Royal Society of Victoria.

TRANSACTIONS

AND

PROCEEDINGS

OF THE

Royal Society of Victoria.

VOL. XX.

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ISSUED MAY 30th, 1884.

THE AUTHORS OF THE SEVERAL PAPERS ARE SOLELY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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Royal Society of Victoria.

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PRESIDENT'S ADDRESS.

Royal Society of Victoria.

ANNIVERSARY ADDRESS

OF

The President,

MR. R. L. J. ELLERY, F.R.S., F.R.A.S., Government Astronomer.

(Delivered to the Members of the Royal Society of Victoria, at their Annual Conversazione, held 14th September, 1883.)

GENTLEMEN OF THE ROYAL SOCIETY,

We meet to-night to commemorate another session of the Royal Society of Victoria under somewhat new conditions. Hitherto our annual meeting has always been held in our own house, but the growth of the Society and the consequent increasing demands for admission to our yearly gathering has resulted in uncomfortably crowded rooms in the Royal Society building. The Council decided therefore to hold the meeting this year in more spacious premises, and chose this, the Melbourne Athenæum, for the purpose.

Since the annual gathering in September last our Society has entered on its twenty-fifth session. It has increased its member-roll considerably, and, aided by the annual grant from Parliament to help in printing our Transactions, the Society is also, financially speaking, in a satisfactory condition. Our meetings have been fully occupied with papers and discussions on scientific and technical subjects, and, on the whole, I believe I am justified in congratulating you upon a vigorous and healthy progress, and upon the useful work it has done. Beyond some addition to our library furniture and improvements in the approaches to the building, the Council have added nothing to our house or premises. But very shortly the question of additions, to afford a more capacious meeting-hall or lecture-room, will have to be considered; for, although this building gives us more room than the house of the Royal Society does at present, one cannot but admit a certain amount of regret at being, by force of circumstances, driven from our home to hold festival in the house of strangers. I therefore hope that your Council will find some way by which, even with our increased ranks, we may hold all future gatherings of this kind under our own roof.

The report of the Council has furnished you with all the details of our past year's history, and I need not, therefore, detain you further on the purely domestic affairs of the Society. Our members will be pleased to learn that the several national scientific and technical departments have been in active operation during the year, and with them, as with ourselves, satisfactory progress is manifested. There is an undoubted and general increase in the desire for knowledge in the various pure and applied sciences, and especially as applied to technical training and to the daily requirements of life.

Some new societies for the prosecution of study and research, more especially in the natural sciences, have come into existence in the provinces, and the older societies and schools are increasing in their good influence and usefulness.

The School of Technology and Museums, presided over by our talented member, Mr. Cosmo Newbery, continues doing good work in our midst. The collections of the Industrial and Technological Museum have been largely increased during the past year by the addition of specimens in each section, and several new divisions have been formed. Amongst them, those of special note are:—The manufacture of mineral and vegetable colours, new ornamental and building stones, timbers from India, Fiji, the Straits Settlements, and Ceylon. It may be mentioned that the knowledge derived from the museum collection of Indian timber has led to the opening of a new trade between this colony and India; and we may hope that the very extensive collection of our economic timbers prepared in the museum workshop for the Calcutta Exhibition may have a like result. The economic botany series has been greatly extended, and is now a really useful educational collection; in it may be found all the more common vegetable substances as used in the arts classified under their natural orders, &c. Another important section, which will be of value, is being formed under the name of the commercial products of the sea. The classes in chemistry, metallurgy, engineering, have been well attended, 149 students having entered during the year. The practical work in the laboratory has been of considerable public interest, and has included the working out of several new metallurgical processes connected with the treatment of the ores of gold, copper, cobalt, tin, &c., and some interesting experiments in the treatment of iron. In the chemical laboratory some advance has been made in the chemistry of waste animal products, and it seems probable that when the laboratory process is properly applied to the noxious trades (factories for manures, &c.) that the manufacturer will find it profitable to decompose and save all offensive material, whether solid, liquid, or gas. This is most important work in the right direction, and one in which I hope Mr. Newbery may have both means and time to prosecute with vigour; for with increasing manufacture, and in the absence of efficient sanitary measures, the importance of the application of science to the discovery of commercially practicable processes for preventing the pollution of the air we breathe, or our streams and rivers, by the waste products of our manufactories, cannot be too urgently or too persistently dwelt upon. The waste products of combustion, more especially smoke, is fast becoming in Melbourne a general polluter of the atmosphere; and although science has provided ample, cheap, and efficient means of preventing this, no heed is taken, until the nuisance and mischief become intolerable, or until wise statesmen, as in some parts of America, make stringent laws to prevent people fouling our greatest commonwealth, pure air, with waste products, which science shows can either be profitably utilised where it is produced, or, at all events, rendered innocuous by simple means.

