

## NOTICES OF MEMOIRS.

## THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND IRELAND.

## SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY FOR 1897.

By Sir A. GEIKIE, D.Sc., D.C.L., LL.D., F.R.S., F.G.S., Director-General. 8vo; pp. 176. (London: Eyre & Spottiswoode, 1898. Price 1s.)

*(Continued from the July Number, p. 318.)*

2. PREPARATION OF MAPS, SECTIONS, AND MEMOIRS.—The results obtained by the Geological Survey are made public in three forms: Maps, Sections, Memoirs and Annual Reports, to which may be added the arrangement of specimens in the three national museums, with their diagrams, handbooks, and other explanatory matter, and also the original papers, which, lying often beyond the scope of the Survey's publications, are prepared by members of the staff and, with the consent of the Director-General, are communicated by them to scientific societies and journals.

(a) *Maps.*—Experiments were tried some years ago as to the feasibility of producing the one-inch Geological Survey maps by colour-printing. But the scale of these maps is so large, the number of sheets so great, and the sale of many of them so comparatively small, that this method of reproduction has not yet been adopted. A large impression of each sheet would require to be printed off and a considerable stock would accumulate, so that any additions and alterations of the maps would be impracticable for many years. The original system of colouring by hand, which has up to the present time been retained, has this advantage, that by keeping the supply of copies of each sheet just sufficient to meet the demands of the public, any alteration of a map which from time to time may be found to be necessary, can be made without the loss involved in cancelling a large stock of copies.

Colour-printing may eventually be applied to the new series of one-inch maps. In the meantime it has been successfully tried in the case of a general map of England and Wales on the scale of four miles to an inch, to which reference will be made further on.

Some idea may be formed of the nature of the colouring work of the Survey maps, from the fact that upwards of 180 different tints and combinations are employed to denote the various kinds of rocks separately discriminated on them. It is difficult to find colours distinct from each other, yet harmonious, and that will not fade on exposure. To guard as far as possible against the risk of fading, every colour is also distinguished by its own symbol, which is legibly engraved where the colour occurs on the map.

Two editions of the one-inch map of England and Wales are issued for those districts of which the Drift survey has been completed, but where the drift covers small areas one edition is

found to be sufficient. One of these editions shows all the superficial deposits, and only the parts of the underlying formations as lie bare at the surface. The other edition presents the underlying formations as these would appear if the superficial accumulations could be stripped off. Each of these editions has its value for special purposes. In all questions of sanitation, water supply, agriculture, and building, it is obviously the "Drift" edition that should be consulted, while, on the other hand, where the information desired has reference to what lies deeper beneath the surface, as in the sinking of deep wells and mines, it is the "Solid" edition that will be most usually consulted. The difference between the two is merely one of colouring, for they are printed from the same copperplate, and as far as the engraving goes are exact duplicates.

The total number of six-inch maps published by the Geological Survey up to the present time is for England and Wales, 223 sheets; Scotland, 127 sheets; Ireland, 10 sheets. The number of one-inch whole-sheets and quarter-sheets (Old Series) for the whole of England and Wales amounts to 261; 238 of these are published only as "solid" maps; 95 are issued in two editions, "solid" and "drift"; of 23 only the "drift" edition is published. Of maps on the one-inch scale, belonging to the New Series, 15 sheets have been published, 11 of which are issued in two editions with and without drift. The number of sheets published of Scotland is 60, and of Ireland 205. The whole of Ireland has been completed and published. Every effort is now being made to complete at as early a date as possible the survey of Scotland, but the extraordinary complication of the geological structure of the Highlands, being far greater than was ever anticipated, renders the progress less rapid than was originally expected.

The desirability of having a general geological map of the country on a smaller scale than that of one-inch to a mile has long been recognized. When the mapping of England was completed, advantage was taken of the existence of an index Ordnance Survey map on the scale of four miles to an inch ( $\frac{1}{253440}$ ). This map, based on the old one-inch maps, had been laid aside, incomplete by the Ordnance Survey, but it was likely to be so useful for geological purposes that at the request of the Director-General it was finished at Southampton. The work of the Geological Survey has been reduced upon this map, of which there are for England and Wales 15 sheets. The whole of these sheets have now been published in chromo-lithography, and when mounted in one sheet present at a glance a clear and vivid picture of the geological structure of the whole country. The price of each sheet is 2s. 6d., and the total cost of the map is £1 17s.

