The Geological Survey under Sir John Smith Flett, 1920–1935

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Sir John Smith Flett (From a photograph by Herbert Hughes, Burlington Gardens, London.) Plate IX.
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VIII. The Geological Survey under Sir John Smith Flett

On 20th July, 1920, Sir Aubrey Strahan retired after forty-five years' service, and G. W. Lamplugh, the Assistant Director for England, followed him in retirement. Their places were taken by John Smith Flett, who had been Assistant Director in Scotland since 1911, and John Allen Howe, who had been Curator of the Museum and Librarian since 1902. Walcot Gibson succeeded Flett in Scotland and W. F. P. McLintock returned to Jermyn Street from the Royal Scottish Museum to take the place vacated by Howe. McLintock had been appointed Assistant Curator in the Jermyn Street Museum in 1907 and had been transferred to the Royal Scottish Museum in 1911, where he was in charge of the geological gallery.

Reorganization

The work of the Coal Conservation Committee now bore fruit, as two District Geologists, six Geologists, two Technical Assistants and one draughtsman were added to the staff. In 1920 Bernard Smith and Henry Dewey were appointed District Geologists, also W. B. Wright, who was transferred from the Geological Survey of Ireland. In 1922 four Geologists were added to the staff of the Survey and two Geologists, Bromehead and Dinham, were promoted to District Geologists. The scientific staff had now been increased by sixteen and consisted of Director, two Assistants to the Director, Howe in England and Wales and Gibson in Scotland, twelve District Geologists, which included the Palaeontologist, the Petrographer and the Curator of the Museum (who was also Librarian), thirty-eight Senior Geologists and Geologists (including the Assistant Curator and the Assistant Librarian), besides Technical Assistants, General Assistants, labourers, warders, messengers, cleaners, carpenters and charwomen who performed various duties in the offices and Museum.

Like the reorganizations of 1867 and 1900, the changes in the Geological Survey which were made as a result of the report of the Coal Conservation Committee of the Ministry of Reconstruction in 1920 and the following years, and its transfer to the Department of Scientific and Industrial Research in 1919, mark a very important stage in the history of the institution and much increased its usefulness and the scope of its activities. During the post-War years changes in the pay and conditions of service were introduced as in other branches of the Civil Service; they had been rendered necessary by the increase in the cost of living and the diminished purchasing power of the pound sterling.

The Committee of the Privy Council for Scientific and Industrial Research, which now controlled the Geological Survey, was appointed by an Order in Council of 28th July, 1915, to direct the application of any sums voted by Parliament for the organization and development of scientific and industrial research. By this Order in Council an Advisory Council was also constituted to. which stand referred proposals for instituting specific researches, for establishing special institutions for the scientific study of problems affecting particular industries, and to award research studentship and fellowships.

In December 1916 the Department of Scientific and Industrial Research was established as a separate Department, for the service of the Committee, accounting for its own Vote and responsible to Parliament through the Lord President of the Council as Minister. The National Physical Laboratory, established in 1900, which had previously been managed by a Committee of the Royal Society, was transferred to the new Department on April 1st, 1918. One of the first steps taken by the Department was the appointment in 1917 of the Fuel Research Board on whose recommendation it was decided to erect a Station with all the appliances necessary for testing and investigating fuels. One of the reasons which influenced the Coal Conservation Committee in recommending the transfer of the Geological Survey and Museum to the Department of Scientific and Industrial Research was the close connexion between the work of these two services. Many other research organizations have subsequently been founded under the aegis of the Department of Scientific and Industrial Research, such as those for Building Research, Food Investigation, Forest Products Research, Water Pollution Research, etc. The Department also makes grants to many Industrial Research Associations and has continued to give grants to approved investigators on problems of science connected more or less closely with industry. Its expenditure during the year ending on 31st March, 1935, was over half a million pounds.

DSIR and the Geological Survey Board

For the scientific supervision of each of its most important research activities the Department of Scientific and Industrial Research appointed a Board. The Geological Survey Board was given special responsibility for the management of the Survey and Museum, and its duties were defined as follows in its terms of reference

1. To undertake, within the limits prescribed in the estimates for the year and by the general policy and the programme of work approved from time to time by the Minister, the management of the Survey and Museum so far as concerns all current business, work of survey or report and distribution of personnel.
2. After consultation with the Director to frame and recommend annually for the approval of the Minister, a programme of work to be undertaken for the coming year and to submit therewith a statement as to the staff arrangements and other provision required for carrying out that programme.
3. To report upon matters bearing on the functions or work of the Geological Survey or Museum; and
4. To submit an annual report of the work of the Survey and Museum with such observations as they think fit.

The first Chairman of this Board was Sir Francis Grant Ogilvie, who became also Principal Assistant Secretary of the Department of Scientific and Industrial Research. He took much interest in the work of the Geological Survey. The Board meets several times a year and considers the programmes and reports on the progress of work submitted by the Director. In addition to the appointed members, there are assessors representing the Ministry of Health, Mines Department, Development Commission and Ministry of Agriculture.