The Schools of Mines at Ballarat and Sandhurst will, if conducted with the vigour which has been displayed of late years, rapidly become most important centres of teaching in the arts and in applied and natural sciences. The Ballarat school has made a considerable step in advance by a judicious increase in the teaching staff, and by the adoption of a scheme by which a limited number of pupils may obtain a complete technical training in practical chemistry, mining, metallurgy, telegraphy, electric engineering, &c., extending over a period of three years. For the efficient accomplishment of this undertaking the committee has added to the staff, and largely to the scientific appliances of the institution. Our members will, I am sure, feel interested in the result of this commendable step on the part of the Council. The School of Mines at Sandhurst is also rapidly increasing its usefulness, and a considerable number of students pass out each year with a most complete and valuable training in chemistry, mineralogy, metallurgy, &c.

The advancement which has marked the past year's history of our own Society is shared also by the several kindred societies in Melbourne, the Medical Society, the British Medical Association, the Pharmaceutical Society, the Microscopical Society, and, to even a greater extent, the Field Naturalists' Club.

To ascertain what Victoria has done in the year towards the advance of natural science, let me first refer to the work of our eminent botanist and fellow-member, Baron Mueller, from whose research and pen has come to us a very large proportion of what is known of Australian botany. A noteworthy fact in connection with his department is the acquisition by purchase of the Sonderian Collection by our

Government. This famous collection was commenced early in the present century by Dr. Sonders, of Hamburg, who died about two years ago; he was a leading authority upon Algæ and on European and North African botany. This collection is a most important addition to the Victorian Botanical Museum, which has been formed by the Government Botanist from his collections extending over nearly forty-four years. Some valuable additions illustrative of the flora of the western coast districts of Australia have also been added through the instrumentality of Mr. John Forrest, who has recently been engaged in a trigonometrical survey of the Gascoyne River district. Some new publications have been issued during the year by the Government Botanist. Additions to the *Fragmenta Phytographiœ Australis* have appeared, as also a continuation of the *Systematic Atlas of the Eucalypti.* A new edition of his volume on *Select Plants for Industrial Culture* is now in preparation, specially adapted for this colony. I called your attention last year to a very important work upon which Baron von Mueller was engaged—viz., *A Systematic Census of Australian Plants.* This has now been published. It enumerates 8646 Australian vascular plants; and the classification is on a simple and somewhat novel method. I am informed that all the collections in the museum are now classified in a similar manner, which will not only make them more readily accessible, but must also materially aid the student as well as the scientific collector. A second volume of the vegetable fossils of the auriferous drifts has been completed, and in its pages are described and compared most of the fossil fruits of the pliocene period. Still, in our miocene deposits, with the masses of fossil foliage, a vast field still remains for exploration and for comparison with miocene plants in other parts of the world, and for the acquisition of more light in connection with the history of our globe; and I hope our talented botanist may be able to do for this what he has so thoroughly and ably accomplished for fossil fruits of the pliocene remains.

Our National Museum already shows signs of being cramped for room, and the director (Professor M'Coy) during the past year has directed his attention to additions of such classes as occupy small space, and has therefore devoted his work chiefly to the zoological and geographical classification of insects, and in filling up gaps in the collection of shells. Important additions have also been made to the collection of fishes by numerous specimens of both Australian and New Guinea species.

Our Observatory has continued its accustomed work in astronomy, meteorology, magnetism, &c. The year has been marked by one or two interesting astronomical events, which have varied the monotonous routine of observation. First, the apparition in September of the Great Comet of 1882; then the Transit of Venus in December; and subsequently the determination by telegraph of the differences of longitude between Singapore and Port Darwin, and then between Port Darwin, Adelaide, Melbourne, and Sydney. The two first occurrences I shall refer to presently.