The value of reduced index-maps for geological purposes was recognized long ago by the preparation of a general map of Wales. When the Geological Survey of the Principality was finished the whole work was reduced to the scale of four miles to an inch and engraved in six sheets, which include parts of the West of England. This map has been on sale for many years.

(b) *Sections.*—The Vertical Sections are drawn usually on the scale of 40 feet to an inch, and are prepared almost entirely to illustrate the succession of strata in the coalfields. Each sheet generally contains more than one section. The materials for the plotting of these sections are sometimes obtained by actual measurements taken by the surveyor himself, but more commonly are supplied by the lessees or managers of the collieries. Sometimes tables of comparative sections are given, in illustration of variations in character and thickness between the seams of coal, ironstone, or limestone in different parts of the same mineral field.

Occasionally, where a group of strata, though of little industrial importance, possesses great geological interest, a vertical section of it has been constructed and published in the same style as the coalfield sections. In this way sections of the Jurassic rocks in Eastern Yorkshire, of the Lower Lias and Rhætic rocks in the West of England, of the Tertiary strata in the Isle of Wight, and of the Purbeck group in Dorset have been issued.

Altogether 90 sheets of Vertical Sections have been published for the three kingdoms.

The Horizontal Sections have been an important feature in the work of the Geological Survey. De la Beche, recognizing the practical disadvantages arising from the construction of sections without any regard to the proportion between height and distance, instituted the practice of drawing them on a true scale. He adopted the scale of six inches to a mile, and invented a system of patterns for the different kinds of rock, which, as he was himself an artist, are appropriate and effective, for they represent in no small measure the general structure of the rocks. The institution of such sections, in lieu of the distorted diagrams too generally employed, was of great service to the survey itself and also to the progress of geology; for it served to correct the evil influences of distorted drawing, with regard not only to geological structure but to the true forms of the ground.

As an illustration of the character of these sections and their usefulness in correcting popular misconceptions as to geological structure and the form of the ground, reference may be made to that which runs from Leicestershire to Brighton and passes through London (Sheet 79). What is called the "London Basin" is by many people regarded as a deep trough of clay, with the Chalk rising steeply from under it both to the south and north, and we may see this conception embodied in actual diagrams in textbooks and elsewhere. But in reality both the London Clay and the Chalk are so nearly flat that their inclination can hardly be detected except by careful measurement. And the section, accurately plotted from borings and well-sections, shows them apparently horizontal, though on further inspection we find that their line of junction, which is well above the datum-line at either end, lies several hundred feet beneath it in the centre.

In all, 193 sheets of such sections for the United Kingdom have been issued.

Besides the usual Horizontal Sections on the scale of six inches to a mile, occasional sections on a larger scale are prepared to illustrate the geological structure of particular localities. In this way the coastline of Cromer and Yarmouth has been represented in detail, and its numerous features of geological interest have been inserted so as to exhibit a kind of picture of the arrangement of the strata in these changing cliffs. Portions of the coastline of Dorset and of the Isle of Wight have been similarly treated.

(c) *Memoirs*.—It has for some years been customary to insert in the Annual Report of the Director-General of the Geological Survey (submitted to the Science and Art Department, and published in its Annual Report) a general statement of the nature and progress of the operations of the Survey for the year. This statement has at last become too voluminous to find a place in that Report. It is now given in the present publication, which is the first "Summary of Progress." It is intended hereafter to continue this series uniform with the Memoirs.

Obviously, in the course of a geological survey, a large amount of detailed information is collected which cannot find a place either on the Maps or the Sections. This material embraces much local detail, and a large body of evidence which is of importance in general geological inquiry. It can only be properly used by being arranged, condensed, and printed. The issue of Memoirs of its work has, therefore, been from the beginning one of the chief occupations of the Geological Survey of the United Kingdom. The form in which these publications have appeared has varied. De la Beche's plan was to publish volumes of General Memoirs, embracing descriptions of particular regions and also essays on special branches of geological inquiry. His own memoir on the geology of Cornwall, Devon, and West Somerset is an admirable example of his method, and has long taken its place among the classics of English geology. Edward Forbes' striking Essay on the "History of the British Flora and Fauna" and Ramsay's on the "Denudation of Wales" appeared in the first volume of these General Memoirs. There were practical difficulties, however, in the way of continuing these volumes when the staff increased, and the literary labour had to be shared by a number of observers, who were, in many cases, more ready to wield their hammers than their pens. When Murchison succeeded to the charge of the Survey, he sought to avoid these difficulties by instituting the practice of accompanying every sheet or quarter-sheet of the one-inch map with an explanatory pamphlet, giving the chief data on which the map had been constructed, with references to the best sections, lists of minerals, rocks, and fossils, and information as to the geological structure of the ground. These pamphlets, containing essential details only, were to be eventually condensed and collated by the Local Director, so as to form a generalized view of each important geological region. This scheme was well conceived, and with some modifications, rendered necessary by the progress of the Survey, has been continued. It is not always possible or desirable to prepare a separate explanation for each sheet or

