do not recollect to have seen mentioned before, though it is hardly likely to have escaped the observation of geologists. He, however, quite fails in analysing its action with correctness. It is the centrifugal force. The ocean is, of course, in a proximate state of fluid equilibrium; therefore unless the centre of a body (f) floating in it, lies in the same position as the centre of gravity of (w) the body of water it displaces, that body will be in a different condition of equilibrium to the water. The centre of gravity of f is necessarily in the same vertical line with that of w; but it may be above it or below it; and, as it is above it or below it, so will it be further from the earth's axis, or nearer to it. Now it would be below it, if f were a hollow shell, ballasted by a sufficiency of material of high specific gravity, to make it float deeply. It would be above it if f were of light homogeneous material, like ice, in part rising above the surface of the water. Now the centrifugal force would urge f towards that parallel of latitude where the centre of gravity of w would be at the same distance from the earth's axis as that of f was, when f began to move. f would tend to move towards the pole, when the distance of its centre of gravity from the earth's axis was less than that of w; and from the pole when it was greater. The latter, as we have seen, is the condition of icebergs.

Mr. Campbell arrives at a similar result, but by an incorrect train of reasoning, in which he seems to forget all about the submerged parts, and to look on the ice-floats as mountains of ice lying on the surface of the water and slipping freely over it. He says:—

'If the curved surface of the whole ocean results from equilibrium in forces which act upon fluids on a revolving globe, so as to drag them towards the centre by weight, and drive them towards the circumference of planes, cut through the axis at every latitude; a solid float, projecting from one foot to three hundred, and free to move, is an unstable excrescence exposed to the same forces which so act on water as to work it into a smooth curve. It is like wax dropped on a spinning top, or ink spilt on a whirling mass. Weight drags it down, and keeps it balanced at a certain distance from the earth's centre, but centrifugal force acts at right angles to gravitation, near the Poles. It drives the float away from the centre of rotation, and it is not directly opposed by the sinking force till the Equator is reached. The force which keeps a stone from falling out of a sling till the string is loosed, must sling ice away from the Poles, unless the mass is of equal dimensions upon all sides of the axis about which it revolves.

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There is no cable to moor the float to the Pole; the cable is "up and down," and the anchor is at the earth's centre. There is force to swing the ship along the sea, and it ought to move south because of the centrifugal force.' (Vol. i. p. 486.)

The centrifugal force, though a *vera causa* in the movements of icebergs, is quite insignificant compared to that of oceanic currents, which depend primarily on the convection of heated water to cold latitudes.

Many natural chronometers are suggested by Mr. Campbell, by which to calculate the time at which Britain lay at various altitudes below the present sea level. They are on the following well-known principle. The fall at the Devil's Bridge near Aberystwith could not have existed before the place itself had emerged from the sea. The uniformity of the width of its bed shows uniformity in the size of the cutting wheel, so to call it, of the river since its first commencement. So again the perfect uniformity of the slate bed, through which it has been cutting, shows that the rate of the operation must have been unchanged. It has sawn through a depth of ninety feet. How much does it saw in a year? We wish Mr. Campbell had himself made some experiments on this problem; he suggests methods of attempting them. Of course, many other streams might equally afford estimates.

It will be observed that Mr. Campbell's theory of floating ice being the great denuding agent, is at direct issue with that of Professor Ramsay. The latter, he justly says, assumes