In my last address I referred to preparations being made for the telegraphic determination of longitude between Greenwich and Australia. Hitherto all Australian longitudes have depended upon observations of the transit of the moon and fixed stars near her path, known as moon culminations, compared with similar observations made at Greenwich on the same day, extensive series of which were obtained many years ago at Williamstown, and afterwards at our present Observatory, as well as the Sydney Observatory. This, although the most accurate of all purely astronomical methods, is not so accurate as that by actual transmission of time signals or clock beats by telegraph from one observatory to another. Of course, the best way to use the latter method would be for Greenwich Observatory to send its clock ticks direct to Adelaide, Melbourne, and Sydney, and then each of these to do the same to Greenwich, the clocks being corrected to true local time; the differences of the times in each case would give the difference of longitude, affected only by the time the electric current takes to traverse all the cables and lines between the Australian cities and Greenwich, and also by the personal equation of the observers. The former quantity is obtained at once from the amount the difference of local time differs when the signals coming from Greenwich to Melbourne (from west to east) from those going from Melbourne to Greenwich (from east to west). For instance, if the difference between Greenwich and Melbourne when signals are sent from Greenwich was two seconds greater than when the signals were sent the reverse way, it would show that half the amount—viz., one second—was the time taken by the current to traverse the lines and the cables and act on the signal instruments. This is called retardation of current and relay time. When sent from Greenwich, the signals being retarded, would arrive late, and Melbourne, being to the east, would make the difference of longitude too great. On the other hand, when the signals are sent from Melbourne to Greenwich they go west, and the retardation has the opposite effect, and would make the difference of longitude too small. By taking the half of this small difference we get the correction to be applied due to the retardation. Unfortunately, however, it is practically impossible to send direct from Greenwich to Melbourne, so the operation has to be done in steps. The longitude of Singapore from Greenwich has been determined in six steps by different astronomers. First, from Greenwich to Mokattam, in Egypt; second, Mokattam to Suez; third, Suez to Aden; Aden to Bombay, Bombay to Madras, and Madras to Singapore. So that to connect Australia it was necessary to exchange signals between Singapore and Australia. Were it not for the great difficulty and danger to submarine cables to connect them direct with land lines, the signals might have been sent direct from Singapore to Melbourne; but it was necessary to establish an observatory at Port Darwin, at the Australian end of the cable, as well as at Singapore. In the British arrangements for observing the Transit of Venus last December the desirability of this undertaking was kept in view, and the Australian astronomers were communicated with on the subject. It was eventually arranged that Australia should establish an observing station at Port Darwin, and that a member of the British observing party, at that time on its way to Brisbane, would, at the cost of the British Government, establish an observatory at Singapore, and do the requisite work there. The several colonial astronomers communicated with their respective Governments, asking authority to act in the matter, which was at once granted, each colony agreeing to contribute towards the expense of the expedition. A gentleman who had already had experience in transit work at our Observatory was selected for the task. The British observers came here on their way to Brisbane, and arranged all the necessary preliminaries. The Australian observer got to Port Darwin on the 29th December, erected his observatory, and secured the requisite observations for local time under most difficult circumstances, for it was the wet season, and with the valuable aid and co-operation of the telegraph officers at that place completed a very satisfactory series of signals with Captain Darwin, at Singapore, and Captain Helb (of Batavia), at Banjoewangie, as well as with the observatories of Adelaide and Melbourne. He returned to Melbourne early in March, after a thoroughly successful expedition. The results are not yet completed, but there is little doubt the longitude thus determined will be a little more than a second of time less than that hitherto adopted, showing the latter to have been correct within the limits of the moon-culminative method. There is one element of uncertainty still remaining, due to the number of steps by which the whole difference has been obtained, and to the chance of small errors in each being cumulative, but when the whole work shall have been revised I have no doubt this uncertainty will vanish.

Our members will be glad to hear that the Observatory is to be shortly furnished with a new transit circle, equal in dimensions and optical capacity to any in the world, and fitted to cope with any class of meridian observation we may be called upon to perform. It will have an object-glass of 8-in. aperture, and be constructed in the most modern form, with some improvements suggested by the present Astronomer Royal of England, Mr. Christie. The building for its reception is now in course of construction, and the instrument itself is expected to arrive very shortly.

