ingenious treatise which had recently been published by Mr. Billings, in which the method of construction in Carlisle Cathedral was clearly developed. The subject was one of the greatest importance to the advancement of architectural science, for it would assuredly lead to the adoption of fixed principles, and remedy the numerous defects which arise from the practice of blindly following what has been done before, without any regard to the objects for which buildings are specially intended.

The following paper was then read:—

ON THE PRESERVATION OF RAILWAY SECTIONS, AND OF ACCOUNTS OF BORINGS, SINKINGS, ETC., IN ELUCIDATION OF THE MEASURES RECENTLY TAKEN BY THE BRITISH ASSOCIATION.—BY THOMAS SOPWITH, ESQ. F.G.S., NEWCASTLE-ON-TYNE.

The blank chart which accompanies this paper has been prepared by a Committee appointed by the British Association at Glasgow, in 1840, with a view to the collection and preservation of a regular series of sections of railway cuttings, which, by their intersection of mineral districts or of rocks presenting any remarkable geological features, may afford useful information, and be worthy of being kept as geological and mining records.

An object apparently so easy of attainment, and of such obvious importance and utility, seems scarcely to require comment, and it would appear more surprising that it should in any case have been neglected, than that any arguments should be required to enforce its general observance. The facts of the case, however, are a sufficient evidence that due attention has not hitherto been devoted to this interesting department of geology and engineering; for on many lines of railway no measures have been taken to preserve a regular

and systematic record of the geological features presented during the progress of the works, and in other cases, where such details have been carefully measured and preserved, they have not been reduced to that uniformity of scale and colour which is indispensably necessary for an extensive series of sections of this description. To societies like the present, considerations of this kind cannot be too strongly urged or too often repeated, since it is only by the co-operation of numerous and influential parties that great public objects can be effected. At first sight, it may appear of comparatively small importance whether such details are kept or not, and it is very possible that in certain cases it may be difficult to foresee any practical inconvenience or loss as likely to result from the want of the particular information afforded by accurate sections. This may be the case under certain circumstances; but my object is now to show, that, as a system, the preservation of detailed drawings of railway cuttings, and of borings and sinkings, is of great importance; that it not only furnishes information of the greatest value in a scientific point of view, but is intimately connected with our national prosperity, and the continuance of our greatness both as an agricultural and commercial nation. I shall endeavour to impress on the minds of those present, and of all who take any interest in our proceedings, that there is an intimate connection between geological science and the prosperity of all nations which depend as much as we do on the subterranean products of the earth; that not only individuals, but communities, may be greatly benefited by a due regard to the practical results of science; and that the laws of physical science are never neglected without a corresponding injury to those whose pursuits require attention to the phenomena of nature. More particularly is it my object to show that extensive railway cuttings in mineral districts are instruc-

tive pages in the book of nature, opened by the engineer, and presented in an attractive form to the perusal of the geologist. Soon, however, the opportunity passes away; the silent operations of nature, clothing the rocks and soils in grasses, mosses, and lichens, shut the volume to the geologist, and open another page for the instruction of the botanist—exemplifying to the former the common but too often forgotten adage, that "opportunity neglected can seldom be regained."

In elucidation of the subject, then, I shall briefly advert to the rapid progress of geological science. Within the limits of living memory, nothing could be more vague and indefinite than the state of geological science, if indeed such a term can be applied to the small extent of what was then known. The first geological map of this kingdom appeared in 1815, and though it is extremely interesting and valuable, when considered as the result of the labours of a single, and in a great measure unassisted, individual, yet a single glance at that map will show, in a manner more striking than any verbal description, the vast progress made in a quarter of a century. The last edition of Mr. Greenough's Geological Map of England and Wales—Mr. Griffith's Map of Ireland—Mr. M'Culloch's Map of Scotland, and Mr. Murchison's beautiful Map and Sections of the Silurian region—are magnificent examples of what has been done, and are in all probability only an earnest of the still further advances to be made, in reducing the grand phenomena of the structure of the world to such practical results as tend to the welfare of its inhabitants. As regards general views, nothing can be more satisfactory than the rapid improvement here alluded to; the next steps are to attend with equal zeal to such details as are of practical utility.