Under the Wharton Committee in 1900 a Consultative Committee (subsequently called the Committee of Advice) had been constituted which met once a year to consider the Director’s report and programme. The members of this Committee were selected by the Board of Education and were representative of scientific institutions, universities and industries concerned in the work of the Geological Survey. This Committee, however, had no administrative functions but acted purely in an advisory capacity. It made recommendations which in many cases were of great value, though it was not always possible to put them immediately into execution. The Geological Survey Board, which now superseded the Committee of Advice and took over its functions, was intended to exercise

closer supervision and more active direction.

Work programmes

Completing the 'Special Reports on Mineral Resources'

With the considerable increase of staff which the Geological Survey received during these post-War years it was possible to increase the rate of progress. Before embarking on new programmes, however, it was considered advisable to clear off the remains of war work. Further volumes of the ‘Special Reports on Mineral Resources,’ written partly by members of the staff and partly by other geologists, and based on information collected during the War, and immediately thereafter, were published as rapidly as possible. The thirty-one volumes of this series give an accurate account of British mineral resources, and several of them have gone through more than one edition. The principal gap in the series is the absence of a special memoir on Cornish tin mining, but an excellent historical and descriptive account of this subject had been prepared by J. H. Coffins and published by the Royal Geological Society of Cornwall and is still on sale.

Study of the composition, structure and properties of British coals

Another subject which required considerably more attention than it had received was the study of the composition, structure and properties of British coals. During its whole history the Geological Survey of Great Britain had contributed very little to a knowledge of these most important matters. De la Beche was fully alive to the interest and value of this class of research, and his ‘Report on Steam Coals for the Navy’ (1848) was classical. Percy also had made many elaborate studies on fuels, and the work was done in the old School of Mines in Jermyn Street. It was published in the volume on fuels which is one of his notable contributions to metallurgy. Sir Aubrey Strahan and Dr. W. Pollard had made a well-known contribution to the knowledge of Welsh coals, and had discussed the problems of anthracitization. But although coals were the most important rocks and minerals of Great Britain, and although an immense amount of work had been done on the geological sequence and structure of British coalfields, there had been little scientific research into the chemistry and petrography of British coals.

One of the principal reasons for this state of affairs was that the task was beyond the resources of the Survey staff. To do the work well and thoroughly it was necessary to provide laboratories and elaborate appliances of a technical character that would require a large expenditure of money and a staff highly trained for the purpose. In America it had been found best to erect special laboratories for this purpose, and they were not under the control of the Geological Surveys. This problem was solved when the Fuel Research Station was set up under the auspices of the Department of Scientific and Industrial Research to prosecute investigations into all questions connected with the origin, properties and utilization of fuels. In matters of geology reference is made to the officers of the Geological Survey, and consequently each department has its proper field of work to which it restricts itself, while furnishing the sister organization with information when called upon. Experienced officers of the Geological Survey serve on all the local committees of the Fuel Research organization and keep in close touch with the investigations. The arrangement works satisfactorily for all parties.

Building stones, brick clays, cements

In very similar manner the Building Research Station supplements the work of the Geological Survey so far as building stones, brick clays, cements, etc., are concerned. Since the report on the stone used in the Houses of Parliament (1839) there had been no official publication on this subject in

which the Geological Survey had taken part, but constant enquiries for information were being received and answered by officers of the Survey. These referred mostly to sources of supply, but no means existed of testing the materials or of forming an opinion regarding the weathering properties of stones that were new to the market. This work is now regarded as in the province of the Building Research Station which is carrying out elaborate investigations into these and many kindred problems. In all cases the Geological Survey serves as a reference in questions of geology and is prepared to collect material and report on the geology and visible resources of any locality which is under consideration.

Underground sources of water supply

Another direction in which the work of the Geological Survey has continued to expand is in the provision of information regarding underground sources of water supply. The collection of records of borings has always been a matter of special importance not only in the coalfields but also in those parts of Britain in which coal does not occur but where water is largely obtained from water-bearing strata. It is not known at what time the Geological Survey began to collect boring records systematically, but we know that Logan in South Wales was gathering shaft sections and bore records before 1840. In the south and east of England surface supplies of water are less important than wells and borings, and, especially in the London districts, the number of deep bores for water is very large. The particulars obtained from these records regarding the presence or absence of certain geological horizons, and their thickness and lithology, are of the greatest possible importance to the geologist. Many of the early Geological Survey memoirs contain much information derived from these sources. Whitaker's 'Geology of London,' vol. II, published in 1889, contains records of many well-sections in the district described. The first of our Water Supply Memoirs, that on the County of Sussex, appeared in 1899 and was compiled by Whitaker and Reid. Since that date almost every year has seen an addition to the series, which now comprises twenty-eight volumes, containing records of wells in most of the counties of the south and east of England. The most active contributor was Whitaker, both before and after his retirement from official service. His knowledge of this subject was unequalled, and his industry was exceptional. Of recent years Mr. L. Richardson has given very valuable assistance and is the author of several memoirs on the counties of the West of England.