Following the course I have usually chosen in addressing you on similar occasions to the present, I will now refer to a few subjects of scientific and general interest.

First, then, as matters on which I can speak with the most confidence, I take the chief astronomical events of the year. The Great Comet of 1882—for by this name it will now be known—was one of the most remarkable ever seen by astronomers of the present time, if we except, or rather couple with it, the great comet of 1842. At the date of our last annual meeting this visitor was nearly in the height of its glory, and I referred to it at some length and to the speculations then rife concerning it. It vanished from our sight some months ago, and the history of its apparition is now complete. This visitor was first seen by terrestrial mortals, so far as can be ascertained, on 7th September at the Observatory, Cape of Good Hope. It passed its perihelion on 18th September, and was visible to the naked eye till 8th February, and with telescopes till April, and even, it is stated by some observers, as late as 7th May, making an almost unprecedented period of 215 days. It was remarkable, also, for its great brilliancy at perihelion, its great magnitude and long-continued brightness, and more especially for the peculiarity of its nucleus and other physical features. When first seen here it was very close to the sun, and going rapidly towards it; and on the day of its perihelion passage we saw it from the Observatory with the naked eye at noonday immersed in the rays immediately surrounding the sun, and fully expected to see it either passing across the solar disc or occulted by the sun itself. Cloudy weather, however, supervened, and we lost sight of it till several days after perihelion; but at the Observatory of the Cape of Good Hope there was clear weather, and the astronomers there saw the rare spectacle of a comet approaching the sun, visually touching its edge, and disappear as it passed in front of it. It has been an old wish of astronomers to witness such an occurrence, with the view of ascertaining the amount of opacity, if any, presented by the head and nucleus of these bodies. Moreover, it had been stated that in 1819 the comet was seen passing over the sun's disc like a cloud, but doubts have always been entertained as to the accuracy of this statement. Messrs. Finlay and Elkin, assistants at the Cape Observatory, watched most carefully with splendid instruments to solve this question; but although they saw the comet until it seemingly touched the edge of the sun, no sign was seen of it after, and it passed over the whole solar disc without a trace being visible, although the observers knew its exact position and could keep the wires of their telescope bisecting the position it occupied. If there was any opaque matter it was too minute to become visible with the powerful telescopes used. The comet at this part of its orbit moved with immense velocity—at least sixteen times the mean velocity of the earth in its orbit, or nearly 300 miles a second. It passed around the sun, making the half-circuit of that body in three and a half hours, with a velocity almost inconceivable. Had it not been for its great velocity at this portion of its orbit, when in rounding the sun it swept through its coronal regions, it must have been drawn into our luminary, or at least become greatly altered, both in physical appearance and in the character of its orbit after perihelion. That its orbit was not sensibly affected by so close an approach has been shown by the calculations of Dr. Kreutz, but the character of the comet underwent a remarkable change after it. The nucleus round and nebulous before perihelion became afterwards shaped like a long grain of rice, and was seen to contain first two and then three bright condensations forming a triple nucleus. About 14th October Professor Schmidt, the astronomer at Athens, observed a thin shining cloud of matter to break off from the comet, move away and disappear. The most recent calculations of the elements of this comet's orbit leave but little doubt that it is of very long period—793 years—and not of one almost counted by days, as at first appeared probable. It has been surmised that it is a second return of a great comet which appeared 371 years before Christ. The last glimpses of it with the naked eye were obtained from the 7th to the 10th February. Our last measure obtained with the great telescope was on 27th April. I have, however, been informed it was seen later than this in New Zealand.

