rubbish talked by those who take part in this agitation. Unfortunately this is not the case. As in every other relation of life, the old saying holds good, "Throw enough mud and some of it is sure to stick," and such as does stick can only be got rid of by thorough washing and efficient whitewashing. It is to this part of the work that we now wish to call the attention of all thoughtful men; and we can not help thinking that their work will be all the easier from the fact that the "compulsory" clause has been eliminated from a "Bill" that has already proved somewhat weak as an "Act," but which would have been still weaker as a legislative measure had not the amendment proposed in the House of Commons been ultimately carried in the House of Lords.

THE BRITISH ASSOCIATION.

THE meeting which has just been brought to a conclusion in Bristol may fairly be regarded as a highly successful one. The weather, though at first somewhat oppressive, has been on the whole eminently favourable for garden parties, conversazioni, and excursions. The destruction of the Colston Hall by fire raised difficulties at the last moment, but the emergency arrangements of the local committee amply met the requirements of the case. Although the seating accommodation of the People's Palace is far inferior to that of the Colston Hall, its acoustic properties are greatly superior. A brilliant audience met to hear Sir William Crookes's presidential address, and the members and associates attended in large numbers to listen to the discourses of Prof. Sollas and Mr. Jackson. Prof. Sollas's lecture on Funafuti was clear, lucid, and well illustrated, while Mr. Herbert Jackson's discourse on Phosphorescence, with his admirable experiments, is universally regarded as a brilliant success. The conversazione at Clifton College was well arranged and highly appreciated; the exhibits including a demonstration of the spectra of rare atmospheric elements by Prof. Ramsay and of wireless telegraphy, attracting large numbers, and the tastefully-lighted Close forming a pleasant promenade in the open air. The garden parties and the Saturday excursions have also gone off well. The Mayor of Bath took special trouble to make the excursion to Bath a pleasant one, and invited many members to visit the city and environs, the new excavations of the Roman Baths being especially visited and explained. Members who look forward to the meeting as a pleasant opportunity for social converse with their scientific *confrères* and with people of standing in the locality, have every reason to be well satisfied with the arrangements which have been made in Bristol. The old city has well maintained its tradition of hospitality. Sir William Crookes, speaking on Saturday at the banquet given by the Chamber of Commerce to distinguished visitors and guests, said that he had attended many meetings of the British Association, but could remember no occasion when the welcome accorded was more hospitable and enthusiastic, or the arrangements more carefully planned. In fact, it was agreed by all the members that the local arrangements have been a model of what such arrangements should be. The local hon. secretaries, Mr. Arthur Lee, J.P., and Dr. Bertram Rogers, have been indefatigable in their exertions, and have given nights as well as days to the work, hence everything has progressed with perfect smoothness.

The visit of four men-of-war has served to give an added interest to the meeting in its social aspect. This was a new feature, and was much appreciated both by the visitors and the local members. The ships' companies were not forgotten in the local arrangements, several entertainments being arranged for them. The officers of the Association provided for a lecture to be given to them upon a suitable topic, but it had to be cancelled, as the commander was unable, on account of his early departure, to grant leave to the 350 officers and men for whom arrangements had been made.

The very successful smoking symposium and concert given by the Scientific Societies of Bristol in the beautiful hall of the Merchant Venturers' Society's Technical College, assuredly gave no evidence of dulness. An excellent and humorous programme, capital speeches by the High Sheriff (Mr. Richardson Cross, the well-known oculist), Dr. Ryan (Professor of Engineering in University College, Bristol) and the president of the meeting, and the customary appurtenances of such a gathering, put all who were present in excellent humour.

We have alluded specially to the social aspects of the meeting. But they in truth form a not unimportant part of the work of the British Association. It is pleasant even to serious students of science to meet in the flesh those who have been hitherto met only on the printed page, and to find them after all eminently human; while words of kindly encouragement from older to younger workers are stimulating to renewed effort. Good work has been done in the Sections; but of this we hope to furnish an outline later on. The conference on terrestrial magnetism and atmospheric electricity, under the presidency of Prof. Rücker, was extremely well attended. Delegates from Germany, France, Holland, Italy, etc., were present, and most important conclusions were arrived at.

Everyone agrees that the local representatives of science have done all they could to stimulate interest in the neighbourhood of Bristol and the scientific work which is there being prosecuted, and it is, we hope, not invidious to make special mention of the work done by the Masters of Clifton College and the Professors at the Bristol University College to make the meeting successful. The local secretaries and their staff have spared no efforts to render the general arrangements efficient in themselves and intelligible to the members. The numbers in attendance approach 2500. The applications for tickets for the longer excursions on Thursday have been so numerous as to render their allotment a matter of difficulty; and the final four days' excursion to Devonshire will probably be taken by the limiting number of 100 visitors.

As to the work of the General Committee, the report of the Council of the Association was read by Prof. Schäfer at the meeting of the Committee on September 7, and among the matters of scientific interest referred to in it are the following:—

The Council have elected the following men of science who have attended meetings of the Association to be corresponding members:—Prof. C. Barus, Brown University; M. C. de Candolle, Geneva; Dr. G. W. Hill, West Nyack, N.Y.; Prof. Oskar Montelius, Stockholm; Prof. E. W. Morley, Cleveland, Ohio; Prof. C. Richet, Paris; Prof. W. B. Scott, Princeton, N.J. The Council were invited to nominate one or two members to give evidence before the Committee appointed by the Government to report on the desirability of establishing a National Physical Laboratory, and at their request Prof. G. Carey Foster, F.R.S., and Prof. W. E. Ayrton, F.R.S. gave evidence before this Committee. A report has been presented to Parliament, and the Council trust that the deliberations of the Committee will result in the establishment of a National Laboratory.

In regard to the resolutions referred to them for consideration and action, if desirable, the Council report as follows:—(1) That the Council appointed a committee to consider the desirability of approaching the Government with a view to the establishment in Britain of experimental agricultural stations similar in character to those which are producing such satisfactory results in Canada. The committee having reported that much is already being done in this direction by County Councils and

Agricultural Societies, advised that the co-operation of these bodies should first be invited. The committee was re-appointed for this purpose, and sent in a report, the principal recommendation of which was adopted by the Council, and is as follows:—"Your committee recommend that the Board of Agriculture be informed that, in the opinion of the British Association, there is an urgent need for the co-ordination of existing institutions for agricultural research, and that the Association hopes that steps may be taken towards this end, including the strengthening of the scientific work of the Board of Agriculture and the provision of the means for dealing adequately with scientific questions which may come before it." At the request of the Council this report was brought by the President to the notice of the President of the Board of Agriculture, from whom the following reply, dated July 26, was received:—"I have laid before the Board of Agriculture your letter of the 18th inst., and I am desired to express to the Council of the British Association for the Advancement of Science the thanks of the Board for the attention which the Council have been so good as to give to the important subject of agricultural research. The Board will not fail to bear in mind the views set out in the resolution communicated to them in the letter above referred to."

(2) That a committee was appointed to report to the Council whether, and, if so, in what form, it is desirable to bring before the Canadian Government the necessity for a hydrographic survey of Canada, and that the following formed the committee:—Prof. A. Johnson (chairman and secretary), Lord Kelvin, Prof. G. H. Darwin, Admiral Sir W. J. L. Wharton, Prof. Bovey, and Prof. Macgregor. The committee reported to the Council, and it was decided, in conformity with the recommendation contained in the report, that the following resolution should be sent to the Canadian Government:—"The Council of the British Association have learnt with regret that the Government of the Dominion of Canada is contemplating the discontinuance of their tidal survey of Canadian waters. Whilst the work already carried out is primarily connected with hydrography and navigation, they consider that science will incur a great loss if the work of the survey is discontinued. They would, therefore, urge on the Government the desirability of continuing the tidal survey as heretofore." The President transmitted the resolution to the Governor-General, who forwarded it to the Government of the Dominion of Canada for their favourable consideration. In reply, the Council were informed that "in view of the limited appropriation made by Parliament, it has been deemed advisable to defer the prosecution of the survey for the present and to confine the work to the maintenance and operations of the tidal gauges already established, and the preparation of tide tables."

(3) That a committee was appointed by the Council to consider the following resolution:—"That, in view of the facts (*a*) that a committee of astronomers appointed by the Royal Society of London, in consequence of a communication from the Royal Society of Canada, has recently considered the matter, and has arrived at the conclusion that no change can now be introduced in the *Nautical Almanac* for 1901, and (*b*) that few English astronomers are attending the Toronto meeting of the Association: the committees of sections A and E are not in a position to arrive at any definite conclusion with respect to the unification of time; but they think it desirable to call the attention of the Council to the subject, in which the interests of mariners are deeply involved, with the view of taking such action in the matter as may seem to them to be desirable." Several members of this committee had also served on the committee of the Royal Society, and after careful consideration of the whole question the committee saw no good reason for dissenting from the conclusion which had been recently adopted by the Royal Society and reported in the following terms:—"The committee report that as there is a diversity of opinion amongst astronomers and sailors as to the desirability of the adoption of civil reckoning for astronomical purposes, and as it is impossible to carry out such a change in the *Nautical Almanac* for the year 1901, they do not recommend that the Council of the British Association should at present take any steps in support of the suggested change of reckoning." The President has transmitted this report to the Royal Society of Canada.

