THE SCOTTISH SCHOOL OF GEOLOGY*

I.

FOR the first time in the history of University Education in Scotland, we are to-day met to begin the duties of a Chair specially devoted to the cultivation of Geology and Mineralogy. Though Science is of no country nor kin, it yet bears some branches which take their hue largely from the region whence they sprang, or where they have been most closely followed. Such local colourings need not be deprecated, since they are both inevitable and useful. They serve to bring out the peculiarities of each climate, or land, or people, and it is the blending of all these colourings which finally gives the common neutral tint of science. This is in a marked degree true of Geology. Each country where any part of the science has been more particularly studied, has given its local names to the general nomenclature, and its rocks have sometimes served as types from which the rocks of other regions have been classified and described. The very scenery of the country, reacting on the minds of the early observers, has sometimes influenced their observations, and has thus left an impress on the general progress of the science. As we enter to-day upon a new phase in the history of Geology among us here, it seems most fitting that we should look back for a little at the past development of the science in this country. There was a time, still within the memory of living men, when a handful of ardent original observers here carried geological speculation and research to such a height as to found a new, and, in the end, a dominant shool of Geology.

In the history of the Natural Sciences, as in that of Philosophy, there have been epochs of activity and then intervals of quiescence. One genius, perhaps, has arisen and kindled in other minds the flame that burned so brightly in his own. A time of vigorous research ensued, but as the personal influence waned, there followed a period of feebleness or torpor until the advent of some new awakening. Such oscillations of mental energy have an importance and a significance far beyond the narrow limits of the country or city in which they may have been manifested. They form part of that long and noble record of the struggle of man with the forces of nature, and deserve the thoughtful consideration of all who have joined or who contemplate joining in that struggle. I propose on the present occasion to sketch to you the story of one of these periods of vigorous originality, which had its rising and its setting at Edinburgh—the story of what may be called the Scottish School of Geology. I wish to place before you, in as clear a light as I can, the work which was accomplished by the founders of that school, that you may see how greatly it has influenced, and is even now influencing, the onward march of the science. I do this in no vainglorious spirit, nor with any wish to exalt into prominence a mere question of nationality. Science knows no geographical or political limits. Nor, though we may be proud of what has been achieved for Geology in this little kingdom, can we for a moment shut our eyes to the fact that these achievements are of the past, that the measure of the early promise at the beginning of this century has been but scantily fulfilled in Scotland, and that the state of the science among us here, instead of being in advance, is rather behind the time. And thus I dwell now on the example of our predecessors, solely in the hope that, realising to ourselves what that example really was, we may be stimulated to follow it. The same hills and valleys, crags and ravines, remain around us which gave these great men their inspiration, and still preach to us the lessons which they were the first to understand.

The period during which the distinctively Scottish School of Geology rose and flourished may be taken as included between the years 1780 and 1825—a brief half-century. Previous to that time Geology, in the true sense of the word, can hardly be said to have existed. Steno, indeed, more than a hundred years before, had shown, from the occurrence of the remains of plants and animals imbedded in the solid rocks, that the present was not the original order of things, that there had been upheavals of the sea into dry land and depressions of the land beneath the sea, by the working of forces lodged within the earth, and that the memorials of these changes were preserved for us in the rocks. Seventy years later, another writer of the Italian school, Lazzaro Moro, adopting and extending the conclusions of Steno, pointed to the evidence that the surface of the earth is everywhere worn away, and is repaired by the upheaving power of earthquakes, but for which the mountains and all the dry land would at last be brought beneath the level of the waves.

But none of these desultory researches, interesting and important though they were as landmarks in the progress of science, bore immediate fruit in any broad and philosophic outline of the natural history of the globe. Men were still trammelled by the belief that the date and creation of the world and its inhabitants could not be placed further back than some five or six thousand years, that this limit was fixed for us in Holy Writ, and that every new fact must receive an interpretation in accordance with such limitation. They were thus often driven to distort the facts or to explain them away. If they ventured to pronounce for a natural and obvious interpretation, they laid themselves open to the charge of impiety and atheism, and might bring down the unrelenting vengeance of the Church.

