THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. IX. — SEPTEMBER, 1905.

ORIGINAL ARTICLES.

I.—EMINENT LIVING GEOLOGISTS:

JOHN WESLEY JUDD, C.B., LL.D., F.R.S., F.G.S.

(WITH A PORTRAIT, PLATE XXI.)

JOHN WESLEY JUDD was born at Portsmouth February 18th, 1840. His father belonged to a branch of an old Kentish family that had been settled for several generations in the Isle of Wight. His mother was the daughter of a Scotchman who had "come South" from the ancient kingdom of Fife. The Christian name given to the subject of this sketch was the result of an attempt on the part of his parents to find a compromise between the two national religions in which they had been respectively brought up.

As a boy Judd showed a strong predilection for the study of science. His interest was first directed to astronomy, and having made a telescope with cardboard tubes for himself, he spent many of the night hours in observing celestial objects; this pursuit led him to devote much of his time to mathematical studies. At a later date, however, geology began to attract his attention, and the reading of Lyell's "Principles of Geology" appears to have determined his devotion to that science.

When only 4 years old the lad lost his mother, and before he reached the age of 8 his father removed to London, having received an appointment at Somerset House. The boy's school life, which had commenced at Portsmouth, was continued at Camberwell, and when the time for leaving school arrived his fondness for study led him to adopt the teaching profession. In 1858 he entered a training college at Westminster, but in the following year an opportunity seemed to present itself for taking up more purely scientific work than lies in the way of an elementary teacher. The newly-formed Department of Science and Art instituted in 1859 an experiment in the direction of securing teachers of science by awarding certificates as the result of examination. Judd entered for these examinations in the subjects of geology and mineralogy, and obtained first-class certificates entitling him to teach these sciences. Unfortunately, however, the demand at that time for scientific instruction was too

limited to justify the enterprise on the part of the Science and Art Department, and it was soon abandoned. Judd, after some futile attempts to obtain employment as a teacher of science, resigned himself to the work of general elementary teaching and became master of a school at Horncastle in Lincolnshire. Here, however, he spent all his spare time in scientific studies, devoting the greater part of his nights to work in a small chemical laboratory which he had fitted up in his house. His holidays during three years' residence in Lincolnshire were spent in rambling about the county and making himself acquainted with its geological features.

Although the examination for the teachership in science led to no direct practical result, yet it proved the turning-point in Judd's career by introducing him to the notice of the two examiners—his subsequent friends and colleagues, Professor (afterwards Sir Andrew) Ramsay and Mr. (afterwards Sir Warrington) Smyth. These geologists, after the perusal of the young candidate's papers, both communicated with him, giving him warm encouragement and offering their assistance if he came to the Royal School of Mines to continue his studies.

It was not, however, till the beginning of 1863 that Judd found himself able to accept the invitation. He then entered the Jermyn Street School by passing the examinations of the first two years with the object of taking the courses of the third year. It was, however, possible at that time to attend all the series of lectures during one year, and very gladly he availed himself of the opportunity of listening to the discourses of Hofmann, Tyndall, Huxley, Ramsay, Smyth, Percy, and Willis, as well as to occasional lectures by Owen, Jukes, and others. At the end of the third year Judd, instead of sitting for the Associateship, became a candidate for one of the newly instituted Royal Exhibitions. This he did in the hope of being able to spend three years in higher studies and research. But on winning the exhibition he found that no arrangements could be made, within the circumscribed limits of the Jermyn Street building, for such advanced work, and he somewhat reluctantly accepted an offer to become analytical chemist in the iron and steel works of Messrs. Cammell & Co. at Sheffield.

The residence of Judd at Sheffield, though limited to less than a year, exercised a very important influence upon his future career, for it was there that he formed the acquaintanceship of Henry Clifton Sorby, who became his lifelong friend. Mr. Sorby taught him to make thin sections of rocks, and fully impressed upon him the value of this method of research. This was in the year 1864—a period when the microscopic study of rocks had attracted but little attention either in this country or abroad. The residence at Sheffield was brought to a sudden end by a railway accident in which Judd nearly lost his life.

After many months of confinement to a sick bed, Judd was ordered by the doctors to abstain from settled employment for some years, and he gladly availed himself of the opportunity to return to Lincolnshire and devote an out-of-door life to continuing the

geological studies of the county which he had already commenced. The result of these labours was seen in two noteworthy additions to geological knowledge. In the first place, he was able to show that the strata which form the base of the Lincolnshire Wolds—which had been vaguely referred either to the Jurassic or the Lower Greensand—are really representatives of the Neocomian of the Continent, and an examination of the Speeton Clay of Yorkshire proved that all the zones shown to exist in Lincolnshire are present there also under different mineral conditions. In the second place, a study of the fossils in the great belt of oolitic limestones running north and south through the county of Lincoln, and continued southwards into the Midlands and northward into the East Riding of Yorkshire, demonstrated that these rocks are of *Inferior Oolite* age, and not Great Oolite, as had hitherto been supposed. His work in Lincolnshire was varied by trips to the Continent, where, with knapsack on back, he visited and studied the various equivalents of the Lincolnshire strata.

