Geological Survey of Great Britain and Ireland: A contemporary account of the Survey, 1897

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This document is a transcription from the Geological Survey of Great Britain and Ireland 1897 Summary of Progress. There have been no changes to the original text, though new headings, bullet points and illustrations have been added for this Earthwise version. This issue provides a very useful contemporary account of the history of the Survey as well as detail on methods, processes and outputs of the Geological Survey

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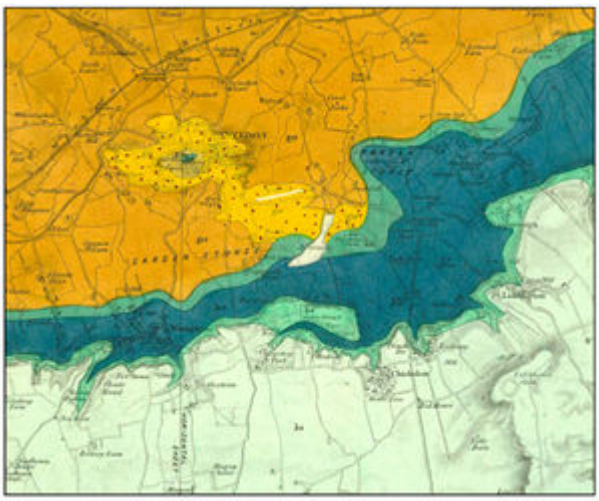
Geological Survey of Great Britain and Ireland

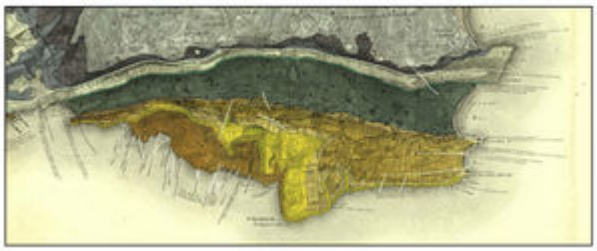
Introduction



Extract of a hand-coloured 1:63,360 scale
geological map. Swindon.

As no official publication up to the present time has given an account of the origin, history, organisation, methods, and aims of the Geological Survey of the United Kingdom, advantage is taken of the opportunity offered by the preparation of the present Summary of Progress to prefix an Introductory Section, in which these particulars may be specially set forth.

The objects for which the Geological Survey is carried on are of a twofold character, scientific and practical. It is charged with the preparation of a detailed map of the United Kingdom, in which the geological structure of every district is worked out, the boundaries and limits of the various rocks and superficial deposits are traced, and the outcrop of each important seam or vein is represented. Such a map forms the basis for an exact knowledge of the geology of the country, anti is thus of fundamental value in the interests of pure science. It is also intimately connected with many of the most important questions of everyday life. Thus by discriminating and delineating the different kinds of superficial deposits and subsoils, the map provides a basis for the solution of some of the chief problems in agriculture. It affords information which is absolutely necessary in questions of water-supply, drainage, and other sanitary matters. It supplies data required by the engineer in constructing roads and railways, by the architect in providing materials for new buildings, by the mining surveyor in determining the position of new pits and mines.



Extract of a hand-coloured 1:63,360 scale
geological map, Dorset.

Besides preparing the map, the Geological Survey constructs detailed sections explanatory of the geological structure of the country; also memoirs descriptive of the geology of the district, represented on the sheets of the map, and larger monographs illustrative of the various geological formations of Britain. It. collects specimens of the minerals, rocks, and fossils of each of the three kingdoms, arranges and describes them, and displays them to the public in the Museums in London, Edinburgh, and Dublin.

Besides its contributions to the progress of geology as a science, the Survey from the very beginning of its existence has kept in view the general utility of its operations. It has been constantly called upon by the various public Departments to furnish information in regard to the practical application of geology. The general public, also, has continually sought assistance of a similar kind. Examples of this practical side of the Survey work will be given in a later part of this Report. Each of the three offices in London, Edinburgh, and Dublin has become a centre of reference for information and advice on questions in which a knowledge of the geology of the country is requisite. The following introductory pages contain

(1) a brief narrative of the origin and progress of the Geological Survey and of the Museum of Practical Geology, up to the present time.

(2) a description of the various kinds of work carried on by the Survey in the field, in the office, and in the museum, with an account of the publications, issued and in preparation, by the establishment.

The Origin and History of the Survey and Museum

Henry T. De La Beche and the origins of the Survey

Henry Thomas De La Beche 1796 - 1855. Appointed director General 1835. Fellow of the Royal Society 1819; President of the Geological Society 1847-49; Knighted 1848; Awarded Woolaston Medal 1855.

The Geological Survey of the United Kingdom and the Museum of Practical Geology, Jermyn Street, owe their origin to Henry Thomas De la Beche, one of the most illustrious geologists of this century. After various geological researches prosecuted early in life on the Continent and in the south of England, he eventually undertook a more detailed examination of the rocks of Devon and Cornwall. Supplying himself with the maps of the Ordnance Survey, on the scale of one inch to a mile, he began to map the geological structure of that part of the country. This labour was carried out with his own hands and at his own charges. As it advanced, be was led to perceive that it might possess great public importance in regard to the development of the mineral resources of the kingdom. An accurate delineation of the courses of the mineral veins, coalseams, and other helpful substances contained among the rocks beneath the surface, and of the bearings of the faults thatÂ· dislocate and shift them, could hardly fail to prove of much practical value as well as of scientific interest. After he had made some progress with his self-imposed task, De la Beche was induced to apply to the Government of the day for recognition and assistance. The Ordnance Survey, indeed, under the enlightened supervision of Colonel Colby, had already encouraged the surveyors of its staff to keep a record of their observations respecting the relations between variations in the topography of the

land and changes in the characters of the rocks underneath. In this manner the geology of the district mound Ludlow, together with that of the Forest of Dean and the central parts of Herefordshire, had been with more or less precision traced upon the Ordnance sheets * [Proc. Gcol. Soc. vol. i. p. 447.] De la Beche represented to the authorities that the work on which he was engaged would be much more efficiently carried out if it were conjoined with that of the general trigonometrical survey of the whole country, which was then in progress. His views were eventually approved of, and in the year 1832 he was appointed by the Board of Ordnance to affix geological colours to the maps of Devonshire, with portions of Somerset, Dorset and Cornwall. By the spring of 1834 he was able to publish four sheets of the geological map of the county of Devon, whereon the general geological structure was depicted with a minuteness and beauty of execution such as had not before been equalled. Three additional sheets of the Ordnance Survey were completed by the end of that year, while another was nearly finished.

Ordnance Geological Survey — 1835

This rapid progress and the obvious advantages to be derived from the maps, led to a more definite recognition of De La Beche's labours. In the spring of 1835 the Master-General and Board of Ordnance consulted the Professors of Geology in the Universities of Oxford and Cambridge (Buckland Sedgwick) and the President of the Geological Society (Lyell), as to the expediency of combining a geological examination of the English counties with the geographical survey then in progress. Supported by the strongly expressed approval these distinguished men, the Treasury agreed to place on the estimates a grant to defray the additional expense which will be incurred in colouring geologically the Ordnance countymaps. * [Proc. Geol. Soc. val. ii. p. 154; Op. cit. vol. ii. p. 358.] As the sum thus granted amounted to only £300 a year, most of the expense of the mapping still fell upon De La Beche himself. He also undertook the lion's share of the field surveys, though he had the occasional assistance of some of the Ordnance surveyors who possessed geological experience. But he had gained the first and fundamental object which he had in view. His enterprise was officially recognised as a national Geological Survey, of which he himself became Director.

Museum of Economic Geology — 1841; Museum of Practical Geology — 1851

Museum of Practical Geology. First floor with one of the subjects named as John Thackery.


Museum of Practical Geology.