On the part of the public these memoirs, though of a technical description, have been highly appreciated. The first two volumes on Sussex, for example, have been sold out and a third has been published. As a matter of fact, the published information represents only a small part of the accumulated records in the possession of the Geological Survey, as every well record from any part of Great Britain that can be obtained is filed in the Survey Offices, and if any deep wells are being sunk an officer will visit them to keep in touch with the work and check the accuracy of the log. Specimens are also collected when anything of interest turns up. The people engaged in making deep wells, such as the engineers, boring firms and contractors, as well as urban or county officials and private consultants, are fully aware that the Geological Survey makes intensive study of these questions and possesses a large amount of unpublished information. Consequently, they frequently consult the officers of the Survey, and in turn they are very willing to contribute copies of the boring records of wells which they have made. Year by year the accumulated information increases and its value becomes more widely known. This is one of the most useful services which the Geological Survey can render to the public, and at the same time it brings to our knowledge many particulars regarding the geology of Great Britain that are of high interest from both a practical and a purely scientific point of view.

In connexion with public health the demand for water supplies constantly increases. New towns spring up and the existing towns expand, and the need for water becomes more and more insistent. Recent years (1933, 1934) have seen periods of prolonged drought, when, especially in the smaller

towns and villages, a considerable amount of hardship has been experienced through lack of water. The Government has supplied large sums, amounting to approximately a million pounds, to assist in providing water supplies where the shortage is greatest. Consequently, there has been great activity in searching for underground water, and a Committee has been appointed by the Minister of Health and the Secretary of State for Scotland to advise on the inland water survey for Great Britain, on the progress of the measures undertaken and on further measures required, and, in particular, to make an annual report on the subject. The programme of research is at present under consideration, and by arrangement with the Department of Scientific and Industrial Research it has been agreed that the task of correlating the information on underground water shall be undertaken by the Geological Survey. This is a very promising development of its work which, though: not purely geological, is related to geology and also likely to prove of much practical value. It is at least encouraging that the work done for so many years in a field which was to some extent outside the normal duties of the Geological surveyors has been regarded as of national importance and is to be prosecuted in a more systematic manner and on a larger scale.

Geology and agriculture

It has long been recognized that an intimate connexion subsists between geology and agriculture, and the geologist, surveying the country field by field, knows well that fertility varies greatly and depends largely on the nature of the rocks from which the soil has been formed. Although notes on the soils and agriculture of the districts had been printed in many of the Survey memoirs, they were of too casual and perfunctory a character to be of much interest as contributions to the study of British soils. Horace Woodward, who took much interest in this subject, made a careful survey of the experimental farm at Rothamsted as a guide for the use of the soil experts of that institution. But it seemed to be exceedingly difficult to interest agricultural authorities in the relation of geology to soils, though Hall and Russell had published a most attractive study of the subject which was generally regarded as laying a sound foundation for future research. After 1920, however, Sir Thomas Middleton took his seat as an assessor to the Geological Survey Board, representing the Ministry of Agriculture and the Development Commission (of which he was Secretary). He at once instilled new vigour into the study of these problems, and it is now arranged that all experts studying soils under Government auspices or encouragement in Great Britain will have the assistance of officers of the Geological Survey, who will furnish information regarding the geology and petrology of the districts of which the soils are being investigated. It is definitely established that one of the principal factors in determining the characters of soils is the nature of the parent material, and though a complete classification has not yet been attained, there has been a great advance attended by a much closer approach to agreement on fundamental principles.

In this connexion it may ‘be mentioned that the Geological Survey has published maps of North and South Ayrshire (on the one-inch scale) showing soil textures. The soils are classified and mapped according to their physical characters, and a description of the methods employed is given in the North Ayrshire memoir. The work was done by Professor Berry and Messrs. Louden and Melville of the West of Scotland College of Agriculture, and the maps are the only soil maps that have been published by the Geological Survey of Great Britain.

In the early days of the Geological Survey of Ireland many specimens of soils and subsoils were collected, but this was afterwards discontinued. In 1907, however, ‘A Description of the Soil Geology of Ireland’ was published by J. R. Kilroe, who was for many years on the Irish staff.

Oil-fields

Little attention has been given to the study of oil-fields in Britain, for the sufficient reason that no British oil-field worth mentioning has yet been discovered. In Scotland since 1860 the oil shales of

the Lothians have been regularly worked and a great industry has been built up as a result of the fundamental discoveries made by James Young and other pioneers. The geology and technology of the oil shales of Scotland have been detailed in a well-known memoir of the Geological Survey of Scotland which is now in its third edition and is the principal source of information on the subject with which it deals. During the later years of the Great War, in the course of the tireless search for British sources of mineral substances hitherto imported, the possibility of the occurrence of liquid oil in Great Britain, in quantities sufficient to justify exploitation, was eagerly canvassed and it was decided to make a series of exploratory borings. Advice was obtained from Lord Cowdray and his skilled technical geologists, who had much experience in the oil-fields of California and Mexico, and twelve sites were selected, ten in England and two in Scotland. The work went on for three or four years and was discontinued only after the War was ended. Some of the borings reached a depth of over 4,000 feet, but none yielded oil in useful amount; in fact, all the holes were ‘dry’ except one at Hardstoft in Derbyshire and one at D’Arcy near Dalkeith in Scotland. The search was consequently abandoned. The Geological Survey of Great Britain took little part in this adventure except that it furnished the geological information on which the sites were selected and that officers of the Survey visited the borings at intervals and took full records and suites of specimens of the rocks passed through. These are still preserved in the Museum of Practical Geology. The quest for oil in England still goes on, and has been stimulated by the Petroleum Production Act of 1918, under which notification of intended borings must be given to the Geological Survey who will have full liberty of access and the right to obtain a complete record of the geology of the boreholes.