Among those who were specially interested in the results of this work was the amiable Oxford professor, John Phillips. Phillips made the suggestion that Judd should complete a geological map and memoir on Lincolnshire, as he had himself done for Yorkshire. But, on the other hand, Professor Ramsay urged Judd to accept a temporary post on the Geological Survey, promising him the opportunity of surveying the districts south of Lincolnshire, where his previous experience would be of special use. He accordingly joined the Survey in 1867, and for four years was engaged in the survey of Rutland and parts of the adjoining counties. The result of this work was to demonstrate the necessity of a revision of the whole of the Lower Oolites of the Midland districts as far south as Oxfordshire and Gloucestershire. Over the whole of this area the rocks hitherto mapped as Great Oolite were re-mapped as "Lincolnshire Limestone" and "Northampton Sand," and placed in the Inferior Oolite, while the limits and divisions of the true Great Oolite were defined. During this period Judd was able to apply the methods which had been taught him by Sorby to the investigation of the nature and origin of the ferruginous rocks of the Northampton Sand. His paper on the subject, containing a full discussion of the microscopical and chemical characters of the rocks, was read before the Geological Society in March, 1869, but was withdrawn in consequence of a new regulation being made that such papers must appear in the Survey Memoirs. It was at last published, but without figures, in 1875.

A former colleague and fellow-worker on the Geological Survey for many years writes of his work as follows :—

"Professor Judd joined the staff of the Geological Survey in 1867, and was occupied during three years in the county of Rutland and bordering portions of Leicestershire, Lincolnshire, and Northamptonshire, that are included in Sheet 64 of the old series map.

"In the course of his investigations he proved beyond question that the important group of limestones which form 'the cliff' of

Lincolnshire belong to the Inferior Oolite, and not to the Great Oolite as had been generally believed. Much confusion had arisen through the correlation of the Collyweston Slate with the Stonesfield Slate. These and other matters connected with the stratigraphy of the Lower Oolites, and especially with the age and relations of the Northampton Sands, were clearly expounded by Professor Judd. The acceptance of his views necessitated the revision of some of the previously published maps of the Geological Survey, and during the last year (1870–71) he was occupied on the Geological Survey he carried his revisions as far as he was able from the neighbourhood of Northampton into parts of Oxfordshire; but much yet remains to be done in the area near Chipping Norton.

“The description of Sheet 64 was written by Professor Judd in the memoir on ‘The Geology of Rutland,’ etc., issued in 1875 by the Geological Survey. This memoir contained an important Introductory Essay, ‘On the Classification of the Jurassic Strata of the Midland District, and their Correlation with those of the Cotteswold Hills and the North-East of Yorkshire respectively.’ In this essay, as pointed out, some of the views had been foreshadowed in previous writings by Brodie, Lycett, and to a certain extent by Morris, while Samuel Sharp of Northampton and Thomas Beesley of Banbury had concurrently been working on the Lower Oolites in their respective districts, and had been ‘independently led to similar conclusions’ with regard to the Lincolnshire Oolite and Northampton Sand. Nevertheless, the whole subject was dealt with by Professor Judd in a masterly way, and his original observations not only placed the subject on a sound basis but formed the guide to all subsequent workers in the Midland area.”

The special work for which Judd had joined the Survey having been completed, he accepted an offer from his friend Mr. Matthew Arnold, in 1871, to join the Education Department for a time, and to act with him as an Inspector of Returns under the Education Act of 1870. For over a twelvemonth he was engaged in inspecting elementary schools and training colleges in the London area between Westminster and Edmonton. Geology was not, however, entirely neglected during this period, for he had undertaken to furnish the Geological Survey with a memoir on the districts he had surveyed in Rutland, etc., with an essay on the classification of the Lower Jurassic Strata of the Midland district. This work was published in 1875. At this period, too, he was led to pay a considerable amount of attention to the question of the age of the Wealden formation and its relations to the strata above and below it, the Jurassic and Neocomian.

Released from the work of school inspection, Judd returned with zest to geological pursuits. The patches of Jurassic strata in the north-east of Scotland attracted his attention, and, after two years of hard work in the district, he was able to show that these patches of Mesozoic strata owe their preservation to the action of great faults, by which they had been let down among the older and harder rocks. He also, with the aid of Dr. Joass and Dr. Gordon, collected

the fossils of the various beds, and showed the exact age and relations of the whole series from the Trias to the Upper Oolites.