quarter-sheet, for much reduplication of geological information would thereby be involved. Several quarter-sheets or sheets may be described together in a single Memoir.

Occasionally these Memoirs, when dealing with an important district, have been expanded beyond the limits of mere Sheet Explanations, and have taken the form of octavo volumes. Such, for instance, are the Memoirs on the Yorkshire Coalfield, on North Wales, on the geology of the Weald, on the geology of London, on the Isle of Wight, and on Cowal, Argyllshire.

The chief literary work on which the staff of the Survey is now engaged is the preparation of the General Memoirs to which the Sheet Explanations were designed to be preparatory. It appeared to the present Director-General that these Memoirs should consist of two series. In the first place, it is desirable that the local details which remain unpublished, or which have been scattered through separate Explanations, should be collected, condensed, and arranged so as to present a description of each important district of the country. As examples of this mode of treatment, the volumes on the Weald, London, and the Isle of Wight may be referred to. In the second place, it is obviously necessary, in the interests of geology, that the contributions made by the Survey to that science should be systematically set forth, and that a full account should be given of each of the geological formations of which the framework of the British Isles is built up. To carry out this requirement a stratigraphical rather than a geographical treatment is needful. A series of Monographs is demanded devoted to the description of the various rock-systems of the country, and brought up to the time of publication by giving not only what has been done by the Survey but an outline of the work of other observers.

The information obtained by the Survey in its progress is necessarily scattered through many maps, sections, and memoirs. The work of the service would be incomplete and difficult of consultation if it were left in this disseminated state. It needs to be gathered together, arranged, and put into connected form, so as to present an intelligible account of the geology and mineral products of these Islands. The task is a heavy one and cannot be speedily finished; but satisfactory progress is being made. A Monograph on the Pliocene deposits of England in one volume, and five volumes of another on the Jurassic rocks, have already been published; one on the Upper Cretaceous rocks is far advanced, and others are in preparation. Each Monograph will embrace one system or group of rocks, and may consist of one or more volumes according to the importance of the system and the area which it occupies in the country.

In the preparation of the memoirs, and for museum purposes, much assistance is now derived from photography. Several members of the staff have become expert photographers, and a large number of views of geological sections, coast-cliffs, and other natural or artificial exposures of rock have been taken. These serve as illustrations for the memoirs, and some of them are mounted to

accompany the specimens in the museums. It is in contemplation also to employ photography for the duplication of the six-inch field-maps.

Besides the geological Memoirs, the Survey has published a series of Decades of British organic remains, with plates and descriptions, also Monographs of important genera or groups of fossils, including Professor Huxley's essays on *Pterygotus*, the Belemnitidæ, and the crocodiles of Elgin, and Mr. Newton's memoirs on Cretaceous fishes and Pliocene vertebrates.

3. **PETROGRAPHICAL WORK.**—In the earlier days of the Geological Survey each member of the staff determined for himself, by such tests as he could apply, the various rocks encountered by him in the field. Only in rare cases were chemical analyses made for him. The study of rocks had fallen into neglect in this country, being eclipsed by the greater attraction of the study of fossils. The introduction of the microscope into geological investigation has, however, changed this apathy into active interest. It is now recognized that apart from mere questions of nomenclature, rocks contain materials for the solution of some of the most important problems in physical geology. Accordingly, microscopic inquiry has in recent years been organized as one of the branches of the Geological Survey, and now affords constant and material aid in the progress of the mapping, three members of the staff being specially detailed for petrographical work in the office and in the field. Chemical analyses are likewise made, so as to afford all available information as to the composition of the mineral masses encountered in the field.

