Committee, or, in his absence, with one of the honorary secretaries, with respect to any *ad interim* arrangement that may have to be made requiring the subsequent sanction of Sub-Committee A.

10. All the administrative work of the Central Institution, general questions of discipline, and the superintendence of the library and museum, shall be in charge of the Organising Director and Secretary of the Institute, who shall act under instructions from Sub-Committee A.

GEOLOGICAL SURVEY OF THE UNITED KINGDOM [1]

THE completion of the one-inch Geological Survey Map of England and Wales affords a fitting opportunity for directing public attention to the history and progress of this great national undertaking.

As far back as the year 1832 that enthusiastic geologist, Henry T. De la Beche, began at his own expense to prepare geological maps of the mining districts of Cornwall and Devon. Being impressed with the great public utility of such maps in a country deriving so large a portion of its wealth from its mineral resources, he applied to the Government of the day for recognition and assistance. Eventually he and his two or three assistants were incorporated as a portion of the staff of the Ordnance Survey. From this modest beginning De la Beche's genius conceived the idea of founding a great central establishment in London, in which specimens of all the ores and other mineral products of the country should be selected and arranged for public inspection and reference, and where should also be preserved copies of the plans of mines and collieries, from which it would be possible to learn at any moment what areas had been exhausted and the condition of the abandoned underground workings. But besides the practical applications of science, he contemplated the foundation of a school in which all the sciences concerned in mining operations should be taught by the ablest professors in the country, and of a museum in which the rocks, minerals, and fossils of the British Islands should be thoroughly illustrated and made completely available to the public for instruction as well as for economic purposes. Being gifted with indomitable perseverance and no common measure of personal tact, he succeeded in impressing his views upon the Government. By degrees the Geological Survey was fully organised and equipped, and the Mining Record Office and the Royal School of Mines were established, De la Beche himself becoming the Director-General of the whole scheme. The accommodation afforded him at first in the buildings in Craig's Court soon proving inadequate, Parliamentary sanction was in the end obtained for the erection of the present establishment in Jermyn Street, which was opened in 1851, and which, as was then said by the late Sir Roderick I. Murchison, "stands forth, to the imperishable credit of its author, as the first palace ever raised from the ground in Britain which is entirely devoted to the advancement of science."

In the meantime, while its offshoots were showing such vigorous growth, the original and parent Geological Survey was extending its operations over the country. The objects for which it was created were twofold. In the first place it was meant to advance geological science by the production of an accurate and detailed geological map of the United Kingdom, with the necessary sections and descriptive memoirs, and by the collection of a full series of specimens to illustrate the mineralogy, petrography, and palæontology of the various geological formations. In the second place it was designed to be "a work of great practical utility bearing on agriculture, mining, road-making, the formation of canals and railroads, and other branches of national industry." This original conception of the object of the Survey has been steadily kept in view. From the districts first surveyed in Devon and Cornwall the mapping was pushed forward into the south-west of England, and then into South Wales. In 1845, the importance of the work having now been fully realised by the Government, some changes were made in the organisation. In particular, the charge of the whole scheme was transferred from the Board of Ordnance to the Office of Woods and Works. A branch of the Survey was likewise equipped for the investigation of the geology of Ireland, where some progress had already been made by Capt. Portlock, R.E. Nine years later—viz. in 1854—the operations of the Survey were extended to Scotland, and the whole establishment was finally placed under the Science and Art Department, which had now been created. The basis of the Geological Survey map is the one-inch map of the Ordnance Survey. In Ireland and Scotland, where Ordnance county maps on the scale of six inches to a mile have long been in existence, the geologists of the Survey made use of this larger scale for their field work, which was subsequently reduced and published on the one-inch scale. In England corresponding six-inch Ordnance maps having meanwhile appeared, the Geological Survey of the northern counties was carried on upon them. The surveys of the northern coalfields and other mineral tracts have been engraved and published on this larger scale. These maps embody a mass of accurate information regarding the structure and resources of our mineral districts, and have been much appreciated by those who are practically interested in the development of this branch of the national industry.