The study of the Mesozoic strata of the east coast of Scotland naturally led to the examination of the equivalent beds in the western coasts and islands, and here Judd, in addition to working out minutely the succession of Jurassic and Triassic rocks, was able to show that interesting representatives of the Carboniferous and Cretaceous systems—the presence of which had been hitherto quite unsuspected—actually occur in these Western Highlands.

The preservation of patches of younger rocks in the west of Scotland, while as in the eastern area partly due to the action of great faults, is to a still greater extent the result of the protection afforded by the vast masses of igneous rocks with which they are associated. Judd's attention was therefore soon directed to the unravelling of the complexities of these rock-masses, and of their relations to the Mesozoic strata. The task was at the time one of great difficulty, for no Ordnance Maps of the district had been published, while the facilities for travelling in the district, especially to a man of small means, were far less than even at the present day.

Macculloch had demonstrated that these igneous rocks are of later date than all the Secondary strata with which they are so closely associated, while Zirkel had proved that among the rocks of Skye true granites and gabbros occur. Other writers, however, had maintained the Jurassic age and a metamorphic origin for these rocks. The result of Judd's work was to establish the fact that between the most perfect granites and gabbros there exists every gradation, to rhyolites and pitchstones on the one hand, and to basalts and tachylytes on the other hand; and thus that the distinction between 'plutonic' and 'volcanic' rocks is a purely artificial one. That all these igneous rocks must be of Tertiary age he proved by showing that they overlie and are intrusive in the youngest Cretaceous strata (Chalk of the Zone of *Belemnitella mucronata*).

As the result of a general survey of the igneous rock-masses, he was able to state that they indicate the existence of five centres of eruptive activity—the sites of great Tertiary volcanoes; and that concerning the dimensions and history of these volcanoes important evidence can be obtained; the extinction of these great volcanoes was shown to have been followed by sporadic outbursts all over the area. He maintained that the general order of succession in the eruption of the igneous materials was from the acid to the more basic varieties.

The results of this work in the Western Isles of Scotland attracted much interest among geologists, and the veterans of the science—Lyell, Darwin, and Scrope—were warm in their praise and kindly in their encouragement and aid. In 1874 Sir Charles Lyell, then nearly blind, invited Judd to spend part of the Summer at his home in Forfarshire and to visit and talk over many of the scenes of the master's early labours, while helping to revise a new edition of the "Elements of Geology." After the death of Lyell,

Darwin used to invite Judd from time to time to meet him and discuss current geological topics. Scrope, at this period too old and infirm to undertake further travels, sent Judd to visit the different volcanic districts of Europe, which he himself knew so well, aiding him the while by conversation and correspondence. Never surely was young geologist so fortunate and happy in securing the friendship and teaching of men like Lyell, Darwin, and Scrope!

As the results of his travels over Europe, Judd published a series of papers under the title of "Contributions to the Study of Volcanoes." He also read before the Geological Society a paper on the ancient volcano of Schemnitz. In his earlier memoirs he had been content to adopt Bunsen's classification of rocks in an Acid and a Basic series. He now, however, showed that such a simple classification was beset with difficulties, and proposed the term "Intermediate" for that extensive class of rocks which could not be conveniently assigned to either of Bunsen's classes. The French geologists, later, adopted the same plan, calling the intermediate rocks "Neutral." At a later date Judd proposed the separation of the smaller group of "Ultrabasic rocks" as a distinct class. His study of the contemporaneous volcanic rocks of Bohemia and Hungary led to the recognition of the fact that a geographical distribution of rocks exists, not less marked than that of animals and plants, and this idea crystallized in the suggestion of the term "petrographical province," which is now so universally adopted. While travelling over the volcanic districts, Judd was able to send to his friend Professor Story Maskelyne large collections of rock-specimens, which were deposited in the Mineral Department of the British Museum.

During his journeys upon the Continent for the purpose of studying the volcanic rocks, Judd never lost sight of the importance of making himself acquainted with the best methods of teaching science. His frequent intercourse with his former teacher and constant friend—Professor Huxley—had led him to recognize the supreme value of practical teaching in science, and, while visiting the various universities and mining schools of the Continent, this point was kept constantly in view. In 1876 the opportunity of taking up the teaching of geology arrived, through the resignation by Sir Andrew Ramsay of the professorship of geology in the Royal School of Mines on his appointment to the Directorship of the Geological Survey. By the unanimous vote of the Council Judd was recommended for the vacant post, and at once entered on its duties.

After lecturing for a year at Jermyn Street, it was found that the impossibility of obtaining laboratory accommodation necessitated the removal of the geological division to South Kensington, to which place most of the other divisions of the school had already been transferred, and in 1881 the sphere of work of the school was enlarged by the creation of the Royal College of Science. Here, with the assistance of Huxley, Judd organized a system of practical teaching in geology, similar to that already established for biology,

and this system during the next twenty-five years was gradually developed with the co-operation of able students, who became his assistants, among whom may be especially mentioned Professor Cole, the late Mr. A. V. Jennings, Dr. W. F. Hume, Mr. T. H. Holland, Dr. Evans, Dr. Cullis, and Professor Skeats.