Such was the state of inquiry when the Scottish Geological School came into being. The founder of that school was James Hutton—a man of a singularly original and active mind, who was born at Edinburgh in 1726, and died there in 1797. Educated for the medical profession, but possessed of a small fortune, which gave him leisure for the pursuit of his favourite studies, he eventually devoted himself to the study of Mineralogy. But it was not merely as rare or interesting objects, nor even as parts of a mineralogical system, that he dealt with minerals. They seemed to suggest to him constant questions as to the earlier conditions of our planet, and he was thus gradually led into the wider fields of Geology and Physical Geography. Quietly working in his study here, a favourite member of a brilliant circle of society, which included such men as Black, Cullen, Adam Smith, and Clerk of Eldin, and making frequent excursions to gather fresh data and test the truth of his deductions, he at length matured his immortal "Theory of the Earth," and published it in 1785. Associated with Hutton, rather as a friend and enthusiastic admirer than as an independent observer, was John Playfair, Professor of Natural Philosophy in this University, by whose graceful exposition the doctrines of Hutton were most widely made known to the world. His classic "Illustrations of the Huttonian Theory" is one of the most delightful books of science in our language—clear, elegant, and vivacious—a model of scientific description and argument, which I would most earnestly recommend to your notice. Sir James Hall, another of this little illustrious band, had one of the most inventive minds which have ever taken up the pursuit of science in this country. His merits have never yet been adequately realised by his countrymen, though they are better appreciated in Germany and in France. He was in fact the founder of Experimental Geology, since it was he who first brought geological speculation to the test of actual physical experiment. This he accomplished in a series of ingenious researches, whereby he corroborated some of the disputed parts of the doctrines of his master, Hutton. These were the three chief leaders of the Scottish school; but to their number, as worthy but less celebrated associates, we must not omit to add the names of Mackenzie, Webb Seymour, and Allan.

It would lead me far beyond the allotted hour to attempt any adequate summary of the work achieved by each of these early pioneers of the science. It will be enough for my present purpose if I try to sketch to you what were the leading characteristics of this Scottish School, and what claim it has to be remembered, not by us only, but by all to whom Geology is the subject either of serious study or of pleasant recreation.

Born in a "land of mountain and flood," the geology of the Scottish School naturally dealt in the main with the inorganic part of the science, with the elemental forces which have burst through and cracked and worn down the crust of the earth. It asked the mountains of its birthplace by what chain of events they had been upheaved, how their rocks, so gnarled and broken, had come into being, how valleys and glens had been impressed upon the surface of the land, and how the various strata through which these wind had been step by step built up. It encountered no rocks, like those which had arrested the notice of the early Italian geologists, charged with fossil shells, and corals, and bones of fish, such as still lived in the adjoining seas, and which at once suggested the former presence of the sea over the land. Neither did it meet with deposits showing abundant traces of ancient lakes, and rivers, and land-surfaces, each marked by the presence of animal and plant remains, like those which set Steno and Moro thinking. The rocks of Scotland are as a whole unfossiliferous. It was, therefore, only with the records of physical events, unaided by the testimony of organic remains, that the Scottish geologists had to deal. Their task was to unravel the

* A Lecture delivered at the opening of the clas of Geology and Mineralogy in the University of Edinburgh, by Archibald Geikie, F.R.S., Nov. 6, 1871.

complicated processes by which the rocky crust of the earth has been built up, and by which the present varied contour of the earth's surface has been produced,—to ascertain, in short, from a study of the existing economy of the world, what has been the history of our planet in earlier ages.

Hitherto, while men had been accustomed to believe that the earth was but some 6,000 years old, they sought in the rocks beneath and around them evidence only of the six days' creation or of the flood of Noah. Each new cosmological system was based upon that belief, and tried in various ways to reconcile the Biblical narrative with fanciful interpretations of the facts of Nature. It was reserved for Hutton to declare, for the first time, that the rocks around us can never reveal to us any trace of the beginning of things. He too first clearly and persistently proclaimed the great fundamental truth of Geology, that in seeking to interpret the past history of the earth as chronicled in the rocks, we must use the present economy of nature as our guide. In our investigations, "no powers," he says, "are to be employed that are not natural to the globe, no action to be admitted of except those of which we know the principle. Nor are we to proceed in feigning causes when those appear insufficient which occur in our experience."* This was the guiding principle of the Scottish School, and through their influence it has become the guiding principle of modern Geology.

There were two directions in which Hutton laboured, and in each of which he and his followers constantly travelled by the light of the present order of nature—viz., the investigation of (1) changes which have transpired beneath the surface and within the crust of the earth, and (2) changes which have been effected on the surface itself.

1. That the interior of the earth was hot, and that it was the seat of powerful forces, by which the solid rocks could be rent open and wide regions of land be convulsed, were familiar facts, attested by every volcano and earthquake. These phenomena had been for the most part regarded as abnormal parts of the system of nature; by many writers, indeed, as well as by the general mass of mankind, they were looked upon as Divine judgments, specially sent for the punishment and reformation of the human species. To Hutton, pondering over the great organic system of the world, a deeper meaning was necessary. He felt, as Steno and Moro had done, that the earthquake and volcano were but parts of the general mechanism of our planet. But he saw also that they were not the only exhibitions of the potency of subterranean agencies, that in fact they were only partial and perhaps even secondary manifestations of the influence of the great internal heat of the globe, and that the full import of that influence could not be understood unless careful study was also given to the structure of the rocky crust of the earth. Accordingly, he set himself for years patiently to gather and meditate over data which would throw light upon that structure and its history. The mountains and glens, river-valleys and sea-coasts of his native country, were diligently traversed by him, every journey adding something to his store of materials, and enabling him to arrive continually at wider views of the general economy of nature. At one time we find him in a Highland glen searching for proofs of a hypothesis which he was convinced must be true, and, at their eventual discovery, breaking forth into such gleeful excitement that his attendant gillies concluded he must certainly have hit upon a mine of gold. At another time we read of him boating with his friends Playfair and Hall along the wild cliffs of Berwickshire, again in search of confirmation to his views, and finding, to use the words of Playfair, "palpable evidence of one of the most extraordinary and important facts in the natural history of the earth."