The Transit of Venus of December, the last for 125 years, was successfully observed at various points of the earth's surface, and the results are now in process of computation; and astronomers are awaiting with great interest to know the outcome: whether the sun's distance given by this, the direct method, or that by the indirect methods, shall be accepted as the most probable. Our actual knowledge of the sun and its surroundings, although a great advance has taken place during the past few years, is still very small. Year after year adds, however, something to it; but it must be remembered that it is only on the occasion of total eclipses that, until very recently, any opportunity has been afforded to study the immediate surroundings of our luminary outside its visible surface. In his work on the sun, Professor C. A. Young says, regarding the structures around the sun, "which are hidden by the glare of our atmosphere, the progress of our knowledge must be very slow, for the corona is visible only on about eight days in a century in the aggregate, and then only over narrow strips of the earth's surface, and but from one to five minutes at a time by any one observer." What he says here of the corona applies also to other portions of the solar surface and surrounding regions; and although since the eclipse of 1870, when Janssen and Lockyer showed that some of the curious phenomena hitherto witnessed only during moments of total eclipse could by the aid of powerful spectroscopes be seen at almost any time, it is not to be wondered at that at the occurrence of every total eclipse astronomical expeditions should be fitted out by various countries, and that different nationalities should vie with one another in the completeness of appliances, and in an earnest effort to win for their particular country the honour of adding some item to the already secured knowledge of our great central luminary. The eclipse of 6th May last was visible as total over a narrow track in the Pacific, which crossed several small islands known as Rance, Buffon, Beveridge, Flint, Caroline, and Channel Islands. To these islands various astronomical expeditions repaired, and, strangely enough, both the English, American, and French expeditions selected Caroline Island, a low island in long. 150 deg. 6 min. W., lat. 9 deg. 54 min. N. From news to hand, it seems the weather, which had been cloudy and wet, cleared up in time for the eclipse, which was observed successfully throughout by all. This opportunity for again searching for the supposed planet Vulcan was utilised, and one of the American astronomers (Mr. Holden) reports :—"No planet as bright as a star of a 5½ magnitude"—a star just visible to the naked eye on a dark night—"could be discovered." Most satisfactory photographs of the various phases, and spectroscopic examinations of the coronal and chromospheric regions were obtained, and a substantial addition to our knowledge of the physics of the sun will no doubt result from this undertaking, for each nationality appears to have attacked different problems, or the same only in different ways. The next total solar eclipse, in 1885, will be visible in New Zealand, and perhaps it may then fall to the lot of some of us to have the opportunity of witnessing the grand and rare spectacle of a total solar eclipse.

My previous quotation from Professor Young's book on the sun reminds me of a most interesting fact in connection with the subject, the result of some carefully conducted experiments in solar photography by the well-known astronomer, Dr. Huggins. Although the beautiful appearance known as the corona, which springs into visibility during the moments of a total eclipse, has been secured on photographs over and over again, astronomers have scarcely entertained the hope of seeing, much less photographing, it without an eclipse. Nevertheless, Dr. Huggins announced to the Royal Society on the 21st of December last year that he had obtained photographs of the clear sun, showing the corona faintly but distinctly. He had found that photographs of the spectrum of the corona obtained in Egypt during the total eclipse of May, 1882, indicated a strong predominance of light in the most refrangible or blue end of the spectrum. It therefore occurred to him that it might be possible to get a photographic impression of the corona if all other rays but those of which it appeared to be chiefly composed were excluded. After numerous experiments in sifting the sun's rays, so to speak, from all but the intrinsic light of the corona, he finally succeeded in finding a medium which had the power of absorbing nearly all the rays which belonged to the light of the sky and illumination of our atmosphere, and transmitting those of high refrangibility emanating from the corona. This being done, the rest was a question of delicate photography; and unmistakable photographs of that phenomenon were obtained in clear sunshine, an achievement which opens up a wide range of new possibilities.

I know of no science which has been so rapidly and practically applied to general use as electricity, especially as regards telegraphy, telephony, electro-metallurgy, and electric lighting. In a lecture given in February last by Mr. Preece, F.R.S., at the Institute of Civil Engineers in London, he sums up the recent progress of telegraphy. He states that there are 80,000 miles of submarine cables at work, and £30,000,000 has been embarked in them. In the United Kingdom there were in 1869, 8678 miles of wire in use; in 1883 this had increased to 69,000 miles, and the number of messages sent on them average 603,000 per week. The Morse instrument is now almost generally used, and there are 1330 in the English Post Office Department and 40,000 on the Continent. Reading by sound is fast superseding the old *dot and dash* record on tape. In 1869 there were no sounders used in England, whilst at the beginning of this year there were 2000; and it is remarkable that, while hardly any other instrument is used in America, there is scarcely one used on the Continent of Europe. He further states that in Japan last year over 2,000,000 messages were sent over their wires, of which 98 per cent. were in the native tongue.