But De La Beche's bold and far-seeing mind had conceived a much more extensive scheme than the preparation of a geological map and as soon as he felt himself secure in his first step, he proceeded to take the next. 1835 he submitted to the Government a proposal that the exceptional opportunities enjoyed by himself and his staff to collect specimens illustrative of the applications of geology to the useful purposes of life should he token advantage of, and that such collections, displaying the mineral resources of the country, should be placed in a room or rooms under the Board of Public Works. His plans being eventually accepted, rooms were assigned to him for the accommodation of the Survey collections in Craig's Court, Charing Cross, and he was asked to carry out his scheme under the control of the Office of Woods and Forests. Besides the extensive series of specimens gathered together during the mapping of Devon and Cornwall, there was another large assemblage of samples of British building-stones which had been collected by the Commission (whereof De La Beche was a member) appointed to enquire into the most suitable materials for rebuilding the new Palace of Westminster after the burning of the old Houses of Parliament in 1834. The specimens thus accumulated were arranged by De la Beche with reference to the instruction of the public, in illustration of the mineral resources of the country. Materials for making roads, for the construction of public works or buildings, for useful or ornamental purposes in the arts, for the preparation of metals, were grouped in such a way, and with such explanatory labels, maps, models, diagrams and sections, as to convey a large amount of useful information in the most compact and accessible form. In this manner the Museum of Practical Geology took its rise. The collections were in fair working order by the year 1839, though not ready to be opened to the public for two years later. De La Beche was appointed Director - an office which for some years he filled gratuitously. The infant

Metropolitan School of Science Applied to Mining and the Arts — later, School of Mines[1]

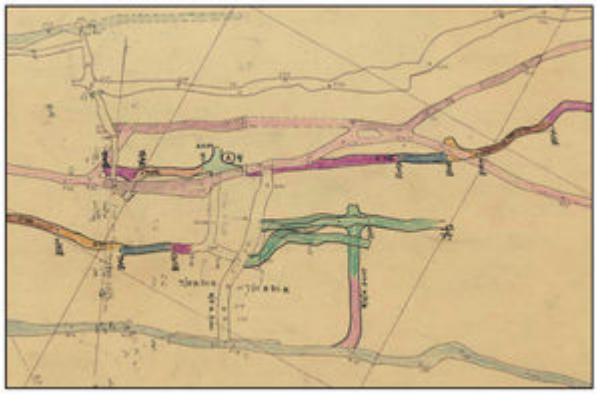
Warrington Wilkinson Smyth 1817 - 1890. appointed Mining Geologist 1845, Lecturer in Mining to School of Mines 1851-90. Appointed Inspector of Mineral property of the Duchy of Cornwall 1851 then Chief Mineral Inspector to the Crown; Fellow of the Royal Society 1858; President of the Geological Society 1866-68; Knighted 1887.

A further part of the Director's wide-reaching scheme was soon put into execution in the premises at Craig's Court. He had planned that besides obtaining information from specimens, models, diagrams, and maps, the public should be enabled at a moderate cost to procure analyses of rocks, minerals, and soils, from the establishment under his control. He was authorised to fit up a laboratory and to appoint a. Curator of the Museum one of the ablest analytical chemists of his time, Richard Phillips. He likewise procured the sanction of the Office of Woods for the institution of lectures, having for their object the illustration of the applications of geology and of its associated sciences, to the useful purposes of life. Owing to the want of a suitable theatre and other appliances the design of providing lectures could not be carried into execution for twelve years. But eventually in the autumn of 1851, when the building in Jermyn Street was inaugurated, De La Beche's scheme was carried out by the opening of the School of Mines.

1. ↑ The School of Mines continued to form part of the Jermyn Street establishment more than twenty rears. The progress of scientific education in that interval, however, demanded more space for practical instruction than the building could supply. Accordingly, in 1872, the Department of chemistry, physics, and biology were transferred to more commodious quarters

erected by The Science and Art Department at South Kensington, and the other departments were similarly transferred as space could be provided for them. The last Professor at Jermyn Street was the late Warrington W. Smyth, on whose death, in 1890, the mining instruction was also removed to South Kensington.]

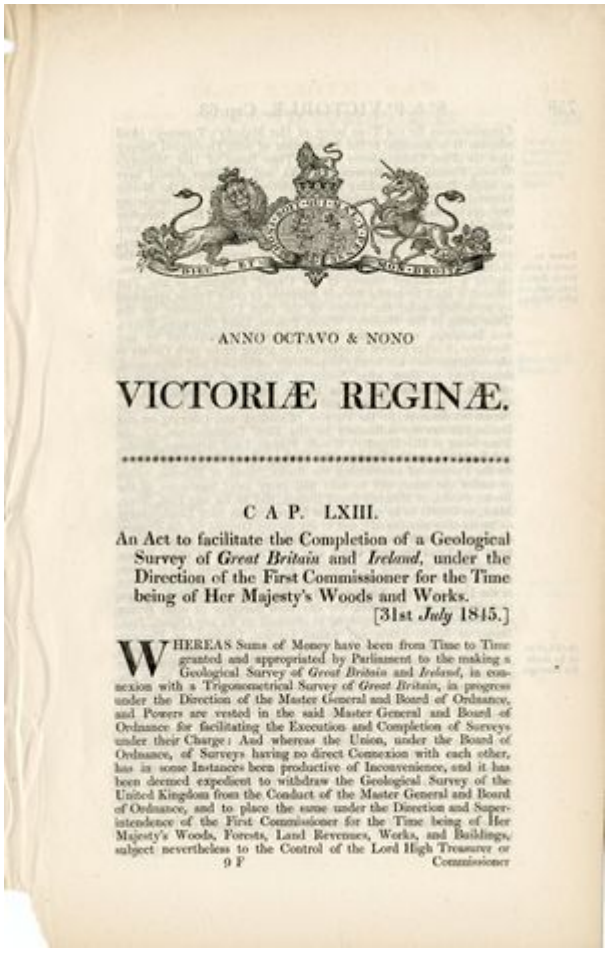
Mining Record Office



Section from a mine plan. Lowland Lead Mines. West Glencrieff. 1955.

There was one further department which owes its foundation to the indomitable energy of De La Beche. In 1838 the British Association had memorialised the Government to take steps to collect and preserve all plans recording the mining operations of the United Kingdom, inasmuch as great loss of life and destruction of property had arisen from the want of the proper preservation of such documents the Director of the Geological Survey was accordingly authorised to form a Mining Record Office as part of his establishment at Craig's Court. This new undertaking started in 1840, under the charge of T.B. Jordan; who was succeeded in 1845 by Robert Hunt. A large series of mining plans was gradually accumulated, and a yearly volume was issued embodying the statistics of the mineral industries of the United Kingdom. These statistics were obtained from the information voluntarily supplied by the proprietors, lessees, and others. Eventually, however, an Act of Parliament compelled the mine-owners to furnish the statistics to the Inspectors of Mines, who published them in their Report to the Home Office. As it thus became unnecessary that two similar returns should be published, and as it seemed desirable that the work of the Mining Record Office should he brought into closer relations with the Inspectors of Mines, that office was in the year 1883 transferred to the Home Office, under which the Inspectors serve.

Account of the work of the Survey



ANNO OCTAVO & NONO

VICTORIÆ REGINÆ.

C A P. LXIII.

An Act to facilitate the Completion of a Geological Survey of *Great Britain* and *Ireland*, under the Direction of the First Commissioner for the Time being of Her Majesty's Woods and Works.
[31st *July* 1845.]

WHEREAS Sums of Money have been from Time to Time granted and appropriated by Parliament to the making a Geological Survey of *Great Britain* and *Ireland*, in connexion with a Trigonometrical Survey of *Great Britain*, in progress under the Direction of the Master General and Board of Ordnance, and Powers are vested in the said Master General and Board of Ordnance for facilitating the Execution and Completion of Surveys under their Charge: And whereas the Union, under the Board of Ordnance, of Surveys having no direct Connexion with each other, has in some Instances been productive of Inconvenience, and it has been deemed expedient to withdraw the Geological Survey of the United Kingdom from the Conduct of the Master General and Board of Ordnance, and to place the same under the Direction and Superintendence of the First Commissioner for the Time being of Her Majesty's Woods, Forests, Land Revenues, Works, and Buildings, subject nevertheless to the Control of the Lord High Treasurer or

9 F Commissioner

Victoriae Reginae. C A P. An Act to facilitate the Completion of a Geological Survey of Great Britain and Ireland, under the Direction of the First Commisioner for the Time being of Her Majesty's Woods and Works. [31st July 1845].

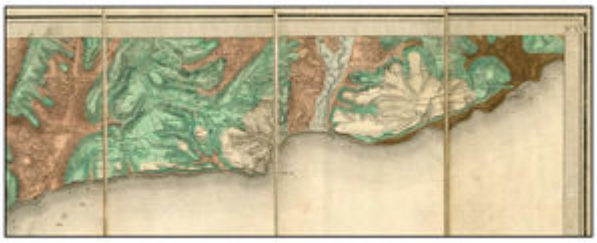
Introduction

We may now trace briefly the progress of the Geological Survey from its commencement to the present time. As above stated, it was begun as a private enterprise by De La Beche previous to the year 1832, and was first established as a branch of the Ordnance Survey in 1835. Ten years afterwards, in 1845, the staff was considerably increased, and the Survey was transferred from the Board of Ordnance to the 'Office of Woods and Works,' so that the whole of the geological organisation, including , the Survey, Museum, and Mining Record Office, was thus united in one Government Department, under De La Beche as Director-General. The Survey, which had hitherto been that of Great Britain, now became that of the United Kingdom. The staff in England and Wales was placed under A. C. Ramsay, its Director for Great Britain, while a small force was placed in Ireland, in charge of Henry James, R.E.

The Great Exhibition of 1851 led to the establishment in 1853 of a Department of Science and Art, under the Board of Trade, to which the Jermyn Street organisation was transferred. In 1856 this Department was placed under the control of the Lords of the Committee of Privy Council on Education, and this arrangement has continued up to the present time.