The original specimens from which the thin slides have been prepared are kept in cabinets, so that if any accident should befall a slide, a new slice can at once be cut. The mounted slides are arranged in separate cabinets. A large number of such slides has now been accumulated. From Scotland alone nearly 8,000 have been determined, and are ready for reference at any moment.

But besides assisting the field-work, the petrographers are engaged in determinations required for the arrangement of rock-specimens in the museums at Jermyn Street, Edinburgh, and Dublin. The collectors employed under the supervision of the surveying officers to make illustrative series of specimens of the rocks of each district, send these up to the office for examination and for insertion in the museum. In the course of the research thus imposed on them, the petrographers are from time to time enabled to make important original contributions to petrographical science. Moreover, by conferring in the field with the officers who are engaged in mapping, they are enabled to realize the nature of the problems to be dealt with by the surveyor, and the points on which petrographical assistance is needed. Their determinations are embodied in the Memoirs on the geology of the several districts.

4. **PALÆONTOLOGICAL WORK.**—In a country where the geological formations are to a large extent fossiliferous, it is necessary to pay close attention to the organic remains found in the rocks, to collect specimens of them, to determine these specifically, and to regulate thereby the geological boundary-lines upon the maps. The duty of



examining and reporting upon fossils collected by the Geological Survey is entrusted to the palæontologists, who occasionally visit the field, but are mainly engaged at the museum. With reference to the exigencies of field-work a somewhat similar system is followed with regard to fossil evidence as in the case of the petrography, though the same minute detail is not necessary. The officer, when in doubt about any species, the names of which are needful in separating formations and drawing their mutual boundary-lines, collects specimens of them and sends them up to the office for identification. They are compared by the palæontologist with published descriptions and named specimens, and a list of their specific names (as far as they can be made out) is supplied to the surveyor.

Besides such specimens as may require to be identified in the course of the mapping, full collections from the formations of each important district are made by the collectors under the guidance of the officers by whom the district has been surveyed. Every specimen is numbered and registered in the collector's book, so that its source and destination can at once be found. Lists of the fossils are drawn up by the palæontologists for insertion in the published Memoirs. A selection of the best specimens is placed in the cases, drawers, or cabinets of one or other of the three Museums. Fortunately in the case of the palæontologists also, though much of their work is necessarily of a routine official character, opportunities are afforded to them of making interesting and important additions to palæontological science. It was from this department of the Survey that Edward Forbes produced some of his best work, that Salter made his fame as a palæontologist, and that Professor Huxley enriched geological literature with his memoirs on Silurian Crustacea, Old Red Sandstone fishes, and Triassic reptiles. Within the last few years fresh distinction has been won by Mr. E. T. Newton, of the same department, from the investigation and restoration of a series of remarkable reptiles from the Elgin Sandstones.

5. THE MUSEUM OF PRACTICAL GEOLOGY AND THE GEOLOGICAL SURVEY COLLECTIONS IN EDINBURGH AND DUBLIN.—For the complete illustration of the geology of a country it is necessary not only to construct geological maps and sections, and to publish printed descriptions, but also to collect and exhibit specimens of the minerals, rocks, and organic remains. Each branch of the Geological Survey has from the beginning kept in view the gathering of such specimens, and the galleries of the Museums in London, Edinburgh, and Dublin may be appealed to as evidence of the manner in which the duty has been discharged. The Museum in Jermyn Street is intended to be primarily illustrative of the minerals, rocks, and fossils of England and Wales, but as far as space will admit an endeavour is made to exhibit what is specially characteristic of the other two kingdoms. For more detailed illustrations of Scottish geology recourse must be had to the Museum at Edinburgh, and for those of Irish geology to the Museum at Dublin.