'A period of intense cold, which prevailed throughout all high latitudes, and in all elevated regions of the earth, simultaneously; and which caused an enormous growth of ice during one or more geological periods. But no attempt is made to account for this cold period. The theory which this volume is intended to illustrate is, that the present time is the "glacial period," and that an explanation of ice-marks is to be found in the present condition of other parts of the globe. The marks in Scandinavia suggest glaciers on the scale of glaciers in Greenland; the marks in Great Britain suggest sea-ice on the scale of Labrador ice; the change of climate at one place is accounted for by a change in the course of an ocean current, caused by a change in the level of sea and of land. All are agreed as to the facts; the questions left for argument are, the cause of the change, which has surely taken place, the nature of the ice which made the spoor, and the amount of work which this engine has done. Mr. Ramsay attributes many rock-basins and their lakes to glaciation, and few agree with him; these volumes go further, and attribute these and many of the main lines of denudation in Northern Europe and elsewhere to glaciation, *combined with ocean-currents*. Mr. Giekie and other observers attribute marks in Ross-shire to land-ice. Their difficulty is how to get their glaciers over watersheds, and account for the cold of the exceptional glacial period. Mr. Ramsay appears to have proved that glaciation coincided with the deposition of certain breccias of Permian age in Britain. The stones are glaciated stones, that is certain; their position rests on good authority. If the glacial period began soon after the coal formation, and has endured till now, the acknowledged work of denudation gains the aid of an engine which works faster than streams and waves do. If arctic currents are now to be added to the list, they are bigger and stronger tools than land-glaciers, and may have helped to do the work, which has certainly been done somehow.' (Vol. ii. p. 147.)

Mr. Giekie's recent work on geological action well deserves attention; no writer has illustrated the scenery of the Highlands of Scotland with greater scientific ingenuity, or in a more attractive form. But we must leave him and Mr. Campbell to settle between themselves the controversy between floating Arctic currents and the effects of land-glaciers. We, however, take this opportunity of referring to a recently published volume on a curious form of glacier. It is on 'Ice Caves in France and Switzerland,' and elsewhere, by the Rev. G. F. Browne, a member of the Alpine Club. This gentleman having palled, as we presume, in his interest in peaks covered with snow, devotes himself with a marvellous passion to holes filled with ice. His enthusiasm is irrepressible, and the reader is lured on till he shares in it; although few excursions are less attractive at first sight than those in underground holes, on ice-covered floors, beneath dripping roofs, with the possibility of shooting downwards into the bowels of the mountain, never again to emerge. There is a great deal of scattered literature upon these natural ice caves; but the thoroughness and extent of Mr. Browne's explorations has wholly superseded what others have done in this direction before him. He has visited and carefully measured a dozen caves, and has added a description of several others from the accounts of travellers. They are by no means uncommon in mountains where natural caves exist; and a family likeness runs throughout them. They are mostly from 2,000 to 6,000 feet above the sea level; they usually consist of a deep hollow in a fir wood, and thence a lateral pocket sloping downwards. The ice forms plentifully in summer, and the peasants who quarry the ice, universally maintain that more ice forms

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in hot dry weather and in summer than at other times. Lastly, the ice is universally made up, more or less, of prisms. It divides readily into hexagonal shapes. Even in one case the individual prisms could be pushed out by the finger like knots in a plank of wood. A great deal of discussion has taken place on the theory of these ice caves. The cause of their origin that finds favour with the author, is that they are necessarily the receptacles of the coldest air during several past hours. Cold air subsides, owing to its specific gravity, and cannot possibly be dislodged, for the sun is unable to get at it. This explains a great deal, but it does not explain all. The freezing goes on in summer nights, when there is no air in the neighbourhood at the freezing-point. We should have thought that radiation into space was a powerful additional cause, and one that would act on every clear night. It would not even require a still night. The temperature of the cave would be lowered by radiation, even though wind was blowing. It is well known that by the exposure of shallow pools of water in sheltered places in India, to the still night air, ice is habitually produced. Also that the temperature of a thermometer laid on the grass, in a still quiet night, sinks many degrees below that of the air above. The grass radiates into space, the air next to it is chilled, and, there being no wind, the cold air is not displaced. Now all this would invariably take place in an ice cave under a clear summer sky, whether the wind blew or whether it did not. The temperature of the cave, owing to its depth, would be pretty independent of summer and winter changes. Owing to its elevation, the mean annual temperature of its locality would be rarely higher than 40°. Owing to its being the receptacle of the chilled air of the coldest nights, the temperature of the cave would be yet further diminished. And lastly, nocturnal radiation into a clear sky, through the rare dry mountain air, would account triumphantly for the remaining few degrees required to bring the temperature below 32°. We wish Mr. Browne would register the temperature of these caves during a few clear and cloudy summer nights. It would test the theory we have advanced.

