

Geological Survey under Sir Roderick Impey Murchison, 1855-1871

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Sir Roderick Impey Murchison (From an old engraving.) Plate II

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III. The Geological Survey under Sir Roderick Impey Murchison

In May 1855 Sir Roderick Impey Murchison was appointed Director-General of the Geological Survey and Museum and of the Metropolitan School of Science applied to Mining and the Arts. The choice was an obvious one, as Murchison was at that time at the height of his fame and was (with

the possible exception of Lyell) regarded as the leader of British geology. The life of this wonderful man has been recorded in a charming biographical work by his pupil and devoted admirer, Sir Archibald Geikie. It is consequently unnecessary to recapitulate the stages of his career. At the age of 63 years he assumed his new duties, not light-heartedly but with an earnest desire to justify his appointment, which had been supported by the unanimous recommendations of the staff, and had the special approval of H.R.H. the Prince Consort.

Murchison had been President of the Geological Society (1831-33 and 1841-43) and of the Royal Geographical Society (1844, 1845, 1852, etc.). His numerous papers on Continental geology had given him a European reputation, and his travels in Russia and the Urals had received the distinguished commendation of the Czar of Russia. He was the founder of three recognized geological systems, the Silurian, the Permian, and the Devonian (the latter in conjunction with Sedgwick and Lonsdale). His upward progress had been continuous and as yet no breath of serious criticism had challenged his conclusions. Proud of his Highland descent, he was famous for his generosity and hospitality. Nothing pleased him better than to preside at the Annual Meeting of the Royal Geographical Society or to fill the Chair at a Geological Society dinner. His lofty and dignified manner did not conceal a genuine honesty of purpose and a wide sympathy with all earnest workers in geological science.

Murchison was an excellent Director. He had the loyal support of his staff. He 'was diligent and attentive to business, and his high social standing made him prominent in the eyes of the public and gave weight to his demands for progress. Above all, he was trusted by everyone, as his enthusiasm for geological science and his rectitude were universally recognized.

In taking over the work of De la Beche, he had one disqualification. He had little interest in the economic applications of geology which for De la Beche had been of prime importance. Furthermore, Murchison does not seem to have been much concerned with the education of students of Mining and Metallurgy. For De la Beche the School of Mines was one of the principal projects of his life. The eminence of the professors in the new School was, however, sufficient guarantee of its efficiency, and except when his interference was unavoidable Murchison wisely left the courses of instruction of them. As a field geologist his methods were rapid and superficial. He recognized that he belonged to the 'heroic' school of geologists and that the new men had new ideas. The time was coming when as much care and labour would be spent on the geology of a single county as the older geologists spent on a province. Although tremendously engrossed in his duties, public and official, in London, Murchison went regularly to the field and visited his staffs.

He was fortunate, however, in having two Local Directors who were as capable as any who have held that responsible position. Ramsay in England and Jukes in Ireland were men in the prime of life, and unequalled as field geologists by any of their contemporaries. The methods of field geology in Great Britain were developing rapidly, and much attention was now being paid to the geology of the superficial deposits and the origin of surface features, which Murchison never understood. The work of the Geological Survey was advancing into the Midland coal-fields and the Secondary rocks of the south of England. Murchison's original investigations in his later years were practically confined to the older formations and especially to his beloved Silurians.

In 1855, the first year of Murchison's directorship, the English staff comprised, in addition to Ramsay, four geologists: Aveline, Bristow, Howell and Hull. It was quite obvious that this number was insufficient to secure rapid progress, and application was successfully made for an increase of staff. Four geologists were appointed, Bauerman, Best, Drew and A. Geikie, and were sent to the field to be trained in routine surveying by the senior men. The Palaeontologist was J. W. Salter, and Huxley, newly appointed, acted as Naturalist. Huxley, besides working on the arrangement of fossils in the Museum, appears to have been principally engaged in the preparation of catalogues for the

press and research on British palaeontology. Warrington W. Smyth as Mining Geologist gave much help to his colleagues in the field who were working in districts where mineral deposits were important.