Beginnings — 1832–1867

South-west England



Part of Ordnance sheet 22, Sidmouth to Lyme Regis, the first completed sheet, geologically coloured (De la Beche's personal copy, 1834 colouring scheme).

The mapping which De La Beche began in the south-west of England was so rapidly executed by him, and the few assistants associated with him, that in a few years be had completed the geological investigation of the whole of Devon, Cornwall, and West Somerset. By the year 1839 the maps of this region, embracing no fewer than fourteen of the Ordnance sheets on the scale of one inch to a mile, were published geologically coloured. These maps were not executed with the detail and precision now attainable on the larger scale employed by the Survey. They were, however, much more minute than anything that had preceded them, and. they are still, to this day, the only available maps of the region which they depict. Besides the maps there appeared in 1839 the well known 'Report on the Geology of Cornwall, Devon, and West Somerset', by Henry T. De La Beche, F.R.S., &c., Director of the Ordnance Geological Survey' - which served as a model for the subsequent official memoirs of the Survey.

South Wales

Having completed the mapping of the south-west of England De La Beche transferred his staff to South Wales; where another important mineral-field awaited detailed examination. By the year 1845, when the Survey passed from the Board of Ordnance to the Office of Woods and Works, the maps of nearly the whole of Somerset the western half of Gloucestershire the counties of Monmouth, Glamorgan, Carmarthen, and Pembroke and nearly the whole of Brecknock and Herefordshire, together with part of Worcestershire, had been completed and published. At that time the geological interest and industrial importance of a full and accurate delineation of the superficial deposits of the country had not peen recognised. The surveyors accordingly attended chiefly to the representation of the rocks beneath these deposits, and made no attempt to trace the limits and variations of the different accumulations now comprised under the general term 'Drift.'

Ireland

Before a branch of the Geological Survey was established in Ireland, Captain J, E. Portlock had instituted in the northern counties of that island a geological department of the Ordnance Survey, which in 1837 included a geological and statistical office, a museum for geological and zoological specimens, and a laboratory for the examination of soils. Unfortunately, this useful organisation was in a few years broken up and the materials collected were removed to Dublin. Portlock, however, was enabled to prepare and publish, under the authority of the Master-General of the Board of Ordnance, his Report on the Geology, of the County of Londonderry, and of parts of Tyrone and Fermanagh,' which, with map, sections, views, and numerous plates of fossils, appeared in 1843, and served as the starting point for the detailed investigation of the geology of Ireland. The Geological Survey began its labours in Ireland ill the year 1845 under Captain (afterwards Sir Henry James, as

Director. During these early years the energies of the staff were concentrated on the ground lying to the south of Dublin and extending thence into the southern counties.

Progress by 1854

By the time the Geological Survey was transferred in 1854 to the Science and Art Department, great progress had been made in the mapping of England and Ireland. The survey, of the whole of Wales had been completed and published, and the field-work was advancing eastwards into the central counties of England, In Ireland, the maps of the counties of Dublin, Kildare, Wicklow, Carlow, Wexford, Kilkenny, Waterford, and almost all Cork had been completed, and , the field-work was being pushed into King's County and Queen's County, and across. Kerry and Limerick. In the same year, 1854, the operations of the Survey were extended into Scotland, where A.C. Ramsay broke ground in East Lothian.

Change of scales

A County Series field slip on the scale of 1:10,560 or six inches to one mile.

Up to this time the field-work of the staff in England and Wales had been conducted upon the basis of the Ordnance maps on the scale of one inch to a mile, no larger scale being available. In Ireland, however, maps on the scale of six inches to a mile had been published by the Ordnance Survey, and these from the beginning were adopted as the ground-work of the Geological Survey. Maps on this larger scale were available also in Scotland, and were from the first made use of for geological purposes. As the Geological Survey advanced northwards in England, it found the six northern counties mapped on the six-inch scale, and at once adopted this larger scale as the basis of the field-work.

Start of systematic Drift surveying — England six northern counties and Scotland

As the great advantages of the use of the larger scale came to be recognised in practice, it was found that the superficial accumulations could be expressed on this scale without unduly interfering with the delineation of the structure of the rocks underneath. At the same time, increased attention was now being paid to the drifts which had been so long neglected. Their paramount importance in relation to soils had long been recognised, but their great geological interest as records of the Glacial Period was more gradually perceived. As the possession of a detailed topographical map now enabled the surveyors to trace the superficial accumulations with a precision quite unattainable on the old one-inch sheets, it was determined to delineate the distribution of these surface deposits at the same time that the boundaries of the underlying rocks were being followed. Hence in the six northern counties of England, in Scotland, and thenceforth everywhere in Ireland the drifts were

distinguished and expressed upon the six-inch maps.

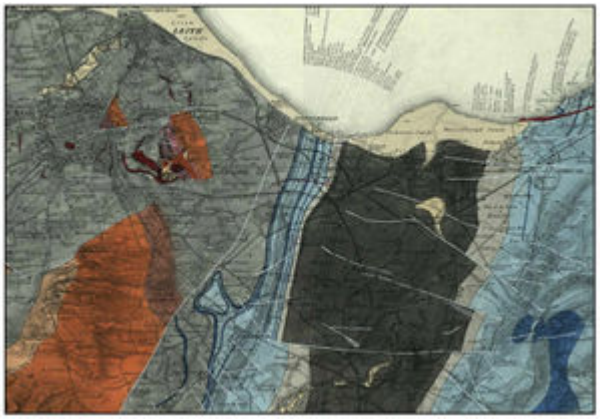
1867 — expansion under Murchison and the creation of the Geological Survey of Scotland

Sir Robert Impey Murchison 1792 - 1871. Appointed Direstor General 1855. Fellow of Royal Society 1826; President Geological society 1831-33. 1841-43, President Royal Geographical Society 1844-45,1852-53,1857-59, 1863-71; Knighted 1845; President British Association for Advancement of Science 1846; Copley Medal 1849; Brisbane Gold Medal 1859; Knight Commander, Order of the Bath 1863; Wollaston Medal 1864; Baronet 1866.

The great practical and scientific advantages of carefully mapping the superficial deposits on a large scale was amply shown by the experience of a few years. It was found, however, that the tracing of the distribution of the various kinds of Drift greatly increased the amount of labour entailed in the preparation of the general map of the country, thus necessarily diminishing the area surveyed each year and reducing the rate of progress of the Survey. At last, in 1867, a great increase was made in the strength of the staff, which was also reorganised with a view to greater efficiency. A distinct, branch of the service was established for Scotland under a separate Director (A. Geikie), the English branch remaining under the supervision of A. C. Ramsay, and the Irish under J. B. Jukes, while Sir R I. Murchison, who had succeeded De La Beche in 1855, continued Director-General of the whole. At this important epoch in the history of its organisation, the Survey of England and Wales had completed and published the maps of the country as far north as a line drawn from Liverpool to

Selby, and as far east as Retford, Melton Mowbray, Market Harborough, Huntingdon, London, Chatham, and Folkestone. Considerable progress had been made with the mapping of the north of Lancashire and Westmoreland, and a portion of the great Northumberland coalfield had been surveyed. In Ireland the maps of the larger half of the island had been published, and the field-work had been pushed northwards to a line drawn from Castlebar to Drogheda. In Scotland, where the staff had always been disproportionately small, the maps of the basin of the Forth had been completed from the north of Fife to Berwick-on-Tweed. The backward state of the Ordnance Survey had necessitated the transference of the staff to the west side of the country where six-inch maps where available, and some progress had been made with the examination of the south of Ayrshire.

1880's — completion of the first Survey, England, Ireland and transference of focus to Scotland



Extract from Geological Survey of Scotland Sheet 32 Edinburgh.

The whole energy of the staff was now directed to the complication as quickly as possible of the one-inch map of each of the three kingdoms. That of England and Wales was finished in 1883, and that of Ireland in 1887. The completion of these maps liberated some of the officers in England and in Ireland, who were accordingly transferred to the Scottish staff. As the Survey of Scotland was commenced long after that of the sister kingdoms, and was carried on for many years by a staff of only two surveyors, it is not yet completed. At the present time the unsurveyed portions of the country include the central mountains of Sutherland and Ross, with most of Inverness-shire, the western parts of Argyllshire, and most of the Western Isles.