The study of nature is, under all circumstances, a de-

lightful and instructive pursuit, and all who have leisure to prosecute attentive studies therein, find greater interest as they advance from general views to minute details. In geology this is particularly the case, but with this important advantage, that whereas in botany, entomology, and various other branches of natural history, it is only occasionally that new and important practical results can be obtained, of such a nature as to have any direct bearing on the welfare of mankind,—in geological pursuits, the whole scope and object of inquiry is intimately connected with the very existence of the human race. The dust of which we are formed and to which we must return—the sustenance derived whether from animal or vegetable food—the raiment which we wear —the fuel which warms—the houses which protect us—the implements employed in agriculture, and mechanical arts—the trees which ornament the land and form the bulwarks of the ocean—all these have not a remote, but an immediate dependance on geological conditions. Climate greatly depends on the elevations and depressions of a district, and the conformation of its coasts and the navigation of its rivers are also dependant thereon. Thus there is scarcely any subject relating to the physical conditions which affect our comfort and prosperity that is not closely identified with geology; and hence it follows that detailed information on geological features must ever be considered as a valuable accession to human knowledge.

If the leading results of geological investigation are thus widely extended, it is equally obvious that its connection with agriculture and mining are of the first importance. In these departments it is that exact specific information should be collected, and for obtaining such specific information nothing can be more admirably adapted than the sections presented by railway cuttings, and by borings and sinkings. The exact nature and depth of the soil and

substrata, the rocks and clays beneath, and in short the geological structure of the district, is matter of information, the value of which is now becoming more and more appreciated, and fresh discoveries of the relations existing between chemistry and agriculture may render an intimate knowledge of geological structure still more important. Railway cuttings afford this species of information in the most satisfactory manner, but they afford it only for a time. Even in an agricultural point of view it is worth the attention of the landowner to preserve such a record. What now appears merely interesting, may, in a more advanced state of science, be important, and carefully preserved sections may form a body of evidence indicating the direction in which drift has been carried, and thus leading to further generalizations connected with the sources whence the soil has been derived; for, as Professor Sedgwick has justly observed, it is not so much a knowledge of the geological structure lying beneath him, as a knowledge of the general law which has prevailed when the soils, or the materials which compose them, were distributed over the face of the country, that will benefit the agriculturist. Occasions may often arise when the agriculturist would gladly ascertain the general nature and disposition of the stratification; and the preservation of railway sections, in a local museum, would afford much valuable information of this kind. They would open to every farmer, in the vicinity of a railway cutting, an opportunity of learning a practical lesson in geology; and many, who from want of information or other causes, cannot now derive benefit from the actual sections on the sides of a railway cutting, may a few years hence appreciate the value of this information, and deeply deplore that the opportunity is lost for ever.

If railway sections are interesting and valuable, as indi-

cating the nature of the earth's surface in relation to agriculture, they are still more important as regards the general nature of geological structure, and more especially the position and inclination of such rocks as are connected with mineral treasures. Geology is a science of facts, and the accumulation of well ascertained data is the surest, indeed the only way to arrive at correct conclusions. It will, therefore, appear at once that a collection of accurate sections cannot fail to throw much light on all investigations of geological structure. Who that has had even the passing glance which a railway transit affords of the magnificent sections on the North Midland Railway, but must be convinced of the importance of having them transferred to paper, and preserved as one of the most instructive lessons which art has yet afforded to the geologist and miner! while the extensive mining operations, which have been commenced by Mr. George Stephenson, point out more strongly than any comment, the close connection which exists between an exact knowledge of the conditions of strata and those subterranean operations which are essential to our existence as a nation.