The amount of work overtaken during these years by the members of the staff was prodigious. Huxley, for example, in 1856, in addition to cataloguing and naming fossils, preparing lists and research for the British Organic Remains, gave 50 lectures on Natural History to the students. Warrington Smyth in the same year gave 60 lectures on Mining, and 40 on Mineralogy. Ramsay lectured on Geology. All the senior members of the staff took part in the series of evening lectures to working men. They all assisted in the field work in the summer season, and were also liable to be called on to give answers to any sort of scientific question that was sent in by Government departments. In the field each surveyor seems to have reported on an area of from 100 to 200 square miles each year. The work, of course, was often very sketchy but still wonderfully good considering the speed at which it was done. In the coalfields, for example, it was enough to trace the boundaries of the various sub-divisions of the Carboniferous with some details as to the outcrops of the principal coal seams. At this period only the most casual attention was paid to the 'drifts.' As a general guide to the distribution of workable coals, no doubt these surveys were useful for the purposes of the mining industry. More detail was shown on the Vertical and Horizontal sections published to explain the maps.

Ireland

At this period (about 1856) six-inch maps were not published for the whole of England. For some reason, however, a large part of Ireland had already been published on the six-inch scale, but on the other hand the one-inch maps which were to be produced by reduction from the six-inch maps had not yet made their appearance. Consequently, publication of the Irish Survey's work (started in 1845) was delayed till the one-inch maps were ready (1855). For part of Scotland, however, six-inch maps were available, and De la Beche began the work in the Lothians in 1854 towards the close of the year. The area selected was near Dunbar. Apparently Ramsay was the officer sent to Scotland, and he spent about two months there. The six-inch geological maps of the Edinburgh district began to appear in 1861, and the whole of the subsequent mapping of the Geological Survey in Scotland (with unimportant exceptions) has been executed on the six-inch scale. The Haddington one-inch map is the only one on which Ramsay's name appears as a surveyor. When Archibald Geikie joined the Survey in 1855 he carried on Ramsay's work in East Lothian and Midlothian. For a time Geikie was accompanied by H. H. Howell, who surveyed the Midlothian and Fife coalfields and, when this was done, returned to England. Geikie then remained as the sole representative of the Geological Survey in Scotland and carried the work southwards and westwards into the adjacent counties. No office was opened in Scotland and the geologists did their winter's work at the headquarters in London, where Geikie assisted Ramsay by relieving him of the course of lectures to the School of Mines and the popular lectures to working men.

Scotland

At first the mapping in Scotland was entirely confined to the 'solid' rocks, but after a few years authority was given to survey the 'drifts' also. The first Scottish Sheet to be issued from the press represented Edinburgh and the district around the capital (1859). Six-inch geological Sheets of the Midlothian and Haddington coalfield were first published in 1861, in which year also the memoir descriptive of the Edinburgh Sheet was published. In 1861 also, after Howell's departure, John Young and James Geikie joined the Scottish Survey, and in 1862 the name of B. N. Peach appears on the staff lists for the first time. Ramsay continued to act as Local Director and made occasional visits to Scotland to inspect and ascertain the progress of the work.

The young men who served on the Geological Survey of Scotland between 1855 and 1865 were evidently carefully selected, as they all made their mark in the history of Science. Of Archibald Geikie a fuller account will be given at a later stage. H. H. Howell, after working in England for many years, became Director of the Geological Survey of Scotland in 1882. John Young was educated in Edinburgh and had graduated in medicine, but abandoned that career and became a geologist. In 1866, after five years' work on the survey of the South of Scotland, he was appointed Regius Professor of Natural History in the University of Glasgow, where he continued for 36 years to play a conspicuous part in academic life.

B. N. Peach, one of the most famous geologists that Scotland has produced, was the son of an amateur geologist of great distinction, Charles Peach, who in the leisure of an active life, spent mostly in official duties in the Revenue and Coastguard departments, had made many notable discoveries that had attracted the attention of Murchison and other prominent scientists. The younger Peach was educated at the School of Mines and held the Associateship of that institution. He was as good a naturalist and palaeontologist as a field geologist, and after a long and distinguished service on the Geological Survey of Scotland he continued for many years to work at his maps and to collaborate with Dr. Horne in contributions to Scottish geology. James Geikie, a younger brother of Archibald Geikie, joined the Survey as Assistant Geologist in 1861, became District Surveyor for Scotland in 1869 and left the Geological Survey in 1882 to succeed his brother as Murchison Professor of Geology in the University of Edinburgh. As a field geologist, a writer on geological science and a Professor of Geology, he was one of the outstanding figures of his generation and has done more than any other man to advance the study of geology in his native country.

The brothers Geikie were both first-class geologists and men of literary ability. They wrote many books which hold a high place in the literature of geological science. At an early stage in their careers each of them chose his special field. Archibald devoted himself to the study of volcanoes, while James concentrated his attention on glaciation. But they were not narrow specialists and their text books of geology were deservedly popular. James Geikie has been described as the most eminent glacialist of his day by Baron de Geer, the most eminent of living glacialists.