Having disposed of the agencies of water, frozen by the cold of space, the author of 'Frost and Fire' examines those of rock-substance, molten, as he considers, by the primæval heat of the earth. His object is primarily to show that when molten bodies of all sizes, from a grain's weight to that of a planet, and of nearly all materials, are left to cool, they do so with mighty throes. At first they splutter, and they throw out burning sparks, and seethe with vapours long after the source of heat has been removed. When they are so far cooled as to be crusted over, the subsequent period is by no means one of repose. The crust cracks, molten matter is forced through the cracks, there are subsidences in one part of the surface of the crust, and elevations in another. And when the whole mass is cooled down and has been cut upon, it will be found as porous and cellular within as it is rugged without. The obvious corollary is that all volcanic eruptions, elevations, disturbances, or other tool-marks, have their counterpart in what may be observed at the period of cooling of any molten mass, say of sealing-wax. And, also, that the porous structure, invariably observed in these small masses, necessarily exists on an enormous scale in the substance of the earth. Its presence, in fact, accounts for all volcanic phenomena.

'A comparison of forms in hollow spheres of hot water; in sparks thrown off by hot silver, iron, glass, and other substances; in "bombs" projected from terrestrial volcanoes, and in meteorites attracted from space; makes it probable that a flattened spheroid with a frozen crust, through which luminous fluids and hot vapours now escape in all directions, may now have a solid chambered spongy core, packed above bent rays, and about a centre of motion; made of materials which do not easily melt, and which freeze at high temperatures. According to astronomical calculations founded on the earth's movements, the average density of the whole mass is 5·67, water being 1. The specific gravity of iron is 7·7; but hollow iron ships float in water, like pumice stones, and a spongy mass of any material might have any apparent density according to its structure and state of expansion. Chambers may be filled with the hot fluids and gases, which radiate through holes in the frozen crust and shine with terrestrial light when they follow the paths of rays and strive to escape. Jets of vapour and fountains of sparks so escaped from the fire ball of 1864, and they so escape from shining furnace sparks.' (Vol. ii. p. 386.)

We wish Mr. Campbell had worked out more thoroughly the causes and the limits of that porosity, which certainly is found in many bodies freshly solidified from a fluid state. If the circumstances under which they froze admitted of gas of any kind being frothed up with the fluid, we should expect the solid to be porous, but such does not seem at first sight to be the case in the instances he mentions. Thus he describes the preparation of silver from the ordinary lead ores by Pattinson's process. A pool of pure molten silver is finally obtained 2½ feet wide and 4 inches deep. This is set to cool; and,

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in cooling, it goes through the utmost commotion for the space of an hour, and ends in being 'hollow, chambered and crystallised like slag, or Icelandic lava, or glacier ice.' Mr. Campbell certainly accredits it with having had 'hot oxygen locked up in it;' but we cannot conceive how oxygen ever got there, nor, supposing it to have been there, why it did not set itself free long before the expiration of the hour. The violent commotion did not begin till after the crust had fully formed.