The importance of preserving mining records has been duly appreciated by the British Association, and very satisfactory progress has been made by the Committee appointed by that body, at Newcastle, in 1838. Arrangements have been made in connection with the Museum of Economic Geology, under the able superintendence of Mr. De la Beche, and the subject will doubtless ere long receive the attention which it deserves, as one of the elements of our commercial greatness. To such records of the deep and rarely accessible parts of the mineral strata, the sections of railway cuttings, and of borings and sinkings, are a most useful auxiliary, and both are entitled to the attention not only of scientific bodies and parties locally interested, but to the

notice of the legislature, upon whom it especially devolves to take every prudential measure that can promote the future prosperity of the kingdom.

To dwell upon, or even to allude to the exceedingly valuable nature of documents of this kind, must seem to every one conversant with the subject, like proving that light is better than darkness, or knowledge preferable to ignorance. The most eminent geologists and miners have expressed their opinions with great clearness, and with an earnestness proportioned to their conviction of the importance of the subject. I have quoted several of these opinions in a work which has been some time before the public; but, though there is a general concurrence in the utility and importance of such geological and mining records, there is far from being any active progress made in furtherance of the end in view. Individuals are with difficulty induced to labour for remote advantages; the engineer is too fully occupied with the immediate objects of his professional duty, to have much time to devote to the geological features of his work; and thus, until some further arrangements are made, comparatively little progress can be expected in obtaining accurate sections of railway cuttings.

In the mean time, however, the opportunity is passing away, and if much is not to be expected, still something may be done. In societies like the present, there are usually found many who have both the will and the power to labour in the field of science, and who probably only require to know the objects proposed, to devote a portion of their time and energies to them.

And here I will take occasion to remark, that in this respect, that is to say, in directing the labours of scientific individuals, the British Association has been eminently useful. Many persons, who prefer forming their opinions from the vague and distorted statements in newspapers, to

inquiring and judging for themselves, are apt to form an erroneous idea of the proceedings of the British Association, and to suppose, that unless some new and astounding revelations in scientific pursuits or mechanical inventions are propounded at each meeting, the institution has failed in its objects. I think, however, it deserves attention, that the chief utility of its proceedings consists not in the assemblage of its members, nor in the matters which are incidentally brought before the sectional meetings, but in the encouragement which it munificently affords to useful objects in the various departments of art and science. The investigations of the ablest scientific men are pursued from day to day and from year to year, with funds furnished by the Association, and its harvest of science is not to be looked for in its crowded meetings and hospitable re-unions, but in the volumes of its transactions, which are yearly printed, and in the promotion of useful objects effected through the influence of its recommendation. The subject of this paper is an example of the latter. The chart which I now produce, is engraved for and under the immediate superintendence of the Committee appointed by the British Association, and I doubt not that in this district, so rich in mineral productions and so rich in natural sections, many highly interesting copies of such sections will be prepared before the next meeting of the British Association. These sections will form an important and useful portion of the Museum of this Society, and if lent for a short time to the Museum of Economic Geology in London, copies of them *will be made for that Institution.* In order to draw attention to the practical means of effecting these objects, I shall point out a few of the leading considerations which have had the attention of the Committee.

In the first place, then, uniformity is an essential element in a collection so extensive as this will necessarily be, if

it receives the attention which the subject demands. In order to secure this, it was thought expedient to print a number of blank charts, to be supplied to all persons employed in measuring and delineating sections; so that, being bound in volumes on a regular and systematic arrangement, an easy reference might at any time be made. These blank charts are to be had on application to Mr. Jordan, at the Museum of Economic Geology, in Craig's Court, Charing Cross, London; or to the Secretary of the Institution of Civil Engineers, 25, Great George Street, Westminster, by any parties who are willing to contribute any share of information in the form of sections drawn and coloured on these blank charts.*