Many interesting particulars of the progress of field work in Scotland in the years 1855 to 1865 will be found in A. Geikie's 'Long Life's Work' and 'Life of Ramsay,' in the biography prefixed to John Young's 'Essays and Addresses' and in 'James Geikie, the Man and the Geologist.'

England

Under Murchison's strong hand and steady guidance, the Survey work in England extended eastwards from the boundaries of Devon and Somerset and South Wales. Bristow and Aveline were busy in the Isle of Wight, the Hampshire Basin and the Salisbury Downs and the Cotswolds. These maps were issued in 1855-1860. In the later part of this period they were assisted by Whitaker, Bauerman, Trimmer, Trench, Drew and Polwhele. Work was then advancing into the South Downs, the Weald and the London Basin. After Jukes departed to Ireland in 1850, work in the Midland coalfields was continued by Selwyn, Hull, Howell and Aveline, with assistance by Trimmer, R. Trench and Warrington Smyth. In 1860 the Midland coalfields had been published on the Old Series one-inch maps, including Staffordshire, Warwickshire, Derbyshire, Leicestershire and Nottinghamshire. The Yorkshire and Lancashire coalfields were still to be examined, but a very large and important area of productive Coal Measures had been carefully mapped for the first time. If it is remembered that six-inch maps were not yet available for this area and that the field work was being done on one-inch Ordnance Sheets, the mapping of these Midland coalfields is perhaps as good as could have been expected under the circumstances. In the Secondary and Tertiary rocks each surveyor was reporting an area of 200 to 300 square miles surveyed during the season. In the coalfields the area done was

much smaller. In Scotland, however, where six-inch mapping was being done, an area of 100 square miles for each surveyor seems to have been accomplished. In Ireland the mapping was altogether on the six-inch scale from the start, but now one-inch maps were ready and the results of the work were being reduced and published on that scale.

Murchison reported in 1859 -

Seeing the advantages of laying down the geological features of such an important district upon the six-inch scale, and knowing that the Board of Ordnance has published a skeleton survey of London and the environs on that scale, I have directed that as in Ireland and in Scotland, the real work around the metropolis should be carried out, and, if thought expedient, published, both on the larger as well as on the smaller scale. The usual publication on the one-inch scale, though essential to complete the general work, would be inadequate to enable the surveyors to lay down those detailed delineations and variations of the surface and subsoil in and around London, which engineers and proprietors would expect to see issued by the Government geologists.

This appears to have been the beginning of six-inch survey in England and Wales. In 1860 Hull was mapping on the six-inch scale in the Lancashire coalfield, and several six-inch maps of that district were published in that year and others were engraving. Some of these are still on sale, not yet having been revised.

1862-1871 and the end of Murchison's Directorship

In 1862 Murchison, now 70 years of age, was at the apex of his celebrity. He was President of the Royal Geographical Society and delivered from the Chair his ninth Anniversary Address, which occupies 80 printed pages of the Journal. His Annual Reports as Director of the Geological Survey, etc., show that he did not neglect his official work and that he was prompt to press on the authorities, as occasion offered, the urgent need of continued support and improvement for the institutions under his charge. With the work of the Survey on the Secondary and Tertiary rocks of England he does not seem to have concerned himself very closely, and, though he approved highly of the important economic work that was being done in the Midland coalfields, there is no evidence that his personal acquaintance with it was of an intimate nature. He determined, however, to carry his explorations into the Highlands of Scotland and to clear up the mystery of the geological age of the Highland Schists. As he was now by no means so active as in the years when he had surveyed his 'Siluria' of the Welsh borderland, and traversed the Urals and the Alps, he enlisted the aid of his ablest lieutenants. In 1859 he was accompanied by Ramsay, who appears to have agreed with him in all essential matters. In 1860 he took with him Archibald Geikie and they spent two months on the ground. Murchison returned triumphant, and the results of his travels appeared in two famous papers in the Quarterly Journal of the Geological Society. It is sad to relate that the united efforts of these three eminent Directors produced the greatest fiasco of Murchison's career, and the mistakes he made have proved the chief blot on his record as a geologist. Archibald Geikie apparently had doubts, but Murchison's easy self-confidence amounted to recklessness, and he claimed to have established the Silurian age of all those rocks now known as the Moine Gneisses and the Dalradian Schists. He believed that these were merely the metamorphic representatives of the fossiliferous quartzites, shales and limestones of the Durness and Assynt district, which he regarded as Silurian, and in this way he extended his much-loved Silurian formation over the greater part of Scotland.