Mining Industry Act of 1926 and the collection of borehole information

A similar provision was made in the Mining Industry Act of 1926 with reference to all borings and shafts for minerals intended to reach a depth of over 100 feet. For many years the Geological Survey has collected bore records in every part of Britain, whether the borings were made for minerals or for water. These records are carefully filed and their sites marked on special maps. Many of them have been published, but by far the greater number have never been printed, and of these many are confidential and cannot be communicated without permission from the parties for whom the bore was made. After the passing of the Act of 1926 opportunity was taken to strengthen this department by the appointment of assistants in England and in Scotland whose chief duty it is to visit notified borings and check the boring logs and take specimens when anything of interest is observed.

Special provision has been made that the information can be kept confidential when this is requested, and as a matter of fact, nearly all borings for minerals are, for a time at least, confidential. No difficulty has ever been experienced with the mining firms in whose interest the borings are being made: on the contrary, they welcome the visits of Survey officers and often send a request for them when something unexpected has been encountered in the course of the work. Our collection of bore records is increasing more rapidly than ever, and their value is much enhanced by the fact that the records have been verified on the spot in the course of the work and their interpretation discussed fully with the local experts before the boring was discontinued.

Geological mapping programmes

The routine field work, which, together with the preparation of maps and descriptive memoirs, constitutes the essential task of the Geological Survey and which had been practically discontinued during the last years of the War, was resumed after the close of the War and the retirement of Sir Aubrey Strahan. No essential alteration in the organization of the field work was considered necessary at this time. The formation of groups or units consisting of three or four geologists, under the control of a District Geologist, had proved to be a very efficient and satisfactory arrangement. Although first formally instituted by Sir Jethro Teall after the Wharton Committee’s Report in 1900,

it was really the continuation and regularization of a method of working which had been to some extent employed under Ramsay and Geikie. With a few modifications to meet exceptional circumstances it has proved sufficiently elastic and at the same time convenient and easily administered.

England and Wales

The increase of staff made it possible to open new districts and at the same time to continue work in the districts in which survey had been in progress and was not yet finished. As it was obviously recommended by the Ministry of Reconstruction that the revision of the coal-fields should have priority and, as the provision of in-creased staff was meant to accelerate that work, it was decided to start revision in four additional coalfields. These were Northumberland, Cumberland, Yorkshire and Lancashire. In all these districts no serious work had been done since 1883, and some of the maps dated from 1860. As mining operations in all these fields had been very actively carried on in the intervening years, the maps were practically obsolete. In some parts of these fields mining had been started after the maps appeared, and the area was already completely worked out and exhausted; and for some areas of Coal Measures no six-inch maps had been published owing to the suspension of six-inch publication about the year 1881.

In each of these districts a branch office was opened, namely at Newcastle, Whitehaven, York and Manchester. The officers in charge were Carruthers, Bernard Smith, Bromehead and Wright. This step was taken for two reasons—first, because there was no room for the staff in the London office in Jermyn Street, which was already overcrowded, and the provision of office quarters in the neighbourhood of Piccadilly would have been exceedingly expensive; and secondly, because it was felt that it would be advantageous to have the field staff working in each coalfield as closely as possible in touch with the mining engineers, coal-masters and others in the district during the winter months when the information on which the maps and memoirs were founded was being brought together with view to publication. This policy has fully justified itself and has been approved by the Geological Survey Board on several occasions when it has been passed under review. As much of the information embodied in coalfield maps is taken from the plans of mines and the sections of shafts that are accessible only in the mining offices, it has both saved the time of the staff and improved the accuracy of the work to have the geologists resident during the whole of the year in the districts they are mapping. At the same time it has brought the geologists into closer personal relations with the mining community and has greatly increased the applications for information received from the general public.

In the other districts in which survey had been going on before the War a great deal of half-finished work remained to be completed and brought to publication. It was necessary, for example, to issue the final maps and memoirs on the revised survey of the South Wales coal-field, a task which was accomplished in 1921. The North Wales coalfield had been completely revised before the War, but the maps and memoirs did not appear till 1923 and subsequent years. The coalfields of the West Midlands were partly revised, but much work remained to be done. The Birmingham, Coventry and Lichfield memoirs were published before 1926, and work was continued on the South Staffordshire, Shrewsbury and Forest of Wyre fields and is not yet finished and published. The work of T. C. Cantrill in this area deserves to be specially recognized, as on him fell the onerous task of carrying on the survey and at the same time completing much work that had been left unfinished by his predecessors.