The scale on which these charts are constructed is 40 feet to an inch, which is as small as can be employed with clearness; and to have made it larger would have caused an inconvenient area to be occupied by the drawings. A stratum four feet thick thus appears one-tenth of an inch in thickness, according to this scale, and this is amply sufficient to represent any seams of coal or other conspicuous objects. The chart extends 800 feet in length and 600 feet in height, according to this scale. At first sight it may appear that as a scale of length this is unnecessarily large, as nearly seven sheets will be required to represent one mile of section. It must be kept in mind, however, that it is only in a few particular places that the cuttings present instructive sections, and that the desired collection by no means involves a continued drawing of many miles of cutting. If this were so, it would become necessary to adopt one scale for the horizontal distance, and a greatly enlarged scale of heights. Sections, thus constructed, are indispensable for engineering purposes, but ought to be avoided as much as possible in

* These blank charts will be furnished by the Secretary to any one who will undertake to fill them up

geological sections. The distortion of scale completely prevents the very intention of the section, which is to convey a correct idea of the relative thickness and inclination of strata. In surface models, where the intention is to afford a general idea of a district, it is sometimes desirable to enlarge the vertical scale, and this was done in the model of Dean Forest, which, on a former occasion, I had the honor of submitting to this Association. Since that time I have constructed a model of the principal coal field of that district on the natural scale: the result is, that though the latter is unquestionably the correct and most scientific mode of construction, yet it gives a fallacious idea of the nature of the surface—the steep hills and narrow valleys of that romantic forest sink into gradual undulations, which would never be recognised as the type of a picturesque country; and the two models, which are now placed in juxta-position, in the Museum of Economic Geology, afford a good practical lesson as regards the proportionate scales to be employed. To give to the mind a graphic idea of a country, the vertical scale should be increased about three times; but when the object is to convey to the mind clear ideas of the geometrical relations of the surface as they are in nature, and not as they are presented on the retina, then a uniformity of vertical and horizontal scale is to be observed. In geological sections, however, nothing but necessity can justify the distortion of scale, and the Committee, fully aware of the great scientific value of correct proportion, decided that the charts should be constructed accordingly, so that the drawings thereon should be a faithful transcript of nature.

Another advantage proposed to be gained by the form of chart engraved by the Committee is, that, ranging as it does 600 feet in height, it admits of each part of the railway being shown at its proper elevation above the datum line of the railway, and also the rate of ascent. Thus, if the datum or

base line on which the sections of the railway were originally made, is Trinity high-water mark, the commencement of the railway may possibly be 70 feet above such datum. If the railway rises 30 feet in a mile, a line drawn from 70 on the left side to 74.5 on the right will represent at once the true inclination of the railway, and the height of each portion of it above Trinity high-water mark. On the next sheet, supposing the section continued, the line will begin at 74.5 on the left and rise to 79 on the right. If now an interval of ten miles occurs, in which there is no valuable geological information afforded, and in which the rate of ascent is uniformly 30 feet in a mile—if a drawing is to be made of a cutting at the end of the ten miles, the line of railway will begin at 79 ft. + 300 ft. = 379 ft. on the left hand, and rising to 383.5 ft. on the right. In this manner, at whatever part of the railway a cutting occurs, it may at once be placed in its true relation to the base or datum line. When the general section of the cutting is thus drawn along the chart, there will always remain a considerable portion of the sheet unoccupied—the deepest cuttings will rarely occupy more than two inches in height, and whether this is near the top, or middle, or bottom of the sheet, (according as it is more or less elevated above the datum line,) matters not, as there will in any case be space left for two purposes, viz., to delineate any remarkable developement of thin strata or other peculiarity of structure on an enlarged scale of four feet to an inch, and thus all inconvenience arising from the minuteness of the general scale is entirely avoided; and on a still larger scale of delineation, to represent any fossils that are found within the limits of the section. The latter may either be the true size of the fossil, or magnified or diminished according as the dimensions may render expedient.

A volume of accurate sections, with enlarged details of strata and accurate drawings of fossils, would be a valuable

acquisition to every local museum; and as a knowledge of science advances, there is no doubt the means of extending it will rapidly increase. Thus in the compass of the last few months an admirable adaptation of the process of electrotyping has been made to a geological purpose, viz., the obtaining cheap and perfect fac-similes of fossil remains. By this process, several beautiful examples of which (produced by Mr. Jordan) were exhibited by him at the last meeting of the British Association, it is not too much to hope that local museums may be furnished at a small cost with accurate transcripts of the very best specimens of fossils, and this would add fresh interest and value to the drawings of fossils proposed to be kept in connection with the sections of railway cuttings.