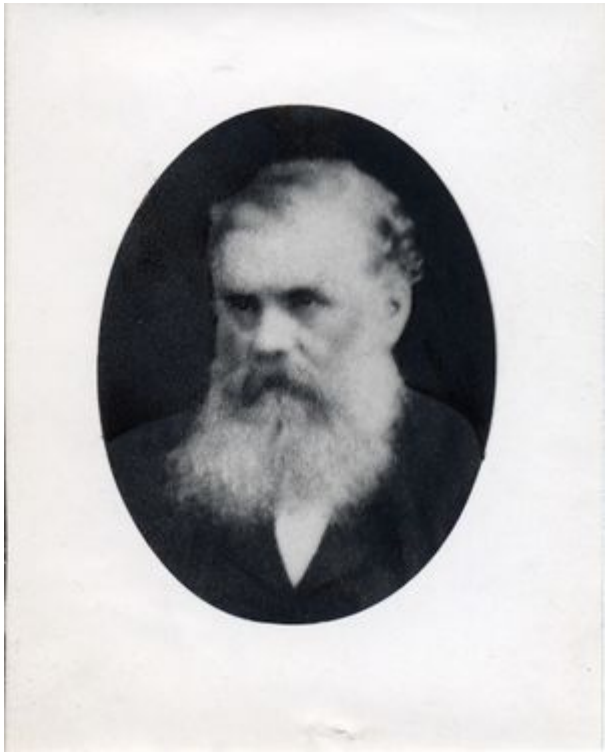
When the one-inch map of England was completed, most of the staff was detailed for the purpose of mapping the superficial deposits in the southern half of the kingdom, and thus providing materials for a complete agronomic map of the whole of Britain. An opportunity has at the same time been afforded to revise the published maps and bring them up to date. The nature and extent of this revision will be more particularly noticed in subsequent pages. When the one-inch map of Ireland was finished the staff was reduced, partly by transference to Scotland and partly by retirement, only such a number of officers being retained as might suffice for the necessary revisions which the progress of time requires. To these revisions also fuller reference will be made in the sequel.

Survey Administration

To conclude this historical retrospect a brief notice may be given of the successive changes which have taken place in the administration of the establishment. On the death of Sir Henry De La Beche, the office of Director-General was, in 1855, conferred on Sir R.I. Murchison, who held it until the time of his death in 1871. It was then given to Sir A. C. Ramsay, who retired at the end of 1881, and

was succeeded by Archibald Geikie. Ramsay, who had been made Local Director for Great Britain in 1845, became Senior Director for England and Wales, on the augmentation and reorganisation of the staff in 1867, and he retained that post until his promotion in 1872. He was then succeeded in it by H. W. Bristow, who retired in 1888.

Ireland



T. Oldham.

The first Director for Ireland, Sir Henry James, after serving for only one year, was succeeded in 1846 by Thomas Oldham, who resigned the office in 1850 on his appointment to be Director of the Geological Survey of India. J. B. Jukes was then transferred from the English staff and held the Directorship until his death in 1869. He was followed by Edward Hull, who retired from the service in 1890, after which the duties of the Directorship for Ireland were merged in those of the Director General.

Scotland

When the Scottish branch of the Survey was established in 1867, A. Geikie was appointed Director, having previously served in the Survey of Scotland almost from its commencement. On his promotion to be Director-General at the end of 1881, the Directorship for Scotland was conferred on H. H. Howell, of the English staff, and is still held by him. On R. W. Bristow's retirement, H. H. Howell became also Senior Director for England and Wales.

Staff complement

Scottish Survey staff in 1868. Standing, (left to right) I. Geikie, J. Horne, J. Croll, C. R. Campbell, B. N. Peach, D. R. Irvine, T. M. Skae, and R. L. jack. Seated, E. Hull and A. Geikie. From: Wilson, R.B. A history of the Geological Survey in Scotland. NERC, IGS, 1977.

At present the whole staff of the Geological Survey, exclusive of the Museum of Practical Geology, consists of 52 persons of whom:

27 are stationed in England and Wales

18 in Scotland

7 in Ireland

The various posts are thus arranged:

1 Director-General

1 Director for England and Scotland

3 District Surveyors and Resident Geologists

1 Palaeontologist

16 Geologists

17 Assistant Geologists

1 Assistant Palaeontologist

1 Curator

1 Assistant Curator

4 Assistants in the Fossil Department and Fossil Collectors

2 General Assistants

1 Assistant Clerk

1 Draughtsman

1 Commissionaire

1 Messenger

The collectors are placed under the supervision of the fieldofficers. The assistant-geologists are promoted, as vacancies occur, to the ranks of the geologists. Over these officers come the district-surveyors, who supervise the work of a number of geologists or assistant-geologists in a wide district. The district-surveyors report to their director, who takes general charge of the work in his own kingdom. The Director-General is the head of the whole organisation and is responsible for its conduct. He personally visits the officers in the field in each of the three countries, and is thus enabled to see that the work is being everywhere conducted on the same lines, and that the results obtained harmonise. It is his duty to bring the experience gained in one kingdom to the elucidation of difficulties met with in another, and to decide from time to time when the surveyors of one branch may usefully be sent to see the work in progress by another branch. It will be understood that to these duties in the field are added the general correspondence and administration of the whole service, and editorial labour connected with the issue of the various publications.

The work of the Geological Survey

The combined scientific and practical objects which De La Beche set before himself as his great aim at the first institution of the Geological Survey have ever since been kept steadily in view. To this day the development of the mineral fields of the country by means of accurate maps, the collection of data for Â· the guidance of those in search of water-supply, the accumulation of information required for the purposes of agriculture, engineering, road-making, architecture these and many other applications of geology to the arts, manufactures, and practical affairs of our social life continue to form a large part of the work of the Survey. But as De La Beche and his early associates clearly recognised from the beginning, all such utilitarian uses of geology must be based on a thoroughly systematic examination of the geological structure of the country. So closely are pure science and industrial progress linked together that at any moment what might be supposed to be a matter of merely theoretical import, may be discovered to have a high practical significance and value. Hence the Geological Survey has been conducted as a strictly scientific investigation, and has thus been able to advance the interests of geological science. The geological structure of the British Isles has been traced out in greater detail than was before attempted in any country, and numerous additions have thereby been made to the general body of geological knowledge.

Field-Work

[Note: Some portions of the following account of the work of the Geological Survey are taken from a paper communicated by the Director General to the Federated Institution of Mining Engineers. See their Transactions vol. V (1893), p. 142.]

Base maps

1832 Standard colours.

The first and most important duty of the Survey is to map in detail the geological structure of the country. When this task was first undertaken by De La Beche the Ordnance Survey maps on the scale of one inch to a mile (1:63,360) which had then been published for some of the southern counties of England, and which he used as the basis of his work, were imperfect and incorrect in their topography. They were among the first undertakings of the Ordnance Survey, before methods of surveying had been brought to the perfection that has since been attained. The possession of a correct topographical map is absolutely necessary as the ground-work of a detailed and accurate geological survey. From the outset the Ordnance maps have afforded the topographical ground-work on which all the geological surveying has been carried on. For many years only the sheets of the general map on the one-inch scale were available, but when, in the progress of the Ordnance Survey, maps on larger scales were prepared, these, as already remarked, were employed for geological purposes.

All the mapping of the Geological Survey is now conducted upon the Ordnance maps on the scale of six inches to one mile (1:63,360) been above remarked. These maps were not available in England and Wales until about two-thirds of the country had been surveyed geologically, and it was only in the six northern counties that they could be adopted. In Ireland, however, and in Scotland, where they were obtainable from the commencement of the geological operations, the whole of the work has been conducted upon them.

It is impossible to overestimate the gain, both in completeness and accuracy, from the substitution of a large-scale map in the general investigation of a complicated geological region. Not only is it then much easier to fix the position of geological boundaries, but an amount of detail may be inserted, for which, though of great importance, no room can be found upon the one-inch scale. The large map serves at once as a map and a note-book, and numerous detailed observations can be taken and recorded upon it at the localities at which they are made.

Occasionally, where the geological structure becomes excessively, complicated, and requires to be mapped out in much detail, maps on the scale of 25 inches to a mile (1:2500) are made use of. Ultimately, however, all the work is reduced to the oneinch scale, this being the scale on which the general geological map of the United Kingdom is published.

Introduction of mapping superficial deposits

First engraved edition (1851) of the one-inch geological map of Snowdon with Andrew Ramsay's MS addition of 'Glacial scratch marks', c.1852. Ramsay (who worked under De la Beche and eventually became Director of the Geological Survey) was the first person to thoroughly examine the evidence for glacial action in North Wales.

Geologists had made considerable progress in the study of the solid rocks before much attention was paid to the looser superficial deposits. The Geological Survey in this respect followed the general rule, and for many years made no systematic attempt to represent the numerous and often complex accumulations of superficial materials. Some of these, indeed, were shown on the maps, such as tracts of blown sand and river alluvium. But it must be remembered that in the south-western counties, where the Geological Survey began its work, superficial deposits are of such trifling extent and importance that they were not unnaturally ignored. Only after most of the southern half of England had been completed was it determined to map the surface-deposits with as much care and detail as had been expended on the older formations lying beno.1th' them. It had been discovered that this course was necessary both on scientific and practical grounds. In the first place, these superficial accumulations contained the records of the later geological vicissitudes of Britain, and were beginning to reveal a story of the profoundest interest, inasmuch as it dovetailed with the history of the human occupation of the country. In the second place, it was recognised that in many various ways these surface-deposits had a direct and vital influence upon the welfare of the population. In agriculture, in water-supply, in questions of drainage, and of the location of dwellings, it was seen that a knowledge of the soils and subsoil, and of the formations from which these are derived, was of the utmost practical importance. It was therefore determined that henceforth, the Geological Survey should not only portray the lineaments of the solid earth, but trace out the drifts and other surface-deposits which, like a garment, overspread and conceal them. It was impossible at first to go back over the ground where the surface-geology had been omitted. But it was arranged that when the whole country had once been mapped those tracts should he re-examined wherein the superficial deposits had not been surveyed. And, in the meantime, over new areas the survey was made complete by tracing out simultaneously both the surface deposits and the older rocks below them.