In their report last year at Toronto, the Council informed the General Committee that the establishment of a Bureau for Ethnology was under the consideration of the trustees of the British Museum. In the course of their reply, dated December 15, 1897, the trustees state "that they are quite of opinion that such a bureau might be administered in connection with the Ethnographical Section of their collections, with advantage both to the objects in view of the Association and to the enlargement of the British Museum collections. They are, therefore, willing to accept in principle the proposal of the British Association, and they would be ready to take the necessary steps for carrying it into effect as soon as certain rearrangements affecting space, &c., which are now taking place within the museum, shall have been finished, as it is expected, in the course of the coming year."

In accordance with the regulations, the retiring members of the Council are: Prof. Edgeworth, Mr. Victor Horsley, Mr. G. J. Symons, Prof. W. Ramsay. The Council recommended the re-election of the other ordinary members of the Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list:—Mr. C. Vernon Boys, F.R.S., Captain E. W. Creak, R.N., F.R.S., Mr. F. Darwin, F.R.S., the Hon. Sir C. W. Fremantle, K.C.B., *Dr. W. H. Gaskell, F.R.S., Prof. W. D. Halliburton, F.R.S., Prof. L. F. Vernon Harcourt, Prof. W. A. Herdman, F.R.S., *Dr. J. Scott Keltie, *Major P. A. MacMahon, F.R.S., Mr. J. E. Marr, F.R.S., Prof. R. Meldola, F.R.S., Prof. E. B. Poulton, F.R.S., Mr. W. H. Preece, C.B., F.R.S., *Mr. L. L. Price, Prof. J. Emerson Reynolds, F.R.S., Mr. W. N. Shaw, F.R.S., Mr. J. J. H. Teall, F.R.S., Mr. W. T. Thiselton-Dyer, C.M.G., F.R.S., Prof. S. P. Thompson, F.R.S., *Prof. J. M. Thomson, F.R.S., *Prof. W. A. Tilden, F.R.S., Prof. E. B. Tylor, F.R.S., Prof. W. C. Unwin, F.R.S., Sir W. H. White, K.C.B., F.R.S.

As to the financial position of the Association, the statement presented by Prof. Rücker showed that the receipts for the past year were 4623*l.* 18*s.* 2*d.*, and that there was a balance of 1703*l.* 3*s.* 8*d.* in the treasurer's hands.

At a meeting of the General Committee held on Monday, it was decided to accept the invitation of the municipal authorities at Bradford to meet there in the year 1900. Dr. Michael Foster was elected President for the meeting at Dover next year. The following Vice-Presidents were also elected:—The Archbishop of Canterbury, the Marquis of Salisbury, the Mayor of Dover, Lord Herschell, the General Commanding the South-Eastern District, Mr. Akers-Douglas, M.P., the Dean of Canterbury, Sir Norman Lockyer, and Prof. G. H. Darwin. Prof. Rücker was appointed a trustee, in succession to the late Lord Playfair. Profs. Schäfer and Roberts-Austen were re-elected general secretaries, and Mr. Griffith assistant general secretary. Prof. G. Carey Foster was elected to succeed Prof. Rücker as general treasurer.

At the meetings of the Committee of Recommendations, the following sums of money were voted for scientific purposes:—

Synopsis of grants of money appropriated to scientific purposes by the General Committee at the Bristol meeting, August 1898. The names of the members entitled to call on the General Treasurer for the respective grants are prefixed.

Mathematics.

	£
*Rayleigh, Lord—Electrical Standards (and £75 in hand)	225
*Judd, Prof. J. W.—Seismological Observations... ...	75
*Rücker, Prof. A. W.—"Science Abstracts"	100
Kelvin, Lord—Heat of Combination of Metals... ...	20
Fitzgerald, Prof. G. F.—Radiation in a Magnetic Field	50

Chemistry.

*Thorpe, Dr. T. E.—Action of Light upon Dyed Colours	10
Hartley, Prof. W. N.—Relation between Absorption Spectra and Constitution of Organic Substances ...	50
Ramsay, Prof. W.—Chemical and Bacterial Examination of Water and Sewage	10

Geology.

*Hull, Prof. E.—Erratic Blocks	15
*Geikie, Prof. J.—Photographs of Geological Interest ...	10
*Marr, Mr. J. E.—Life Zones in British Carboniferous Rocks	10
Dawkins, Prof. W. Boyd.—Remains of Irish Elk in the Isle of Man	15
*Dawson, Sir J. W.—Pleistocene Fauna and Flora in Canada	30
Hicks, Dr. H.—Records of Drift Section at Moel Tryfan	5
Hicks, Dr. H.—Ty Newydd Caves	40
Lloyd-Morgan, Prof. C.—Ossiferous Caves at Uphill ...	30

Zoology.

*Herdman, Prof. W. A.—Table at the Zoological Station, Naples	100
*Bourne, Mr. G. C.—Table at the Biological Laboratory, Plymouth	20
*Woodward, Dr. H.—Index Generum et Specierum Animalium...	100
*Newton, Prof. A.—Migration of Birds	15
Hoyle, Mr. W. E.—Apparatus for keeping Aquatic Organisms under definite Physical Conditions... ...	15
Lankester, Prof. E. R.—Plankton and Physical Conditions of the English Channel during 1899	100

Geography.

Keltie, Dr. J. Scott.—Exploration of Socotra	35

Economic Science and Statistics.

*Sidgwick, Prof. H.—State Monopolies in other Countries (Balance in hand)	
*Price, Mr. L. L.—Future Dealings in Raw Produce ...	5

Anthropology.

*Munro, Dr. R.—Lake Village at Glastonbury	50
*Brabrook, Mr. E. W.—Ethnographical Survey	25
*Evans, Mr. A. J.—Silchester Excavation	10
*Penhallow, Prof. D. P.—Ethnological Survey of Canada (and unexpended balance in hand)	35
Tylor, Prof. E. B.—New Edition of "Anthropological Notes and Queries"	40
Garson, Dr. J. G.—Age of Stone Circles	20

Physiology.

*Schäfer, Prof. E. A.—Physiological Effects of Peptone...	30
Waller, Dr. A.—Electrical Changes accompanying Discharge of Respiratory Centres	20
Gotch, Prof. F.—Influence of Drugs upon the Vascular Nervous System	10
Schäfer, Prof. E. A.—Histological Changes in Nerve Cells	20
Schäfer, Prof. E. A.—Micro-Chemistry of Cells ...	40

* Re-appointed.

	£
Schäfer, Prof. E. A.—Histology of Suprarenal Capsules	20
Gotch, Prof. F.—Comparative Histology of Cerebral Cortex	10

Botany.

*Farmer, Prof. J. B.—Fertilisation in Phæophyceæ ...	20
Darwin, Mr. F. Assimilation in Plants	20
*Stebbing, Rev. T. R. R.—Zoological and Botanical Publication...	5

Corresponding Societies.

*Meldola, Prof. R.—Preparation of Report...	25
	£1485

Re-appointed.

INTERNATIONAL CONFERENCE ON TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY.

OPENING ADDRESS BY PROF. A. W. RÜCKER, M.A., D.Sc., SEC. R.S., PRESIDENT OF THE CONFERENCE.

THE President of the Section of Mathematics and Physics has already expressed the pleasure with which British physicists welcome the distinguished band of visitors who have assembled to take part in the International Conference on Terrestrial Magnetism. None join in that welcome with more cordiality than those who are especially interested in the science with which the Conference will be occupied. To us it is a source both of gratification and pride that the International Committee, to whose action this meeting is due, should have allowed us to play the part of hosts to the eminent men from many lands who have responded to their call. Some, whom we would gladly have seen here, but who have been prevented from attending by various causes, have nevertheless shown the interest which they take in our proceedings by sending written communications. Thus our meeting is as fully representative as we could have hoped.

It may be interesting to those who are unaware of the fact if I remind the Conference that this is not the first occasion on which students of terrestrial magnetism have taken counsel together during a meeting of the British Association.

