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ORIGINAL ARTICLES.

I.—EMINENT LIVING GEOLOGISTS: PROFESSOR CHARLES LAPWORTH,
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(WITH A PORTRAIT, PLATE V.)

CHARLES LAPWORTH was born in 1842 at Faringdon, in Berkshire. Five years afterwards his parents removed to Lower Newton, one of the farms rented by his grandfather. He attended the country school at Buckland village, about two miles off, and the vicar of the parish, the Rev. Joseph Moore, finding him an omnivorous reader, generously lent him books from his own library and practically directed his early education. At the age of 15 he became a pupil teacher in the school, and in the year 1862 entered the Training College at Culham, near Oxford, passing out thence in 1864 with a first-class Government certificate. Of the posts as schoolmaster which were then offered him he selected that connected with the Episcopal Church at Galashiels, because it would give him a home and work in the fascinating borderland of Sir Walter Scott. This post he retained for eleven years, and was married in 1869 to the daughter of Mr. Walter Sanderson.

His holidays were spent in wandering over the Border region, and in the year 1869, in company with his friend Mr. James Wilson, he began the study of the geology of the district round the town, zest being given to the work by the discovery of fossils in rocks which had hitherto been considered barren. His first paper, "On the Silurian Rocks of Galashiels," was read before the Geological Society of Edinburgh in 1870, and was published by that Society and in the pages of the GEOLOGICAL MAGAZINE. While at Galashiels he wrote his paper "On an Improved Classification of the Rhabdophora" (1873).

In 1875 he was appointed to one of the assistant masterships in the Madras College, St. Andrews, and from that year until 1881 he continued to teach subjects which, though not absolutely uncongenial to him, gave little or no scope for scientific teaching or scientific methods. But the post afforded much that he wanted, longer holiday-time for research, greater leisure for reading, and, above all, frequent association with such friends as Nicholson and the literary

and scientific men of the place. His holidays were spent in continuing his work on the stratigraphy and fossils of the Scottish Uplands. Here he wrote his papers on the Moffat Series, the Scottish *Monograptidæ*, the Distribution of the *Rhabdophora*, and others.

But in 1881 came a welcome change, and he was able to throw his entire energy into science, scientific teaching, and geology. His researches and papers had by this time made his name familiar to workers in the older fossiliferous rocks, and, backed by many of the most famous British and foreign geologists of the day, he applied for, and was elected to fill, the newly established Chair of Geology and Mineralogy at the Mason College, Birmingham, his title being afterwards modified at his own request to Professor of Geology and Physiography. He at once plunged into the teaching work of his Chair, but the greater leisure and opportunities the post afforded allowed him to complete and publish his Girvan paper, to carry out serious field-work in the Highlands of Scotland, to make discoveries in the Midland district, and, later on, to begin that work in the Ordovician districts of Shropshire which was to lead him down, stage by stage, to the uttermost depths of the Longmyndian rocks. As the years have gone on he has practically devoted all his energies to geological and geographical work—not only as a teacher, investigator, and writer, but as outside lecturer, textbook writer, university examiner, scientific adviser, and in the other multifarious obligations which appertain to the Geological Professor of modern days.

Lapworth was elected a Fellow of the Geological Society of London in 1872, was awarded the Murchison Fund in 1878, the Lyell Fund in 1882 and 1884, the Bigsby Gold Medal in 1887, the Wollaston Medal in 1899, and went on to the Council of the Society in 1894. The honorary degree of LL.D. was conferred on him by the University of Aberdeen in 1884. In 1888 he was elected a Fellow of the Royal Society, receiving a Royal Medal in 1891, and serving on the Council in 1895–1896. He has acted as examiner in Geology to the Universities of Oxford, Cambridge, London, Victoria, and Wales, was President of the Geological Section of the British Association in 1892, is an honorary member of the Geologists' Association and other scientific societies at home and abroad, and is now President of the Geological Society of Glasgow.