As certain coalfield memoirs were sold out it became necessary to prepare and issue new editions, and this entailed a good deal of work in bringing the information up to date, though a full revision was impossible. Thus Gibson revised the Stoke-upon-Trent memoir, Wilson the memoir on ‘The Concealed Coalfield of Yorkshire’ and Robertson the ‘Abergavenny’ and ‘Merthyr’ memoirs. For the

first time also the geology of the concealed coalfield of Kent was investigated and described in Survey publications by Dines and Crookall.

Scotland

In Scotland, also, energy was concentrated on coalfield revision and, to accelerate progress, work in the Highlands was discontinued for several years. The Scottish coalfields were about half revised at the close of the War. No change was made in coalfield programmes, and the work went on in Ayrshire, Stirlingshire and Lanarkshire. At a later period revision was begun in Fifeshire and Dumfriesshire. The primary survey of the Highlands was resumed in 1926.

Coalfield revision

It will be seen that during this period five units in England were employed on the revision of coalfields and the surrounding areas, and two units in Scotland also did coalfield work for a large part of the year. Only one unit, in the south-east of England, was entirely occupied in surveying areas in which coal did not occur, and even there the concealed Kent coalfield was being investigated. The result was a very great increase in the publication of coalfield maps and memoirs. This was completely in accordance with the recommendations of the Ministry of Reconstruction, for if we survey the state of matters in 1935 we find that a great advance has been made since 1920. In Scotland the revision is now practically completed and the maps and memoirs are nearly all published. In England the Cumberland coalfield is revised and published. The revision of Northumberland is nearly complete. About three-quarters of the Lancashire field and more than half the Yorkshire field are revised. North Wales, South Wales, the Midlands and the West Midlands fields had been revised before 1920 though not completely published. Much work, however, still remains to be done. The maps of County Durham, for example, are entirely out of date, and parts of Lancashire and Yorkshire are still unrevised. Work is going on in the Forest of Dean, but of the Bristol and Somerset fields no recent maps are available. Meanwhile some of the older maps that were published from 1900 to 1910 are ripe for revision, as, for example, Leicestershire, parts of South Wales and Midlothian. It is generally admitted that maps that are thirty years old are not of much value.

In 1927 the revision of the Whitehaven coalfield was so far advanced that Dr. Bernard Smith and his staff were taken back to London and the local office was closed.

It must be confessed that progress in the coalfields in large measure entailed neglect of other areas, many of which were in much need of revision. One unit, however, was kept at work in the London district and the south-east of England. A re-survey of the Thames Valley from Reading to Sevenoaks has been completed and extended into the Weald. Much of this ground had not been previously surveyed on the six-inch scale'. Of the south coast of England from Chichester eastwards a suite of maps was published in revised form, though not based on a thorough re-survey. In other districts the assistance of non-official geologists who knew the ground well was secured; Mr. Osborne White wrote memoirs on Marlborough, Saffron Walden and other Sheets, and new colour-printed maps were sent out with partial revision. Mr. L. Richardson also gave valuable help in Moreton-in-the-Marsh and Cirencester, and Professor Boswell in East Anglia. At a later period a full revision of the district around Cambridge was undertaken and is still in hand, while a revised edition of the Oxford memoir was prepared by Pringle and others. It is not possible, however, to disguise the fact that the maps of a large part of the centre and south of England are unsatisfactory. They remain in the state in which they were fifty years ago when Sir Archibald Geikie reported the original survey of England as completed. Most of these Old Series hand-coloured one-inch maps are not based on a six-inch survey and have few or no particulars regarding the Drifts. For the use of water-engineers, agriculturists and for many industrial purposes, they are very seriously defective. In Scotland much

has been done by the re-publication of the Southern Uplands, based on a revision by Peach and Horne, but some of the maps of the more populous parts of Scotland are badly in need of revision.

Highlands and Islands

During this period, however, the most striking and original work was being done in the Highlands and islands of Scotland. The survey of Banffshire, left in an unfinished state by Horne, was completed by Read, and thereafter attention was directed to a large area in northern and central Sutherland, where complexes of schist and granite extended over wide stretches of country. This was fully mapped and described, and the Orkneys were then surveyed for the first time, a comparatively simple matter. Wilson and his staff then proceeded to Shetland and have now completed the original survey of this most complex and fascinating group, and the results are being prepared for publication. This unit has been transferred to northern Skye to finish the survey of the island which was begun in the south nearly forty years ago by Harker.

In the west of Scotland the original survey of Mull was in hand before the War and was interrupted for a time. After the tragic death of Clough—killed by a shunting railway wagon—the superintendence of this group was assigned to Bailey, who carried on the work with great energy. No part of Britain has proved more complicated than Central Mull, and the intricacy of the structure was often too great to be represented even on the six-inch maps. The history of the Mull volcanoes, and of the various stages through which their activity passed, makes one of the most wonderful chapters of the geology of Britain. Not only was the sequence of lava eruptions and of intrusions exceedingly difficult to decipher, but the tectonics also were often of types not previously recognized. When the geological work on Mull was completed and the maps and memoirs were issued, it was universally admitted that new lustre had been added to the records of the Geological Survey of Scotland. For originality and thoroughness the work controlled by Clough and Bailey in Mull is fit to stand comparison with the work done under Horne and Peach in unravelling the history and structure of the North-west Highlands. It was also an appropriate sequel to Harker’s notable achievements in the survey of the southern part of Skye.