In 1878 Professor Judd married Jeannie Frances Jeyes, a niece of his old friend and fellow-worker in the geology of the Midlands—S. Sharp, Esq., F.S.A., F.G.S. In 1877 he was elected one of the Secretaries of the Geological Society, and served that office for ten years till he was elected President, during the years 1886 and 1887. He had received the Wollaston Fund in 1868, and in 1891 was awarded the Wollaston Medal.

During nearly thirty years that he has been engaged in teaching, only the Summer vacations have been available for field-work. But in these vacations the igneous rocks of the Western Isles and other parts of Scotland have been examined and the collections made subsequently studied in the laboratory. The results have been published in a series of petrographical memoirs in the *Quarterly Journal of the Geological Society*. Teaching the science with London as a centre, all questions concerning the geology of the London Basin were naturally of special interest to him, and thus he was led to the publication of papers on the geology of the London and Hampshire Basins and the correlation of their strata. With the aid of a pupil, the late Mr. Collett Homersham, he was able to study the materials obtained in a deep boring at Richmond, and to show that there, and also in the deep well at Meux boring in the Tottenham Court Road, richly fossiliferous deposits of Lower Oolite age occur.

One who has known Professor Judd for many years, and is competent to judge of the value of his work as a geologist, writes:—

"The breadth and accuracy of Judd's knowledge is the characteristic which from the first has most impressed me. Trained in youth as a practical chemist, well grounded at the Royal School of Mines in physics and biology, early to appreciate the importance of the microscope in the study of rocks, with his experience in the field as a worker on the staff of the Geological Survey greatly widened by study of some of the most interesting districts on the Continent, he could deal with all sides of a problem, whether petrological, or physical, or palæontological, and he contrived, notwithstanding the incessant demands of educational work in later years, to keep well up to date in the literature of the science. He has made—and this can be said of very few—valuable contributions to all departments of geology, and in proof of this I need only recall papers in the *Mineralogical Magazine*, such as that on Scapolite, those in this periodical on glacial questions and on volcanoes, afterwards developed into his well-known book, those, chiefly in the *Quarterly Journal*, in which he dispelled the fog which obscured our Neocomian deposits, his memoir on the geology of Rutland, and the papers on the west coast of Scotland, which, whether the verdict on one point be ultimately for or against him, will always rank as classic.

In fact, whatever work he has done, whether scientific, educational, or administrative, has always been characterized by a careful observation, a conscientious thoroughness, and an earnest desire to arrive at the truth."

When Professor Huxley retired from his professorship in the Royal College of Science in 1885, he retained the post of Honorary Dean, but many of the duties of the office were undertaken by Professor Judd, who on the death of Huxley in 1895 was made Dean and created a C.B. He was elected a Fellow of the Royal Society in 1877, and has served twice for periods of two years each on the Council, acting as a Vice-President of the Society in 1902 and 1903. In 1887 he was President of the Geological Section of the British Association at the Aberdeen meeting, and some years subsequently had the honorary degree of LL.D. conferred upon him by the University of that city. He has acted for a considerable time as Chairman of the Seismological Committees both of the British Association and the Royal Society, and is Foreign Secretary of the Mineralogical Society.

While educational, official, and other duties have necessarily limited his opportunities for research during recent years, he has found time for study of materials obtained by boring in the Nile Delta, for work upon the products of the great eruption at Krakatoa, on the rocks brought home from the Ruby district of Burma by Mr. C. Barrington Brown, and especially on the cores and other specimens obtained in the boring in the Coral-reef of Funafuti. Various incidental questions like those of the nature of Sarsens, the materials employed in the building of Stonehenge, the nature of the rocks forming Rockall, with problems arising out of the study of rock-forming minerals, have engaged his attention and formed the subject of numerous papers. Of larger works for students he has written a revised edition of Lyell's *Elements* under the name of "The Student's Lyell"; "Volcanoes: What they are and what they Teach"; a translation, with introductory notice, of Behren's "Microchemical Analysis"; and critical introductions to Darwin's geological books, one of these having been translated into French by his old friend Professor Renard.

From the teaching work, which has occupied so much of his time and energies during nearly thirty years, Mr. Judd has now just retired, having reached the age limit. Many hundreds of his students now occupy important teaching posts or are engaged in the geological surveys of our own country, the Colonies, India, and Egypt, while still more are engaged in mining and metallurgical work in all parts of the globe.

One of his old Assistants who knows his methods of teaching, and has gone through the work of the Royal College of Science with him, writes:—

"As a teacher of geology Professor Judd holds a position of the highest distinction. The courses of instruction designed and gradually evolved by him have long been regarded as among the most perfect and complete of their kind. He was one of the very

first to introduce into the academic curriculum systematic practical instruction in the subject, and of the many excellent courses in geology now open to students in various parts of the world, not a few are based, wholly or in part, upon the methods originated by him and carried out so ably and for so many years in the Royal College of Science.