In considering the general scope of Professor Lapworth's work and the bearing of its results, it will be well to divide it into four branches, Field Geology, Geology in the Laboratory and Study, Teaching, and Applied Geology.

1. *Work in the Field.*

The development of the geology of the Southern Uplands may be said to form the keynote of Lapworth's field-work. The stratigraphy of highly complicated districts had already been frequently studied in outline; and in mountain districts it had been pointed out again and again that the apparent sequence was not to be trusted. But the detailed unravelling of such districts had been seldom attempted

with any success. It is well known that previous to Lapworth's researches the Silurian rocks of the Southern Uplands had been considered to be a normal ascending sequence of greywackés, of enormous thickness, interrupted by occasional thin seams of black, graptolitic shale. As the graptolite fauna of each shale mass was broadly the same as that of every other mass, it was naturally considered that the Upland series had been rapidly deposited, without any important organic change taking place from base to summit; and that, consequently, graptolites were of no use for zone work. Important negative conclusions in the matter of evolution followed as a corollary.

One of the first things that made Lapworth suspect that things were not as they seemed was, that graptolites of highly divergent types, though found near together, were never met with on the same slab of rock; and this was followed by the discovery that there was always a difference, sometimes generic and always specific, in the faunas of contiguous and successive bands in each shale mass.

When he had discovered that on proceeding downwards from the greywacké of Dobb's Linn a definite sequence of graptolites was met with down to a certain point, he hit upon the important fact that a corresponding and practically identical sequence was met with also, but in inverted order, in descending beyond this point until greywackés were again reached. It is said that, on first suspecting this, Lapworth rushed into the field and, reaching Dobb's Linn in the twilight, he rapidly collected one series of graptolites in descending to the critical point which he placed in his right-hand pockets, and another in descending below it which he put in the left-hand pockets; he then carried both series off to his lodgings to compare in the lamplight. The comparison verified his hypothesis, and he now held the proof that in this locality, at all events, half the rock succession was inverted. Indeed, he had got hold of the right end of the clue which subsequently enabled him to unravel the complicated stratigraphy of the region. To this task he now devoted his spare time for seven or eight years, nor did he stop until he had followed the divisions of the Moffat Shale from sea to sea, mapping the critical areas in great detail, sometimes on the 6 inch scale, but in most instances surveying and constructing his own larger scale maps of the special localities, in which he could insert the zones as they occurred in the field. At the same time he acquired the large collection of graptolites necessary to verify his conclusions and complete his knowledge of the fauna.

Although probably himself satisfied that the hypothesis of a chronological sequence of graptolite zones, which worked so well in elucidating the complicated structure of the Moffat region, must be in the main a correct one for the Uplands generally, Lapworth proceeded to apply the severest test that he could think of to his conclusions. For that purpose he selected next the Girvan area, where the rocks have a different facies and graptolite-bearing seams are rare or subordinate, but where it was already known that there is a vast array of other Silurian fossils and very

great lithological variety in the strata. Here Lapworth found his work much facilitated by the rich collections of fossils already made from this district by Mrs. Robert Gray, and he was free to devote himself to working out the stratigraphy and collecting graptolites. The outcome of the stratigraphical work on the Girvan succession was published in a paper to the Geological Society in 1882, but the publication of some of the broader structural questions connected with the surrounding area and the Uplands as a whole was deferred for some years, and was then published as a paper on the Ballantrae Rocks in the *GEOLOGICAL MAGAZINE* in 1889.

It is needless to say that the Girvan work entirely confirmed that of Moffat in all particulars. The succession of rocks in the new area, although more than twenty times the thickness, was found to tally with that of Moffat, the chronological order of the fossils common to the two areas agreed, the succession of physical changes was coincident, and the type of structure indicated that Moffat and Girvan were parts of the same grand region of deposition and of the same great system of earth-movement. It is characteristic of Lapworth, however, that not one of these coincidences is so much as hinted at in his first Girvan paper. The local facts were described and the local inferences drawn, but the reader was left to compare the Girvan and Moffat phenomena, and to draw from them the inevitable conclusions for himself.