'With cold the resistance comes and the battle rages. When the silver is pure the fire is extinguished, and freezing speedily begins. First a few crystals form on the surface, then a network, then a thin skin. If a bit of gold or silver is tossed in about this stage, it floats like a small iceberg, and gathers a thin raft about it. The silver-ice may be pushed about, for it is a floating body; and if pushed down, it rises again high above the fluid. It stands higher than ice in water; far higher than solid lead in fluid. . . . Molten silver is within; it is compressed by the forming shell, and hot oxygen is squeezed out of the mass (?). The surface at this stage begins to break up and bubble; it is upheaved; silver escapes where resistance is least, generally near the edge, where the heat of the cup keeps the crust thin and soft. . . . To prevent loss from boiling over at the edge, the workmen commonly prick the silver plate in the middle; they break holes in the ice, and the silver pool wells up like water in a pond. Then comes the time of rapid upheaval and disturbance. Bits of broken crust rise and fall like the lid of a box, and hot springs of boiling silver gush out in shining fountains of glittering light. They freeze as they overflow. . . . There is scarce a mountain form or fantastic lava shape in Iceland, a branching shape in a metal vein, or an ice-form off Labrador, that may not thus be copied in freezing silver. Throughout this period, the explosive force within casts showers of spherical drops whirling into the air. . . . And many of them cool as hollow shells about chambered interiors.'

Part of this violent action is intelligible enough. The molten mass is caked in by its crust, and further freezing expands that mass and cracks the crust, just as freezing water bursts water-pipes. But there is a far greater amount of eruption than is due to the difference of bulk between the molten mass and the same in a condensed solid form. There is, in addition to this, the equivalent contents of all the vacant chambers in the cellular mass. Wherever there exists a cell, an amount of silver that would have sufficed to fill that cell must have been ejected through the crust. Was the cell a vacuum when it was first made? Iron behaves in just the same way; but we happen also to know that a moderate pressure puts a check upon its tendency to be porous. A cannon, as formerly made out of a single block of metal, was always cast in a vertical mould, a few feet longer than the intended cannon. These extra feet were porous. They were cut off, and the residue was sound. Therefore the fact that small objects invariably freeze in a chambered form, does not prove that the depths of the earth, lying under pressures of which we can find no equivalent on its surface, are chambered also. Again, there is a limit to the size of the chambers that may be blown by vapour pressure from within, which is due to the cohesion of the material that forms the wall of the chamber. It is not possible to blow so large a bubble in spirits of wine as in water, nor in water as in soap and water. There is a limit in all these cases, which practically cannot be reached. There is similarly a limit to the size of a bubble under the earth's crust, though what that limit may be Mr. Campbell's remarks give us no assistance in ascertaining. The tenor of his argument is to ignore its existence.

There seem abundant causes for volcanic eruption, in the double fact that steam is commonly blown out of volcanoes, and that volcanoes are almost invariably situated near the sea, whose waters might supply their steam boilers. But Mr. Campbell's arguments go further. They would lead us to expect vapours of other kinds to be in constant and violent action. However, even on the most moderate hypothesis his facts and analogies are of very great interest. He describes all the volcanic effects of cones, craters, tubes and geysers; and shows that every one of them exists on every scale, from Hecla and its larger neighbors, to natural miniature vents of all kinds (mostly cold now), with which Iceland abounds; and on a yet more miniature scale in his own interesting table-geology.

'To understand the formation of tubes by heat, the action must be watched; and there is a very lively, harmless young specimen, whose operations can be watched close to the Geysers. A little mud spring is in a hollow to the north of the Great Geyser; it is almost hidden amongst the ashes, and about as big round as a stewpan; in it the formation of tubes by hot vapour is going on. The spring was betrayed by a ploutering poppling sound, which, to a hungry Scot with the brevet rank of cook, was absurdly suggestive of boiling porridge. A vision of a nursery and a rosy maid, a stewpan and a fire, rose up as if by magic amongst the cinders; but there is no porridge to be had in that benighted land. A deaf French traveller who was supposed to be dumb, was startled into speech and exclaimed, "Chocolate!" The spring was full of half liquid boiling tough clay, through which steam and other hot vapours escaped; and as the vapours burst through the surface and rose, the mud flowed back and filled up the holes as fast as they were made. This small tube-making engine was like Vesuvius, when the lava was soft in the centre and vapours were escaping through it. If the material gets tougher, the soft tubes will be finished and the poppling will cease, as it had ceased in Vesuvius in 1842, when the lava was hard though hot, and vapours were escaping freely through a rough tube. In course of time the mud may be baked into stone, and the tubes will then resemble larger tubes in the same neighbourhood. They may become vents for hot vapours, or for hot water, or lastly they may be filled up with some other material, and become strings like those which abound in all parts of the earth's crust. The little natural engine is making tubes of the same pattern as those which are made by larger engines moved by the same force. By watching it the whole process may be learned, as the action of a large steam engine is learned from a model.' (Vol. ii. pp. 104, 405.)