Fifty-four years ago the then President of the Association, the Very Rev. George Peacock, Dean of Ely, stated in his address that the period was drawing to an end for which a series of magnetic observatories had been established by international co-operation. "Six observatories," he stated (*Brit. Assoc. Rep.*, 1844, p. xliv.), "were established, under the zealous direction of M. Kupffer, in different parts of the vast empire of Russia, the only country, let me add, which has established a permanent physical observatory. The American Government instituted three others, at Boston, Philadelphia, and Washington; two were established by the East India Company, at Simla and Singapore; from every part of Europe, and even from Algiers, offers of co-operation were made." The observations thus provided for were to be carried out for three years only, but as nearly the whole of that time was spent in preparation, the period was doubled. When the term thus fixed drew to an end, the question arose as to whether it was desirable to extend it further, and M. Kupffer (Director-General of the Russian System of Magnetic and Meterological Observations) addressed a letter to Colonel (afterwards Sir Edward) Sabine, suggesting the propriety of summoning a Magnetic Congress to be held at the next meeting of the British Association.

In accordance with that suggestion the Congress was held during the meeting of the Association at Cambridge in 1845. The number of distinguished foreigners who attended in person was considerable in spite of the difficulties of travel fifty years ago. Amongst those who were present was M. Kupffer, Dr. Erman, of Berlin, the celebrated circumnavigator and meteorologist, Baron von Senftenberg, the founder of the Astronomical and Meterological Observatory of Senftenberg in Bohemia; M. Kreil, the director of the Imperial Observatory at Prague; Dr. von Boguslawski, the director of the Royal Prussian Observatory at Breslau; Herr Dove, professor of physics in the University of Berlin; and Baron von Waltershausen, a gentleman who had taken part in the magnetic observations of Gauss and Weber at Göttingen, and had executed a magnetic survey of portions of Italy and Sicily. In addition

to these a number of well-known British men of science were invited to be present, amongst whom I need only mention the Marquis of Northampton (President of the Royal Society), Sabine, Sir John Herschel, Lloyd, Airy, Brown, and Sir James Ross, then recently returned from his celebrated expedition to the Antarctic seas. Letters were also received from Wilhelm Weber, Gauss, Loomis, Lamont, Quetelet, Von Humboldt, and others.

The principal question which this conference had to decide was whether "the combined system of British and foreign co-operation for the investigation of magnetic and meteorological phenomena, which [had then] been five years in progress, must be broken up" (*Brit. Assoc. Rep.*, 1845, p. 69). I will not trouble you with a recapitulation of the recommendations of the Congress, some of which have been carried out, while others have not yet been realised; but one resolution will, I am sure, so exactly express your own sentiments that I venture to quote it, viz.: "That the cordial co-operation which has hitherto prevailed between the British and foreign magnetic and meteorological observatories having produced the most important results, and being considered by us as absolutely essential to the success of the great system of combined observation which has been undertaken, it is earnestly recommended that the same spirit of co-operation should continue to prevail." Whatever changes half a century may have wrought in the problems which press upon magneticians, and in the difficulties which confront them, there can be no doubt that they are still of the same spirit as that in which this resolution was framed.

It is true that we sometimes meet with the objection that international conferences of all kinds are now too numerous, and that their decisions from their very number and complexity cease to attract attention or to command respect. Admitting that this objection is not without weight, it may be answered by two remarks. The closer union between scientific workers in different countries which these meetings encourage, the strengthening of the ties of intellectual sympathy by those of personal friendship are in themselves good. It is surely a hopeful omen that science, as she reaches her maturity, forgets or ignores the political and geographical boundaries which sometimes seemed so important in her youth, and that workers for the common good are more and more learning that it is good to work in common.

But there are special and cogent reasons why the science of Terrestrial Magnetism should be cosmopolitan. The advance of some sciences is most easily achieved by the methods of guerilla warfare. In a hundred different laboratories widely separated workers plan independent attacks on nature. In different universities and colleges little groups are devising stratagems and arranging ambuscades in the hope of wresting from our great opponent some of the treasures which she yields only to the violent who take them by force. But for those who would unravel the causes of the mysterious movements of the compass needle concerted action is essential. They cannot, indeed, dispense with individual initiative, or with the leadership of genius, but I think that all would agree that there is urgent need for more perfect organisation, for an authority which can decide not only what to do, but what to leave undone.

The advance of the science of Terrestrial Magnetism must depend upon the establishment, the maintenance, and the utilisation of the records of observatories. The bulk of the material to be dealt with must in any case be vast, and every needless addition to it, every obstacle in the way of its being readily comprehended and easily used, is a drawback which proper organisation should prevent.

Thus it is wasteful to devote to the multiplication of observatories, in regions of which we know much, energy and funds which would be invaluable if applied to districts of which we know little or nothing. I take some credit to myself in that within the last few months I have assisted in checking well-intended but mistaken proposals to add to the number of the magnetic observatories which we already possess in this country.

Again, it is desirable that the records of the observations should be so published as to be ready for application to the problems the solution of which they are intended to subserve, and that the individual worker should not be harassed by petty differences in the methods of presentment, which often entail on him labour too enormous to be faced. On this point something has already been done by international co-operation, and we may hope that this meeting will do much to complete the task.

Lastly, there are many investigations which are now undertaken independently at irregular intervals which would be far more useful if planned in common. Thus there has of late been a great outburst of energy in Europe devoted to magnetic surveys more detailed than have ever before been accomplished. Is it too much to hope that when the time comes for these to be repeated they may be carried out simultaneously, and reduced by the same methods, so that we may have a magnetic map of Europe in which no uncertainty as to the accuracy of details is introduced by the necessity for correcting for the secular change over long intervals of time?

Taking it, then, for granted that international co-operation is desirable for purposes such as these, I come next to the question of the nature of the machinery by which it shall be secured. And here I may at once state that the arrangements under which we are meeting to-day are in some respects abnormal, and that plans for the future will have to be formally or informally considered before we part. Meanwhile, it is desirable that I should state precisely the circumstances which have brought us together.

The last meeting of the International Meteorological Conference was held in Paris in September 1896. It was attended by several men of science specially interested in Terrestrial Magnetism, and, perhaps on this account, a new departure was taken by the International Committee, in the appointment of a "Permanent Committee for Magnetism and Atmospheric Electricity," to which certain specific questions were referred. Eight gentlemen were nominated as members of this Committee, with power to add to their number. We in turn co-opted eight other magneticians, taking care that as far as possible all countries in which Terrestrial Magnetism is specially studied should be represented. About the same time, and, as I believe, in ignorance of the establishment of this Committee, a suggestion for the assembling of an International Conference on Terrestrial Magnetism was made in the journal of that name by Prof. Arthur Schuster. It appeared to me and to Prof. Schuster himself that it would be a great pity if this suggestion resulted in the establishment of a rival organisation, and I at once submitted to the Committee the question whether, in their opinion, it was desirable that we ourselves should take the responsibility of summoning an international meeting, with the view of obtaining a wide discussion of the points submitted to us by the Meteorological Conference. This suggestion was approved, and as the British Association was willing to allow us to organise the Conference as a branch of Section A (Mathematics and Physics), to undertake the expense of sending out the necessary notices, to print our papers in its Report, and to extend to foreign members of the Conference all the privileges of foreign members of the Association, it was also determined that so hospitable an invitation should be accepted with the gratitude it deserved. But although the main result has been achieved, and a representative gathering of magneticians has assembled in Bristol, it cannot be denied that our relations to the various bodies with which we are connected are somewhat complicated, and that our constitution is devoid both of simplicity and symmetry. I take it that these facts are signs of health and vigour rather than symptoms of decay. Terrestrial Magnetism has been attracting far more attention of late years than in the not very distant past. The necessity for meeting, for common action, for common publication has been forced upon us. We have cared more for meeting than for the terms on which we were to meet, more for acting together than for drawing up an elaborate deed of partnership, more for the promotion of science than for a flawless paper constitution. Thus, and in my opinion most wisely, we have sought to attain our ends, not by starting a brand new International Association, but by making use of machinery which is already in existence, which has stood the test of time, and is, as I believe, capable of being put to new uses in meeting our wants and supplying our deficiencies.

I confess, however, that in this arrangement we have been compelled to pay scant attention to the simplicity and even to the logical consistency of our schemes. We are an International Conference on special subjects—Terrestrial Magnetism and Atmospheric Electricity—summoned by a Committee owing its authority and bound to report to another International Conference of wider scope, which regards our sciences as branches of Meteorology.

On the other hand, this Committee is for the moment a part of the Committee of the Section of Mathematics and Physics of the British Association, though it retains its right of separate

meeting, more especially for the discussion of its report to the International Meteorological Conference. It is evident that here there is plenty of opportunity for collision between rival authorities, for confusion between conflicting jurisdictions; but to all questions as to the precise limits of authority and jurisdiction it is sufficient to reply in the most general terms. The whole of the arrangements are temporary, to meet an immediate pressing need. The work of the Conference will be conducted like that of a Department of the British Association. The members of the International Committee will act as the Committee of the Department, but some of their work will be done on the General Committee of Section A, of which other magneticians will also be members. Should it be necessary, they will hold some separate meetings, and some such meetings will certainly be necessary to discuss their report to the International Meteorological Conference. These general regulations will probably suffice for all practical purposes. If cases occur which they do not cover, we must deal with them as they arise.