Needless also to remind readers of the *GEOLOGICAL MAGAZINE* that the officers of the Geological Survey, unhampered in their methods and possessed of detailed maps to work with, have in the course of time entirely confirmed Lapworth's conclusions in the two areas, and, by adopting the zonal method which he initiated with such success, they have been able in some particulars to advance beyond his original conclusions. The great Survey Memoir on the Scottish Uplands is not only the record of a fine piece of survey work, but a monument to the genius of the man who made it possible.

This Upland work, together with its demonstration of the value of the graptolite as a zone index, brought Lapworth into conflict with the views of many of the established authorities of the time. Particularly was this the case with the veteran Barrande, whose well-known theory of 'Colonies' had been founded to get over difficulties almost precisely similar to those which existed in South Scotland. Barrande devoted his final "Defense des Colonies, No. 5," to the matter, but, far from subscribing to Lapworth's views, he maintained the validity of his colonies and even named a new one after his antagonist. But, neither on this nor on any other occasion, has Lapworth turned aside from his course to indulge in controversy; he has simply gone straight on with his work.

Having demonstrated that the Southern Uplands were the relic of a wide area of orogenic movement, Lapworth was next naturally drawn to a region in which earth-movement had had even greater play than in the Uplands. The experience already gained would constitute the basis of his researches and enable him to get over preliminary difficulties, while he would learn the effects of a much

more complicated movement, carried on through a longer period, over a greater area, and to a higher degree than in the south. Hence he started work in 1882 in the Durness-Eriboll district of the Scottish Highlands, working after the same model as before, by selecting definite bands of rock, zoning them, and running them as clues through the complex. Here, however, fossils ceased to be the guide, and it was only by noticing lithological differences that the selected strata could be individualized and recognized from point to point. These were mapped in detail, as before, in order to bring out the structure. In a short time Lapworth had ascertained the true succession amongst the unaltered rock-formations, and made out enough of the tectonic facts to destroy once for all the old idea of an upward succession into the so-called 'newer gneiss.' The structure was of Alpine character, and "the stratigraphical phenomena identical with those developed by Rogers, Suess, Heim, and Brögger in extra-British mountain regions." These results were published in 1883 in the earlier pages of "The Secret of the Highlands." In the later pages he introduced, summarized, and discussed the phenomena and principles of mountain structure developed in Heim's great work on "Gebirgsbildung," in preparation for the understanding of the higher stages of the Highland work. Corresponding stratigraphical results had been simultaneously obtained by Callaway in the Assynt district, and the Geological Survey began their mapping of the North-West Highlands. The Surveyors followed the zonal method, obtained the same non-metamorphic succession, and in the course of a few years not only demonstrated the Alpine structure of the region, but proved the existence of some of the grandest and most important phenomena known to the world of geology. It is to be hoped that at no distant date we may see in a Survey Memoir on the Highlands a worthy companion volume to the great Upland Memoir.

Lapworth returned to the Highlands in the following Summer, but the plain living and hard thinking brought on a serious illness which prevented him from writing further on the tectonic side of the subject. But not before he had reached conclusions on dynamic metamorphism somewhat similar to those arrived at on other grounds by Lossen in the Harz and Lehmann in the Erzgebirge. These views were summarized in a short paper published by the Geologists' Association (1885), and more fully developed later on in his edition of Page's "Introduction to Geology" and elsewhere.

When Professor Lapworth went to Birmingham it was thought that the fossiliferous Llandovery rocks of the Lickey Hills were the oldest rocks in the Central Midlands. But in the year 1882, aware that the earlier geologists had paralleled the quartzites of Nuneaton and the Lickey with those of the Wrekin and Caradoc, which had later on been shown by Callaway to be at least older than the Upper Cambrian, he suggested that these rocks were probably the outstanding parts of a buried land surface older than the Silurian. In less than a month actual proofs of this view were discovered at the Lickey by Mr. F. T. S. Houghton and by Lapworth himself.

