the weather seems to have the power of removing the blue part of the colouring matter." In my notes on the rocks of the Co. Galway, I find: "The original colour of the Felsite associated with the granite on the north of Galway Bay seems to be a purplish green or grey, but at the coast they weather red, while inland they weather a yellowish or dirty white."

On the disintegration of rocks has been noted—"At the sea-shore south of Baltimore, Co. Cork, the slates immediately above the influence of the waves have by the weathering out of their slaty cleavage become so rugged and sharp that they can be compared to nothing but knives placed side by side with their edges looking upwards; this appears to be remarkable, for if these rocks are followed only a little inland, they seem scarcely weathered as the ice striæ are quite perfect on them." "The slates composing the Little Skellig, off the coast of Kerry, are weathered along the nearly vertical cleavage planes, giving them a sharp serrated surface, while similar rocks on the main land only a little removed from the sea-coast are scarcely weathered."

"On the Aran Islands, Galway Bay, the subaërial agencies seem to denude the limestones quicker than on the mainland, for on those islands the perched blocks having protected the portion immediately under them, now stand on pedestals from four to six inches high, while inland, the pedestals under the blocks rarely exceed four inches, and generally their average is about two inches and a-half."

"The veins of Eurite that traverse the Granites on the north of Galway Bay, are scarcely affected by the weather, and thereby give a record of the amount of waste the mass of the granite rocks have undergone since the ice disappeared from that country. From them it would also appear that the granites disintegrate more freely near the sea than away from it; for inland these veins stand from half an inch to two inches above the mass of the rock, while near the sea they have been remarked as much as three and a-half inches, and rarely, if ever, are less than an inch and a-half; moreover in some places near the sea, even the Eurite veins are weathered."

NOTICES OF MEMOIRS.

I.—On Denudation in Scotland since Glacial Times.

By James Geikie, Esq., *of the Geological Survey of Scotland.*

[Being the substance of a paper read before the Geological Society of Glasgow, 28th November, 1867.]

MR. JAMES GEIKIE began by remarking that, throughout the wide domain of Geological inquiry, there was perhaps no subject of which it was easier to gain some idea, and yet, at the same time, more difficult to acquire an adequate conception, than denudation. We all know how rains and frosts and chemical decomposition were employed unceasingly in modifying the aspect of hills and plains,—how rivers were ever deepening and widening the valleys in which they flowed—how the sea, by its constant wave-action, aided by

frosts and other agencies, tended to reduce to its own level the solid lands, with all their infinite variety of outline. It was no less generally known how the Geological structure of a country must always influence its configuration—how the softer rocks would generally lie in the valleys, and those of a more durable nature occupy the heights—how the contour of the heights would vary according as these were formed of schists of granite, of dolerite, of quartz-rock, or of any other well-marked species—and how this peculiar character was due to the unequal manner in which the different masses yielded to the touch of the atmospheric forces, so that a trained eye could oftentimes detect at a considerable distance the nature of the rocks by reference to the aspect of the hills alone. But while all were willing to admit that the subaërial agents might do something towards modifying the surface of a country, yet many would not allow that its straths and valleys had been mainly formed by these seemingly feeble forces. Nor when we reflected on the enormous time required by the hypothesis which they rejected, could it be wondered at that some geologists, whose chief stumbling-block was *time*, should have summoned up subterranean action to account for certain appearances connected with the superficial phenomena of our country, still less should we be surprised when the sea was appealed to as having been chiefly instrumental in moulding the land into hill and dale.

There were probably few who began this study, that were not at first more deeply impressed with the energetic action of the waves along a sea-coast, than with the less obtrusive work carried on by the subaërial forces. Gaunt cliffs and long-retiring caves and inlets seemed to assure them, that rather in the restless activity of the breakers, than in the puny rains and rivers of the land, they had found the power which hollowed out the deep places of the earth. No one could heartily accept the theory which referred to atmospheric erosion the moulding of the land into hill and valley, who had not worked out his belief for himself in the field. This was the only way to learn what denudation, whether submarine or subaërial, really was. When we came impartially to consider the subject, we should find that a vast variety of agents had been at work, from the earliest geological times, in shaping out the contour of our country. Thus, it was not disputed that subterranean movements of elevation and depression, and the waves and currents of the sea, had, in many cases, determined the direction in which streams and rivers should flow; but the cutting out of the valleys and the fashioning of the hills must be attributed principally to the action of the atmospheric forces.