Murchison's conclusions were attacked by James Nicol, at that time Professor of Geology in the University of Aberdeen. Nicol had written much on the geology of the Southern Uplands of Scotland and of the Scottish Highlands. Before 1855 Murchison and Nicol had collaborated in several

researches, but in 1859 at the meeting of the British Association in Aberdeen Nicol had stated very clearly that the Eastern Schists did not pass into or rest conformably on the Durness and Assynt fossiliferous strata but were brought into their present position by a series of folds and faults. Nicol maintained his position in spite of the authority of Sir Roderick. He made a reply in 1866, and thereafter a controversy went on in which many distinguished geologists took part. In his main contention Nicol proved to be right, and Murchison very definitely in the wrong, but the matter was not settled till 1884, when the work of Lapworth, Peach and Horne finally explained the complicated structure of the North-west Highlands.

Murchison, however, at this time displayed great unwillingness to revise any of his former opinions. In the last edition of his 'Siluria' he maintains his views on the Highland Succession. He was wholly sceptical of Ramsay's theories of the origin of valleys and the efficiency of glacial erosion, and with many other prominent geologists he opposed Darwin's theories of evolution, which were being ardently advocated by Huxley.

Huxley's connexion with the Geological Survey and the Royal School of Mines lasted for 31 years. He was appointed in 1854 as Naturalist at a salary of £200 a year to take up the duties hitherto performed by Edward Forbes. In 1855 he was made a regular officer of the Survey, 'with a commission to work out the natural history of the coast.' On Edward Forbes's death Huxley was offered the vacant Professorship of Natural History at Edinburgh, but declined. As a teacher and lecturer in Jermyn Street he achieved a very great success and his lectures to working men were highly appreciated. At first he seems to have done a certain amount of field work, and in 1856 he prepared a report 'On the recent changes of level in the Bristol Channel,' but soon he was entirely absorbed in Museum duties, lecturing and laboratory work. At this period he was lecturing also at the School of Art and at the London Institution and had several books and scientific articles in hand. He continued to hold the Fullerian Professorship of Physiology at the London Institution till 1867, when he resigned and was succeeded by Michael Foster.

During his service on the Geological Survey, Huxley performed a vast amount of work, most of which was entirely independent of his official duties. As his fame increased as a teacher, lecturer, reviewer, controversialist, philosopher, educational reformer and administrator, the calls upon his time became more and more exacting. He was as versatile as he was brilliant, yet through a large part of his scientific life he was continuously engaged on work on British Palaeontology and the curation of the fossil collections in the Museum of Practical Geology. His aim from the first seems to have been to make these collections as valuable as possible to the student of Geology and Natural History and he has left some interesting notes on the ideals he was striving to attain. For many years Huxley selected and named large numbers of British fossils for display in the Museum cases. In this work he had the assistance of Rhind (who died in 1857) and afterwards of Etheridge and Sharman. The preliminary stages were apparently completed by 1859, in which year 10,985 fossils were added to the Museum exhibits and it was reported by Murchison that the fossil collections shown in the Museum had received their final arrangement with the exception of the Pleistocene series. A Catalogue of the Fossils in the Museum of Practical Geology was also in preparation and was published in 1865 under the joint authorship of Huxley (Lecturer on Natural History in the Royal School of Mines) and Robert Etheridge (Palaeontologist). To this volume Huxley contributed a very interesting Introductory Preface of 70 pages explaining the purpose and practical utility of the study of fossils.

During these years J. W. Salter, who was appointed in 1846, was constantly at work on British Palaeontology both in the field and in the Museum. In 1854 Salter was appointed Palaeontologist to the Geological Survey, and for a time he was responsible for the palaeontological work in Ireland, but in 1857 W. H. Baily, who had originally been employed as an artist to make drawings of fossils, went to Ireland to take charge of palaeontology there. Salter continued to work in Jermyn Street till

1863, when he resigned.