The same year Lapworth and Mr. Jerome Harrison proved that the rocks of Nuneaton, Hartshill, and Atherstone, instead of being Coal-measures and Millstone Grit as laid down on the published maps, were also parts of this buried land and of Cambrian age. This was established by Lapworth's finding of Cambrian fossils in the shales of Stockingford, above the Quartzite, and volcanic rocks of Uriconian type underneath it. These discoveries, of course, demanded fresh maps of the districts implicated; in 1886 the officers of the Survey came down, satisfied themselves as to their correctness in the Nuneaton district, and brought out new editions of their maps in order to include them. In 1898 the same thing was done for the Lickey Hills, the official surveyor being on this occasion an old student of Lapworth's, trained by him on those very hills. The more crucial parts of both these districts had already been mapped in detail by Professor Lapworth, sometimes in company with his students.

The further discovery of calcareous beds in the upper part of the Nuneaton Quartzite, by Dr. T. Stacey Wilson, led to the searching of the rocks for fossils along this line of country by Professor Lapworth, and the discovery of a bed of limestone bearing *Hyalites* and other fossils characteristic of the lowest fossiliferous Cambrian or Etcheminian horizons of America and elsewhere (1897).

In 1886 work was begun in the Shelve district of Shropshire, and in the course of two or three years the sequence was made out and compared with that of South Scotland, North Wales, and Scandinavia (1887, 1894). In later years the more detailed mapping of the greater part of that area has elucidated its structure, while at the same time the more complicated Caradoc region on the east of the Longmynd has been studied. Failing to find in that district a satisfactory base to the Ordovician System, the Cambrian rocks were next dealt with, the first outcome being the discovery of *Olenellus* and its accompanying fauna at the top of the basal Shropshire Quartzite (1888). This discovery resulted directly in the finding of the equivalent of the *Olenellus* Limestone at Nuneaton, and indirectly in the finding of *Olenellus* in the 'Fucoid Beds' of North Scotland. Thus a definite Lower Cambrian horizon became marked out over a large area, and the base of the Cambrian System was drawn at the bottom of the Quartzite.

It was, however, soon found impossible to complete the study of the Lower Palæozoic sequence of this region without mapping the underlying floor of Dr. Callaway's Uriconian and Longmyndian rocks and working out the sequence and structure of the Harlech anticline, which has been more or less completed by Lapworth and his friend Dr. Stacey Wilson.

This bald enumeration of thirty-three years' field-work naturally leads to a brief consideration of the causes which have contributed to its success. The principal reasons appear to the writer to be the following:—(1) Careful mapping on lines similar to those adopted by the Geological Survey, but usually in greater detail; the difficult areas being done on as large a scale as possible, and

the crucial points visited many times over until their structure has become quite clear. To this class of work Lapworth was naturally drawn by his early interest in physical geography, when he was always seeking to explain the causes underlying observed phenomena. His untiring industry, actuated by what has been called 'a genius for stratigraphy' and a good eye for a country, filled even the dullest routine work with interest. (2) The observation of minute lithological changes whether in a vertical or a lateral direction. (3) The zonal collection and identification of fossils from every band which yields them. (4) The capacity to 'see solid' into a map so that a complete picture of the solid structure is constantly present before the mind. (5) The careful thinking out of the bearing of facts observed and entered on the maps in the light of many possible theoretical explanations, until a consistent hypothesis is hit upon by the method of trial and error. (6) But, above all, the power to realize vividly the conditions which might have given rise to the observed phenomena; so that in imagination he sees them at work and studies their results. It has been said more than once that it is of no use to contradict Lapworth when he has made up his mind on a geological question, "because he was there when the rocks were made."