As a result of his wanderings and reflection, he concluded that the great mass of the rocks which form the visible part of the crust of the earth was formed under the sea, as sand, gravel, and mud are laid there now; and that these ancient sediments were consolidated by subterranean heat, and, by paroxysms of the same force, were fractured, contorted, and upheaved into dry land. He found that portions of the rock had even been in a fused state; that granite had erupted through sedimentary rocks; and that the dark trap-rocks or "whinstones" of Scotland were likewise of igneous origin.

When the sedimentary rocks were studied in the broad way which was followed by Hutton and his associates, many proofs appeared of ancient convulsions and re-formations of the earth's surface. It was found that among the hills the strata were often on end, while on the plains they were gently inclined; and the inference was deduced by Hutton that the former series must have been broken up by subterranean commotions before the accumulation of the latter, which was derived from its *débris*. He conjectured that the later rocks would be found actually resting upon the edges of the older. His search for, and discovery of, this relation at the Siccar Point, on the Berwickshire coast, are well described by his biographer Playfair, who accompanied him, and who, dwelling on the impression which the scene had left upon him, adds: "The mind seemed to grow giddy by looking so far into the abyss of time; and while we listened with earnestness and admiration to the philosopher who was now unfolding to us the order and series of these wonderful events, we became sensible how much farther reason may sometimes go than imagination can venture to follow." Sir James Hall afterwards, by a series of characteristically ingenious experiments, showed how the rocks of that coast-line may have been contorted by movements in the crust of the earth under great superincumbent pressure.

Hutton was the first to establish the former molten condition of granite, and of many other crystalline rocks. He maintained that the combined influence of subterranean heat and pressure upon sedimentary rocks could consolidate and mineralise them, and even convert them into crystalline masses. He was thus the founder of the modern doctrines of metamorphism regarding the gradual transformation of marine sediments into the gnarled and rugged gneiss and schist of which mountains are built up. Let me quote the eulogium passed upon this part of his work in an essay by M. Daubrée, which eleven years ago was crowned with a prize by the Academy of Sciences at Paris:—"By an idea entirely new, the illustrious Scottish philosopher showed the successive co-operation of water and the internal heat of the globe in the formation of the same rocks. It is the mark of genius to unite in one common origin phenomena very different in their nature." "Hutton explains the history of the globe with as much simplicity as grandeur. Like most men of genius, indeed, who have opened up new paths, he exaggerated the extent to which his conceptions could be applied. But it is impossible not to view with admiration the profound penetration and the strictness of induction of so clear-sighted a man, at a time when exact observations had been so few, he being the first to recognise the simultaneous effect of water and heat in the formation of rocks, in imagining a system which embraces the whole physical system of the globe. He established principles which, in so far as they are fundamental, are now universally admitted."

(*To be continued*)

* Hutton's "Theory of the Earth," i. p. 160; ii. p. 549.

SCIENTIFIC SERIALS

Annalen der Chemie und Pharmacie, clix., for July, opens with a concluding communication "On the constitution of the twice substituted benzenes," by E. Ador and V. Meyer. The authors converted sulphanilic acid into bromobenzine-sulphonic acid, and fused the potassium salt of this acid with potassic hydrate. The dihydroxylbenzine produced was found to be resorcin; Meyer and others have proved that resorcin belongs to the 1 : 4 series, and therefore sulphanilic acid must also be regarded as containing the SO_3H and NH_2 in the places 1 and 4 respectively. Sulphanilic acid treated with nitrous acid yields a diazo-derivative $C_6H_4N_2SO_3$, this on boiling with water is converted into phenol-sulphonic acid, which was found to be identical with Kekule's paraphenolsulphonic acid. At the end of the communication, a valuable table of the twice substituted benzines, showing the place of attachment of the second substituted group is given; it however differs in some respects from the arrangement of other chemists. Ernst and Zwenger have prepared ethyl and amyl gallates by passing hydrochloric acid through a boiling solution of gallic acid in the anhydrous alcohols; at present they have not succeeded in preparing the methyl gallate.—A very exhaustive paper follows "On some substances crystallised from microcosmic salt and from borax," by A. Knop, in which the crystallisation of phosphostannic, phosphozirconic, and phosphoniobic acids from microcosmic salt, and of stannic acid, zirconic acid, noria, and niobic acid from borax are thoroughly discussed.—Lieben and Rossi have prepared "normal valeric acid" by the action of boiling alcoholic potash on butyl cyanide, they find that the valeric acid thus obtained does not agree in properties with either of the acids already known. They have also prepared normal amylic alcohol from the above acid, by heating the calcic valerate with calcic formiate, the valeric aldehyde being converted into amylic alcohol by the action of sodium amalgam. The alcohol