The intermittent character of geyser action and volcanic explosion, due primarily to continuous infiltration of cold water into heated chambers, is no more difficult to conceive than the existence of intermittent springs, owing to the continuous infiltration of water from a higher level. It does not at all follow that the same tension that occasionally throws up the volcanic matter far above the sea-level should uniformly resist the percolation of more sea water. A great many natural arrangements may be conceived and made in models, any or all of which may exist in action in nature. A supply of the nature of an intermittent spring might feed Stromboli. The giving way of subterranean reservoirs might be the immediate cause of the far more rare eruptions of Etna and Vesuvius. The mechanism of the geyser is well understood. In all these cases, when the imprisoned gas has once got free access to the bottom of the tube of eruption, and has in any degree overmastered the pressure of the column of molten lava that weighs upon it and seals its egress, the complete ejection of the lava becomes a necessary consequence. By every five feet or so of the column of lava that boils over, an effective increase of power to the extent of one atmospheric pressure is obtained by the imprisoned gas. It has ridden itself of that amount of its fetters. Consequently the eruption goes on with rapidly accelerating violence, and the whole contents of the tube are shot out with force. If only a detached volume of the gas has obtained access to the bottom of the tube, then its loss of tension by its own expansion is a set-off against the diminution of resistance due to the partial emptying of the tube, and the explosion is not so complete. Every imaginable variety in this respect may occur in practice.

We will now refer to Mr. Campbell's numerous experiments and to his argument, to show the course which polar and equatorial currents would follow on the globe. It is an important link in his reasoning, because he dwells on the often mooted remark that the general shape of the sea coasts and valleys of the world are very suggestive of the outline of ocean currents. There is not one of Mr. Campbell's experiments that is correct. He describes well enough the well-known cause of the divergence of meridians, combined with the earth's rotation; why winds blowing from the North-pole become easterly, and those towards the North-pole become westerly; but then he plunges into rude experiments to confirm this explanation. In doing so he falls into a blunder, and even partly stumbles out of it in ignorance of his mishap. First of all he states (the italics are our own):—

'The result of motion upon a moving surface is easily understood and easily illustrated. . . . If a graving-tool is moved along the rest of a turning lathe so as to mark a revolving disc, straight lines drawn from circumference to circumference and back, become opposite spiral curves. . . . According to the pace at which the disc and point move, so is the pattern drawn; and one very common result is the pattern on the back of a watch. . . . *Opposite radiating spirals* are made by dropping melted wax upon the convex top of a bull's eye lens while it is moving horizontally; and upon the inner edge of a concave bowl. In one case the falling wax moves from centre to circumference, in the other from circumference to centre, and the movement *in both cases, at first, is direct.* . . .' (Vol. i. pp. 474, 475.)

He makes the experiment in various ways:—

'Many trials gave various curves, but they were all spirals crossing meridians from east to west, when the map [he had fixed a map on an horizontal wheel] was spun from west [? through south] to east. . . . The *opposite curve* drawn from circumference to centre, is copied by dropping fluid into a whirling bowl, so that it *tends to move along a radius*, in converging lines. (Vol. i. p. 476.)