"Throughout his career as a teacher of science Professor Judd has been an enthusiastic advocate of the system employed in the Royal College of Science of enabling the student to concentrate his whole attention upon one subject at a time, instead of requiring him to study several different and not necessarily cognate subjects simultaneously. He has also strongly upheld the principle of making practical teaching in the laboratory strictly sequential to, and directly illustrative of, the lectures. In his own department, whenever possible, the laboratory work has been arranged as an immediate extension of the lectures, in which the student has had an opportunity of examining systematically and illustrating experimentally such data and principles of the subject as are capable of exemplification in this manner; and it is doubtless to this excellent system of simultaneous theoretical and practical work that the very real knowledge of their subject which has characterized such a large proportion of his pupils has been mainly due. Another feature which has determined the success of Prof. Judd's teaching is his freedom from conservatism: if the advances made in his subject or in any branch of it have pointed to the desirability of changes in the method of its presentation to the student, he has never shrunk from the abandonment of methods already adopted or from such wholesale reconstruction of his courses as may have seemed necessary to bring them into touch with the most recent views.

"The relations between Professor Judd and his students have always been of the pleasantest and most cordial kind. He has invariably taken a keen personal interest in all who have come under his charge, and has always been ready to help and advise them, not only in their geological studies, but also in all matters connected with their college life and their future career. He was constantly invited to act as an officer of the many clubs and societies of the college, and in such a capacity always set an excellent example to those associated with him by the very conscientious manner in which he performed the duties which his acceptance of office entailed, notwithstanding his very heavy duties as Professor and Dean. These and many other traits endeared him to the students, among whom he was very popular, and by whom he was regarded with great respect and esteem. It must be a constant source of pleasure to him to feel that the many hundreds of students who have passed through his hands, and who are now distributed all over the world, will always entertain the pleasantest recollections of their association with him; they will learn with regret that he has relinquished the post which he has filled so long and honourably."

LIST OF SCIENTIFIC PAPERS AND BOOKS BY PROFESSOR
JOHN W. JUDD.

1867. "On the Strata which form the base of the Lincolnshire Wolds": *Quart. Journ. Geol. Soc.*, vol. xxiii, pp. 227-251.
1868. "On the Speeton Clay": *Quart. Journ. Geol. Soc.*, vol. xxxiv, pp. 218-250.
1869. "On the Origin of the Northampton Sand." This paper was read at the Geological Society on March 10th, 1869, and an abstract of it appeared in the *Phil. Mag.*, vol. xxxviii, pp. 400-401. Its publication was undertaken by the Geological Survey, but was delayed till 1875, when it appeared as chapter vi of the "Geology of Rutland," pp. 113-138, but without illustrations.
1870. "Additional Observations on the Neocomian Strata of Yorkshire and Lincolnshire, with notes on their Relations to beds of the same age throughout Northern Europe": *Quart. Journ. Geol. Soc.*, vol. xxvii, pp. 326-347.
1870. "On the use of the term Neocomian": *GEOL. MAG.*, Vol. VII, pp. 220-227.
1870. "On the Age of the Wealden": *Brit. Assoc. Rep.*, xl (sect.), p. 77.
1871. "On the Punfield Formation": *Quart. Journ. Geol. Soc.*, vol. xxvii, pp. 207-227.
1871. "On the Anomalous Mode of Growth of certain Fossil Oysters": *GEOL. MAG.*, Vol. VIII, pp. 355-359.
1873. "The Secondary Rocks of Scotland," First Paper.—Strata of the East Coast: *Quart. Journ. Geol. Soc.*, vol. xxix, pp. 97-195.
1874. "The Secondary Rocks of Scotland," Second Paper.—On the Ancient Volcanoes of the Highlands and the Relations of their Products to the Mesozoic Strata: *Quart. Journ. Geol. Soc.*, vol. xxx, pp. 220-302.
1875. "On the Structure and Age of Arthur's Seat, Edinburgh": *Quart. Journ. Geol. Soc.*, vol. xxxi, pp. 131-148.
1875. "Contributions to the Study of Volcanoes."—Introduction; The Lipari Islands: *GEOL. MAG.*, Dec. II, Vol. II, pp. 1-16, 56-70.
1875. "Contributions to the Study of Volcanoes."—Vulcano: *ibid.*, pp. 99-115.
1875. "Contributions to the Study of Volcanoes."—Stromboli: *ibid.*, pp. 145-152, 206-214.
1875. "Contributions to the Study of Volcanoes."—The Island of Ischia: *ibid.*, pp. 245-257.
1875. "Contributions to the Study of Volcanoes."—The Ponza Islands: *ibid.*, pp. 298-307.
1875. "Contributions to the Study of Volcanoes."—The Great Crater-lakes of Central Italy: *ibid.*, pp. 348-356.
1875. Instructions on Volcanoes: Arctic Manual published by Admiralty.
1875. "The Geology of Rutland, and parts of Lincoln, Leicester, Northampton, Huntingdon, and Cambridge (Sheet 64 of the 1 inch Geological Map): with an Introductory Essay on the Classification and Correlation of the Jurassic Rocks of the Midland District of England": *Memoirs of the Geological Survey of England and Wales*, pp. xvi-320, with 11 plates and 19 woodcuts.
1876. "Contributions to the Study of Volcanoes."—On the Origin of Lake Balaton in Hungary: *GEOL. MAG.*, Dec. II, Vol. III, pp. 5-15.
1876. Review of "Bořický's Memoirs on the Basalts and Phonolites of Bohemia": *ibid.*, pp. 35-38.
1876. "Method of Determining the Species of Felspars in Rocks," being an account of Szabo's Flame-reactions.—Science Conferences held in connexion with the Loan Collection of Scientific Apparatus: *Vol. on Chemistry, Biology, Geology, etc.*, pp. 418-419.
1876. "On the Origin of Lakes," a reply to criticism: *GEOL. MAG.*, Dec. II, Vol. III, pp. 187-189.
1876. "Contributions to the Study of Volcanoes," Second Series.—The Ancient Volcanoes of Europe: *ibid.*, pp. 53-63.
1876. "Contributions to the Study of Volcanoes," Second Series.—On the Volcanic Outbursts which preceded the Formation of the Alpine System: *ibid.*, pp. 200-215.