The Ordnance Map of England and Wales is divided into 258 squares, known as sheets or quarter-sheets. These can now be procured as sheets of the Geological Survey, except those last completed, which are now in preparation. As the whole ground has been surveyed, the remaining maps may be expected to appear with no great delay. To make the maps fully available for the information of the public, sections and memoirs are issued. The sections are of two kinds. One of these, called Horizontal Sections, of which 130 have been published, are drawn on a true scale of six inches to a mile, the profile of the ground being accurately shown by levelling, with the geological structure underneath. Many of these sections are accompanied by explanatory pamphlets. For various economic purposes, such as railway-cutting, tunnelling, water-supply, mining, road-making, building, and so on, these Horizontal Sections are of the utmost value. The second kind, called Vertical Sections, are drawn on the scale of forty feet to an inch, in explanation of the detailed structure of our coalfields. One of the most valuable parts of the work of the Survey is embodied in its "Memoirs." At first these were issued in goodly octavo volumes, either embracing a number of disconnected essays, some of which, like Edward Forbes's famous paper on the history of the British flora, have become classics in geological literature, or devoted entirely to the description of a particular area, such as John Phillips's well-known treatise on the Malvern Hills. After 1855, when, on the death of Sir Henry De la Beche, Sir R. I. Murchison became Director-General, this form of memoir was postponed in favour of shorter explanatory pamphlets with which each sheet or quarter-sheet was to be accompanied. These were designed to supplement the map and sections, and to make their information at once intelligible to the public by giving detailed information regarding the natural sections, characteristic fossils, economic minerals, &c., in each district. It was fully determined, however, that, as the Survey advanced, ample monographs should be prepared for each geological formation or important district. Among the other publications of the Survey are the "Decades" and "Monographs" of organic remains, of which seventeen have been issued; the "Mineral Statistics" of the Mining Record Office, which have appeared as an annual volume for the last thirty years; and various catalogues and other works, which swell up the total separate printed publications of the Survey of the United Kingdom to upwards of 270. It ought to be stated here that, first under De la Beche, and subsequently under Murchison, the work of the Survey depended largely for its efficiency and breadth of view on the Local Director, Prof. (now Sir A. C.) Ramsay, who on Murchison's death was appointed Director-General in 1872, and continued in that post until his retirement from the service at the end of 1881. He was then succeeded by Prof. Geikie, who had for more than fourteen years held the office of Director of the Survey in Scotland, and who since his appointment has pushed on the completion of the one-inch map of England and Wales, which is now announced by him as accomplished. The completion of the map of what is termed the "Solid Geology" of England and Wales—that is, the rocks underlying the superficial deposits—terminates indeed an important part of the work of the Survey.

But much remains to be accomplished. The one-inch map of Ireland will be completed in a few years; but that of Scotland, not having been begun till much later, and having always had a much smaller staff, will require longer time. From the last published report of the present Director-General we learn that such of the staff as are qualified for the difficult mountainous area of Scotland will be transferred to that region as soon as

[1] From the *Times*.

they have prepared their recent work for the engraver. The staff retained in England will have to complete the survey of the superficial deposits, which is so valuable as a basis for the agricultural valuation of land, as well as for other purposes. For some years past the mapping of these deposits has advanced simultaneously with that of the rocks underneath them. Two kinds of maps are supplied to the public, one indicating the superficial accumulations, and therefore invaluable as an agricultural map, and the other showing the "solid geology" or older rocks that lie below. The importance of mapping the superficial deposits, however, both from an industrial and scientific point of view, was not recognised until comparatively recently. Over the larger part of the country, therefore, these deposits are not expressed upon the Survey maps, and it is to the completion of this work that one part of the energy of the staff must now be directed. It will be desirable also to resume the survey of the coalfields on the cale of six inches to a mile, which has been temporarily interrupted in order to hasten the completion of the one-inch map. The South Wales coalfield, for example, was mapped some forty years ago, and so much has been done in the interval towards the development of that vast mineral basin that the maps are so antiquated as to be of comparatively little practical value. We learn from the same report that the most important work lying before the Survey in England and Wales is the geological description of the country. As the issue of explanatory pamphlets to accompany the one-inch maps was not begun until 1857, there is a large area of ground of which no published account has been given, except on the maps and sections. Printed explanations of each sheet are now to be supplied, and from these and all the data in possession of the Survey a series of Memoirs or Monographs is to be compiled which will embrace a generalised view of the geological structure and of the minerals and industrial resources of the whole country. It is the fate of geological maps, as well as of other human productions, to get out of date. As the nation has expended so ungrudgingly to carry on a Geological Survey which is acknowledged to stand at the head of the geological surveys of the world, it would be worse than folly to lose the benefit of all this expenditure by allowing the maps to become obsolete. New openings are continually being made which throw fresh light on what lies beneath us. It will be the duty of Parliament to see that a permanent staff, which need not be a large or costly one, is always retained for the purpose of keeping the maps up to date. Meanwhile it is pleasant to see that the work of this worthy national enterprise is being carried on with vigour, and that its staff are fully alive to the importance of the duties that still lie before them.