In 1849 De la Beche had begun the publication of a series of Decades-' Figures and Descriptions of British Organic Remains.' The term 'Decade' seems to signify that each part contained 10 plates, at first engraved on copper but subsequently lithographed. Four of the first five Decades were written by Edward Forbes and published in 1849 to 1856. In 1849, 1853 and 1864 Salter published three Decades on Trilobites. Huxley (along with Sir Philip de Grey Egerton) published two Decades on Fossil Fishes, and Egerton published two more and Huxley one on the same subject. After 1855 the series dragged and the thirteenth and last Decade did not make its appearance till 1872. At first two artists were employed to draw the figures—C. R. Bone and W. H. Baily—but after 1860 artists seem to have been engaged who were not on the regular staff.

Huxley also contributed to the 'Monographs of the Geological Survey,' of which four volumes appeared— in 1859 'Pterygotus' by Huxley and Salter, in 1864 'The Belemnitidae' by Huxley, in 1877 'The Elgin Crocodiles' by Huxley, and in 1878 'The Chimaeroid Fishes' by E. T. Newton. The publication of 'Palaeontological Memoirs,' suspended in 1878 under Ramsay, was resumed in 1908 under Sir Jethro Teall.

It does not seem that Huxley contributed to the Sheet Memoirs or District Memoirs of the Geological Survey, and though he continued to take much interest in Palaeontology, and published many papers on fossils, the above list contains the whole of his official Survey publications.

Salter, on the other hand, was busy not only in preparing Decades but also in assisting the field geologists by naming and describing the fossils sent in by them and the field collectors. He also named many fossils for the Museum and took part in the preparation of catalogues. One of his principal achievements was the description of the fossils of North Wales which accompanied Ramsay's memoir, published in 1866. He also worked with Phillips on the palaeontology of the Malvern Hills (1846) and furnished notes and catalogues of fossils for other District and Sheet memoirs. In 1863 he resigned from the Survey and from that date till his death in 1869 he worked at palaeontology in Cambridge. His contributions to the palaeontology of the Palaeozoic rocks of Britain were of permanent value and probably the most important is his Catalogue of the Fossils in the Sedgwick Museum, which was published after his death.

As assistants in the palaeontological work in the Museum Huxley had secured the services of two young men, Robert Etheridge, who joined in 1857, and George Sharman, who joined in 1855. They both became well-known palaeontologists in after years and both held the post of Palaeontologist to the Survey. Etheridge, in fact, succeeded Salter in 1863. Before joining the Survey he had been Curator of the Natural History Museum in Bristol. In 1881 he was transferred to the British Museum, as Assistant Keeper of Palaeontology.

Murchison was justly proud of the great success of the Institution under his charge, which he knew was superior to any other institution of the same kind existing at that time. In his Report for 1859, for instance, he says:

When the Maps of the Geological Survey and the accompanying Sections were exhibited at the Exposition in Paris, 1855, it was universally admitted by the most competent judges of all nations, that no such elaborately detailed work, whether as regards the fields or other sources of mining wealth, had been attempted in any part of the World.

Again in his Report for 1862 he remarks that:

In conclusion, it is very gratifying to be able to state that the working of the Geological Survey of the United Kingdom and the Royal School of Mines has been so carried on as to elicit high praise from a foreign gentleman of great distinction, recently Minister of Finance of the kingdom of Italy, himself a distinguished mathematician and crystallographer.

Signor Sella having been employed by his Government to visit the mining and geological schools and establishments of the different kingdoms of Europe, with the view to the formation of a geological survey of Italy, thus writes in a published official document after an examination into the detailed operations of our Survey:

‘England is without doubt the country where geological maps are prepared with much greater accuracy than in any other land. The singular importance of her mining industries, the spread of the elementary principles of geology, the zeal applied by the geologists charged with these labours, and the precision of their works, have been so accomplished that few undertakings of the British Government have so much contributed to the benefit of the public as the Geological Survey of the United Kingdom.’

The success thus attained was accompanied by certain disadvantages. In many of the Colonies and Dominions Geological Surveys had been set up on the model of the Geological Survey of the United Kingdom, and it was usual to obtain an experienced officer trained in field work and in the preparation of maps for publication by the British Geological Survey. Logan had gone to Canada in 1842, and though he was rather a volunteer than a regular officer of the staff, his connexion with the Survey under De la Beche had no doubt been one of his chief recommendations. In 1842 A. Murray went to Canada, and subsequently became Director of the Geological Survey of Newfoundland. Oldham left the Irish Survey in 1850 to control the Geological Survey of India. Selwyn, after founding the Geological Survey of New South Wales in 1852, succeeded Logan as Director of the Geological Survey of Canada in 1869. In addition to these losses, Wyley left the Irish branch of the Survey in 1855 to undertake geological mapping in South Africa.