Telephony has made also immense progress, and we see our streets now so netted with wires that the sparrows must find their locomotion seriously interfered with. This multiplication of overhead wires in a densely built and populous city is fast becoming a serious and difficult problem. Few people, I think, quite realise what mischief might accrue if some of the heavily laden posts were, through fire or any other accident, to break or fall; and the simple rupture at a busy time of day of one of the wires which cross some of our thronged thoroughfares might lead to most serious consequences. Surely science will furnish some more common-sense mode of carrying on this most valuable application of electricity than that of multiplying, apparently almost indefinitely, these potential elements of overhead dangers.

In my last address I spoke somewhat at length of the progress of the application of electricity to illuminating purposes, and I shall now only refer to a few of the most interesting points in connection with it. There can be little doubt that, financially speaking, electric lighting so far has been a failure, for the tens of thousands invested or expended in it do not appear to have produced a tangible percentage; nevertheless, I believe a well and carefully managed company in the Australian cities, not unduly burdened with the purchase of concessions, use of patents, &c., would soon pay as well as gas companies. Hitherto competition has been so keen as to be ruinous, and an immense amount of public lighting has been done simply for advertisement purposes.

The only gain has been to the science of electric lighting, for more perfect and more economical methods of producing and using the light have from time to time been introduced, and the generating machines, or dynamos, as they are called, are not only much better, but much cheaper than a year ago. The various forms of incandescent lamps are much superior. The carbons of the arc lights are purer, and therefore give a steadier light than formerly, while the conducting wires and the methods of arranging them so as to combine efficiency with safety have been greatly improved. I believe the future prospects of electric lighting are good, for no one denies the advantages it possesses over gas under many circumstances, such as for theatres, churches, public buildings, &c.; while, light for light, it appears to be as cheap as gas. Such being the case, what is to prevent its unlimited extension, and the ultimate defeat of gas as an illuminant? In a lecture I gave some years ago at the Public Library I stated that "the cost of distribution would, I am afraid, be a serious obstacle to its general use for domestic purposes." Our experience up to the present time supports this view; and it is found to be impracticable to distribute the current for electric lighting over large areas from one centre except at a great loss. If this illuminant were to be generally adopted in Melbourne it would be necessary, in order to do it economically, to have a distributing centre for every square equal to that between Collins, Bourke, Elizabeth, and Swanston streets; and it will always be a most wasteful plan to supply light to any but the most moderate distances from the producing station. A year or two ago we were induced to hope that this great difficulty would be overcome by the use of the secondary or storage battery; but this is not yet realised, although we read of recent instances where it has been used for local domestic illumination with complete success and great economy. Should this be the case, the field open for electric lighting and for the transmission of power will be immensely widened, and we shall watch with great interest any progress in this direction.

Before concluding I will detain you a few moments on more strictly society matters.

You will be pleased to learn that the Section A has been reconstructed with a strong list of members and associates, with our Vice-President (Mr. Kernot) as chairman. The scope of our Society is large, and provision has been made for the formation of sections. Although Section A, which takes physical, astronomical, and mechanical science, and engineering, has done important work in the past and now promises increased vigour, the other sections, which include social science and statistics, geography and ethnology, literature and fine arts, medical and microscopical science, natural history, geology, &c., are as yet a dead letter. The fact is that it is the rule to form new societies for the study and encouragement of these sciences rather than carry them out in connection with the older Society. This, no doubt, is the natural tendency; nevertheless, speaking from a long experience, I think it a matter for regret, for our community is not yet large enough to maintain, in an effective state, a number of scientific societies. Unity is strength; and if all interested in the progress of science, or engaged in her various byways, were to unite together, not only would more useful work be done, but the work would be more valuable on account of being subjected to wider criticism. All our societies combined would form a strong body, capable of fostering and even subsidising scientific research; and would also by its strength probably be able to carry into practical effect many things for the public good which may have been elaborated by the investigations and discussions of the general body. Every branch of scientific investigation is now so linked together, so dovetailed piece by piece into one another, that there is hardly a subject that can be broached that does not touch upon the province of four or five of the sciences; it is therefore evident that a scientific society anywhere, to be thoroughly effective, should be a congress of all. It is, I fear, too late now to hope that we can ever effect the union of all our scientific societies in