No one-sided theory, therefore, that should seek to explain all the phenomena by reference to one set of influences alone could be accepted.

On the present occasion, Mr. J. Geikie could not pursue this subject further. The origin of our mountain and valley systems dated back to much more remote periods than the advent of the Glacial epoch; and there was nothing more certain than this—that the direction

followed by the Glacier ice of that age was influenced to a great degree by the pre-existing configuration of the country. In selecting matter for illustration, he thought it better to confine himself to one small corner in this great field of inquiry, in the belief that by thus restricting the sphere of their investigations, they should be enabled to attain a better idea of the scope and bearing of the general question. The subject proposed to be considered was denudation in Scotland since Glacial times. Now it was very evident that before we could have any proper notion of the denudation of a country, we should first ascertain, as well as we could, the nature and geological origin of the rocks which appeared to have been denuded. For it was plain that until we knew how these rocks came to be amassed, we could never hope to gain any proper estimate of the degree of erosion to which they might have been subjected since the time of their formation. How could we expect to appreciate the amount of waste which strata had experienced, until we had first carefully examined these, and considered their geological relations, and gathered together all the evidence we could with regard to their former extension? Denudation was thus a much more complicated study than it might at first appear to be; and he would repeat that it could only be thoroughly grasped by those who were content to work the matter out for themselves in the field. No doubt we might make up our minds on book evidence as to the probability of this or that theory of denudation; but it was one thing to believe—it was a very different thing to feel that we believe.

Before we could arrive at any conclusions regarding denudation in Scotland since the Glacial period, the deposits of that age must be critically examined. We must inquire into the mode of their accumulation so as to ascertain what degree of waste they had sustained since deposition, and how much of that erosion might be due to the action of the sea during the marine stage of the Glacial epoch—how much to that of the atmospheric forces in subsequent times. In short, our investigation should involve a study of the whole history of the Drift formation. In the remarks that were to follow, however, he did not pretend to offer anything like a digest of that history. On the contrary, he would limit attention to those portions of the evidence that seemed best fitted to recall the general aspect which appeared to have been presented by the drift accumulations during the various stages of the Glacial period.

The lecturer then described some of the more characteristic features of these deposits of clay and sand and gravel which are so abundantly scattered athwart the face of the country, and to which geologists had given the general title of the "Glacial or Drift Formation." These accumulations were found capable of being divided into more or less well-defined groups, relatively of different ages, but all belonging to one great geological period. At the base we had the stony "Till," or Boulder-clay, and above that, in certain cases, came vast heaps of sand and gravel; while in other districts the Till was over-

lain by finely stratified fossiliferous clays, or sometimes by a very coarse Upper Boulder-clay. Much still remained to be done in the working out of the history of these deposits in detail, but the general succession of geological changes which they indicated were nevertheless sufficiently ascertained.

Geologists were agreed that the observed phenomena could only be explained by reference to what is now taking place in arctic and alpine regions. The rounded contour of our hills, the flutings and sculpturings of our valleys, the scratched and polished rock-surfaces that everywhere abounded, bore emphatic testimony to the former passage of a great sheet of ice, under which, at some distant period, these islands of ours, in common with the high latitudes of Europe, Asia, and America, lay buried—only the loftier mountain tops peering above the desolate waste. And in like manner did the accumulations of sand and gravel and clay, and the pell-mell heaps of the Upper Boulder earth, testify to the subsequent presence of the sea over certain areas of the same regions.

Mr. Geikie stated that during the early stages of the Glacial epoch the surface of our country, by the constant grinding action of the great ice-sheet, came to assume certain characters which are still very legible. He showed that the general trend of the ruts and scratches impressed upon the rocks by the passage of the glaciers was, in the northern hemisphere, from north to south, but that the form of the ground often had considerable influence in turning them from that general direction. Thus in our own country they were found to radiate downwards from the high grounds, following the lines of the principal valleys.

During the continuance of this Arctic condition of our country, the waste of the underlying rocks must have been considerable. Mountains of schist had been in some measure deprived of the outlines which, under usual atmospheric action, they must have assumed. Hills of shattered and much jointed greywacké, which ought to rise up in broken, serrated, and peaky tors, showed instead a rounded and hummocky contour. Valleys which, from the nature of their strata, we should have expected to present steep or vertical walls, have been moulded into smooth and undulating hollows. Glens, at one time roughened with countless crags, and bristling with jagged points of rock, have had their sharp angles and rude corners cut away—the present ruinous and tumbled aspect of many of our Highland glens being due to subsequent atmospheric waste, which was gradually effacing the traces of Glacial action. The waste material that resulted from all this scooping and grooving and planing went to form the Boulder-clay. Some of it gathered underneath the great glacier as a *moraine profonde*—some of it was carried out to sea by icebergs.