D. H. Williams left in 1845 to become Geological Surveyor to the East India Company, while Arthur Wynne went to India as a geologist in 1862, although he returned in 1883 and resumed work on the Irish staff. Frederick Drew became geologist to the Maharajah of Kashmir in 1862 and published several interesting books on that country. Hilary Bauerman in 1858 became geologist to the Boundary Commission in North America. H. B. Medlicott, one of the Irish geologists, departed for India in 1863 and subsequently became Director of the Geological Survey of India. Richard Trench, also an Irish geologist, joined the Geological Survey of India in 1860. John Young was appointed Professor of Natural History in Glasgow University in 1866. Gould went to Tasmania in 1859. Wilson joined the Geological Survey of India in 1857.

In the staff of lecturers in the School of Mines and assistants in the Museum the changes arising from transference were equally numerous: Edward Forbes (Professor of Natural History in Edinburgh University, 1854), Joseph Dalton Hooker (Kew Gardens, 1847), Arthur Henfrey (Botanist, Lecturer in St. George’s Hospital, 1847), Frederick McCoy (Palaeontologist, Cambridge Museum, 1846), J. W. Salter (Palaeontologist, Cambridge, 1863), Lyon Playfair (Secretary, Science and Art Department, 1853), G. G. Stokes (Lucasian Professor, Cambridge, 1859).

Although Murchison in his Reports continues to express great satisfaction at the progress of the Survey’s work and does not fail to point out the annual increases in the sale of maps, etc., there were already signs of impending changes. In 1862 a Commission was appointed to report on the combined institutions of which Murchison was Director General. The members of this Commission were Lord Granville, Sir C. E. Trevelyan and Robert Lowe (afterwards Chancellor of the Exchequer).

The Secretary was Henry Cole, Secretary of the Department of Science and Art. In their Report, dated June 1862, they noted that the progress of the Geological Survey was satisfactory, and devoted most of their attention to the state of the School of Mines and suggested several reforms. These were intended to bring the School into more direct relation with the scientific instruction given in other parts of the country and at the same time to make the School more useful to the mining interests. Apparently the professors had brought forward various suggestions for improving the course of studies, but no changes of importance seem to have been made at this time in the curriculum.

For the first time the name Royal School of Mines is suggested as the proper appellation of the School. It was noted that the Registers of the Museum were incomplete and defective, and suggestions were made to increase the accommodation for the professors. In order that the Museum should be opened to the public on certain nights each week it was recommended that 'certain portions' should be provided with artificial light. Another suggestion that seems to have been adopted is that a certificate of proficiency should be given to students who passed an examination at the close of three years of study. This is the origin of the Associateship of the Royal School of Mines, which was made retrospective and given to all students who had previously received diplomas of the School.

It will be remembered that similar questions had been raised in 1854 and De la Beche had not accepted the proposals. His position was perfectly clear: he was intensely interested in creating a school for the training of mining engineers similar to the well-known mining academies of Saxony, France and other countries, and he had no desire to see that school (which had already a great reputation) converted or absorbed into a Normal College of Science which would give certificates of competence to teachers of elementary science. The proposal was allowed to lie dormant but was subsequently revived. Murchison followed De la Beche's lead, and nothing of importance eventuated at this time. But there was already a growing feeling that a training college in Science under the Science and Art Department was desirable, and it was also clear that the accommodation in Jermyn Street was insufficient and that the curriculum required extension in several directions.

Some rearrangement of the working and space took place at this time and the palaeontologists were given rooms in an adjacent house at 27 Jermyn Street, part of which was already used as a laboratory. A room on the north side of the Museum hitherto assigned to the palaeontologists was converted into a hall for the exhibition of mining models.

For some years Murchison had been urgently pressing, as occasion offered in his Annual Reports, and also no doubt through other channels not so obvious, the necessity of strengthening the Survey. The rapid progress of the early years under De la Beche could not be maintained. To a very large extent this was due to the improvement in geological mapping which had been a direct result of the publication of the early maps. The public had learned to appreciate accurate and detailed work, and though the maps were acknowledged to be the best of their kind at the time when they appeared, it was recognized as possible to improve them considerably. Equally important was the fact that the surveyors themselves had learned so much of the art of geological surveying that their previous achievements were regarded as unsatisfactory and they strove to produce better and better maps every year. The progress of geological science had been so rapid, and the state of knowledge had improved so much, that far more was expected of an official surveyor. Geology was now a subject which was of interest to a large number of educated people, and maps which contained only a partial or incomplete representation of the structure of the country were not considered satisfactory. The industrial applications of geology were much better understood, and the great advance which had been made in manufactures, arts and the means of communication all led to a demand for geological maps showing considerable detail with the greatest accuracy.