The geologists of this unit were then transferred to Ardnamurchan, Coll and Tiree. It had long been known that Ardnamurchan contained the remains of a volcano of intricate structure, and vivid descriptions had been given of some of its more prominent features by Macculloch, Judd and Geikie. The work of Richey and his colleagues proved that here also there was much variety and novelty, and, though the complexity was not so astounding as in Central Mull, the structures were generally of the same type and many of the rocks were exactly similar. The excellence of the field surveys ‘in Mull and Ardnamurchan was rivalled by the petrographical and chemical work done for that unit by Dr. H. H. Thomas. His contributions to the memoirs on these districts hold a very high place in the literature of British petrography.

Almost simultaneously with the publication of the Ardnamurchan memoir an account of the geology of Arran was prepared by Dr. Tyrrell of Glasgow University for the Survey. These three centres of volcanic action in Tertiary times in the west of Scotland have consequently received very special attention during the post-War years and a great advance has been made in our knowledge of one of the most interesting episodes in the geological history of Great Britain.

Only in Scotland is there any considerable area of ground that has not yet been surveyed for the first time. In the interior of Inverness-shire there are four one-inch sheets amounting to about 1600 square miles that have never been examined even in a preliminary way. It is mostly an area of mountains and glens, typical deer-forest, but from a geological point of view it must contain much that is of interest. The whole of the Outer Hebrides also remains to be surveyed, but the recent work of Professor Jehu and Dr. Craig of Edinburgh University has given many indications of the nature of

the geology of these islands. The condition of Scotland thus contrasts strongly with that of Ireland, of which the survey was completed nearly fifty years ago.

Geophysical methods

The question of the Geological Survey undertaking geophysical methods of investigating geological structure came prominently before the Geological Survey Board in 1925. At that time Sir John Cadman, Chairman of the Anglo-Iranian Oil Company, was a member and both he and the Chairman of the Board, Sir Francis Grant Ogilvie, were deeply interested in the geophysical methods and their possible applications to the work of the Geological Survey.

Early in 1926 Sir John Cadman generously invited the Board to send two Survey officers to Persia as the Company's guests to investigate the geophysical work being there carried out with the Eotvos torsion balance. The invitation was accepted and Dr. W. F. P. McLintock, Curator of the Museum, and Dr. J. Phemister were selected for the work. These officers spent over two months in Persia and on their return presented a report which was published in the 'Summary of Progress' for 1926.

The results described seemed so promising that it was decided to acquire a torsion balance and test out the methods in this country. Work was commenced in August 1927 with a survey over the concealed outcrop of the Swynnerton dyke in Staffordshire. Thereafter surveys were made over the buried channel of the River Kelvin, near Glasgow, the concealed outcrop of the Pentland fault, near Edinburgh, and over a region of pronounced magnetic anomaly at Thrussington, Leicestershire. In all these cases the results, with full accounts of the methods by which they were obtained, were published in the Summary of Progress, in the Mining Magazine or in the Transactions of the Royal Society of Edinburgh. These investigations showed that the torsion balance was an extremely useful instrument for mapping suitable concealed structures such as faults, dykes, unconformities, buried channels and sub-drift topography.

Coincidently with this work a series of tests were made by Dr. A. F. Hallimond with the Schmidt vertical magnetic variometer. He carried out surveys over the Swynnerton dyke, over a region of magnetic anomaly known to exist near Melton Mowbray, and over the Pentland fault. The results of these surveys appeared in the 'Summaries of Progress 'for 1929—1931 and amply demonstrated the value of this method for detecting concealed masses of magnetic rock. Drs. McLintock and Phemister also described a magnetic survey made by them over the Lornty dyke, near Blairgowrie, wherein they demonstrated an interesting form of permanent magnetization in the igneous rock.

Museum of Practical Geology

Pressure of work in connexion with the organization of the new Museum and offices caused the suspension of this branch of work in 1931 and the instruments and equipment were transferred on loan to the school of Geophysics established at that time at the Imperial College of Science.

Meanwhile in the Museum of Practical Geology, in Jermyn Street, matters were going from bad to worse. This had never been one of London's brightest spots, though in the early days of Queen Victoria's reign it was regarded as a model for Europe to copy. The attendance had now dropped to about 2000 a month. When it was re-opened to the public after the War it was obviously in need of a complete overhaul, and the Office of Works was requested to undertake the work. Some plaster had fallen from the north-east corner of the ceiling, and when the workmen had erected a scaffold and started to repair they were astonished to find that one of the great cast-iron beams that supported the roof was broken. An immediate search was made and five more beams in the same quarter proved to be fractured. The Museum was at once closed to the public as dangerous, but the staff continued to work in it as usual.