Uniformity of colour is also highly desirable, but less important than uniformity of scale. Several specimen sheets have been prepared, and may be had on application, as already described. The colours used in Mr. Greenough's last edition of his geological map of England and Wales, or in Mr. Murchison's Silurian System, will afford a good scale of colour to those who are possessed of these works. The colours used in the Ordnance Survey may be adopted, or each artist may employ his own judgment, provided, however, that in every case each sheet shall contain a written description of the rocks, &c. represented by each colour, and also consecutive letters or figures to distinguish the colours on the section and reference. If this is carefully attended to, it is not of material consequence what colours are employed, since in copying, at any future time, this can be easily improved upon. It is not so much for nicety of detail, that attention is now urged, but for those more important geometrical data, which can only be obtained by measuring the strata while they remain exposed to view, and by accurately delineating them on a uniform scale.

The British Association has already granted a sum of £200 in furtherance of the objects I now treat of, and to this sum it is hoped that a further addition will be made if the progress of the collection shall prove to be commensurate with its interest and importance. It will be gratifying to the Committee, at the next meeting of the British Association, if the seed they have endeavoured to sow in the shape of blank sections, shall bring forth the good fruit of those accurate records which the talents and perseverance of many members of this Society are so likely to produce. Those who are interested in the mining operations of this part of the kingdom, cannot but see how valuable and how practically useful is every section that throws light on the stratification of the coal field—its inclinations, its disturbances. Not only are the great features of anticlinal and synclinal axes clearly developed, but even the lesser faults—the gradual thickening or diminishing of strata—the occurrence of rocks usually identified with particular seams of coal. All these are matters which closely concern the coal and land owner, independently of the more general advantages in a scientific point of view. Those gentlemen who have recently bestowed attention on the relations existing between geology and agricultural pursuits, would turn with ardour to pages so fraught with information as those I have endeavoured to describe. The approval of a Society established as this is, for the attainment of objects so closely identified with those which the British Association have endeavoured to encourage, will tend much to further the interests of geology, by directing attention more widely to the subject.

Equally important is it, that the members of this Society should use their influence in collecting and preserving copies of all borings and sinkings made in the district. The small chart which accompanies this paper is a convenient form for drawing such sections on a uniform scale; the lines and

writing upon it sufficiently explain its object and mode of being used for drawing sections. The copper plate which I had made for my own use, is at the service of any member of this Society, and I have ascertained from the engraver, Mr. Collard, of Newcastle-on-Tyne, that impressions can be sent by post, pre-paid, at the cost of 10s. a hundred. By sending a post-office order, therefore, for 5s., 10s., or 15s., to Mr. Collard, 50, 100, or 150 copies of this lesser chart may be had at any place by post, without further expense. Contributions of accurate sections, in this or any other convenient form, will, in time, become a valuable local record, and tend to familiarize the public with those geological details, which, on a larger scale, are sought to be obtained from railway cuttings, and, on a still larger scale, from accurate records of mining operations. The charts which I have described, simplify the process and secure uniformity; the one can be had, through the munificence of the British Association, gratuitously, and the other for the mere cost of paper and printing; and, I doubt not, that if the opinions of the able and intelligent members of this Society coincide with those expressed in this paper, that at future meetings of this Society, and at the next meeting of the British Association, many of these engraved charts will picture forth with geometrical accuracy and graphic colouring, the important and highly interesting details of the geology of the midland districts of England, to be studied by the agriculturist, the miner, the engineer, the geologist, and by all who recognise in a correct knowledge of subterranean wealth, the strong foundations and only lasting means of preserving, what the late President of the Geological Society has justly termed, "our country's exalted position among the kingdoms of the earth."

T. S.

GEOLOGICAL MODELS.