As a matter of fact many of the Sheets which were first published had undergone more or less complete revision before 1867. De la Beche's own work in Cornwall and Devon, published in 1834 and 1835, had been amended in 1839. In 1855 there seems to have been a fairly extensive overhaul, as the Quarter-sheets of the one-inch map made their appearance in a somewhat modified form. In some cases this amounted only to a change in the colour schemes; in others there was improvement in the geology. Statistics recently compiled show that in 1868 twenty-four revised Quarter-sheets and twenty-one revised whole Sheets were on sale. In the same year four Quarter-sheets were published that had undergone a second revision. These Old Series Sheets were engraved on copper plates and hand-coloured. Hence it was possible, though it involved considerable labour, to remove any lines that were found to be incorrect and to insert new ones; as the maps were hand-coloured it was a matter of perfect simplicity to change the colour schemes. From the Annual Reports it does not seem that there was any extensive programme of revision, but small modifications were inserted and errors corrected when it was judged to be advisable. Maps were coloured up for sale only in small numbers and there were no large stocks. This highly elastic scheme served its day very well, but when the maps began to be colour-printed and editions of a thousand or more were taken from the press, it became a matter of great difficulty to correct errors, and, in fact, it usually involved the preparation of a new edition based on a complete or partial re-survey.

Another factor which made for slower progress was the necessity for preparing memoirs descriptive of the one-inch maps. De la Beche's great memoir on Cornwall, Devon and Somerset had appeared with commendable promptitude, but Ramsay experienced the greatest difficulty in compiling his account of North Wales. The maps were published by 1852, but the memoir did not emerge from the press till 1866. One reason for the delay was that Ramsay found that much which appeared quite simple during his rapid field survey required careful re-examination and mature consideration before a final judgment was formulated. Moreover, Ramsay now, as Local Director for England, had much official business to transact and many duties that diverted his time from literary work. John Phillips's account of 'The Malvern Hills' was published in 1846; Jukes's 'Staffordshire Coalfield' in 1853. About 1860 the publication of memoirs descriptive of each Sheet came to be recognized as a routine part of the Survey's work. In 1861 the following were issued: Oxfordshire (Sheet 13, by Hull and Whitaker), Northants (53 N.E., by Aveline), Altrincham (80 N.E., by Hull), Edinburgh (32, by Howell and A. Geikie). Thereafter every year saw an addition of four or more memoirs to the list. Of necessity the time of the field officers was occupied in writing these handbooks and seeing them through the press, and undoubtedly a stimulus was given to the more careful collection and more critical study of the geological evidence. This was especially the case as regards the geology of the coalfields, in which detailed accuracy was of prime importance. The examination of mining plans and sections involved considerable expenditure of time but added greatly to the store of knowledge regarding the structures of the coalfields. So long as the work was done on the one-inch scale such labour was to some extent unnecessary, as much detail could not be shown on the published maps. The primary survey of the Midland coalfields was done on that scale, but in Lancashire in 1860 Hull for the first time was able to make use of six-inch maps, and they enormously increased the value of the work, which in that field was very difficult and complicated.

Perhaps the most notable achievement of Sir Roderick Murchison during his tenure of the Directorship was the large increase of staff which he obtained in 1867 and 1868. Thirty-three new assistant surveyors were added to the force, of whom nineteen were appointed in 1867. At the same time the organization was modified. Archibald Geikie became Local Director for Scotland, which was now for the first time placed on the same level as Ireland. Certain of the senior members of the field staff were made 'District Surveyors,' to have superintendence of the training and work of the juniors. The members of this group were, in England Aveline and Bristow, in Ireland Du Noyer, and in Scotland Edward Hull. Of the new geologists 21 were allotted to England, 6 to Ireland and 6 to Scotland. The candidates had to pass a Civil Service Examination before admission, and there were

numerous failures at the first examination in 1867. In the following year, however, the complement was obtained, and Murchison reported that the field staff now numbered 57. The total strength of the Survey was now raised to 77.