2. Work in the Laboratory and Study.

Lapworth's investigations on the graptolites must be regarded as the outcome of his work in the Uplands, for from this region he collected and worked through hosts of these fossils, the difficulty of satisfactorily identifying species causing him to save all specimens which might lead to unmistakeable identification or throw light on the life-history of these extinct hydrozoa. At the time he began the study the classification of the graptolites in general use was in almost as unsatisfactory a state as the grouping of the rocks, and the two studies had to be carried on concurrently. But while this increased the labour it intensified the interest, and directed attention to points which might otherwise have been overlooked. The graptolites, among which excellent work was also being done by Hopkinson and Nicholson, soon began to sort themselves out; the rock-formations resisted much longer. Lapworth's study and comparison of his own collection, with those already made in other parts of the world, gave rise to his paper "On an Improved Classification of the Rhabdophora," which was published in 1873, and has since been either accepted as the standard to which graptolites are referred, or has formed the basis upon which the newer provisional classifications are founded. Having acquired a profound belief in the value of graptolite species for zone work, he took every opportunity for several years to collect specimens not only in Scotland but in Wales and Ireland, and of studying the works and collections of others, thus accumulating a vast amount of material for his invaluable treatise on "The Geological Distribution of the Rhabdophora" (1879-80), in which for the first time not only are graptolite zones established over Britain, but the distribution of the zones and their contents all over

the world, so far as was then possible, was analysed, tabulated, and described, and the inference established that the graptolite was as reliable as the ammonite for a working stratigraphical index.

Some years elapsed before these conclusions were accepted in their entirety, except by his friends and fellow-workers in Scandinavia, but gradually his methods were taken up by first one and then another of the younger men in Britain and abroad, until, eventually, students of Palæozoic rocks in all parts were sending Lapworth graptolites for identification, and numerous papers and appendices to papers, containing descriptions of new species and identifications of old ones, were published (1875, 1877, 1881). St. David's, County Down, Central Wales, and many other British districts soon yielded graptolites in sufficient quantity to enable the rock-horizons to be ascertained, and though the results sometimes conflicted with the apparent stratigraphy, that was only so much the worse for appearances and so much the better for facts. From foreign countries and from the Colonies specimens came in for identification and as tests of the mapping. Led insensibly thereto by their own discoveries, palæontologists fell into the habit of similarly classifying their fossils and employing them zonally, so that now the despised graptolite of thirty years ago has become universally accepted as the guide to the zonal order of the older fossiliferous rocks.

The Upland work demonstrated that graptolites had not been standing still while all the Silurian rocks were being deposited, but that there had been continual variation, modification, and evolution. This, with the material subsequently accumulated, bearing on the life-history and habitats of the group and the probable causes to which their evolution was due, enabled Professor Lapworth to contribute to a paper by Walther an important communication on the "Mode of Life of the Graptolites" (1897), in which he advanced the theory that whilst the earliest and dendroid graptolites stood upright in shallow shore water, the later and more typical forms (*Rhabdophora*) hung suspended from floating sargasso-like seaweeds, so that they were drifted over the sea-waters as 'pseudo-plankton' by currents, and their skeletons thus distributed more or less all over the sea-bed. This gave origin to the wide distribution of graptolite zones, and also, in all probability, was the actuating cause of the morphological evolution of the families and genera of *Rhabdophora*, as well as the explanation of their abundance in black carbonaceous shales.

Later on Dr. Lapworth undertook the task of describing the British graptolites for the Palæontographical Society, and devoted a large amount of time to the correct drawing and illustrating of the fossils. Numerous experiments in the reproduction of illustrations were tried and are still being tried, and a new form of microscope (the Lapworth-Parkes) was worked out, by which even large specimens can be drawn in great detail, and under such conditions of lighting that no important point of structure is omitted, the main purpose being to present the object as like nature as possible without

any interposition of the personality of the artist. The large-scale drawings are afterwards reduced by means of photography to the natural size of the fossil. The monograph is now being written and illustrated jointly by Miss Elles and Miss Wood under Dr. Lapworth's editorship.