The character and mode of accumulation of the true Lower Boulder-clay were next described. As the "ground moraine" of the old ice-sheet, it gathered most abundantly over the surface of the lowlands, its occurrence at considerable elevations being the exception to the rule. It was remarked that in districts where the marine drift occurred,

the Boulder-clay had usually suffered much erosion, while in regions where the sand and gravel did not appear, it had commonly a much less denuded aspect, often forming well-marked terraces in upland valleys, and in straths frequently showing parallel mounds or broad ridges, which were probably, in the main, original inequalities acquired while the till was in course of formation as a *moraine profonde*.

The character and mode of accumulation of the upper or marine drifts were next considered. It was shown that these deposits consisted chiefly of sand and gravel, at other times of a coarse Boulder earth, and in some places fossiliferous clay also occurred. These beds had no doubt been derived chiefly from the waste of the Lower Boulder-clay, and also in some measure from the droppings of icebergs. In a district were the sands and gravels were typically developed it was often found that, as we left the central parts of the broad valleys and straths and approached the contiguous higher grounds, these drifts appeared to thin away from heaps of well-stratified materials to meagre, irregular sprinklings of earth and stony rubbish. The fine sands and gravels with diagonal bedding occupied chiefly the bottoms of the valleys, the kaims and mounds of coarse and angular *débris* lay for the most part along the hill-sides.

These facts appeared to point to a passage from a deeper to a shallower sea-bed. The capricious distribution of the sand and gravel was then touched upon, and it was shown how this might give us an index to the probable maximum of depression attained during the marine period. The evidence furnished by the angular gravels, which seemed to mark out the upper limits reached by the Glacial sea, agreed with the independent testimony derived from the occurrence of the kaims in certain valleys and their absence from others. If we supposed the land to be submerged to the highest levels reached by the coarse angular gravels it would be observed that kaims only occurred in such valleys, as on a depression to this extent would form straits, channels, or comparatively open seas—that it was precisely in the same localities where the lower till was excessively eroded—while in those valleys which, under like conditions, must become long narrow fiords, marine drift did not appear, and the Boulder-clay had not been subjected to the same degree of denudation. In the straits marine currents would have free scope to plough up the deposits of the earlier period, while in the narrow firths no such action could be carried on, as we learned should be the case from a study of our own Highland sea lochs or the fiords of Norway. The later drifts, consisting of terminal moraines and that surface-wash which seems to have gathered under the snow or *néve*, showed us that, after the re-elevation of the land, glaciers continued to reach the sea for a time, and in their downward progress from the snowfields, scooped out the accumulations which had formed during the previous ages.

Having thus given a *resumé* of facts connected with the mode of occurrence of the drift deposits, and the kind of erosion to which they were subjected during the Glacier period itself, the lecturer then pro-

ceeded to examine the nature and degree of subaërial waste experienced since the close of the great age of ice. Every geologist was familiar with the glaciated outline of the elevated regions of our country. The rounded crags, the smoothed and fluted hill sides, and the finely striated rock-surfaces were characters so well-known that he had only to mention them. When he said that these were to be met with everywhere, of course he did not mean that every declivity would show its ice-mouldings, every crag exhibit *roches moutonnées*, or every exposed surface of rock exhibit a series of striations. Such must, no doubt, have been the case when the great ice-sheet first disappeared, but during the long ages that had since elapsed chemical decomposition, frost, and rain had succeeded in obliterating many traces of the ancient glaciers. Notwithstanding all this, however, the memorials of the former presence of a vast body of ice were so abundant that we could not but conclude that the solid rocks of our mountains had suffered comparatively little waste since that covering of ice had vanished. A visitor from Alpine countries, where perennial snows and glaciers abounded, would see little in the outline of our Scottish mountains with which he was not familiar. The finer touches of the great ice chisel would oftentimes indeed be wanting, but its broad effects would all be there, reminding one who wished to be fanciful, of those ancient sculptures from which the hand of time had effaced the delicate finish of the artist but had been powerless to destroy his design.