The cause of these dilapidations was never clearly established, but, as the . side walls of the building were cracked in several places, it seemed clear that there had been some movement of the foundations. It may be recalled, however, that on 19th October, 1917, a bomb exploded in Piccadilly a few yards east of the Museum, and did great damage. It is possible that the roof was injured, though this was not suspected at the time. Steps were now taken to support the broken roof, and a great timber structure was erected in the main hall on which a platform was built to hold the roof beams in place. The slates and lead were stripped from the roof and replaced by light boarding and ruberoid. Sheets of wood were substituted for most of the panes of glass in the roof, and a temporary installation of electric lighting was introduced to illuminate the darkened interior. Most of the cases of exhibits in the Museum were covered with dust-cloths, and the noise and dirt were intolerable. After the north end of the roof had been pronounced temporarily safe an examination was made of the southern part. Not unexpectedly, it was also discovered to be unsatisfactory, and another timber structure was set up to support it. These measures required more than a year for execution and when they were finished the Museum was again opened to the public. The interior now presented a spectacle such as no other museum in the world could furnish.

Much discussion took place regarding the ultimate fate of the building. The construction of a new roof would have been very expensive and it was by no means certain that the old walls would bear the weight. Nothing was done for a considerable time. Meanwhile a new door had been opened in the Piccadilly front which gave access to the Library and Map Room, so that the public might still consult the books and maps. The offices were still in use, but the Museum was to all intents and purposes defunct.

Royal Commission and the plans for a new Museum at South Kensington

In July 1927 a Royal Commission was appointed to consider and report on the condition and organization of Government Museums and Galleries. The Chairman of this Commission was Viscount D’Abernon, and in November Sir John Flett, as Director of the Museum of Practical Geology, was called on to give evidence on the state of this Museum. The members of the Royal Commission lost no time in coming to a decision, and on 22nd December, 1927, it was stated in Parliament that on representations which a delegation of the Commission had made to the Chancellor of the Exchequer it had been decided to transfer the Geological Museum to an appropriate site in South Kensington as soon as financial circumstances permitted. The site which had been suggested by the Bell Committee in 1912 as most suitable for the new building was approved. The period of suspense was over.

The preparation of plans for the new building was undertaken by Sir Richard Allison and Mr. John H. Markham, Architects of H.M. Office of Works. Allison had much experience of museum construction, having been responsible for the plans of the new buildings of the Science Museum, and on his retirement Markham completed the design, and in his hands the form and details of construction took their final shape. The general plan does not differ much from that of the adjacent Science Museum, but an extensive suite of offices and laboratories was provided at the rear of the building for the staffs of the Survey and Museum. Sir Francis Grant Ogilvie, who, before taking up his duties as Principal Assistant Secretary of the Department of Scientific and Industrial Research, had been Director of the Science Museum and of the Royal Scottish Museum, constantly assisted with suggestions based on his long and varied experience in the design and construction of museums. The museum and library furniture, which was entirely new, as the fittings of the old Museum were unsuited and were in most cases useless, was designed by Mr. Allum and Mr. Buck of H.M. Office of Works.

The building was begun in 1929 and was practically completed early in 1933, when it was announced that H.M. Government had decided to convene an International Economic and Monetary Conference to meet in London during that summer. A search was made for a suitable building in which this important Conference could meet, and it was ascertained that the new Museum of Practical Geology was in all respects the most convenient and best adapted for the purpose. Fortunately, none of the special fittings required for the Geological Survey had yet been installed, and the building, though complete, was entirely empty. Very rapidly the interior was converted into conference halls, committee rooms, writing rooms, buffets, lounges, and in the basement accommodation was provided for the press, telephones, typists and messengers. The conference was opened by H.M. King George V. on 12th June, 1933, and was presided over by the Prime Minister, Mr. Ramsay MacDonald. The plenary sessions were finished in August and in October it was announced that if the Conference met again in London the new Museum would not be required for that purpose. The building was handed over to H.M. Office of Works to remove the fittings introduced for the Conference and to prepare for the reception of the Geological Survey.

During the year 1934 great activity prevailed both in the new and old Museums. The library, laboratories and collection rooms were fitted up with their cases, cabinets and racks of drawers, and most of the new furniture for the exhibition floors was delivered. Simultaneously, the collections in the old Museum were packed up by the staff and gradually transferred to South Kensington. The library at Jermyn Street was kept open as long as possible for the convenience of the public, but was finally closed at the end of July. It was installed in its new quarters and again made accessible to callers at South Kensington by the end of October. Over a million specimens, thirty-five thousand books and twenty thousand maps, besides manuscripts and documents, had to be dealt with in the course of the removal. On 31st October the old Museum was emptied and the keys handed back to H.M. Office of Works. The property was then placed on the market and after a time the Crown Lease was sold at £11,000 a year, a sum sufficient to pay interest on the cost of the new Museum and its fittings and provide a handsome surplus for H.M. Treasury. The cost of the Museum building was approximately £220,000, and of furniture and fittings £2,000. The staff of the Survey and Museum began to prepare the new Museum for the reception of the public. It was decided that the opening would take place in June or July, and the period of six months was all too short for the preparations.