1876. "Contributions to the Study of Volcanoes," Second Series.—On the Interval which separated the two great Periods of Volcanic Activity in Connexion with the Formation of the Alpine System: *ibid.*, pp. 337–345.
1876. "Contributions to the Study of Volcanoes," Second Series.—On the Volcanic Outbursts which accompanied and followed the Formation of the Alpine System: *ibid.*, pp. 529–538.
1876. "Formation of Rock-Basins": *ibid.*, pp. 523–525.
1876. "On the Ancient Volcano of the district of Schemnitz, Hungary": *Quart. Journ. Geol. Soc.*, vol. xxxii, pp. 292–325.
1877. Opening Lecture at the Royal School of Mines: *Roy. Sch. of Mines Mag.*, vol. i, pp. 103–106.
1877. "Deep Well-borings in London": *Nature*, vol. xvi, pp. 2–3.
1878. "The Secondary Rocks of Scotland," Third Paper.—The Strata of the Western Coasts and Islands: *Quart. Journ. Geol. Soc.*, vol. xxxiv, pp. 660–741.
1878. "A Problem for Cheshire Geologists" (being an account of the Liassic Outlier at Wem): *Chester Soc. Sci.*, vol. iii, pp. 45–49.
1879. Notes on some of the Antiquities of the Western Coasts and Isles of Scotland contributed to the Rev. J. M. Joass, and published in the Proceedings of the Scottish Antiquarian Society.
1880. "On the Oligocene Strata of the Hampshire Basin": *Quart. Journ. Geol. Soc.*, vol. xxxvi, pp. 660–741.
1880. "On the Classification of the Tertiary Deposits": *Pop. Sci. Review*, vol. xix, pp. 122–136.
1881. "On the Occurrence of the Remains of a Cetacean in the Lower Oligocene Strata of the Hampshire Basin": *Quart. Journ. Geol. Soc.*, vol. xxxvii, pp. 708–709.
1881. "Volcanoes: What they are and what they Teach": vol. xxxv of the International Scientific Series.
1882. "On the Relations of the Eocene and Oligocene Strata in the Hampshire Basin": *Quart. Journ. Geol. Soc.*, vol. xxxviii, pp. 461–486.
1882. "Possibility of finding workable Coal-seams under the London Area": *Nature*, vol. xxv, pp. 311–313, 361.
1883. "On the Methods which have been devised for the Rapid Determination of the Specific Gravity of Rocks and Minerals": *Proc. Geol. Assoc.*, vol. viii, pp. 278–287.
1883. (With Professor G. A. J. Cole) "On the Basalt-glass (Tachylite) of the Western Isles of Scotland": *Quart. Journ. Geol. Soc.*, vol. xxxix, pp. 444–464.
1884. "Krakatoa": *Proceedings of Royal Institution of Great Britain*, May 2nd, 1884.
1884. "On the Jurassic Deposits which underlie London" (with an Introduction by J. Collett Homersham and Appendices by Professor T. Rupert Jones, Dr. G. J. Hinde, and Mr. G. R. Vine): *Quart. Journ. Geol. Soc.*, vol. xl, pp. 724–794.
1885. (With J. Collett Homersham) "Supplementary Notes on the deep Boring at Richmond, Surrey": *Quart. Journ. Geol. Soc.*, vol. xli, pp. 523–528.
1885. Obituary Notice of R. A. C. Godwin-Austen: *Proc. Roy. Soc.*, pp. ix–xiii.
1885. "Report on a Series of Specimens of the Deposits of the Nile Delta, obtained by boring operations undertaken by the Royal Society": *Proc. Roy. Soc.*, vol. xxxix, p. 213.
1885. "On the Occurrence as a Common Rock-forming Mineral of a Remarkable Member of the Enstatite Group (Amblystegite vom Rath)": *Geol. Mag.*, Dec. III, Vol. II, pp. 173–174.
1885. "On the Tertiary and Older Peridotites of Scotland": *Quart. Journ. Geol. Soc.*, vol. xli, pp. 354–418.
1885. Address to the Geological Section of the British Association (Aberdeen): *Brit. Assoc. Rep.*
1886. "On the Gabbros, Dolerites, and Basalts of Tertiary Age in Scotland and Ireland": *Quart. Journ. Geol. Soc.*, vol. xlii, pp. 49–97.
1886. "On Marekanite and its Allies": *Geol. Mag.*, Dec. III, Vol. III, pp. 241–248.