Mr. Geikie next considered the present aspect of the Boulder-clay. He said that in our valleys and straths we could read the history of a Glacial period with as little difficulty as we deciphered its records at higher levels. It was admitted that the subaërial waste experienced by the Boulder-clay had been great, but when we came to estimate what effect this erosion had had in modifying the general aspect of that deposit it appeared to be scarcely appreciable. The greatest waste experienced by the Till took place during the growth of the marine drifts. Waves and currents in narrow straits and open seas had often made havoc of the Boulder-clay, while in the fiords and other sheltered regions the some degree of waste could not be effected. And the configuration thus given to the lower Till had not been obliterated by the atmospheric forces, although these had been so long employed in its reduction. If frosts and rains and rivers had been unable to deprive the lower Till of the general aspect it assumed on the re-elevation of the land, they had been just as powerless to efface the external character of the upper or marine drifts. So perfect were the forms of mounds and kaims of sand and gravel that these were capable of being classified and described by reference to the various kinds of bars and banks of analogous materials which were gathering on the bed of our own seas at the present day. But just as it was seen that the Boulder-clay had been extensively denuded by atmospheric agents, so we learned that the marine drifts had undergone no inconsiderable degree of erosion. From some valleys they had well nigh vanished; in others the kaims had been obliterated and their materials re-assorted by the streams and rivers.

After referring to the proofs of this waste, Mr. Geikie went on to remark that a study of the valleys in which the kaims had been thus denuded would convince the geologists that in former ages our rivers must have greatly exceeded in size their present representatives. The position of some of the older alluvia, and the evidence of river action in places to which streams of the same size as now flowed in the valleys never could have attained, all led to this inference. He thought it extremely probable that it was during the age of forests, when Britain formed a part of the continent, that our rivers reached their greatest development. There were good grounds for believing that at this period glaciers filled some of our higher valleys. In some of the high level river gravels, also, we often met with large boulders, which appeared to have been ice-borne to their present position. And the testimony derived from the nature of the timber dug out of the peat-mosses was quite in harmony with such a supposition. For the climate that nourished the large pine-trees of the English mosses must have covered our rivers with ice in winter. While this excessive climate prevailed, atmospheric waste, no doubt, went bravely on; and even down to much later days, when the peat-mosses were increasing and the ancient forests decaying, the work of denudation must have proceeded more rapidly than now.

Some examples of post-Glacial waste were then cited. He mentioned the case of the gorge through which the River Doon makes its way after escaping from its parent lake. In cutting out this ravine, a mass of rock, equal to at least 70,000,000 of cubic feet had been removed bodily by the stream; and many similar cases might be adduced. But although, locally considered, the denudation thus experienced by drift deposits and subjacent rocks might be often great, it would require a far longer lease of time than had elapsed since the close of the Glacial epoch ere the characteristic features impressed upon our hills and valleys during that period could be effaced. In conclusion, he said they could not fail to be impressed with one consideration, which, above all others, seemed to stand out prominently after a review of such matters as they had been that evening considering—and that was the enormous time required to produce the broader effects of denudation. How many long ages had rolled away since these islands rose above the level of the Arctic Sea in which our marine drifts were amassed, and yet, during all that time, how little change had come upon them at the instance of the atmospheric forces. And if the records of the old Arctic condition—the delicate ice-markings on the rocks, the loose incoherent deposits on the hill-slopes and plains—still remained so perfect, notwithstanding the ceaseless activity of the denuding agents—if the mere skin as it were, and surface-markings of the land were still so largely retained, what should we say to the time required for the growth of that covering itself, and for the production of these strange ice-mouldings and flutings,—and how, above all, could we apprehend (for comprehend we could not) the truly tremendous lapse of time, during which the solid land was gradually sculptured into hills and valleys by the rains and frosts and rivers of the past.—*The Glasgow Herald, November* 30, 1867.

II.—On the Internal Heat of the Earth. By Dr. Julius Schvarcz, F.G.S.[1]

THE author reviewed the evidence upon which is founded the doctrine of central heat as applied to the earth. It is based on three arguments. *First*, gathered from volcanic phenomena,—phenomena which may be explained by the chemical and electro-chemical schools of geologists, at least as satisfactorily as by the supporters of central fire; the *second* argument is adduced from the nebular hypothesis, an hypothesis having now-a-days no other foundation than what is involved in it from the central fire hypothesis; and the *third* is adduced from the supposed uniform increase of temperature down to the centre of our planet, in every part of the earth,—an argument which is again a mere hypothesis.