A rapid reader, with the faculty of quickly 'tearing the heart out of a book,' of 'spotting' mistakes into which a writer may have fallen, and of seeing the importance of an author's facts even when his interpretation is wrong, Lapworth goes to his work, whether in the field or the study, with a clear view of the problems to be faced and a knowledge of the crucial points for testing hypotheses, of which he has generally plenty on hand ready for immediate use. Thus it often happens that the main points in a research are settled in a few days, but, meanwhile, a host of new problems have arisen, and for their solution it is necessary to work out the district thoroughly. As Professor Marcel Bertrand pertinently puts it, Lapworth's widest results have been often arrived at "*à l'aide de ces outils qu'il a forgés lui-même et que d'autres eussent dédaignés.*" This, coupled with a keen zest for outdoor work, which carries him out into the field on every fine day and most wet ones if they happen to be Saturdays or in holiday-time, accounts for the large amount of single-handed field-work that he has accomplished. His own explanation is, that it is simply the natural outcome of a childhood spent among books in lieu of companions, of a manhood blessed by the constant encouragement and aid of his friends, and of almost a lifetime passed in the sympathy of his pupils.

The keenness in understanding and appreciating the work of others, which led Lapworth to abstract parts of Heim's Alpine treatise in order to show that there was nothing new in the principles employed in his own Highland work except their application to that district, and which is further exemplified in his appreciative memoirs of his early scientific friends Linnarsson, Nicholson, and Crosskey, is accompanied by a vivid imagination which enables him to visualize accurately the subjects on which he reads, a power of recognizing connecting links between severed lines of enquiry, and a faculty for picking out those exceptions to laws which indicate the existence of some greater law including the less.

In his two papers "*On the Tripartite Classification of the Older Palæozoic Rocks*" (1879) and "*The Close of the Highland Controversy*" (1885) we see Lapworth in another light. In these tactful endeavours to still controversy, neither of them fruitless, we see such a grip of the subjects dealt with as to indicate complete mastery of the literature, independent thought, extreme care and skill in the presentation of conclusions and suggestions, and just that gentle suspicion of the authority which his own work on the subjects dealt with entitled him to assert. In each case Lapworth brought out the best points in the discoveries of the rival pioneers, and showed that of such points those which were vital were generally the common property of the rivals and their schools; but he indicated most firmly that past

history and dead controversy must never be allowed to clog the wheels of progress. In both cases the old men had built a firm platform on which the new men were standing ready for the next rush forward; they should not be too much concerned about the building of that platform when once they are convinced about its soundness, nor must they spend all their time quarrelling as to how its parts were first put together. The great thing for them is to make the next advance and to see that it is unhampered by questions of authority or nomenclature. It is largely due to the moderate tone of these papers that the Highland question is now no more, and that the term 'Ordovician' has been adopted nearly all over the world.

The appointment of Professor Lapworth to the presidency of the Geological Section of the British Association at Edinburgh in 1892 necessitated the preparation of an address, and gave him the opportunity of welding together his researches and theories in geology and geography by dealing with the rock-fold, the 'wedding-ring' of the two sciences. After treating of the physical and geological aspects of the structure he passed on to apply it to the making of mountains and continents, and to connect it with the form and structure of the earth itself. Further developments of this subject in time and space were communicated to the Geologists' Association and the Royal Geographical Society respectively, and have been treated of in college and other lectures on tectonic geology.

As Lapworth's South Scottish work came into contact with and made Barrande's theory of 'Colonies' untenable, so his views on the effects of mountain movement conflicted with Richthofen's beautiful theory of the coral-reef origin of the limestone masses of the Dolomites. A paper on the Dolomite country by Miss Ogilvie (Mrs. Gordon) was read before Baron von Richthofen, who was present at the Edinburgh meeting, and Lapworth, who had long considered the matter, although he had never visited the ground, took the opportunity of stating his belief that the so-called reef structures were the result of crust-deformation and not of original deposition, and that the associated igneous rocks belonged to the period of movement. The work and conclusions of Miss Ogilvie on this Dolomite region are familiar to tectonic geologists.