Mr. SOPWITH next exhibited and explained a series of geological models, which he has recently constructed for the purpose of facilitating the study of geology, and the nature of several phenomena which cannot be clearly understood without having recourse to solid forms, capable of being dissected and re-arranged in conformity with the existing types in nature which they represent. Owing to the length of the previous discussions, Mr. Sopwith's explanation of these models was not commenced until the hour of adjournment had arrived, and many persons were on the point of departure; it was therefore in a great measure confined to answering the inquiries of the noble Chairman, and to a brief description of the models given to his Lordship and a few members who remained. In consequence of the interest then expressed, Mr. Sopwith intimated his willingness to bring them forward the next time he should have the pleasure of attending one of the meetings of the Society. For the present, it may therefore suffice to say, that these models, twelve in number, were selected by Dr. Buckland from a series of models constructed by Mr. Sopwith, being such as that eminent geologist considered best adapted for the general student. They consist of nearly six hundred separate pieces of wood, fitted together so as to represent various conditions of strata—the effects of denudation, the displacement of strata by faults or dislocations, and the peculiar effects produced in valleys by the relative steepness of strata, as compared with that of the surface. Engravings of three of these models may be seen in the last edition of "Lyell's Elements of Geology," and sets of them have been prepared for sale, the particulars of which may be obtained on application to Mr. Sopwith, Newcastle, or to his agent in London, Mr. Tennant, 149, Strand. Of the utility of such models as lessons in geology, a high opinion has been given in Dr.

Buckland's annual addresses when President of the Geological Society; and the Institution of Civil Engineers, in October last, awarded a Telford medal in silver to Mr. Sopwith for his communication on the use of such models in connection with civil engineering and geology.

ELECTROTYPED COPIES OF FOSSILS.

Mr. SOPWITH exhibited several specimens of fossils copied by the electrotype process, by Mr. T. B. Jordan, of the Museum of Economic Geology,* in London. The thin deposit of copper which is formed on the wax or plaster cast from the original fossils, conveys an exact idea of the minutest details of structure, and Mr. S. pointed out that by these means correct copies of the best specimens of fossils could be multiplied to an indefinite extent, at a small expense, and every village museum might thus obtain electrotyped fossils, corresponding to those which adorn the cabinets of the Geological Society, or of the most careful amateurs. He had also received from Mr. Jordan some beautiful specimens of copies of medals, which were laid on the table, and attracted much attention; and the application of this new and interesting art was shown to be capable of a still wider range, by an egg cup which had been entirely formed by the electrotype process. This specimen of Mr. Jordan's ingenuity shows very clearly that works of art of the most costly description can be multiplied to a great extent, and a richly ornamented urn, gold cup, or

* This Museum, established by Government in Craig's Court, London, is under the direction of Sir Henry De la Beche, whose arduous and untiring exertions have for many years been devoted to the practical applications of Geology to Architecture, Agriculture, and the Arts, and by whose zeal and judgment this establishment promises to be one of the most valuable additions to the means of acquiring a scientific knowledge of the various qualities of stone—the processes used in various manufactures, and in the various and extensive applications of Economic Geology.

teapot, may, by the sure process of the electro-deposit, be formed as soon and as cheaply as a design however plain. Polished copper plates for engraving upon can be deposited at a cost of three shillings per pound, and this price leaves a fair profit to the tradesman. Engraved copper plates can be copied for eight shillings for each pound of copper—that is to say, four shillings for the matrix, and four for the copy—as the first of these, containing the lines in relief, is nearly as heavy as the second, or copy for engraving from. Thus a copper plate, which has cost £100 to engrave, may be faithfully copied for as many shillings. The process is applicable to many elaborate forms of metallic vessels, and hence, Mr. S. observed, we may conclude that it will, ere long, find its way into the workshops of our manufacturers.

A vote of thanks was given to Mr. Thorp, Mr. Wallen, and Mr. Sopwith, for their respective papers.

At the conclusion of the meeting, Mr. Biram exhibited a model of an improved piece of machinery for landing coal corves.