Having carefully studied the literature of the subject, Dr. Schvarcz criticised the observations upon which the hypothesis of central fire is supported, and showed how imperfect and conflicting is the evidence to prove that the increase of underground temperature is really general and uniform.

Before generalising, we must accumulate a greater number of facts, precisely recorded, than are at present at command, and he therefore urged geologists to combine all their efforts in order to multiply geothermometrical observations, especially in countries now unexplored.

He was of opinion that solar impressions of all the climates on our earth's surface, taken collectively, and local reservoirs of lava, not exceeding considerably the depth of thirty-five geographical miles, and manifesting themselves through volcanic cones from local processes of oxydation, must be taken for those secondary causes which remain indispensable elements of any ætiology of underground temperatures, even for theories to come. Electricity, as connected with cosmical magnetism and planetary rotation, may have been an important agent, besides the secondary causes just alluded to.

III.—On a new Phosphatic Deposit, near Upware, Cambridgeshire. By J. F. Walker, B.A., F.G.S., &c.

IT is unnecessary here to give a lengthened account of Mr. Walker's paper (read before the British Association, Dundee) as most of the facts have appeared in two previous numbers of the Geological Magazine.[2]

The author repeats his opinion that this Phosphatic deposit is of the age of the Lower Greensand—it contains fossils of that age as well as extraneous specimens. The bed contains sponges resembling those of Faringdon; and during a recent visit to that locality he obtained several shells which he has also found at Upware.

The phosphatised casts of shells found at Upware, and also at

[1] Being an abstract of his paper read before Section C. of the British Association, Dundee, September, 1867.

[2] Geological Magazine, July, 1867, p. 309. *Ibid.*, October, 1867, p. 454.

Sandy, he regards as derived from the denudation of older deposits; because they are much water-worn, and often bored by Mollusca.

Bryozoa and *Serpulæ* occur attached to the surface of several of the phosphatic nodules at Upware.

REVIEWS.

I.—MORTILLET'S "MATERIALS FOR THE HISTORY OF MAN." 3rd Vol. Nos. 1-8 (in Five Nos.) [MATÉRIAUX POUR L'HISTOIRE POSITIVE ET PHILOSOPHIQUE DE L'HOMME: BULLETIN MENSUEL, etc., par GABRIEL DE MORTILLET. Troisième Année, 1867. 8vo. Paris.]

THIS useful monthly compendium of facts and notions, either published day by day, or communicated to the Editor, about Anthropology, Prehistoric Times, the Quaternary Epoch, the Origin of Species, and Spontaneous Generation, has now reached its third year, and steadily fulfils its mission in aiding the advance of a scientific knowledge of the history of early Man, and of collateral natural-history subjects bearing on the character of races and states of culture. The last two parts of this useful work M. Mortillet has judiciously devoted to a succinct account of everything contributed to the Universal Exhibition at Paris that at all bears on primæval Man and his habits and character. Every quarter of the globe contributed something, though not always arranged in the special galleries illustrative of the History of Labour and Art. Every noticeable object, however, is classified by the Editor in these his "Promenades Préhistoriques à l'Exposition Universelle;" and, as far as possible, they are grouped under such subdivisions as "Caverns," "Quaternary Deposits," "Stone Epoch," "Ground and Polished Stone Implements," "Bronze Age," "Iron Age," etc. After viewing all these very interesting objects, never to be again assembled under one roof, M. Mortillet draws the following conclusions (pages 366, etc.).

It is impossible, he says, after having visited the Galleries of the History of Labour, supplied by Wurtemberg, Hungary, Switzerland, Spain, Denmark, Sweden, Norway, Russia, Italy, England, and especially France, to have any doubt of the existence of a great Law of Progress in Human Nature. We see Industry begin with instruments of Stone, mere flakes, so primitive and rudimentary that they are inferior even to such as are used by the least advanced of existing savages. Little by little the stone is better worked, and its use becomes more varied; and there are numerous implements of bone and deer's horn. Then comes the art of grinding stone; marking an era of progress, and characterizing one of the great divisions of Pre-historic Time,—namely, the Era of Polished Stone. Still later it was that Metal appeared; at first Bronze alone, and afterwards Iron. Stone chipped and flaked, Polished Stone, Bronze, and Iron, are so many successive characteristics of Human Progress before reaching our present civilization. Not only was it possible in the Exposition to follow step by step this onward march of pro-