In the interim the Curator of the Museum, Dr. W. F. P. McLintock, and the Assistant Curator, Dr. A. F. Hallimond, had not been idle. As soon as the main features of the new Museum had been decided on by the architect a general scheme of the displays which were to be exhibited to the public was drawn up and fully discussed. It was decided that the arrangement should be on the following lines

On the first floor or main floor all the exhibits should be of interest to visitors not skilled in geology. Such subjects should be illustrated as the action of wind, rain, rivers, weathering, ice, glaciers, volcanoes, earthquakes, also fresh water and marine deposits, the formation of rocks and their visible characters. In the centre of this floor it was decided to show a collection of precious stones, cut gems, ornamental stones and beautiful minerals both in their native state and cut and polished. The geology of London, the Thames Valley and the south-east of England, with the Hampshire Basin and the Isle of Wight, were to be exhibited with a full set of maps, photographs, diagrams, fossils, rocks, minerals and ores. Many explanatory labels, couched in the most simple terms, were prepared to accompany the specimens. A special feature of the exhibits on this floor was to be the presence of a number of dioramas, in natural colours and well illuminated, showing striking scenes of British geology such as the Needles (Isle of Wight), Lulworth Cove, Cheddar Caves, Edinburgh and the North-west Highlands.

On the second floor or first gallery the space was to be devoted to an exhibition of British Geology, based on the work of the Geological Survey. For convenience of preparation and description Great Britain was divided into provinces, each of which had a certain geographical and at the same time

geological unity; for example, East Anglia, the Pennine Country, North Wales, Devon and Cornwall, the Southern Uplands, and the Northern Highlands of Scotland. One or two geologists who had a thorough knowledge of the district were put in charge of each of these areas with instructions to prepare a full series of exhibits with labels. A very large number of photographs was selected from the Survey's collection to show the physical features of the country and to exemplify the close relation between geology and scenery. Many solid models were also constructed to show the geology and the surface relief. Of each district a descriptive handbook was to be published, written as simply as possible, to serve as a general account and as a handbook to the exhibits. On this floor also a suite of British fossils, stratigraphically arranged, and of rock-making minerals and typical rock structures, was to be exhibited.

On the third floor or second gallery there was to be an exhibition of applied or economic geology illustrating such subjects as building stones, slates, clays, cements, oil fields, iron ores and the principal ores of the metals (copper, tin, zinc, tungsten, gold, silver, etc.), and of the useful non-metallic minerals such as mica, asbestos, talc, magnesite, rock salt, gypsum, china clay, etc.

In this way it was hoped to provide something to interest the general visitor and at the same time to furnish all that was necessary for the student of British geology and the mining engineer or economic geologist who was specially interested in the application of geology to industry and commerce.

The topmost floor or third gallery was reserved for study and research collections, accommodated in cabinets of drawers. All the best material in the Survey collections, if not exhibited in the Museum, was placed in this gallery, divided into four series, rocks, minerals, fossil animals and fossil plants. For the collections there was plenty of room and excellent light, and space was also available for research workers and for the assistants engaged in the curation of the specimens. The public would be admitted to this gallery only when they desired to make a careful study of the research material in the possession of the Geological Survey.

The well-lighted and spacious basement of the Museum was assigned to workshops, store rooms, engineers' equipment and in the centre a large apartment to hold half a million specimens in wooden, dust-proof drawers, sliding in steel racks.

Special attention was given to the provision of ample space for the library and map collections, which are much consulted not only by the staff but also by the public, and had been very unsatisfactorily housed in the old Museum.

One library was placed on the main floor for the use of the general visitors and another, more private, for staff and research workers. In the basement abundant storage was provided to take the accretions for many future years. The rearrangement, cataloguing and indexing of the library, when transferred to its new quarters, would be a task of considerable magnitude requiring many months of work.

The arrangements thus sketched out proved to be satisfactory on the whole, and needed no essential modification. The specimens for exhibit and for the reserve and study gallery were picked out and packed separately before they were sent to South Kensington, and as far as possible the collections, which were in a very dirty condition, were cleaned before packing. Twenty, or more, geologists of the field staff were detailed to prepare exhibits illustrating British Regional Geology in collaboration with the palaeontological and petrographical staffs. Descriptive labels were drafted and many sketch maps and coloured diagrams were executed by the draughtsmen to explain the exhibits. Nearly two thousand photographic enlargements from Survey negatives of British scenery were made, mounted and framed. Sixteen coloured dioramas of geological scenes were designed and constructed by

professional scenic artists, and numerous solid models of interesting British geological districts such as Mull, Shropshire, the Weald of Kent and the Snowdon district of North Wales were made. These preparations involved an immense amount of work in which the field staff actively collaborated with the Museum staff and the petrologist and palaeontologists. By the end of June, after seven months of very arduous work, the new Museum was in such a state that it might be opened to the public, though, of course, much remained to be done before its condition could be regarded as likely to satisfy the critics.

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