With regard to the future, I do not propose to lay before you any detailed scheme, but in discussing the matter among ourselves, the following principles should, in my opinion, be adhered to. The International Meteorological Conference has held a number of successful meetings. I believe that I am correct in saying that the right to attend that Conference was at first confined to those who were officially connected with Meteorological and Magnetic observatories, but that of late invitations have been more widely distributed. If the authorities of that Conference see their way to inviting in future most or all of those who are known to be specially interested in Terrestrial Magnetism, I do not see why the Magnetic Conference, which would then be constituted once in five years, should not meet all our requirements. If, however, additional meetings are necessary, I would urge that they should be held in turn in different countries, and, if possible, in connection with existing societies which play elsewhere the part taken by the British Association in this country.

That a permanent committee should be established is essential, and the mode of appointing this body must no doubt be considered, but I hope that in the course of the next few days the committee may be able to discuss the whole question, and that when the next meeting of the Meteorological Conference takes place we may be able to lay before the Committee suggestions which may lead to the foundation of an International Magnetic Association on a stable and permanent basis.

Another matter of great importance is the maintenance of an international journal devoted to Terrestrial Magnetism. This we now possess, thanks to the energy of Dr. Bauer, and I feel sure that all present will agree that such a means of intercommunication is invaluable. I believe, however, that the enterprise is threatened with financial dangers, and I desire to take this opportunity of urging all those who are interested in its success to do what they can to support it by increasing the circulation. There is every reason for making more use of a common journal. The records of the observatories are necessarily so bulky, that any one who desires to obtain the facts as to the magnetic state of the earth at any given time must collect or consult a large library of quarto volumes, in some of which the magnetic facts are mingled with data interesting chiefly to the meteorologist or astronomer. It is no doubt essential that an account of all the work done at each observatory should be published in a collected form, and that full details of the magnetic observations should be given; but for many, nay, for most, purposes, those who use the records will require only final results; the means of the various elements for the year, for each month, or for any other period which may hereafter be adopted, and the mean diurnal variation, are in general wanted, rather than the hourly values. If these means could be published together, once a year, an enormous boon would be conferred upon magneticians. For special purposes the theorist will have to test his views by reference to the results published in their fullest detail; but it would be no slight gain if the more salient facts could be compared by being placed side by side in the same journal. One advantage such a system would unquestionably possess. It would impress upon the authorities of the observatories the necessity for adhering to a common form of publication.

Some small beginnings have already been made. The Kew Observatory Committee now publish in the *Proceedings* of the Royal Society the annual means of the elements recorded by all the observatories which send their publications to Kew. By comparing two of these tables, the secular change can at once be determined. But the system is capable of extension, not merely to the normal values of the elements, but to disturbances. By common agreement, Greenwich and Parc St. Maur publish in each year the records of the same magnetic storms. If this agreement could be extended, and if the facts thus selected were brought into juxtaposition, we might hope for a fuller and more instructive analysis than is at present usual.

Turning from questions of organisation, the primary business of our conference will be to discuss four questions submitted to our Committee by the International Meteorological Conference.

The first two of these refer to the methods for calculating and publishing the monthly means of the magnetic elements which should, in our opinion, be adopted. I will not anticipate the discussion which will take place on these points, except to say that it will be necessary to bear in mind not only what is desirable, but also what is practicable in view of the resources at the disposal of the directors of the various magnetic observatories.

Another question deals with the relative merits of long and short magnets, and on this point we shall have the advantage of hearing a report on the subject by M. Mascart.

Lastly, there is a very important proposal for the establishment of temporary magnetic observatories at certain specified places. General Rykatcheff and Prof. von Bezold present an excellent report on this subject, and I will only remind you that whereas the accuracy of the mathematical expression of the magnetic state of the earth's surface depends entirely on the number and position of the spots at which the magnetic elements are accurately known, the establishment of temporary observatories will be a costly undertaking, for the carrying out of which all the resources at the disposal of international science will have to be employed.

Another point of considerable practical importance will also be brought before us. The rapid extension of electrical railways and tramways is a serious menace to magnetic observatories. From all parts of the world we hear of observatories ruined or threatened by the invasion of the electrical engineer. Toronto and Washington have already succumbed; Potsdam, Parc St. Maur, Greenwich, and Kew are besieged, and the issue largely depends upon whether these great national observatories can or cannot make good their defence.

It seems to be a law of nature, ruling alike the human race and the humblest microbe, that the products of an organism are fatal to itself. The pessimist might infer that we are in presence of another instance of the universality of the application of this law, and that pure science is threatened by the very success of its practical applications. The smoke of our cities blots the stars from the vision of the astronomer, who, like the anchorites of old, flies from the world to mountains and desert places. It is only in the small hours of the morning when

> "Save pale recluse, for knowledge seeking,
> All mortal things to sleep are given,"

that the physicist can escape from the tremors of the traffic of a great town.

Civilisation as it spreads by aid of the means that science has placed at its disposal is destroying records, and obliterating boundaries by the study of which the anthropologist and the biologist might have read far back into the history of our race. And now in turn the science of Terrestrial Magnetism, which, on the one hand, is forging another link to connect the sun and earth, and, on the other, is penetrating within the surface of the globe to depths beyond the ken of the geologist, is threatened by the artificial earth currents of the electric railway.

That the crisis is serious there can be no doubt, but I will only anticipate the fuller discussion which will take place by stating that magneticians, in common with the rest of the world, recognise the great benefit which electric traction confers upon the community at large. We are not so foolish as to desire to embark on a crusade against a great industrial improvement of which science may well be proud; on the other hand, we must hold fast to the position that provision for the conveniences which are immediately appreciated by the public should be made with as little damage as possible to those studies which are not less for the ultimate benefit of the race.

Had science, when the use of coal was introduced, been sufficiently advanced to devise means for smokeless combustion, an evil, which now in more senses than one darkens the lives of the inhabitants of our great towns, might have been prevented from attaining its present gigantic proportions.

We are now at the beginning of another industrial epoch, which may indeed, if power is transmitted from a distance on a large scale, brighten our skies, but which threatens to saturate the earth beneath us with electric currents. That these may interfere with the general comfort is evident from the injury which has been done to underground pipes at Washington and elsewhere. The construction of a powerful electric railway in the immediate neighbourhood of the laboratories of a college would interfere with its efficiency, and make it impossible to perform experiments of certain types. In such a case, however, something could be done by arranging the experiments to suit the conditions under which they would have to be performed. But in the case of a magnetic observatory no such protective measures are possible. The very object of the observatory is to measure the earth's field, and if that field is artificially altered, no modification of the methods of measurement, however ingenious, can overcome this fundamental defect. I am glad to take this opportunity of acknowledging that both the danger to pure science and the necessity for obviating it have been acknowledged by those who are chiefly interested in the technical applications of science; and in particular that one of the principal technical journals, the *Electrician*, has supported the view that industry can and ought to respect the necessities of research.

If, however, there be any who are inclined to ask whether the careful study of Terrestrial Magnetism has led or is leading to any definite results, or whether we are not merely adding to the lumber of the world by piling up observations from which no deductions are drawn, we may answer that, though the fundamental secret of Terrestrial Magnetism is still undiscovered, the science is progressing. In the presence of several of the most active workers I will not enter into a detailed discussion of the tasks to which they are devoting themselves; I will only ask that the doubter should compare a good summary of the state of the science of Terrestrial Magnetism written fifteen or twenty years ago, such as that contained in the article by Balfour Stewart in the "Encyclopædia Britannica," with what would be written on the same subject to-day. Additions would have to be made to the descriptions of the instruments employed, to the discussion of the theory of the diurnal and secular change, while such questions as the reality of earth-air currents, and the tracing of loci of local disturbance have only been dealt with effectively in very recent times. When, too, we compare the older models of the magnetic state of the earth with that devised by Mr. Henry Wilde we cannot but admit not only that a great advance has been made in forming a simple diagram of the magnetic state of the earth, but that it is possible that the model contains a very pregnant hint as to the physical construction of the earth as a magnetic body.

The fact that Mr. Wilde has imitated the declination and dip with remarkable accuracy all over the surface of the earth by means of a simple arrangement of electrical currents, and by coating the oceans with thin sheet iron, has not attracted the attention it deserves. Whether the physical cause thus suggested be due to the greater depth to which the underground isothermals penetrate below oceans, the bottoms of which are always cold, or whether the geological nature of the rocks is different below the great depressions and elevations of the earth's surface, respectively may be open to question, but I am persuaded that the matter should be more fully investigated.

In conclusion, let me once more revert to the points on which I dwelt at the beginning of this brief address. We meet with the confidence of men who know that their science is progressing, but with the mingled hopes and fears of those who still have to deal with the great unsolved problem of the causes of Terrestrial Magnetism and of its manifold fluctuations. This solution will be most easily attained if we are not merely content to collect facts, but if we so arrange that they shall be easily dealt with. To observe is our first duty, to organise our second, and if these be fulfilled we may hope that a theory of terrestrial magnetism will in the future crown the efforts not merely of him on whom the first glimpse of the truth may flash, but of the international co-operation which has, by way of preparation, made "the crooked straight and the rough places plain."