The Museum of Practical Geology, Jermyn Street, as its name denotes, was from the beginning intended to illustrate the applications of geology to the industries and arts of life, as well as the

more systematic treatment of the science. Its materials were meant in the first place to be taken from the United Kingdom and to form a collection in which the minerals, rocks, and fossils of this country should be displayed to the public in connection with examples of their economic uses. The cases of the Museum now contain an extensive collection of the building and ornamental stones of the British Isles, which has been largely made use of by architects, builders, and others. The granites of Cornwall, Devon, Scotland, and Ireland, the marbles of Derbyshire, Staffordshire, Devonshire, Bristol, the Isle of Man, Ireland, and Scotland, are well represented, together with many varieties of serpentine, limestone, dolomite, sandstone, slate, etc. Materials required in the process of grinding and polishing stones, and those illustrating the preparation of plaster and cements, also find a place. One of the most complete parts of the Museum is the great series of specimens illustrating the ores of Great Britain and Ireland. There are likewise colonial and foreign ores, and an important collection illustrating the metallurgy of the metals. Perhaps the most attractive departments of the Museum are the large horseshoe case, in which are placed examples of minerals and their applications in the arts, and the extensive ceramic collection, in which the connection between the raw material and finished pottery is shown. The collection of British pottery was one of the earliest formed, and is still, perhaps, the most illustrative in the country. Models of geologically important districts and of different mines are placed in the model rooms and in different parts of the Museum. The Library contains a tolerably complete representation of the literature of geology, British and foreign, and may be consulted by persons engaged in geological research. Large geological maps are arranged along the lower gallery of the Museum, and can be drawn down and studied by visitors. An extensive and valuable collection of photographs of geological sections and landscapes in the British Isles has been deposited in the Museum and is accessible to students. A microscope and a series of thin slices of typical rocks have been placed in the library for consultation.

The portions of the Museum of Practical Geology most closely connected with the work of the Geological Survey are the collections of fossils, the series of rock-specimens, and the cases illustrating geological processes and rock-structures.

The large series of fossils has been almost entirely obtained from the rocks of the United Kingdom, and chiefly in the course of the prosecution of the Survey. It has furnished the basis on which the maps of the fossiliferous formations have been constructed. Every important subdivision of the Palæozoic, Secondary, and Tertiary systems is represented by a full series of its characteristic fossils, gathered from the various districts in the British Isles wherein it is developed. These are arranged and tableted in such a way as to be readily accessible to the public. Those who wish to follow out the palæontological details of the Survey maps and memoirs, or to study general textbooks of the science, have thus the fullest opportunities afforded to them.



The palæontologists with their assistants are continually engaged in arranging and revising the collections, and in adding fresh material received from the officers in the field, from donations, or from purchase.

The rock-collections have in recent years been greatly increased and entirely rearranged so as to bring them abreast of modern petrography. They include examples of rock-forming minerals, in illustration of the characters of the more important minerals that enter into the composition of rocks; a series of typical rocks, named, classified, and so arranged close to the eye that the visitor may have no difficulty in observing their general external characters; a section devoted to illustrations of various geological structures such as cleavage, jointing, foliation, plication, the structures of igneous rocks, the effects of contact-metamorphism, the markings made by glacier ice, and the results of weathering in different rocks. But the chief part of the collection is a series of British rocks arranged in stratigraphical order from the oldest gneisses up to the most recent shell-sand. Not only are the sedimentary rocks represented in this series, but a large suite of igneous rocks is included, so that the student of volcanic history may see samples of the lavas and tuffs which have been ejected at each of the periods of volcanic activity in the geological annals of Britain. Diagrams and maps are placed near the specimens to show the geology of the districts from which the latter were taken. Drawings are likewise given of the more important microscopic structures met with in rocks, and especially among those of Britain.

A series of handbooks and catalogues has been issued in explanation of the different parts of the Museum. Thus Mr. F. W. Rudler, the Curator, has prepared a general handbook to the whole contents of the building, and also one to the collection of British pottery and porcelain. There are, likewise, catalogues of fossils. A new guide to the rock-collections and another to the palæontological collections are now being prepared.

The Geological Survey collection, illustrative of the geology of Scotland, is arranged in the upper gallery of the west wing of the Museum of Science and Art, Edinburgh. It includes an extensive series of rocks grouped in petrographical order according to the respective counties from which they come, each specimen being traceable to its locality by a pin with its number fixed to the geological maps exhibited in the table-case below. There is, likewise, a large collection of fossils, mainly Scotch, arranged in stratigraphical order. A handbook to the whole collection prepared by Mr. J. G. Goodchild, the Curator, has been published.

The collections of the Irish branch of the Survey deposited in the Science and Art Museum, Dublin, are similarly arranged, and are illustrated by a handbook so full in its descriptions as to serve as a guide to the general geology of Ireland. This useful publication has been prepared by Messrs. A. McHenry and W. W. Watts.

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