The Drift Survey of Wales, and of those parts of England where the superficial deposits were not originally mapped, now occupies the time of a considerable part of the English staff. In Ireland, also, those tracts where the peat and some other superficial deposits were not delineated are now having this omission remedied. In Scotland the drifts are all mapped at the same time with the rest of the

geology.

First engraved edition (1851) of the one-inch geological map of Snowdon with Andrew Ramsayâ€™s MS addition of 'Glacial scratch marks' c.1852. Ramsay (who worked under De la Beche and eventually became Director of the Geological Survey) was the first person to thoroughly examine the evidence for glacial action in North Wales.

No one who has not given some personal study to the complicated details of surface geology can realise the amount of labour which the mapping of them often involves. The distinctions between the various superficial deposits, though real, are sometimes slight, and as sections are sometimes few and wide apart, and the deposits so often occur in irregular patches, the ground has to be traversed with a detailed scrutiny which is generally not required for the older rocks underneath. Viewed broadly, the superficial accumulations are grouped and mapped by the Survey ill two leading series. First come those which have resulted from the decay of rocks in situ, and then those of which the materials have been transported into their present positions.

Distinctions between different superficial deposits

'Head' superficial deposits created in situ

The first of these two series, in so far at least as it is capable of being mapped, is mainly confined to the extreme southern fringe of England. All over the three kingdoms indeed, the weathering of rocks has for ages been in progress, and here and there, especially in the upland and mountainous districts, accumulations of rotted rock may be observed at the foot of crags and on slopes. But what can there be observed is only what has accumulated since the last glaciers and ice-sheets scraped the loose detritus off the surface to form parts of the great group of glacial deposits. South of a line drawn from the mouth of the Severn to the mouth of the Thames, the land seems never to have lain under a mantle of moving ice, nor beneath a sea covered with drifting ice, though fragmentary sheets of gravel, doubtfully of marine origin, cap many of the plateaux, while traces of ice-transport are found on the south coast. The surface in this southern tract has thus been left undisturbed for a great length of time. Its rocks have slowly decayed and their debris has gradually accumulated above them, with only such slight transport as may have been due to the washing of rain and the sifting of wind. We see the results of this prolonged waste in the brick-earths, clay-with-flints, and other deposits, that form so marked a feature on the Chalk Downs. From the Chalk districts westward across the Jurassic, Devonian, and older formations, even to the farthest headlands of Cornwall, every rock is more or less buried under a covering or 'head' of its own decayed material. Sometimes, as on the Oolitic strata of Dorset or the killas of Cornwall, this upper decayed layer may be traced as a yellow or orange oxidised band, varying from a few inches to many feet in thickness, conforming to the shape of the surface, and presenting a singular contrast to the black gently-inclined shales of the one coast and the purple vertical slates of the other. In the interior, where natural or artificial exposures of the rock are sometimes scarce, the spread of this mantle of disintegrated material is a serious impediment to the mapping of what lies underneath it.

'Transported series of surface deposits'

But it is the second or transported series of surface deposits which chiefly engages the attention of the Survey. In mapping it an effort bas been made to discriminate each of its members, to trace out their relations to each other, and to ascertain the connected geological history of which they are the records. At the same time, regard has been had to the practical applications of the enquiry, the connection between soils and sub-soils has been kept in view, pervious and impervious deposits have been distinguished, and an endeavour has been made to collect and embody on the maps as much information as possible regarding the practical bearings of the surface geology.

Alluvium

As an illustration of the detail into which the mapping in this department has been carried, I may mention that under the single term 'alluvium' we now discriminate and indicate by separate signs and colours a large number of distinct deposits. Thus, there is a group of freshwater alluvia, beginning with the present flood-plains of the rivers and rising by successive terraces to the highest and oldest fluviatile platforms. Deposits of peat are separately traced, and tracts of blown sand are likewise mapped. Another series consisting of marine alluvia ranges in position and age from the mud of modern estuaries and the sands of flat shores exposed at low water, through a succession of storm-benches and raised braches, up-to the highest and most ancient marine terraces 100 feet or more above the present level of the sea. Regarding the origin of some of the high-level gravels, there is still much uncertainty, but the Survey has taken the first necessary step for their ultimate explanation by carefully tracing their distribution on the ground.

Glacial Drifts

But the most abundant and complex group of superficial deposits is that which may be classed under the old name of Glacial Drifts. These have been mapped by the Survey in detail, and much of the progress of glacial geology in this country has been due to the sedulous investigation thus required. The ice-striae on the solid rocks have been observed over so much of the county, that maps may now be constructed to show both the march of the main ice-sheets and the positions or the later valley-glaciers. The various boulder clays have been mapped, likewise the sands and gravels, the esker-drifts, the marine shelly-clays, and the distribution of erratic blocks. A vast amount of information has thus been collected regarding the history of the Ice Age in most parts of the country. Even in the southern or non-glaciated fringe already mentioned, one of the members of the staff, Mr. Clement Reid, has been able to detect interesting evidence that though beyond the limits of the northern ice-sheets, this southern tract nevertheless had its frozen soil and its rafts of coast-ice. In the north of Scotland proofs have been obtained of the long-lingering of the ice-fields in that region ; while in all the mountainous districts the gradual retreat of the valley glaciers, as the climate grew milder, has been shown .by mapping the successive crescents of moraines, one behind the other, up to the very base of the crags that supplied t heir material. In the, present Summary of Progress some interesting illustrations of this side of the work of the Survey will be adduced from the field-surveys of last year. The revision of the maps of South Wales, in particular, has brought to light much fresh evidence as to the local glaciation of that part of the country.

Value of mapping superficial deposits

The survey of the superficial deposits thus combines a wealth of ' geological interest with a great deal of practical value. the geologist may find in it the solution of some problems and the presentation of many more; while the farmer, the water-engineer, the builder, the road-maker, and the sanitary inspector may each in turn gain practical information from it for his guidance.

For purposes of distinction, the mapping of the formations of every age that lie beneath the recent superficial deposits is known in the Survey by lobe somewhat unhappily selected epithet of the 'solid geology.' the object in this part of the field-work is to represent on the maps the exact area which every formation or group of rocks occupies at the surface, or immediately below lobe soil and drift, together with all indications that can be obtained of its structure, such as its variations of inclination, its changes of lithological character, and the dislocations by which its outcrop is affected. While the basis of the work is rigorously geological, facts having an industrial bearing, such as the presence of useful minerals or lobe depth and variations in thickness of water-bearing strata, are observed and recorded.

In those districts of the country where the rocks have long been well known and where the geological structure is simple, the duties of the, surveyor are comparatively light, though it often happens there that the simplicity of the 'solid geology' is compensated for by a great complexity in the overlying 'drifts'. Where, on the other band, the rocks are varied in character and complicated in structure, where they are partially hidden under superficial deposits, and where they rise into mountainous ground, difficult of access and hard to traverse, geological surveying becomes a most laborious occupation. In such a region as that of the north-west Highlands of Scotland, for example, where the physical impediments are great, where the ground is often both rugged and lofty, where the climate is wetter and more boisterous than almost anywhere else in Britain, and where the quarter to be had are often sorry enough and remote from the scene of work, The surveyor has need of all his enthusiasm to carry him bravely through these preliminary obstacles. But when he comes to unravel the structure of the rocks, he may find it to be sometimes almost incredibly complex. He has to climb the same cliff, scour the same crag, and trudge over the same moor again and again before he begins to perceive any solution to the problems he has to solve.

If the complicated 'solid geology' of such a region is enough to tax to the utmost the capacity and energy of the geologist, his task is made still more difficult by the necessity of keeping his eye at the same time ever open to all the variations of the superficial deposits, which in these rugged tracts are often singularly intricate, though they may also he fascinatingly interesting. The ice-striae on the rocks, the scratched stones high on the mountain-sides that mark where the till once lay, the varieties of boulder-clay, the sand and gravel eskers, the scattered erratic blocks and the detection of their probable sources of origin, the moraine-mounds fringing or filling the bottom of the glens, the sheets of flow-peat and the ragged peaty mantle that hangs down from the cols and smoother ridges, the recent alluvia and the successive stream terraces, the lines of raised beach and the estuarine silts-all these and more must be noted as the surveyor moves along, and must be duly chronicled on his map and among his notes.