But although the results of Lapworth's work have conflicted with some of the grandest geological hypotheses of his time, there is probably no other geologist who employs theory as a working tool to a greater extent in his own research, in teaching, and in prompting investigation and discovery in others, or who so instinctively relies upon the scientific use of the imagination. In his favourite 'fold theory,' 'reciprocal' or 'antilogous' theory of deformation, the rock-fold, made up of two homologous and balanced parts, the one positive and the other negative ('antilogues'), is made to do duty as the archetype, and this type, so characteristic of more or less flexible sheets, is traced in the one direction into the wave-shape of fluids, and in the other direction into the fractures and faults of solid bodies. The fold-line or zero line is identified with the elastic

curve, and the fold-shape is regarded as recognizable in all three dimensions and in all gradations of size. When we hear the applications of this theory employed by Lapworth to account for the land and water hemispheres of the globe, the shapes and trends of all crust movements, and hosts of other geological phenomena, we are fascinated with the manner in which the countless facts fall into apparent order and relationship, and for the time are almost willing to accept his sanguine view that "this twisted plate unlocks the whole treasure-house of the new geology." But we confess, all the same, to a feeling of profound satisfaction when its employer asserts that it must be regarded in the meantime as a working hypothesis, a symbolical expression of facts, rather as a means of grouping than of explaining phenomena, until such time as its assumptions and illustrations have been more fully identified with the every-day results and conclusions of the physicist.

How interesting and stimulating is Lapworth's habit of employing some striking theory and stringing upon it crowds of associated facts, those who attended the Shropshire excursion in 1894 will remember, who heard him describe the effects of the rolling in of the Caledonian crust-creep from the north-west upon the Ordovician region, already folded to the north and south, and how the location of the laccolites and other igneous injections in particular parts of the wrinkles was thus determined; or those who joined the long excursion to Birmingham in 1898, and heard the physiography of the middle valley of the Severn explained as the result of the enforced irruption of the original upper Dee in early Glacial times, or the relations of the Triassic and Palæozoic rock of the Midlands pictured as those of a rugged mountain region slowly buried under a sea of desert-sand and marl. In the same way his advanced students are led to store up and correlate countless facts in their memory by their natural harmony with some all-embracing theory, such, for example, as the explanation of the tectonics, lithology, and palæontology of the Palæozoic rocks on the theory of the developmental history of an ancient festoon island region like that of Eastern Asia, or the explanation of the phenomena of the Carboniferous rocks by the struggle for supremacy between the Caledonian and the Armorican crust-creeps. But these theories are always regarded as servants and not masters, merely provisional approximations to the truth.

3. *Teaching Work.*

For twenty years Lapworth has been sending into the world a stream of geologists, many of them equipped, not only with knowledge of their subject, but with enthusiasm and capacity for original work in it. He has watched the Mason Science College grow into the Mason University College, and that again into the University of Birmingham, and has taken an active part in each step of the advance. While he does not disdain to drill his students and drum into them by question and answer the points he wishes them to get hold of, he is rarely content in his lectures with the mere imparting

of information, but almost invariably he happens upon points which rouse genuine interest. His department not only covers so much of Geology as can be crammed into the limited time allotted to the study, but he has started and maintained large classes in Geography, dwelling particularly on those parts of the study which admit of scientific treatment. Indeed, these classes, the bearing of the Edinburgh address, and the bias of much of his own research, are all symptoms of his attitude towards the sister science, regarding Geology as the Geography of the past, and Geography as the Geology of the present. He has aroused a widespread local interest in Geology by delivering afternoon and evening lectures of a more popular but still systematic character, by holding weekly excursions during the Summer, and by delivering occasional lectures in the neighbouring towns. Amongst the characteristic features of his teaching may be mentioned the classes on structural and field geology, his economic courses, and his research classes. His classes on structural geology learn the principles which guide the field geologist's work, and his practical class spends a term in the actual mapping of a Midland district on the six-inch scale, with the accompanying office-work. One or more workers are generally to be found in the research department engaged upon graptolites, trilobites, brachiopods, rock-specimens, or other material collected in the field. In order that he may have a larger amount of time to devote to investigation and to those portions of his teaching which may be regarded as special to himself, the lovers of science in the city and district have provided him with an assistant-professor to take the rest of his College teaching.