He evidently wishes us to understand, first, that water dropped on to the centre of an horizontal wheel, turning as he describes, whirls off in a left-handed spiral to the circumference, and in so doing represents the path of a particle of water urged southwards

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from lying in a state of rest on the North-pole; secondly, that a drop let fall on the circumference of a revolving bowl whirls inwards with a right-handed curve to the centre, and so represents the movement of a particle of water that has been urged from a position of rest on the earth's equator towards the North-pole. He looks upon one experiment as the precise converse of the other, although it is no such thing. A drop spilt from a point at rest, on to the pole of a whirling wheel, is as much at rest in reference to that wheel at the moment of touching it, as if it had previously lain there, because the pole is stationary. But a drop similarly spilt on the circumference of a whirling wheel or bowl is not so. The direction of the line of impact between them is the same as if the wheel had been at rest and the drop had been dashed violently against it at almost a tangent to its rim.

The author's second experiment, therefore, does not illustrate the effect he had intended, but quite another action. It illustrates the course which *easterly equatorial currents* would follow if an impulse to the northwards were given to them. Evidently put on the wrong track by his experiment, for he nowhere seems to discover that he is in error, he proceeds to account for the direction of the Gulf Stream, which flows to the NE., but which, according to his experiment, ought to flow to the NW. He calls into his aid the following theory, 'When any stream runs against a bank or into a bay, it swings off in some new direction, like a charge of shot from a slanting wall' (vol. i. p. 478). And again, if the Gulf Stream, 'instead of running foul of the bank of Panama,' passed through it, 'it would flow on northwestwards till it could flow no further' (vol. i. p. 479). The state of the case really is, that were it not for the obstruction of the American coast, other influences remaining the same, the Gulf Stream would flow to the north-westwards for a while, but the influence of the earth's rotation, combined with that of the convergence of the meridians, would cause it gradually to curve to the right, through N. and NNW., until it ended by running in approximate parallelism to its present course.

Might not an arrangement be contrived, which would accurately accord with the simple conditions of the problem of ocean currents, and trace lines on a globe corresponding to different variations in the constants of those conditions? They would form a very instructive series of curves to compare with the lines of existing currents. The problem in its simplest form is to trace the course of a particle urged to move from the pole to the equator, and thence, if desired, to the other pole, regard being had to the earth's rotation and to the friction of its surface, which retards the velocity of the particle according to the usual approximative law. It would not be difficult to prick out the course of a curve on this principle. We will, for the simplicity of explanation, suppose the particle to be urged from the North-pole towards the equator by a uniform force that would cause it to move south at the rate of one degree an hour if it were not for frictional retardation. Now let the experiment proceed, pricking off the course of the particle at hourly intervals. To find its position at the end of one hour turn the globe through 15°, and prick opposite to 1° on the brass meridian. Then that distance from the pole, diminished according to the table of retardation, gives the true position of the particle. Take this as the next starting point, and turn the globe 15° from it; prick off 1° to the south of it; join the line with the previous position; continue the line in a parallel direction to the course run during the first hour, and for a distance equal to that course (the terminal velocity of the course at the end of the first hour ought to have been taken; but as we proceed further and the speed varies slowly from hour to hour, the error becomes unimportant). This gives the uncorrected position at the close of the second hour. Correct it as before for retardation, and start afresh.

Many ingenious devices are scattered through Mr. Campbell's pages; nay, even the cover of the book is utilised to convey one of them. The cloth binding is pressed into creases that exactly correspond with the ancient ice-marks found on a piece of slate in New Brunswick. It is a pretty and very instructive ornamentation. Another is the description of an instrument we are surprised to find has not come into general use for self-recording the sunshiny hours of all the year, as well as the power of the sunshine. It consists of a spherical glass ball (or hollow sphere filled with acidulated water to check the growth of confervæ) propped in the middle of a concentric wooden cup. The radius of the latter is such that the burning point of the spherical lens shall fall on the inside of the wooden cup, and burn it away when the sun shines. As the sun's path on one day only partially overlaps its path on the preceding day, a partially fresh track is burnt daily; and the hotter the sun, the deeper does the burning penetrate. The instrument is so cheap, so simple in its adjustment, and requires so little care, that we wonder meteorologists

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have not advocated its use. We remember that Mr. Campbell published a description of it, in some scientific journal, a few years ago.