1886. "On the Relations between the Solution Planes of Crystals and those of Secondary Twinning, and on the Mode of Development of Negative Crystals along the former—a Contribution to the Theory of Schillerization": *Min. Mag.*, vol. vii, pp. 81–92.
1887. "On the Discovery of Leucite in Australia": *Min. Mag.*, vol. vii, p. 194.
1887. "On the Unmaking of Flints": *Proc. Geol. Assoc.*, vol. x, pp. 217–226.
1887. "On Tabasheer": *Nature*, vol. xxxv, p. 488.
1887. Anniversary Address to Geological Society ("The Relations of Geology and Mineralogy"): *Quart. Journ. Geol. Soc.*, vol. xliii, pp. 3–57.
1888. Anniversary Address to Geological Society ("The Relations of Geology and Biology"): *Quart. Journ. Geol. Soc.*, vol. xliiv, pp. 3–56.
1888. "The Eruption of Krakatoa and subsequent Phenomena," Part i.—On the Volcanic Phenomena of the Eruption and on the Nature and Distribution of the Ejected Materials: *Phil. Trans.*, extra vol. for 1888, pp. 1–46.
1888. "The Natural History of Lavas as illustrated by the Materials ejected from Krakatoa": *Brit. Assoc. Rep.* (1887) and *GEOL. MAG.*, Dec. III, Vol. V, pp. 1–11.
1888. "On the Development of a Lamellar Structure in Quartz Crystals by Mechanical Means": *Min. Mag.*, vol. viii, pp. 1–8.
1889. "Statcal and Dynamical Metamorphism": *GEOL. MAG.*, Dec. III, Vol. VI, pp. 243–249.
1889. "The Growth of Crystals in Igneous Rocks after their Consolidation": *Quart. Journ. Geol. Soc.*, vol. xlv, pp. 175–186.
1889. "The Tertiary Volcanoes of the Western Isles of Scotland": *ibid.*, pp. 187–219.
1889. "On the Processes by which a Plagioclase Felspar is converted into a Scapolite": *Min. Mag.*, vol. viii, pp. 186–201.
1890. Critical Introduction to New Edition of Charles Darwin's "Coral Reefs," "Observations on Volcanic Islands," and "South America." (The second of these was translated into French by Professor Renard in 1902.)
1890. "On the Relations between the Gliding Planes and the Solution Planes of Augite": *Min. Mag.*, vol. ix, pp. 192–197.
1890. "The Propylites of the Western Isles of Scotland and their Relation to the Andesites and Diorites": *Quart. Journ. Geol. Soc.*, vol. xlv, pp. 341–385.
1890. "Chemical Changes in Rocks under Mechanical Stresses": *Journ. Chem. Soc.*, vol. lvii, pp. 404–425.
1891. "The Rejuvenescence of Crystals": *Proc. Roy. Inst. and Report of Smithsonian Institution*, 1893.
1892. "Additional Note on the Lamellar Structure of Quartz Crystals, and the Methods by which it is developed": *Min. Mag.*, vol. x, pp. 123–134.
1893. "On Inclusions of Tertiary Granite in the Gabbros of the Cuillin Hills, Skye, and on the Products resulting from the Partial Fusion of the Acid by the Basic Rock": *Quart. Journ. Geol. Soc.*, vol. xlix, pp. 175–195.
1893. "On Composite Dykes in Arran": *Quart. Journ. Geol. Soc.*, vol. xlix, pp. 536–565.
1894. Introductory Chapter to Behren's "Manual of Microchemical Analysis."
1894. "The Chemical Action of Marine Organisms": *Fortnightly Review*.
1895. "The Scientific Results of the 'Challenger' Expedition."—Geology, Coral Reefs: *Nat. Sci.*, vol. vii, p. 18.
1895. "On some Massive Minerals (Simple Crystalline Rocks) from India and Australia": *Min. Mag.*, vol. xi, p. 56.
1895. "On the Structure-Planes of Corundum": *Min. Mag.*, vol. x, pp. 149–
1896. (With C. Barrington Brown) "The Rubies of Burma and Associated Minerals: their mode of Occurrence, Origin, and Metamorphoses."—A Contribution to the History of Corundum: *Phil. Trans.*, vol. 187A, pp. 151–228.
1896. "The Student's Lyell" (a revised edition of Lyell's "Student's Elements of Geology").
1897. Inaugural Address at the Opening of the Session 1896–7 of the Royal College of Science and Royal School of Mines.
1897. "Second Report on a Series of Specimens of Deposits from the Nile Delta, obtained by Boring Operations undertaken by the Royal Society": *Proc. Roy. Soc.*, vol. lx, pp. 32–40.