It is obvious that the progress of the mapping in such ground cannot be rapid. If the work is worth doing at all, it should be well done, and if well done, it must be done slowly and carefully. It, is 'evident also that the total area surveyed in a year; if given in square miles, affords no guidance whatever as to the amount of labour involved. There may be a hundredfold more exertion, physical and mental, required to complete a single square mile in some districts than to fill in twenty square miles in others. It is customary in the Survey to estimate not only the area annually mapped by each officer in square miles, hut also the number of miles of boundary-line which he has traced. The ratio between these two figures affords some measure, though an imperfect one, of the comparative complexity or simplicity of the work. In simple ground a surveyor need have no difficulty in mapping from 70 to 100 square miles in a year, each square mile including from a to 6 linear miles of boundary. Hut in more mountainous and difficult districts it may be impossible to accomplish half of that amount of area. In these cases, however, the ratio between area and boundary-lines usually rises to a high proportion. Thus in the Scottish Highlands the average number of linear miles of boundary-lines sometimes rises to as much as 17 miles in every square mile surveyed.

Mapping mining information

In mining districts an endeavour is made to express on the maps the positions of the outcrops of all seams and lodes, the line of every important fault and dyke, with the place of such faults at the surface, and where they cut different seams underground. The information necessary to record these data is mainly furnished by the owners and lessees of the mines and pits, who, as. a rule, most generously give the Survey every assistance. Details as far as possible are inserted on the six-inch Ordnance sheets. Copies are taken of borings and pit-sections, and notes are made regarding variations in the character of the seams or lodes from one part of a mineral-field to another. At the

same time, the district is surveyed in the usual way, and by exhausting the surface-evidence the surveyor is not infrequently able lo supply important additional information beyond what can be obtained from the mining-plans.

Importance of continuous revision

It is the necessary fate of all geological maps to become antiquated. For, in the first place, the science is continually advancing, and the systems of arrangement of the rocks of the earth's crust are undergoing constant improvement, so that the methods of mapping which satisfied all the requirements of science thirty years ago are found to be susceptible of modification now. In the second place, in the progress of civilisation, new openings are continually being made in the ground; wells, roads, drains, railways, and buildings are being constructed, whereby fresh light is obtained as to the rocks below. Geological lines which were traced with the imperfect evidence formerly available can thus be corrected, and new lines which perhaps were not originally suspected can be inserted. If this kind of obsoleteness overtakes geological maps even where only superficial openings are concerned, still more does it affect those which depict the structure of mineral-fields still actively worked. The geological maps of Devon, Cornwall, and South Wales, made some two generations ago by De La Beche and his associates, were for their time admirable in conception and excellent in execution. Nothing approaching to them in merit had then been produced in any part of the world. But the mineral industry of the country bas not been standing still all these years. Enormous progress has been made in working the ores of the western counties, and in developing the great South Wales coal-field. Yet most of the maps still remain as they were originally published, though their revision is now in progress.

It is absolutely necessary, if the value of the labour and expense bestowed on the Geological Survey of the United Kingdom is not to be impaired and lost, that the maps should be revised and brought up to date as frequently as may be required. The necessity for such revision as been passed on the attention of Government by influential memorials from various districts of the country; and, hitherto, as far as the other requirements of the Survey permit, these requests have been complied with. Thus, in consequence of an urgent representation from the proprietors and lessees of the coal-field of South Wales, and from others locally interested in the development of that region, steps were taken a few years ago to place there a staff of surveyors, and the revision of the ground is actively advancing. Already three sheets of the new series of Ordnance maps of South Wales have been published, and one other is now in the hands of the engraver. The inhabitants of Cornwall, likewise, recently memorialised the Science and Art Department to undertake a revision of the geological maps of that county; and, in response to their request, a beginning of the work has been started. The people of North Staffordshire, anxious for the proper development of their coal-field, made a representation that the time had come when a revision of the maps of their district was necessary, and this task has been undertaken by the Geological Survey. Other districts have sent in similar petitions for re-survey with which it has been hitherto impossible to comply, owing to the smallness of the staff. All these tracts of country were originally surveyed on the old and imperfect sheets of the one-inch Ordnance map. But the revisions are conducted on the modern six-inch scale, and the reductions are made upon the new series of one-inch sheets. There can be no doubt that all the other mineral-fields of the country require similar treatment.

The revision of that large part of England and Wales where the superficial deposits were not originally mapped, in order to complete the Drift survey of the whole country, is carried on upon the six-inch maps. 'While this revision is in progress advantage is taken of the re-examination of the ground to make any needful additions or modifications in the 'solid geology.' The work is reduced from the large field-maps to the new series of the one-inch map. Geological maps on the six-inch scale were formerly published for the mineral-fields, but are now no longer engraved, though a large

number of sheets of the coal-fields are on sale. But manuscript copies of six-inch maps relating to any parts of the country of which the one-inch sheets are published, are supplied to the public at the cost of manual transcription.

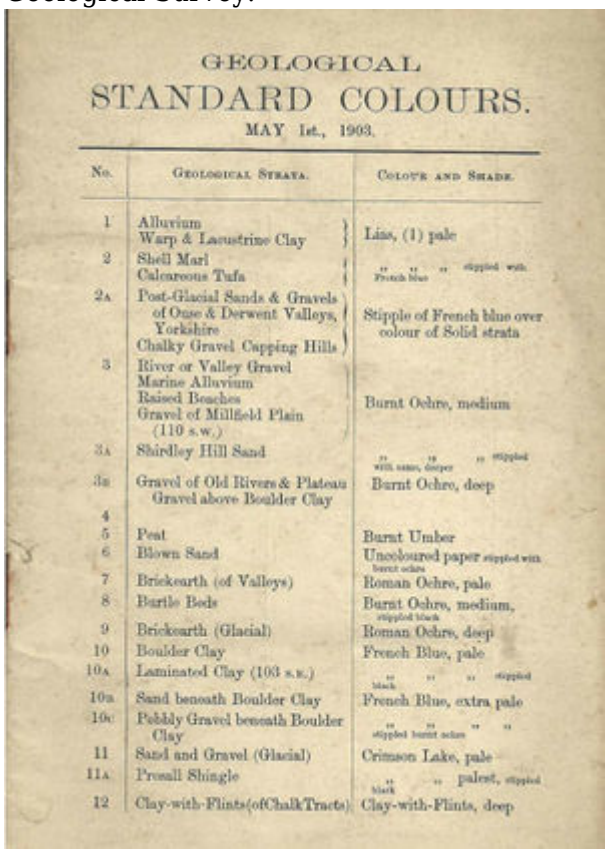
Rock and fossil collecting

Pecopteris miltoni Artis. From the Kidston collection of fossil plants

While the field-work is in progress the surveyors collect, for the purposes of their maps and explanatory memoirs, such specimens of minerals, rocks, and fossils as may be found to require special examination. But a more systematic collection is carried out under their supervision by the collectors, for study by the petrographers and palaeontologists and for exhibition in the museums. Each branch of the Survey has one or two collectors, who move from district to district as their services are required. When one of them begins work in any area, he is supplied with a map on which the field-officer who surveyed it has marked every locality that should be searched, and also with a list of these localities, giving local details as to the rocks to be specially searched or examined, and the kind of specimens to be looked for and collected. When necessary, the surveyor accompanies the collector to the ground and starts him on his duties. Every specimen which the collector sends up to the office has a number affixed to it, and is entered in the lists, which are also at the same time transmitted to headquarters. The specimen are then unpacked and treated by the palaeontologists or petrographers, as the case may be. In this manner a remarkably complete illustration of the geology of the United Kingdom has been accumulated by the Survey, and it is constantly receiving additions and improvements. The chief series is deposited in the Museum of Practical Geology, London; but the geology of Scotland is most fully represented in the Museum of Science and Art in Edinburgh, and that of Ireland in the corresponding Museum at Dublin.

Preparation of maps, sections, and memoirs

A selection of watercolour cakes supplied by the firm of James Newman, some of which were specially formulated for the use of the Geological Survey.



GEOLOGICAL
STANDARD COLOURS.
MAY 1st., 1903.

No.	Geological Strata.	Colour and Shade.
1	Alluvium Warp & Lacustrine Clay	Lias, (1) pale
2	Shell Marl Calcareous Tufa	" " " stippled with French blue
2A	Post-Glacial Sands & Gravels of Ouse & Derwent Valleys, Yorkshire Chalky Gravel Capping Hills	Stipple of French blue over colour of Solid strata
3	River or Valley Gravel Marine Alluvium Raised Beaches Gravel of Millfield Plain (110 s.w.)	Burnt Ochre, medium
3A	Shirdley Hill Sand	" " " stippled with same, deeper
3B	Gravel of Old Rivers & Plateau Gravel above Boulder Clay	Burnt Ochre, deep
4		
5	Peat	Burnt Umber
6	Blown Sand	Uncoloured paper stippled with burnt ochre
7	Brickearth (of Valleys)	Roman Ochre, pale
8	Bartle Beds	Burnt Ochre, medium, stippled black
9	Brickearth (Glacial)	Roman Ochre, deep
10	Boulder Clay	French Blue, pale
10A	Laminated Clay (103 s.e.)	" " " stippled black
10B	Sand beneath Boulder Clay	French Blue, extra pale
10C	Pebbly Gravel beneath Boulder Clay	" " " " stippled burnt ochre
11	Sand and Gravel (Glacial)	Crimson Lake, pale
11A	Presall Shingle	" " palest, stippled black
12	Clay-with-Flints (of Chalk Tracts)	Clay-with-Flints, deep

Geological Standard Colours. A document listing the colours for the different strata that appear on the hand coloured maps.