For many years a Geological Section of the Birmingham Natural History and Philosophical Society has met in his rooms in the Mason College. The largest contributor of papers and subjects for discussion has been the Professor himself, but the first drafts of many papers afterwards contributed to the greater learned societies have often been read and discussed by his students in that Section.

By conducting long excursions for the Geologists' Association, the British Association, and other bodies, into districts with which he was especially familiar, by publishing papers and guidebooks descriptive of the regions to be studied, and by his textbooks on geology and physical geography, his teaching has reached a wider circle.

But more far-reaching still has been his influence amongst specialists. The zonal and graptolite work has been taken up by many observers in similar lines of research, not only in Britain, but all over the world, in Scandinavia, Bohemia, France, Canada, and the United States. The value of his advice and assistance has been felt again and again by scientific investigators. His faculty for picking out exceptional facts, the patience which enables him to listen to a long and detailed account of a research, the avidity with which he seizes on those points which fit in with or run counter to his own theories, his delight in each bit of new discovery, and, above all, his encouraging sympathy and the generous manner in which he gives his own ideas and principles in the hope that they

may bear fresh fruit in new soil, all make him an ideal confidant; for to him there is nothing that is "common or unclean," each branch of research has its separate value, and he has the faculty of giving those who consult him the impression that their work forms a part of some greater whole; there is nothing more encouraging to a young man than to find that what he had perhaps considered an isolated line of enquiry is really linked up with the advance of science as a whole.

Although it comes rather under the head of administrative than educative work, it may be here mentioned that Lapworth's intense belief in the practical and educational value of geology has led him to advocate the teaching of the economic side of the science, not only to miners, prospectors, and engineers, but to those engaged in building, surveying, brewing, and sanitary business, and of the pure science to those who are never likely to make any practical use of it except as a means of enlarging their knowledge of nature.

Throughout a good deal of friendly antagonism to the Geological Survey he has always retained the personal friendship of its Officers and strenuously maintained the vital importance of that institution to the country; and acting recently on a Departmental Enquiry into the functions and work of the Survey he has taken his share in remodelling its scope and administration.

4. Applied Geology.

During his residence in Birmingham Lapworth has been frequently consulted in matters relating to such subjects as sites, water, and minerals. In this way he has had means of acquiring a vast amount of information, otherwise inaccessible, relating to the structure of the Midland coalfields and their surrounding areas. Indeed, it may be said that one of his main inducements to undertake this class of work has been in order to enrich his knowledge of a branch of science which is practically untouched by the learned societies and the textbooks. The complicated geology of the Midlands, a rugged region covered unconformably by Coal-measures and in most places buried up unconformably by New Red Sandstone, gives rise to a series of difficult problems, each of which must be the subject of a special investigation involving scientific methods, the careful mapping of areas, and the disentangling of the involved structure of difficult districts. In the Midland region, at least, it has become abundantly clear that the most complicated questions of stratigraphy, vulcanicity, and palæontology, all have an eventual, if not an immediate, application to the economic side of the subject; and that there is probably no problem in pure geology that will not in the end have its bearing on applied geology.

In conclusion, one would like, were it permitted, to say a word of the man apart from the geologist. But, after all, is it necessary? His personality is so well known, his influence so wide, his geniality and kindness of heart so patent to his friends, that it is quite needless to refer to them; and his enemies have yet to be discovered.

Opponents and antagonists there have been in plenty, but it is in their ranks that we find many of those who respect Lapworth most, whilst not a few of them have become his warmest friends.

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