In comparison it may be interesting to note that in 1934 the personnel of the Geological Survey is given in the Estimates as 118, of which number 10 were District Geologists and 37 were Geologists. The Museum and Library staffs, technical and general assistants, typists, clerks, draughtsmen, messengers, warders, etc., were included in the above mentioned total, but not the labourers and cleaners nor the staff employed in engraving, colouring and printing the maps at the Ordnance Survey Office in Southampton.

It seems reasonable to believe that the large increase of geological staff obtained by Murchison in 1867 and 1868 was at least partly due to the Royal Commission appointed in June 1866 'to inquire into the several matters relative to Coal in the United Kingdom.' This Commission was presided over by the Duke of Argyll and among the members were Murchison, Hunt, Jukes, Hull and Ramsay. The final report was not sent to the press till July 1871, and during these five years a large amount of work was done by the Commissioners and by the experts who gave evidence. At an early date it was decided that the officers of the Geological Survey were to give every possible assistance, and not only those named above but Green, Howell, Bristow, Geikie and Jordan compiled much information and were examined at great length. It was pointed out by the Secretary of the Science and Art Department that 35 Sheets of the Map of England had yet to be surveyed and that the accepted procedure of mapping on the six-inch scale instead of the one-inch scale was not conducive to rapid publication. It was also suggested that attention should at first, at least, be concentrated on the mapping of the coalfields. At that time the Yorkshire and Lancashire coalfields had yet to be finished; the Cumberland, Northumberland and Durham coalfields were only just begun; more than one-half of the Scottish coalfields had yet to be surveyed; the map of Ireland was approximately half completed. By the absence of good geological maps the work of the Commissioners was rendered more difficult, and the importance of satisfactory geological information became especially evident when it was attempted to form statistical estimates of the nation's coal reserves. The large increase of staff could not be expected to operate immediately, and it was not until the new surveyors had received adequate training that their work could be accepted for publication. In fact, for a time, as Ramsay pointed out, the result was to retard progress, as the senior experienced men were diverted from the work of surveying to that of instructing their assistants.

Murchison died on 22nd October, 1871, after an illness which had lasted for a few months but had at first not greatly impaired his activity. He was 79 years of age, and that year he gave the last of his sixteen Presidential Addresses to the Royal Geographical Society at the Anniversary Meeting on 22nd May. This distinction he had always highly valued, and it was his last appearance in public. Almost to the end he continued to attend at the Geological Survey Offices in Jermyn Street and took much interest in the progress of the Survey.

The work which Murchison did for the Geological Survey was of great importance and lasting value. Although he was 63 years old when appointed Director, his astonishing vigour and commanding personality enabled him to accomplish many striking advances. In addition to his activity he had much common sense, and he wisely left the administration of details to his experienced and competent subordinates, while studiously maintaining the prestige of the institution and strongly pressing on the Civil Service authorities the necessity for adequate recognition and support. His eminence as a scientific man, his social position and substantial wealth, his personal friendship with eminent politicians and members of the aristocracy, and his genial, forceful, assertive individuality made him an eminently successful Director. It is true that he did not originate very much. He made no contributions to Survey memoirs and never assisted in the field surveys or the arrangement of the Museum. He continued strictly along the lines laid down by his great predecessor De la Beche. The

Geological Survey had received a large increase of staff. Its publications had been improved in many respects and it was regarded as holding the highest place among institutions of that class in the whole world. Many other Geological Surveys had been erected after its example, and in the British Colonies and Dominions former members of the British staff had been playing a great part in the advancement of geological science. The School of Mines had prospered greatly and was now recognized as holding the premier place as a school of science adapted to industry. Its professorial staff included men of the very highest distinction, and its diploma was universally esteemed. The palaeontological exhibits of the Jermyn Street Museum under the care of Huxley had been brought to a high pitch of efficiency, and Ramsay, Geikie and Warrington Smyth had attended to the petrography and applied mineralogy in a not less competent manner.

Certain improvements had been made on the methods employed in De la Beche's time. Six-inch mapping was now usual in all districts where six-inch maps were available; and in England and Scotland six-inch maps of the coalfields were beginning to make their appearance. Memoirs descriptive of Sheets and Quarter-sheets were being regularly published in place of the voluminous regional memoirs of earlier days. With the increase of staff a much better organization of the field work and publication had been introduced and more attention had been given to the training and inspection of the junior members of the service. These changes, however, might be regarded as only the necessary developments to ensure more efficiency in the work. Murchison, in fact, strengthened the Survey in all its departments, and that he originated so little is really a tribute to the admirable design which De la Beche had adopted from the start.

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