SECTION C.

GEOLOGY.

OPENING ADDRESS BY W. H. HUDLESTON, M.A., F.R.S., PRESIDENT OF THE SECTION.

Introductory.—About this time last year British geologists were scattered over no inconsiderable portion of the northern hemisphere, partly in consequence of the International Geological Congress at St. Petersburg, and partly owing to the meeting of the British Association at Toronto. From the shores of the Pacific at Vancouver, on the one hand, to the highlands of Armenia on the other, there were parties engaged in the investigation of some of the grandest physical features of the earth's surface.

The geologists in Canada were especially favoured in the matter of excursions. Everything on the American continent is so big that a considerable amount of locomotion is required to enable visitors to realise the more prominent facts. If there is no great variety of formation in Canada, yet the Alpha and Omega of the geological scale are there most fully represented, from the great Laurentian complex at the base to the amazing evidences of glacial action, in a country where it is possible to travel for a whole day without once quitting a glaciated surface. But Russia presented equal attractions, and in Finland almost identical conditions were observed, viz. glacial deposits on Archæan rocks. The great central plain of Russia, too, with its ample Mesozoic deposits often abounding in fossils, offered attractions which to some may have been stronger than the mineral riches of the Urals, or the striking scenery of the Caucasus.

It seems almost incredible, even in this age of extraordinary locomotion, that scenes so wide apart were visited by British geologists last autumn. This year we are more domestic in our arrangements, and Section C finds its tent pitched once more on the classic banks of the Bristol Avon, and in that part of England which has no small claim to be regarded as the cradle of English geology. But we may go a step further. For if the strata observed by William Smith during the six years' cutting of the Somersetshire coal-canal imprinted their lessons on his receptive mind, it is also equally true that Devonshire, Cornwall, and West Somerset first attracted the attention of the "Ordnance Geological Survey." And thus it comes to pass that the region which lies between the Bristol Channel and the English Channel claims the respect of geologists in all parts of the world, not only as the birthplace of stratigraphical palæontology, but also as the original home of systematic geological survey.

The city of Bristol lies on the confines of this region, where it shades off north-westwards into the Palæozoics of Wales, and north-eastwards into the Mesozoics of the Midland counties. There are probably few districts which display an equal amount of variety within a limited circumference. The development of the various formations was excellently portrayed by Dr. Wright, when he occupied this chair twenty-three years ago—so well, indeed, that his address might serve as text-book on the geology of the district. In the following year (1876) there appeared the Survey Memoir on the Geology of East Somerset and the Bristol Coal-fields, by Mr. H. B. Woodward, who has since contributed important memoirs on the Jurassic rocks of Britain, which are so largely developed in Somerset and the adjacent counties. Since that date many papers also have appeared in various journals, and some of these, as might be expected, give new and perhaps more accurate interpretations of phenomena previously described. In addition to this, portions of the south-west of England have been geologically re-surveyed, and in some cases new maps have been published.

I would call especial attention to the Survey map on the scale of four miles to the inch, known as the "Index-map," which has recently been issued. Sheet 11 includes this particular district; but if a portion of sheet 2 is tacked on to its southern border, we obtain a block of country about 120 miles square, which has not its equal for variety of geological formation in any part of the world within the same space. If Europe is to be regarded as presenting a geological epitome of our globe, and if Great Britain is an epitome of Europe, then, without doubt, this particular block of the south-west, which has Bath for its more exact centre, with a radius (say) of fifty miles, may be said to contain almost everything to be found on the geological scale, except the very oldest and the

very youngest rocks; while east of the Severn and south of the Bristol Channel true Boulder clay is rare or absent.

It may be convenient to consider a few points which have arisen of late years in connection with the geology of portions of the district now under consideration.

Palæozoic.—If we omit the Silurian inlier at Tortworth, the geological history of the country, more immediately round Bristol, may be said to commence with the Old Red Sandstone, whose relations with the Devonian towards the south-west, have always presented some difficulty. And this difficulty is accentuated by doubts as to the true Devonian sequence in West Somerset and North Devon. Ever since the days of Jukes that region has been fruitful in what I must continue to regard as heresy until the objectors have really established the points for which they are contending. The uncertainty is to be regretted, since it is through these beds of West Somerset that the system is to be made to fit in with the several members of the Old Red Sandstone.

There is a mystery underlying the great alluvial flats of Bridgewater which affects more than one formation; so much so, that one cannot avoid asking why there should be Old Red Sandstone in the Mendips and Devonian in the Quantocks. The line which separates the Old Red Sandstone of South Wales and the Mendips from the West Somerset type of Devonian lies here concealed. I have already suggested (*Trans. Devonsh. Assoc.*, vol. xxi., 1889, p. 45) that, if we regard the Old Red Sandstone of South Wales as an inshore deposit over an area which was deluged with fresh water off the land, we can believe that further out to sea, in a south-westerly direction, the conditions were favourable for the development of a moderate amount of marine mollusca. This view not only does away with the necessity for a barrier, but it also, in a general sense, suggests a kind of gradation between the Old Red and Devonian deposits. Mr. Ussher, whose practical acquaintance with this region dates from a long period, stated a few years ago that, "As far as Great Britain is concerned, the true connections of the Old Red Sandstone beds with their marine Devonian equivalents have yet to be carefully worked out on the ground."[1] I am not aware that further progress has been made in this direction.

The Carboniferous Limestone of the Bristol area has attracted the attention of so many distinguished geologists that its palæontology and general features are tolerably familiar. Of late years we owe some interesting petrographic details to Mr. Wethered. The varying thickness of the Carboniferous Limestone and also of the Millstone Grit in this part of England is noteworthy. If we follow the Carboniferous Limestone in a south-westerly direction, across the mysterious Bridgewater flats, a change is already noted in the case of the Cannington Park limestone, which was the subject of so much discussion in former years. Referring to this, Mr. Handel Cossham (*Proc. Cottes. Club*, vol. viii, 1881–2, p. 20 *et seq.*) was so sanguine as to believe that its identification with the Carboniferous Limestone would have the effect of extending the Bristol coal-field thirteen miles south of the Mendips. However this may be, all further traces of Carboniferous rocks fail at this point. After crossing the vale of Taunton, when next we meet with them in the Bampton district, the Culm-measure type, with its peculiar basal limestones, is already in full force.

In the new "Index-map" the Culm-measures are placed at the base of the Carboniferous series—below the Carboniferous Limestone. It is no part of my purpose to attempt any precise correlation, but I would point out the somewhat singular circumstance that the change to Culm rock occurs only a few miles to the south-west of the line where, in the previous system, we have already seen that the Old Red Sandstone changes into the Devonian. This curious coincidence may be wholly accidental, or it may be the result of some physical feature now concealed by overlying formations.

Since 1895 a new light has been thrown on the Lower Culm-measures by the discovery of a well-marked horizon of Radiolarian rocks. One result of the important paper of Messrs. Hinde and Fox has been to alter materially our views as to the physical conditions accompanying the deposition of a portion of the Culm-measures. The palæontology leads the authors to conclude (*Quart. Journ. Geol. Soc.* vol. li., 1895, p. 662) that "the Lower *Posidonomya*- and Waddon Barton Beds are the representatives and equivalents of the Carboniferous Limestone in other portions of the British Isles; not, however, in the at present generally understood sense that they are a shallow-water facies of the presumed deeper-water Carboniferous Limestones, but altogether the reverse, that they are the deep-water representatives of the shallower-formed calcareous deposits to the north of them. . . . The picture that we [Messrs. Hinde and Fox] can now draw of this period is that while the massive deposits of the Carboniferous Limestone—formed of the skeletons of calcareous organisms—were in the process of growth in the seas to the north [*i.e.* in the Mendip area and elsewhere] there existed to the south-west a deeper ocean in which silicious organisms predominated and formed these silicious Radiolarian rocks."

This is probably a correct view of the case, but one cannot help wondering that the ocean currents and other causes did not effect a greater amount of commingling of the elements than seems to have taken place. As a practical result, this discovery of a Radiolarian horizon in the Culm-measures has been of service in enabling surveyors to discriminate between Devonian and Carboniferous in the very obscure area on the other side of Dartmoor. This, I ventured to predict, would be the case when the paper was read before the Geological Society.

The principal features of the Bristol coal-field are too well known to call for many remarks. It would seem that the Pennant rock was formerly regarded as Millstone Grit, until Mr. Handel Cossham, in 1864, pointed out the mistake. Mr. Wethered gave a good description of the Pennant in his paper on the Fossil Flora of the Bristol coal-field (*Proc. Cottes. Club*, vol. vii, 1878, p. 73). It might seem almost unnecessary to refer to the existence of such a well-known formation as the Pennant, but for the fact that in a recent scheme of the Carboniferous sequence in Somersetshire the Pennant rock was wholly omitted.