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.

Maps

Every surveying officer is responsible for keeping his field-maps inked-in and coloured-up, so that if required to be exchanged with his colleagues they shall be clear and intelligible. He is likewise required to prepare duplicate copies of these field-maps, which, when completed, are transmitted to the office and are kept there for consultation by the public.

As already stated, maps of some of the mineral-fields have been published on the scale of six inches to a mile (1:10,560). These have been prepared by the officers who surveyed them, the geological work being put on a dry impression from the plate of the Ordnance map, which is then sent to the Ordnance Office to be transferred to an electrotype of the plate. Of a few other districts, also, maps on this scale, where the geology is of special interest or complexity, have been prepared and published. But for the country at large it has not yet been practicable to publish maps on so large a scale. Over all the counties which have been surveyed on that scale, MS copies of the six-inch maps can be obtained by the public, as above remarked, at the cost of manual transcription from the duplicate copies retained in the office.

The work surveyed by an officer on the six-inch scale is reduced by him upon a dry impression of the one-inch Ordnance map (1:63 360). A single one-inch sheet may comprise the work of half a dozen surveyors, and in that case the sheet is passed from one to another, each adding his own share. The completed dry proof is then checked at the office and is sent to the Ordnance Survey to be engraved on an electrotype copperplate specially prepared for the purpose from the original Ordnance plate. After the final corrections have been made in the engraved map and the scheme of signs and colours has been engraved on the margin, a copy of this map is coloured as it is to appear on publication, each surveyor again taking the portion for which he is personally responsible. The scrutiny involved in this process serves generally to detect any errors that may have previously escaped notice. This original coloured copy remains as the standard to which all subsequent copies of the same edition of the map are made to conform.

When finally checked and approved, the original coloured copy is sent to the colourists, who colour all the maps by hand, the work being done by women. 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 new 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 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 prices of the maps, regulated by H.M. Stationery Office, are fixed according to the amount of colouring upon them. In England and Wales, full sheets usually range from 3s. to 8s. 6d. and quarter-sheets from 1s. 6d. to 3s. In Scotland and Ireland, the sizes of the maps are different, but their prices are calculated on the same scale, being in Scotland from 4s. to 6s. and in Ireland (where the sheets are similar in size to the English quarter-sheets) from 1s. 6d. to 3s. In some cases the price at which a map is sold is less than the cost of colouring, but it is estimated that the excessÂ· of selling price beyond that cost in other cases will compensate for this loss.

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 recognised. 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 (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 chromolithography, 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 Â£1 17s. 0d..The value of reduced index-maps for geological purposes was recognised 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.

Sections

A geological map can for the most part express only what lies at the surface, though it may afford information, more or less definite, as to what lies below. To supplement the map it is needful to construct sections to show the arrangement of the rocks beneath the surface. A complete and

detailed map should contain sufficient data to allow of such sections being plotted in outline, but these details can usually be filled in only from notes of the sections examined in the course of the mapping. Two kinds of sections-vertical and horizontal-are prepared by the Geological Survey to scale, and are engraved and published in sheets measuring 3 feet by 2 feet. But besides these, numerous measured and also diagram sections are inserted in the text of the printed Memoirs.

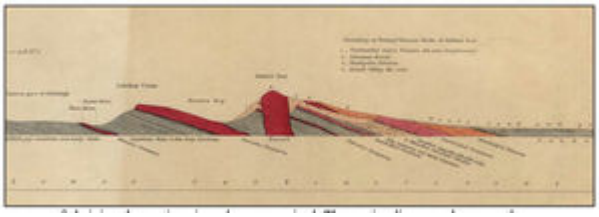
Vertical Sections

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.

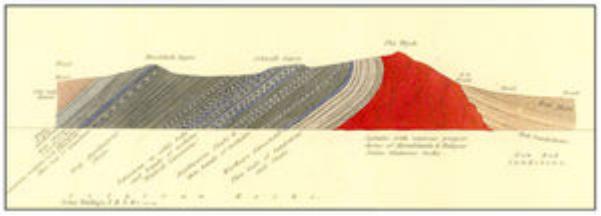
Occasionally, where a group of strata, though of little industrial importance, possesses great geological interest, a vertical section of it has been constructed and published in the same style as the coal-field sections. In this way sections of the Jurassic rocks in Eastern Yorkshire, of the Lower Lias and Rhaetic 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 price of each sheet is 3s.6d.

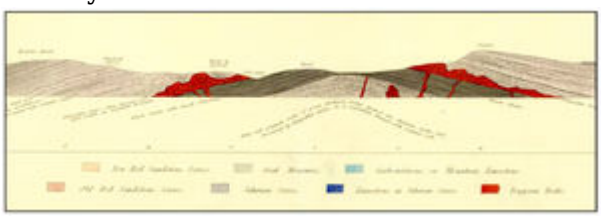
Horizontal sections



Extract from a horizontal section - across Arthur's Seat.



Extract from a horizontal section - across The Wych.



Extract from a horizontal section - Hewlers Heath

The Horizontal Sections have been an important feature in the work of the Geological Survey. De La Beche, recognising 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.

When a line of section was chosen and traced on the one-inch map, it had to be measured on the ground with chain and theodolite. This was the invariable practice until the six-inch contoured Ordnance Survey maps came into use. Where these maps can be used as a basis, the laborious process of chaining the sections is no longer required. The section lines are drawn on these maps and the sections are plotted from them. The contour-lines and benchmarks allow the line of the surface to be traced with a close approximation to accuracy. But in order to ensure final correctness of detail, the ground is gone over with the section (and where needful, an Abney's level) in hand, and each little feature is then put in.

The sections start from Ordnance datum (mean sea-level), but where the ground is low and there is consequently not room to express what is known of the geological structure above that datum, the lines are prolonged below it. The same practice is also followed in mining-districts. An effort has been made to illustrate every great district of the country by means of horizontal sections. Each geological formation, as it varies from one point to another, is crossed by lines of section, so that by comparing these with each other the changes in that formation from district to district can at once be seen. The length of each section varies indefinitely with the nature of the ground, many of them being upwards of 100 miles in length. Thus a series of sections runs from Anglesey and the coast of Merionethshire, across the mountainous ground of North Wales, to the plains of the Midlands. Another group crosses from the central counties to the South Coast. A connected chain of sections traverses the breadth of the island from Liverpool to the coast of Yorkshire.

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 text-books 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.

The Horizontal Sections are engraved on copper and published in sheets, each of which, if the ground be low, may include six lines or 36 miles of section. The same continuous line of section may thus extend over several sheets. Small explanatory pamphlets are usually published with these sheets, giving general information as to their rocks and their local peculiarities. Each sheet of Horizontal Sections is published at the price of 5s. 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 coast-line 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 coast-line of Dorset and of the Isle of Wight have been

similarly treated.

Memoirs

Annual report

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.

General 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 enquiry. 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 enquiry. 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.

Murchison and the introduction of Sheet Explanations

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 generalised 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.

Each surveying officer is expected to contribute an account of the area mapped by him. Where more than one surveyor has been engaged on a map or district, the accounts furnished by the several officers are collated and edited in the office. The Sheet Memoirs are published in paper wrappers and at prices intended merely to cover the cost of production. '

General memoirs (District) memoirs

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.

Two-fold Publication strategy [1897]

A. General memoirs and preparatory Sheet Explanations

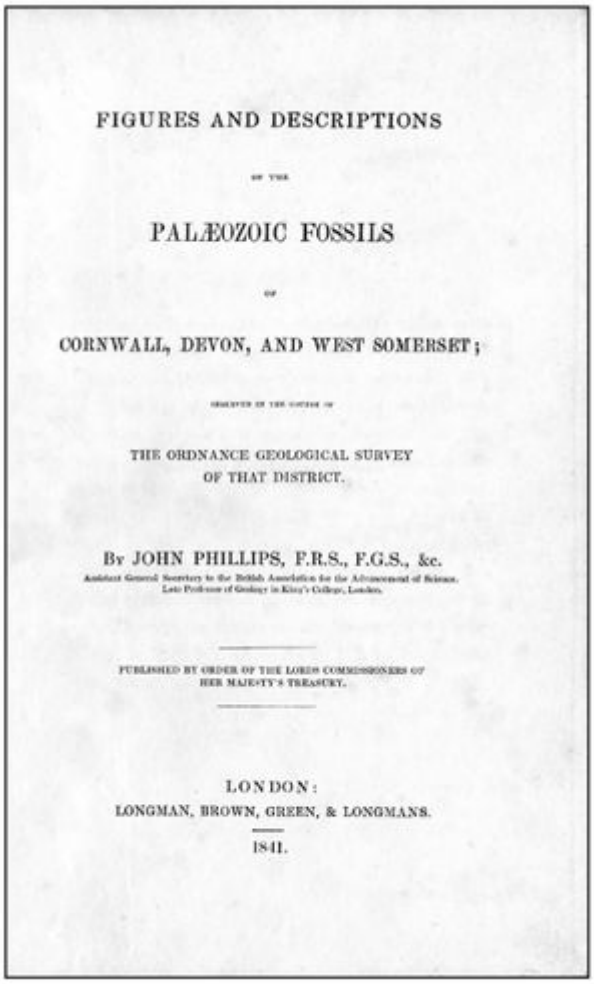
The chief literary work on which the staff of the Survey is now engaged is the preparation of the General Memoirs to which the Sheet Explanations were designed to be preparatory. It appeared to the present Director-General that these Memoirs should consist of two series. In the first place, it is desirable 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.