1897. "William Smith's Manuscript Maps": *GEOL. MAG.*, Dec. IV, Vol. IV, pp. 439-447.
1898. "The Earliest Engraved Geological Maps of England and Wales": *ibid.*, Dec. IV, Vol. V, pp. 97-103.
1898. "The Earliest Geological Maps of Scotland and Ireland": *ibid.*, Dec. IV, Vol. V, pp. 145-149.
1898. Obituary Notice of John Carrick Moore: *Proc. Roy. Soc.*, vol. lxiii, pp. xxix-xxxii.
1898. "On the Petrology of Rockall": *Trans. Roy. Irish Acad.*, vol. xxxi, pt. 3, pp. 48-57.
1899. "Notes on Rockall Island and Bank": *GEOL. MAG.*, Dec. IV, Vol. VI, pp. 163-167.
1899. (With W. E. Hidden) "On a new Mode of Occurrence of Ruby in North Carolina": *Min. Mag.*, vol. xii, pp. 139-149 (also in *Amer. Journ. Sci.*, ser. iv, vol. viii, pp. 370-379).
1901. "Volcanoes and Volcanic Action": *Antarctic Manual*, pp. 188-192.
1901. "Note on the Structure of Sarsens": *GEOL. MAG.*, Dec. IV, Vol. VIII, pp. 1-2.
1902. "Note on the Nature and Origin of the Rock Fragments found in the Excavations made at Stonehenge by W. Gowland, Esq.": *Archæologia*, vol. lviii, pp. 106-118 (also in *Wilts Arch. & Nat. Hist. Mag.*, vol. xxxiii, pp. 47-61, and, 1903, *GEOL. MAG.*, Dec. IV, Vol. X, p. 129).
1904. "The Atoll of Funafuti: Borings into a Coral Reef and the Results," being the Report of the Coral Reef Committee of the Royal Society: *Extra vols. of Phil. Trans.* Sect. x, "General Report on the Materials sent from Funafuti, and the Methods of dealing with them," pp. 167-185; Sect. xii, "The Chemical Examination of the Materials from Funafuti," pp. 362-389.
1904. Obituary Notice of Sir Clement Le Neve Foster: *Proc. Roy. Soc.*, vol. lxxv, pt. 4, pp. 371-377 (also in *Min. Mag.*, vol. xiv, pp. 57-59).
1904. Obituary Notice of Frank Rutley: *Min. Mag.*, vol. xiv, pp. 59-61.

II.—THE CHALK BLUFFS AT TRIMINGHAM.

By Professor T. G. BONNEY, D.Sc., F.R.S., and Rev. E. HILL, M.A., F.G.S.

(PLATE XXII.)

THE huge masses of chalk in the glacial drift on both sides of Cromer, and especially at the headland near Trimingham, have for many years attracted the attention of geologists. In this Magazine (Dec. II, Vol. VII, 1880, p. 55) and in the Survey Memoir on the Geology of the Country around Cromer, published in 1882, Mr. Clement Reid ascribes those at the latter place to the advance of an ice-sheet by which the chalk has been thrust up into a kind of fold and the flint layers have been bent, illustrating his interpretation by a diagrammatic section. We visited the Cromer cliffs for the first time in 1892, and after a careful examination of the Trimingham headland, not only felt more strongly than before certain weak points in Mr. Reid's reasoning, but also observed some facts difficult to reconcile with his conclusions. Since that date we have more than once visited these sections, and found last April that comparatively recent inroads of the sea had made great changes which had shown the relations of the chalk and glacial drift to be, in our opinion, incompatible with Mr. Reid's interpretation.

In 1892 two separate masses or 'bluffs' of chalk, as he describes in the Memoir (p. 95), were exposed in the drift at the base