The interest now shifts from the almost continuous deposition of the later Palæozoics, in one great geosynclinal depression, to an entirely different class of phenomena. Nowhere, perhaps, are the effects of the post-Carboniferous interval better exhibited than in those parts of the south-west of England where Tertiary denudation has removed the Mesozoic deposits. Here we perceive some of the effects of the great foliations which terminated the Palæozoic epoch in this part of the world. The immense amount of marine denudation which characterises this stage is particularly obvious in the anticlinals, which were the first to suffer, as they came under the planing action of the sea.

Attention may be drawn to a peculiarity which has no doubt been observed by many persons who have studied a map of the Bristol and Somerset coal-field. It will be seen that the strike of the Coal-measures is widely different on either side of a line which may be drawn through Mangotsfield to a point north of Bristol. The beds north of this line have for the most part a meridional strike, nearly parallel with the present Cotteswold escarpment; south of this line the strike is mainly east and west, though much curved in the neighbourhood of Radstock and the flanks of the Mendips. Of course this is only part of an extensive change in the direction of flexure, much of which is still hidden under Mesozoic rocks. Mr. Ussher, in the paper previously quoted, tells us that the line of change of strike may be traced in the general mass of the Palæozoic rocks, from near Brecon in South Wales to the neighbourhood of Frome. This means that within the Bristol district two distinct systems of flexure must have impinged on each other in post-Carboniferous times. Have we not here, then, another instance of extraordinary change within the limits of our area? This time it is not a mere change in the nature of a deposit, like that of the Old Red Sandstone into the Devonian, or of the Carboniferous Limestone into the Culm-rock, but a change in the direction of the elevatory forces, which had made its mark on the structure of our island even at that early date.

At this point I ought to quit the Palæozoics; but there is just one subject of interest which claims a momentary attention, viz. the probability of finding workable coal east of the proved Somersetshire field. I avoid the question of coal south of the Mendips as being too speculative, on account of the chances of deterioration of the coal-measures in that direction. But in view of the forthcoming meeting of the British Association at Dover, the question of finding coal to the eastward of Bath becomes a specially interesting subject for discussion. It is also a matter of some consequence whether the hidden basin or basins belong to the meridional or to the east and west system of flexures.

[1] Prospects of obtaining coal by boring south of the Mendips, *Proc. Som. Nat. Soc.*, vol. xxxvi. (1891) pt. 2, p. 104.

The latter is most likely to be the case.[1] The vale of Pewsey has been mentioned as a suitable locality for boring along the line of the recognised axis.

But prospectors should bear in mind the warning of Ramsay, that the basins containing coal are but few in comparison with the number of basins throughout the palæozoic rocks. No doubt the line indicated is more favourably situated for coal-exploration than the eastern counties; where, for instance, the Coal Boring and Development Company has lately gone into liquidation. The unsuitability of East Anglia as a field for coal-prospecting was insisted on in my second anniversary address to the Geological Society (*Quart. Journ. Geol. Soc.* vol. i., 1894, p. 70), and the results seem to have been very much what might have been expected. If coal is to be found beneath the Secondary rocks, the line of search should be carried through the counties of Kent, Surrey, Berkshire, and Wiltshire, though the three latter counties have hitherto been content to leave their underground riches unexplored. The Kent Coal Exploration Company is doing some good work with a reasonable chance of success; though if they wish to find coal sufficiently near the surface they had better adhere as much as possible to the line of the North Downs, since operations on the Sussex side are only too likely to be within the influence of the Kimmeridgian gulf, which was proved to exist at Battle (Netherfield). Mr. Etheridge, I hope, will have something to tell us as to the progress of the Kent Collieries Corporation, who now carry on the work at Dover.

Secondary or Mesozoic Rocks.—Commencing a totally different subject, I must now direct attention to the "red beds" and associated breccias so characteristic of eastern Devonshire. These rest in complete discordance on the flanks of the palæozoic highlands, and must be regarded as forming the base of the Secondary rocks of that district.

By the Geological Survey this series has hitherto been mapped as Trias, but in the new "Index-map" they are coloured as Permian. There is no Palæontological evidence which would connect them with the fossiliferous Permians, usually regarded as of Palæozoic age, but it has been evident for some time past that opinion was inclining to revert to the views of Murchison and the older geologists, more especially as to the position of the breccias so largely charged with volcanic rocks. The subject was dealt with by Sir A. Geikie in his address to the Geological Society, where he speaks of some of these rocks as presenting the closest resemblance to those of the Permian basins of Ayrshire and Nithsdale (*Quart. Journ. Geol. Soc.*, vol. xlviii., 1892, p. 161).

One difficulty which presented itself to the Devonshire geologists in accepting the Permian age of the "red beds" was, that the whole of the lower Secondary rocks appeared as an indivisible sequence, proved by its fossils to be of Keuper age at one end, and therefore inferentially of Keuper age at the other. Dr. Irving, however, considered that at the base of the Budleigh Salterton pebble-bed there is a physical break of as much significance as that between the Permian and Trias of the Midlands. In the marls which underlie this pebble-bed he recognised a strong resemblance to the Permian marls of Warwickshire and Nottinghamshire; and Prof. Hull, who had been studying the sections east of Exmouth about the same time, ultimately acceded to this view.[2] Its acceptance by the Survey thus throws all the Exmouth beds into the Permian; and that formation, according to the new reading, has an outcrop of some thirty-five miles from the shores of the English Channel to within three miles of Bridgewater Bay. The fertility of these red clays, loams, and marls has long been recognised by agriculturists, and it is not improbable that the abundance of contemporaneous volcanic material may in some measure have contributed to this result.

In conformity with the new mapping, the Budleigh Salterton pebble-bed and its equivalents to the northwards are accepted as of Bunter age, and thus constitute the base of the Trias in the south-west. Like most pebble-beds, they are irregularly developed between the Permians and a strip of reddish sandstone (coloured as Keuper), which runs up from the mouth of the Otter to within a short distance of Bridgewater Bay. The materials of the pebble-beds are not of local origin, like so much of the breccia at the base of the Permian. The general resemblance, both as regards scenery and composition, to the Bunter conglomerate of Cannock Chase has been pointed out by Prof. Bonney, who seems prepared to endorse the recognition of the Budleigh Salterton pebble-bed as a Bunter conglomerate. He was not impressed by any marked unconformity with the underlying series. To some extent we may accept this view, since whatever may be the age of the Devonshire breccias and "red beds," they, in common with the Trias, must have been deposited under fairly similar physical conditions in a sort of Permo-Triassic lake basin.

The bulk of the Trias, including the Dolomitic Conglomerate of the Bristol district, is still regarded as of Keuper age, though it is now admitted, as insisted on by Mr. Sanders years ago, that the Dolomitic Conglomerate does not necessarily occupy the base of the Keuper, but is mainly a deposit of hill-talus, which has been incorporated with the finer deposits of the old Triassic lake as the several palæozoic islands gradually became submerged. The great blocks which fell from the old cliffs were formerly regarded as proofs of glacial agency, and there are persons who still believe, more especially with respect to the Permian breccias, that such rocks are indicative of a glacial origin.

In the "Index-map" the Dolomitic Conglomerate and the Red Marl are thus included under the same symbol and colour. But this is also made to include the Rhætic—an arrangement which is hardly in accordance with the facts observed in the Bristol area. On a small-scale map so narrow an outcrop as that of the Rhætic could hardly be shown; yet its affinities are probably with the Lower Lias rather than with the Trias. The late Edward Wilson, whose recent death we all deplore, in his paper on the Rhætic rocks at Totterdown (*Quart. Journ. Geol. Soc.*, vol. xlvii., 1891. p. 545), showed most clearly that the "Tea-green Marls," which had previously been associated with the Rhætic, represent an upwards extension of the Red Marls of the Trias, in which the iron had suffered reduction; though there are indications of a change of conditions having set in before the deposition of the Rhætics. The black Rhætic shales which succeed usually have a sharp and well-defined base in a bone-bed with quartz pebbles, &c., indicating a sudden change of physical conditions, though perhaps no marked unconformity. In the South Wales district the Rhætic limestones are said to be largely of organic origin, and, in addition to a Rhætic fauna, to abound in the lamellibranchs so plentiful in the lowest Lias limestones (*Ann. Rep. Geol. Survey* for 1896, p. 67).