B. Stratigraphical memoirs

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 duplication of the six-inch field-maps.

Palaeontological memoirs



FIGURES AND DESCRIPTIONS

OF THE

PALÆOZOIC FOSSILS

OF

CORNWALL, DEVON, AND WEST SOMERSET;

OBSERVED IN THE COURSE OF

THE ORDNANCE GEOLOGICAL SURVEY
OF THAT DISTRICT.

By JOHN PHILLIPS, F.R.S., F.G.S., &c.
Assistant General Secretary to the British Association for the Advancement of Science.
Late Professor of Geology in King's College, London.

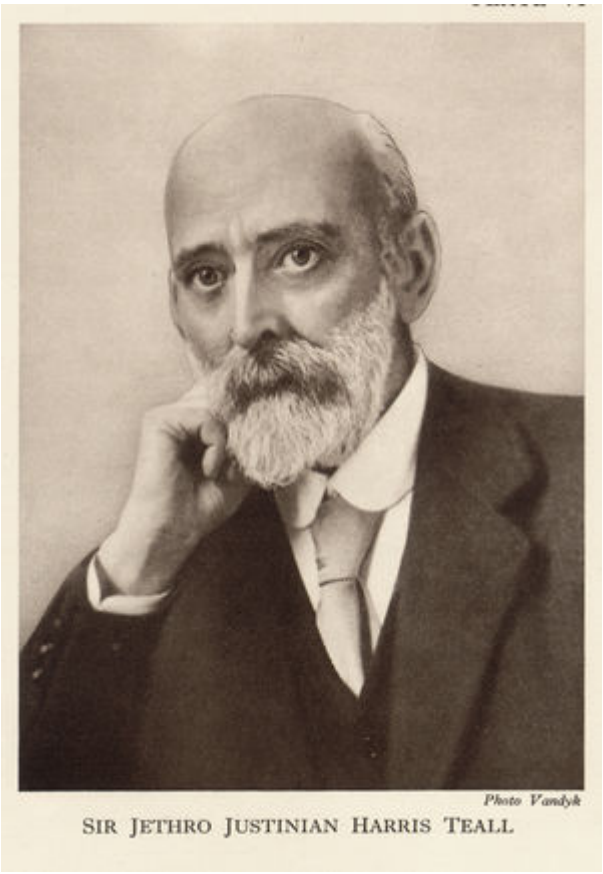
PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF
HER MAJESTY'S TREASURY.

LONDON:
LONGMAN, BROWN, GREEN, & LONGMANS.
1841.

An early Palaeontological memoir by John Phillips.

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 Belemnitidae, and the crocodiles of Elgin, and Mr. Newton's memoirs on Cretaceous fishes and Pliocene vertebrates.

Petrographical work



Sir Jethro Justinian Harris Teall (From a photograph by C. Vandyk Ltd., London.)

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 recognised that apart from mere questions of nomenclature, rooks contain materials for Â·the solution of some of the most important problems in physical geology. Accordingly, microscopic enquiry has in recent years been organised 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.

When an officer engaged in mapping meets with rocks which present difficulties, either as to their classification or as to their bearings on the structure of the ground, he takes specimens of them which he numbers consecutively and sends up to the petrographer at the office, who enters them in a book under the name of that officer, and keeps a record of the destination of each. Those specimens which are selected to be sliced are numbered consecutively in the order in which they are cut, and are entered in books kept for the purpose. When they have been microscopically studied, described, and named, they are again entered in two distinct catalogues, one of which is arranged according to the sheets of the one-inch map and the other according to petrographical types. Every sliced specimen is thus entered four times, and every specimen sent up for examination (whether sliced or not) can at once be found. A report is made out by the petrographer and sent back to the officer, who is thus put in possession of all the details which can be furnished to him regarding the rocks about which he needed assistance. In many cases the thin slides are also sent to the surveyor, who often spends his evenings in their study. The petrographers also confer with the surveyors on

the ground. 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 realise 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.

Palaeontological work

John William Salter 1820 - 1869. Appointed Assistant to E. Forbes 1846, Palaeontologist 1854, resigned 1863.

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 palaeontologists, 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 palaeontologist 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 bas 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 palaeontologists 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 palaeontologists 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 palaeontological 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 palaeontologist, 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.

The Museum of Practical Geology and the geological collection 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 in Dublin.

England and Wales

Museum of Practical Geology. First floor with one of the subjects named as John Thackery.

Museum of Practical Geology.

Museum of Economic Geology. Wood engraving from Illustrated london News 8th April 1848, showing the exterior.

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, &c. 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 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


Museum of Practical Geology. The Library.

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.

Fossils

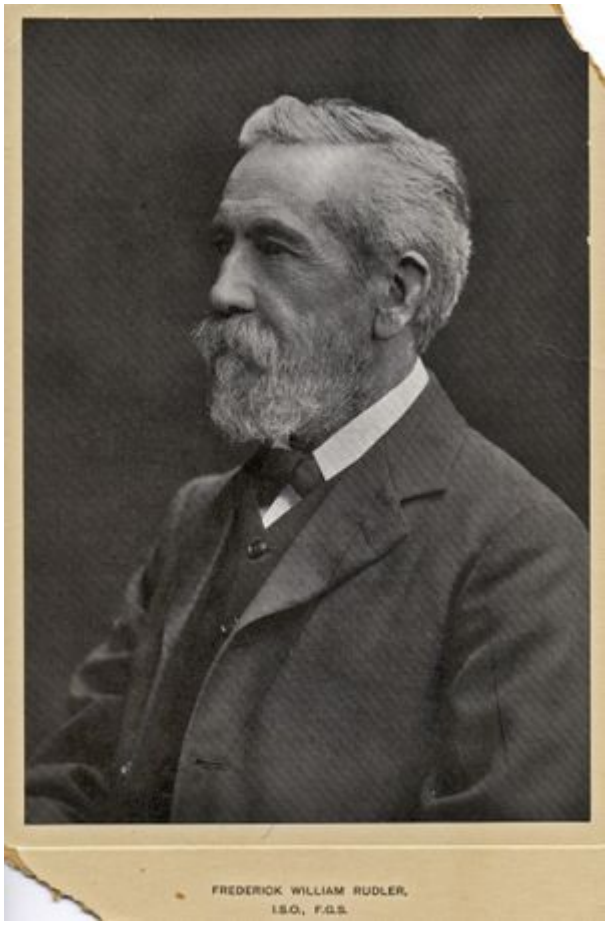
The portions of the Museum of Practical Geology most closely connected with the work of the Geological Survey are the collections of fossils, the series of rock-specimens, and the cases illustrating geological processes and rock-structures.

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 Palaeozoic, 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 tabulated in such a way as to be readily accessible Survey Collections in Edinburgh and Dublin to the public. Those who wish to follow out the paleontological details of the Survey maps and memoirs, or to study general text-books of the science, have thus the fullest opportunities afforded to them. The palaeontologists 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.

Rock collections

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; n. 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.

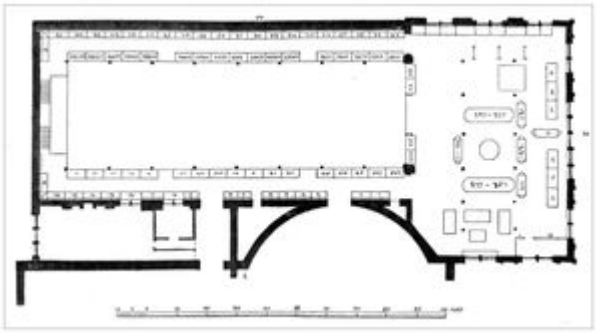
Museum publications



Frederick William Rudler.

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 paleontological collections are now being prepared.

Scotland



Plan of the Survey collection in the Royal Scottish Museum.

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 Scottish, arranged in stratigraphical order. A handbook to the whole collection prepared by Mr. J. G. Goodchild, the Curator, has been published.

Ireland

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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