We have said nothing of his chapters of adventure in the far North, and we do not purpose to do so, because they are out of place where they are. They are, however, particularly amusing, and deserve a book to themselves. He goes into land where miles are measured by a dog's bark. One of them, called 'Peneculam,' being as far as a dog can be heard to bark in still weather. He also sees the migration of the lemens, and he shoots the rapids of the Tornea river, which is no child's play. For all this and for much more, we refer the reader to the book. We now take farewell of it, thanking the author for the many pleasant hours we have spent over 'Frost and Fire,' and though we feel strongly its defects, we assure him we are by no means blind to its great and numerous merits.

Art. VI.—*Œuvres Complètes d'Alexis de Tocqueville.* Tomes VII. et VIII. Correspondance, Mélanges, Fragments Historiques et Notes sur l'Ancien Régime la Révolution et l'Empire, Voyages, Pensées, entièrement inédits. Paris: 1865.

The critics, who, in common with ourselves, had occasion to review four years ago the 'Memoir and the Correspondence of M. de Tocqueville' (which have since been translated into English by an able hand), ventured to remark that, in spite of the zeal and the fidelity with which M. Gustave de Beaumont had portrayed the life and edited the papers of his illustrious friend, his task was still incomplete. Indeed, he himself informed us that much still remained in the shape of unfinished fragments and unpublished letters which might one day form part of a more extended publication. We urged him to give a larger selection of these documents to the world; for although they may not have received that exquisite finish which M. de Tocqueville himself loved to impart to all he published, yet the scattered thoughts of so powerful a mind are sometimes even more forcible and impressive than his mature compositions, and the charm of his tender and meditative letters to his family and his private friends is inexhaustible. M. de Beaumont has given ear to these observations. Encouraged by the prodigious interest which was excited in France and throughout Europe by his former volumes, he has now enlarged the plan of them. A complete edition of the works of Tocqueville has been prepared for the press, which contains, in addition to the writings already well known to all readers, a volume of the speeches and reports prepared for the Chamber of Deputies, a volume of fragments principally relating to the masterly analysis of the French Revolution on which the author was engaged at the time of his death, and an additional volume of Correspondence. These publications are entirely new, and they are of the very highest interest and value. In the selection of the volume of letters previously published, M. de Beaumont was restrained by motives of delicacy from laying before the world the confidential effusions of intimate friendship, and by motives of prudence from calling attention to the political opinions of Tocqueville, especially with reference to the present Government of France. Already time, death, and the progress of events have removed some of the obstacles to publication which existed three years ago. The result is, that the letters now produced have a deeper meaning and a more decided tone than those which had formerly appeared—indeed, it was for this reason that they were then withheld from the public; and many of them have a direct bearing on political affairs, even at the present time, to an extent which the admirers and adherents of the present Government of France will probably consider indiscreet and inconvenient. We rejoice, on the contrary, that M. de Beaumont has had the courage to produce these most remarkable papers. They contain the thoughts of a man, great as a writer, but greater still by his undaunted independence and by his undying love of freedom; and we are not sure that Tocqueville, in the full enjoyment of life and intellect, ever wrote anything more likely to rouse the slumbering spirit of his country, or to guide her back from servitude to liberty, than these posthumous leaves, penned many years ago in the solitude of his Norman home and in the confidence of private friendship. There is in these volumes the same profound insight which pervades all the works of the author into the causes of the French Revolution, and those vices of democratic society, which, under the first and the second Empire, have twice thrown back the French nation from the ardent enjoyment of freedom into a submissive obedience to absolute power. And if it be true that after a vigil of seventeen years, some streaks of dawning light

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