The late Charles Moore always deplored the comparative poverty of the Trias in fossils. In his last communication to the Geological Society (*Quart. Journ. Geol. Soc.*, vol. xxxvii., 1881, p. 67), he set himself to describe certain abnormal deposits about Bristol, and to institute a comparison with the region of the Mendips. He then suggested, on the faith of a sketch by Mr. Sanders, that the famous Durdham Down deposit, already inaccessible, might have been a fissure-deposit in the Carboniferous Limestone like those at Holwell. He also stated that at one time he had been inclined to regard the reptilian deposit on Durdham Down as of Rhætic age; but the discovery of teeth of *Thecodontosaurus*, identical with those of Bristol, in a Keuper Marl deposit near Taunton, induced him to refer the Durdham Down deposit to the middle of the Upper Keuper. He had arrived at the conclusion that the same genera of vertebrata are found in the Keuper and Rhætic beds, though the species, with few exceptions, are quite distinct.

But it is with the Lias that the name of Charles Moore is most intimately associated. Time does not permit me to do more than allude to the wonderful collections of Rhætic and Liassic fossils made by him from the fissure-veins of the Carboniferous Limestone, or of the treasures which are stored in the Bath Museum. There never was a more enthusiastic palæontologist, and nothing pleased him better than to exhibit the fossilised stomach of an *Ichthyosaurus*, stained by the ink bag of the cuttle-fish, on which it had been feeding, or some similar palæontological curiosity. Every one here knows how deeply the West of England is indebted to Charles Moore for his unceasing researches, and I have been thus particular in alluding to them because it was under his auspices that I first became acquainted with the geology of this part of the country thirty years ago.

Amongst more recent work in the Rhætic and Lias, I might

[1] The boring at Burford, where coal was found at a depth of 1100 feet, below a surface of Bathonian beds, at a point thirty-five miles E.N.E. of the extreme end of the Bristol Coal-field at Wickwar, is not included in this category; since it must belong to the meridional system, and is altogether outside the prolongation of the axis of Artois.

[2] (*Cf.* Irving, *Quart. Journ. Geol. Soc.*, vols. xliv., 1888, p. 149, xlviii., 1892, p. 68, and xlix., 1893, p. 79; and Hull, *op. cit.* vol. xlviii., 1892, 60).

mention papers by Mr. H. B. Woodward and Mr. Beeby Thompson, each in explanation of the arborescent figures in the Cotham Marble. The latter revives an old idea with modifications, and his theory certainly seems plausible. Mr. H. B. Woodward's Memoir of 1893 does full justice to the Lias of this district, and much original matter is introduced.

It is, however, in the Inferior Oolite that the most important interpretations have to be recorded since the days when Dr. Wright and Prof. J. Buckman endeavoured to correlate the development of the series in the Cotteswolds with that in Dorset. To this subject I alluded at considerable length in my address to the Geological Society in 1893, pointing out how much we owed in recent years to the late Mr. Witchell and to Mr. S. S. Buckman. In the following year appeared Mr. H. B. Woodward's Memoir on the Lower Oolitic Rocks of England ("Jurassic Rocks of Britain," vol. iv.), wherein he did full justice to the work of previous observers. Meantime Mr. Buckman has not been idle, and his paper on the Bajocian of the Sherborne district (*Quart. Journ. Geol. Soc.*, vol. xlix., 1893, p. 479) marks the commencement of a new era, where the importance of minute chronological subdivisions, based upon the prevailing ammonites, is insisted on with much emphasis. This system he considers to be almost as true for the Inferior Oolite as for the Lias.

There can be no doubt that its application has enabled Mr. Buckman to effect satisfactory correlations between the very different deposits of the Cotteswolds and those of Dorset and Somerset. In subsequent papers also he brings out an important physical feature, viz. the amount of contemporaneous denudation which has affected deposits of Inferior Oolite age in this country. This serves in part to explain the absence of well-known beds in certain areas. For instance, in the Cotteswolds contemporaneous erosion has, prior to the deposition of the Upper *Trigonia*-grit, cut right through the intervening beds, so as to produce in the neighbourhood of Birdlip a shelving trough 6 miles wide and about 30 feet deep. Thus the extensively recognised overlap of the *Parkinsoni*-zone is accentuated in many places.

We have a further instance of good work in the case of Dundry Hill. An inspection of the 1-inch Survey map would lead one to suppose that the Inferior Oolite there rests directly on the Lower Lias. Recently, owing to the investigations of Messrs. Buckman and Wilson,[1] this apparent anomaly has been removed, whilst beds of Middle and Upper Lias age, and even Midford Sands have been recognised. In this way the authors claim to have reduced the thickness assigned to the Inferior Oolite on Dundry Hill by about 100 feet. In the paper above quoted the vicissitudes and faunal history of the Inferior Oolite from the *opalinus*-zone to the *Parkinsoni*-zone inclusive are shown with much detail; whilst the position of the chief fossil-bed in time and place has been well established. The general resemblance of the Dundry fossils to those of Oborne, which I could not fail to notice in working out the Gasteropoda of the Inferior Oolite, now admits of explanation. Although the quondam *Humphriesianus*-zone is richly represented, yet the particular *Humphriesianum*-hemera is held to be absent at Dundry. But if there is a *Sowerbyi*-bed anywhere it should serve to connect these two localities, where, according to Mr. Buckman's phraseology, the principal zoological phenomenon is the acme and paracme of Sonninineæ.

Mr. Buckman, as we have seen, is no longer satisfied with the old-fashioned threefold division of the Inferior Oolite, and his time-table includes at least a dozen hemeræ, with prospect of increase. Granting that it would have been difficult to solve the Dundry problem without a detailed knowledge of ammonite horizons, there arises the question as to the utility of such minute subdivisions for the purposes of general classification. Mr. Buckman has earned the right to put forwards, if he pleases, the several stratigraphical rearrangements in which from time to time he indulges. The Inferior Oolite has been his especial playground, and, as the kaleidoscope revolves, this formation is perpetually made to assume different proportions, even to the verge of extinction. But this practice is not without its disadvantages; whilst the invention of new names tends to clog the memory, and the novel use of old ones is apt to produce confusion.

We have not quite finished with Dundry yet, since that classic hill serves to illustrate in Mesozoic times a peculiarity of which I have already pointed out two notable instances in this district, where an abrupt and seemingly unaccountable difference is observed in beds which are approximately synchronous. The problem to be solved is this—why does the fossiliferous portion of the Inferior Oolite on Dundry Hill resemble that of the neighbourhood of Sherborne, both in lithology and fossils, rather than that of the Cotteswolds, only a few miles distant?

Nine years ago Mr. Buckman offered an ingenious solution of this difficulty (*Proc. Cottes. Club*, vol. ix., 1890, p. 374), though his recent investigations at Dundry, and especially his appreciation of the effects of contemporaneous erosion, may have caused him to alter his views. Like most people who wish to account for strong local differences, he placed a barrier of Palæozoic rocks between Dundry and the southern prolongation of the Cotteswold escarpment. At that time it was not fully realised that the Inferior Oolite in the Bath district is, for the most part, limited to the *Parkinsoni*-zone, so that the comparison was really being made between beds of different age as well as different physical conditions. The question resolves itself into one of local details, which are not suited for a general address. Still, I think it may be taken for granted that, notwithstanding the east-and-west barrier of the Mendip range, which acted effectually previously to the *Parkinsoni*-overlap, there was in some way a communication by sea between Dundry and Dorsetshire, more especially during the *Sowerbyi*-stage, and this most probably was effected round the western flank of the Mendips. Thus, without acceding to the necessity for a barrier facing the southern Cotteswolds, we may readily believe that much of the Inferior Oolite of Dundry Hill is to be regarded as an outlying deposit of the Anglo-Norman basin. If this be so, it is difficult to avoid the conclusion that the low-lying area of the Bridgewater flats was, during part of the Inferior Oolite period, occupied by a sea which was continuous from Sherborne to Dundry, and that, although the barrier of the Mendips was interposed, communication was effected round the west flank of that chain. This would make a portion of the Bristol Channel a very ancient feature.

We must now take a wide leap in time, passing over all the rest of the Jurassics, and just glancing at the Upper Cretaceous system, which reposes on the planed-down surface of the older Secondary rocks. The remarkable double uncomformity is nowhere better shown than in the south-west of England. Some of the movements of the older Secondary rocks, prior to the great revolution which brought the waters of the Cretaceous sea over this region, have been successfully localised by Mr. Strahan, more especially in the south of Dorset.

Owing to Tertiary denudation the Chalk in this immediate district has been removed, and we have no means of judging the relations of the Cretaceous deposits to the Palæozoic rocks of Wales. If we may judge by results recently recorded from Devonshire (*cf.* Jukes-Browne and Hill, *Quart. Journ. Geol. Soc.* vol. liii., 1897, p. 99), the Lower Chalk especially undergoes important changes as it is traced westwards, and generally speaking terrigenous deposits seem more abundant in this direction. At the same time the more truly oceanic deposits, such as the Upper Chalk, appear to be thinning. As regards the possible depths of the Cretaceous sea at certain periods, we are supplied with some interesting material in Mr. Wood's two papers on the Chalk Rock (*Quart. Journ. Geol. Soc.*, vol. liii., 1897, p. 68, and vol. liii., 1898, p. 377), which has been found especially rich in Gasteropoda at Cuckhamsley, near Wantage.