THE ORIGIN OF THE SCENERY OF THE BRITISH ISLANDS[1]

THE Scottish Highlands must be looked upon as the relics of an ancient tableland cut out of highly crumpled and plicated schists. Among the eastern Grampians large fragments of the plateau exist at heights of more than 3000 feet, forming wide undulating plains terminating here and there at the edge of precipices. In the Western Highlands, the erosion having been more profound, the ridges are narrower, the valleys deeper, and isolated peaks are more numerous. It is the fate of a tableland to be eventually cut down by running water into a system of valleys which are widened and deepened, until the blocks of ground between are sharpened into ridges and trenched into separate prominences. The Highlands present us with far advanced stages of this process. In the youngest of British tablelands—that of the volcanic region of Antrim and the Inner Hebrides—we meet with some of the earlier parts of the change. That interesting tract of our islands reveals a succession of basaltic sheets which appear to have spread over the wide valley between the Outer Hebrides and the mainland, and to have reached southwards beyond Lough Neagh. Its original condition must have been like that of the lava-fields of Idaho and Oregon—a sea-like expanse of black basalt stretching up to the base of the mountains. What may have been the total thickness of basalt cannot be told; but the fragment remaining in Ben More, Mull, is more than 3000 feet thick. So vast has been the erosion since older Tertiary time that the volcanic plateau has been trenched in every direction by deep glens and arms of the sea, and has been reduced to detached islands. It is strange to reflect that all this revolution in the topography has been effected since the soft clays and sands of the London Basin were deposited.

The intimate relation of a system of valleys to a system of drainage lines, first clearly enunciated by Hutton and Playfair, has received ample illustrations from all parts of the world. Yet the notion is not yet extinct that in some way or other valleys have been as much, if not more, determined by subterranean lines of dislocation as by superficial erosion. Some favourite dogmas die hard, and though this dogma of fracture has been demolished over and over again, it every now and then reappears, dressed up anew as a fresh contribution to scientific progress. We have only to compare the surface of a much dislocated region with its underground structure, where that has been revealed by mining operations, as in our coal-fields, to see that valleys comparatively seldom, and then only as it were by accident, run along lines of dislocation, but that they everywhere cut across them, and that faults rarely make a feature at the surface, except indirectly by bringing hard and soft rocks against each other.

In Britain, as in other countries, there is a remarkable absence of coincidence between the main drainage system and the geological structure of the region. We may infer from this fact that the general surface, before the establishment of the present drainage system, had been reduced to a base-level of denudation under the sea, the original inequalities of configuration having been planed off irrespective of structure; or at least, that the present visible rocks were buried under a mass of later unconformable and approximately level strata, on the unequally upraised surface of which the present drainage system began to be traced. Where the existing watershed coincides generally with the crest of an anticline, its position has obviously been fixed by the form of the ground produced by the plication, though occasionally an anticline may have been deeply buried below later rocks, the subsequent folding of which along the same line would renew the watershed along its previous trend. Where drainage lines coincide with structure, they are probably, with few exceptions, of secondary origin; that is, they have been developed during the gradual denudation of the country. Since the existing watershed and main drainage lines of Britain are so independent of structure, and have been determined chiefly by the configuration of the surface when once more brought up within the influence of erosion, it may be possible to restore in some degree the general distribution of topography when they were begun.

One of the most curious aspects of the denudation of Britain is its extraordinary inequality. In one region the framework of the land has been cut down into the very Archæan core, while in the immediate vicinity there may be many thousands of feet of younger strata which have not been removed. This inequality must result from difference in total amount of upheaval above the base-line of denudation, combined with difference in the length of exposure to denudation. As a rule the highest and oldest tracts will be most deeply eroded. Much of the denudation of Britain appears to have been effected in the interval between the close of the Carboniferous and end of the Triassic period. This was a remarkable terrestrial interval, during part of which the climate was so arid that salt lakes were formed over the centre of England. Yet the denudation ultimately accomplished was enormous, thousands of feet of Carboniferous rock being entirely removed from certain areas, such as the site of the present Bristol Channel. An interesting analogy to this condition of things is presented by the Great Basin and adjoining tracts of Western America, where at the present time great aridity and extensive salt-lakes are accompanied by great erosion.

This deeply-eroded post-Carboniferous land was eventually screened from further degradation, either by being reduced through denudation to a base-level or by being protected by submergence. It was to a large extent covered with Secondary rocks, though the covering of these may have been but thin over what are now the higher grounds. The present terrestrial areas emerged at some period later than the Chalk. In England there were three tracts of land—Wales, the Pennine Chain, and the Lake District. The eastern half of the country, covered with Secondary rocks, was probably the last portion to be uplifted above the sea; hence the watersheds and drainage lines in that tract may be regarded as the youngest of all.

The history of some of the valleys of the country tells the story of the denudation. The Thames is one of the youngest

[1] Abstract of the third of a course of lectures given at the Royal Institution, February 19, by Archibald Geikie, F.R.S., Director-General of the Geological Survey. Continued from p. 348.