Tertiary, Pleistocene, and Recent.—Although the Tertiaries of the Hampshire basin are within the "Index-map" which we have been considering, they may be regarded as beyond our sphere. Some of the gravels of Dorsetshire, which have gone under the name of plateau gravels, are held by Mr. Clement Reid to be of Bagshot age. Many of the higher hill gravels most likely date back to the Pliocene, and even further, and represent a curious succession of changes, brought about by meteoric agencies, where the valley-flat of one period, with its accumulated shingle, becomes the plateau of another period—an endless succession of revolutions further complicated by the Pleistocene Cold Period, which corresponds to the great Ice Age of the north.

In the more immediate neighbourhood of Bristol, since some date in Middle Tertiary time, the process of earth-sculpture, besides laying bare a considerable amount of Palæozoic rock,

[1] *Quart. Journ. Geol. Soc.*, vol. iii., 1897, p. 669. *Cf.* also *Proc. Brist. Nat. Soc.*, vol. viii., 1897, pt. ii. p. 188.

has produced both the Jurassic and Cretaceous escarpments as well as the numerous gorges which add so much to the interest of the scenery. These phenomena have been well described by Prof. Sollas (*Proc. Geol. Assoc.*, vol. vi., 1881, p. 375), when he directed an excursion of the Geologists' Association in 1880. Should any student wish to know the origin of the gorge of the Avon at Clifton, for instance, he will find in the Report an excellent explanation of the apparent anomaly of a river which has been at the trouble of sawing a passage through the hard limestone, when it might have taken what now seems a much easier route to the sea by way of Nailsea.

The origin and date of the Severn valley is a still bigger question, and this was broached by Ramsay, some five-and-twenty years ago, in a suggestive paper on the River Courses of England and Wales (*Quart. Jour. Geol. Soc.*, vol. xxviii., 1872, p. 148). He there postulates a westerly dip of the chalk surface, which determined the flow of the streams in a westerly direction towards the long gap which was being formed in Miocene times, near the junction of the Mesozoic with the Palæozoic rocks. The still more important streams from the Welsh highlands had no doubt done much towards initiating that gap; and by the end of the Miocene period, if one may venture to assign a date, the valley of the Severn, which is one of the oldest in England, had already begun to take form, though many of the valleys of Wales are probably much older.

We may now be supposed to have arrived at a period when the physical features of this immediate district did not differ very materially from what they are at present. The great Ice Age was in full force throughout Northern Europe, and, according to views which meet with increasing favour, the German Ocean and the Irish Sea were filled with immense glaciers. What was taking place at that time in the estuary of the Severn?

This is a case which requires the exercise of the scientific imagination, of course under due control. There is probably nothing more extraordinary in the history of modern investigation than the extent to which geologists of an earlier date permitted themselves to be led away by the fascinating theories of Croll. The astronomical explanation of that "will o' the wisp," the cause of the great Ice Age, is at present greatly discredited, and we begin to estimate at their true value those elaborate calculations which were made to account for events which in all probability never occurred. Extravagance begets extravagance, and the unreasonable speculations of men like Belt and Croll have caused some of our more recent students to suffer from "the nightmare."

Nevertheless Croll, when he confined his views to the action of ice, showed himself a master of the subject, and his suggestions are often worthy of attention, even when we are not convinced. Writing in the *Geological Magazine* in 1871, he points out that the ice always seeks the path of least resistance; and he refers to the probability that an outlet to the ice of the North Sea would be found along the natural hollow formed by the valleys of the Trent, the Warwickshire Avon, and the Severn. Ice moving in this direction, he says, would no doubt pass down into the Bristol Channel and thence into the Atlantic. Again (*op. cit.* Dec. 2, vol. i., 1874, p. 257), referring to the great Scandinavian glacier, he says, "it is hardly possible to escape the conclusion that a portion of it at least passed across the south of England, entering the Atlantic in the direction of the Bristol Channel." These views were not based on any local knowledge, but merely on general considerations. The problem as to whether there are any traces of the passage of such a body of ice in the basin of the lower Severn must be worked out by local investigators. Irrespective, too, of the hypothetical passage of a lobe of the North Sea glacier, we are confronted by a much more genuine question, namely, what was the possible termination towards the south of the great body of ice with which our more advanced glacialists have filled the Cheshire plain?

A recent president of the Cotteswold Field Club, of whom, unfortunately, we must now speak as the late Mr. Lucy, took a lively interest in the Pleistocene geology of the district, and his papers in the *Proceedings* of the Cotteswold Field Club have always attracted attention. His map of the distribution of the gravels of the Severn, Avon, and Evenlode, and their extension over the Cotteswold hills, prepared in conjunction with Mr. Etheridge, is a valuable contribution to the history of the subject (*Proc. Cottes. Nat. Club*, vol. v. pt. ii., 1869, p. 71). Again he wrote on the extension of the Northern Drift and Boulder-clay over the Cotteswold Range (*op. cit.* vol. vii. pt. i., 1878, p. 50), and on this occasion described the interesting section in the drifts presented by the Mickleton tunnel. In his previous paper, Mr. Lucy had carried the drifts with northern erratics to a height of 750 feet, but he now claimed that "the *whole* Cotteswold Range had ceased to be dry land at the time the Clays and Northern Drifts passed over it." We perceive from this passage that Mr. Lucy was a "submerger," and in this respect differed from Croll, who most probably would have attributed the phenomena to the action of his great ice-lobe traversing the south of England.

The question which more immediately concerns us relates to the value of the evidence which would require either a glacier or a "great submergence" to account for these things. The alleged phenomena are in many cases capable of other interpretations. We have the authority of Mr. Etheridge that little or no true Boulder-clay occurs in the Cotteswold area (*Proc. Cottes. Nat. Club*, vol. xi., 1893, p. 83). On the other hand, the distribution of much of the erratic gravel is probably due to agencies of earth-sculpture long anterior to the great Ice Age. There remains one special piece of evidence adduced by Mr. Lucy in favour of his contention, and this he considered of so much importance that it formed the principal part of the subject of his annual address to the Field Club on quitting the chair in 1893 (*Proc. Cottes. Nat. Club*, vol. *cit.*, p. 1).

He there referred more especially to the discovery *in* the Inferior Oolite, on Cleeve Cloud, of quartzose sand and of a boulder of a similar character to some described in his previous papers. The sand and the boulder, he says, belong to the period of the great submergence. Similar sand also appears in several places on the hillside. He had previously recorded boulders of Carboniferous Limestone, Millstone Grit, &c., in the northern Cotteswolds, but not at so great an elevation. He further proceeds to account for the absence of striæ, and of the fact that the Cotteswold rocks are not *moutonnée*, on the supposition that the soft oolites would not retain striation, but would be crushed by pressure. Consequently he claims the top of Cleeve Cloud as a fine example of "glacial denudation," whatever that may mean. The boulder from Cleeve Cloud is now in the Gloucester Museum, and might well become a bone of contention between the submerger and the glacialist as to how it got into its elevated position of over 1000 feet. Fortunately there is a third explanation, which, if it be correct, shows how dangerous it is to build theories, as well as houses, upon sand. Other distinguished members of the Cotteswold Club are of opinion that the whitish sands on Cleeve Common belong to the "Harford Sands," which constitute an integral part of the Inferior Oolite itself. There may be some difference of opinion as to the concretionary nature of the boulders, though these may well be nothing more than the "doggers," or "pot-lids," so characteristic of calcareous sandstones. Mr. Winwood believes that "the so-called foreign boulder" in the Gloucester Museum evidently came from the "Harford Sands."

So far, therefore, the evidences of glacial action in the Cotteswolds do not rest on a very sure foundation. Yet the Severn valley separates that range from an area on the west, where there are clear evidences of local glaciation, as described in the "Annual Report of the Geological Survey for 1896." Portions of this material find their way into the river bed and elsewhere as Drift which has most probably been rearranged—hence the so-called Boulder-clay and Drift in the bed of the Severn. Once more, then, in the cycle of geological time we perceive that our district lies on the confines of two distinct sets of phenomena. West of the Severn and north of the Bristol Channel the evidences of considerable local glaciation are obvious, whilst this can hardly be said of the Cotteswolds, the Mendips, or the Quantocks.

To the more recent geological history of our district it will be sufficient to allude in the briefest terms, when I remind you of the paper by Mr. Strahan on the deposits at Barry Dock, and the still later one by Mr. Codrington on the submerged rock valleys in South Wales, Devon, and Cornwall. Here we have important testimony to certain moderate changes of level which have taken place, and a picture is presented to us of the Bristol Channel as a low-lying land surface, with streams meandering through it. Thus a depression of something like 60 feet appears to be the most recent change which the geologist has to record in the estuary of the Severn.