Melbourne, but the great desirability of such a state of things may impress on us the importance of forming our working sections as opportunity arrives. There is no lack of fields for research; and I should like to see more of our members engaged in particular lines of investigation, to follow up perseveringly their special inquiries, and to promptly publish the results. Natural history, social and sanitary science, engineering, microscopical investigation, medical and physiological science, geography, and ethnology, all offer to us in this part of the world unbounded fields from which to raise crops of knowledge for the benefit and enlightenment, if not for the substantial advantage, of the community. Social and sanitary science have strong claims on our attention; and I hope that our members will earnestly take these subjects in hand, for it must be remembered that it is incumbent upon a Society such as ours to perform its functions for the advance of science, and for the welfare of the people among whom it exists. Every member and associate of the Royal Society therefore becomes in this view morally indebted, and is in duty bound to assist to the best of his power in attaining the objects of the association.

TRANSACTIONS.

Art. I.—*The Influence of Light on Bacteria.*

By Arthur Downes, M.D., and Thos. P. Blunt, M.A. F.C.S.

[Read 12th April, 1883.]

In the *Proceedings of the Royal Society of London* (Vol. XXVI., 1877, p. 488, and Vol. XXVIII., 1878, p. 199) we reported the results of an investigation from which we concluded that light is inimical to the development of *Bacteria*, and, probably, injurious to "unprotected" protoplasm generally.

Dr. J. Jamieson, in a paper recently read before the Royal Society of Victoria, attacks our inferences, attributing the observed effects not to light but to solar heat.

We scarcely think that Dr. Jamieson can have seen the text of our papers, or he would have noted that in nearly every experiment of the long series special care was taken to exclude so fundamental an error as that which he attributes to us.

Without troubling the Society with a long communication, we think that a consideration of two facts alone will show that Dr. Jamieson's criticism cannot be substantiated.

In our experiments our usual method of procedure was to place in each of a number of test-tubes a small quantity of cultivation liquid. The tubes were then plugged with cotton wool, loosely capsuled, and divided into two sets. The one set were encased, each tube separately, in thin, tarnished leadfoil (such as paperhangers use for damp walls) so as to thoroughly exclude light. The two sets were exposed side by side to full sunlight. When the insolation was sufficient the uncovered tubes remained clear for an indefinite period, while the encased speedily swarmed with *Bacteria*.

Now, if Dr. Jamieson will compare the temperature of two tubes—encased and non-encased respectively—exposed to the solar rays, he will find that the former becomes slightly the hotter.

This in itself disposes of his theory that the germinal matter in the non-encased tubes is destroyed by solar *heat;* for if that heat were sufficient for such a result, it should obviously suffice also for the destruction of germs contained in the encased cultivation liquid.

Professor Tyndall, in repeating our experiments, is forced to the same conclusion, namely—that the energy which here prevents putrefaction is energy in the radiant form.

Secondly, Dr. Jamieson will find in the second of the papers in the *Proceedings of the Royal Society* details of experiments which distinctly show that the waves of greatest refrangibility are the most active; in other words, to use the old phraseology, that the effect is associated chiefly with the "actinic" rays. This fact, which may readily be substantiated by any one who will carefully repeat our experiments, must again prove that Dr. Jamieson's supposition of heat destruction is quite untenable.

Art. II.—*The Influence of Light on Bacteria.*

By James Jamieson, M.D.

[Read 12th April, 1883.]

At the meeting of this Society on 8th June last I read a paper on this subject, in which I detailed the results of certain experiments, made for the purpose of testing the conclusions arrived at by Professor Tyndall, and by Messrs. Downes and Blunt. I was led at first to agree fully with these gentlemen, that the effect of exposure to the sun's rays of solutions inoculated with bacterial germs is to prevent the development of the bacteria. Continued observation, however, showed me that the fullest exposure to diffused light has no such effect; and, further, that long continued exposure to the direct rays of the sun need not have that effect. Finding, also, that insolation seemed to fail when the temperature was moderate in degree, I was led, perhaps rashly, to conclude that the destructive influence was exerted, not by direct sunlight *per se*, but by the elevated temperature accompanying it. This conclusion seemed all the more reasonable, since degrees of temperature were actually attained, which are known, if continued long enough, to be destructive to the *Bacterum termo*, the organism under investigation. Whether my interpretation of the nature of the injurious influence at work was a correct one or not, it was certainly shown by my later experiments, (Exps. VI. and VII., *Transactions Roy. Soc. Vict.* 1882, p. 120), that exposure to the sun's rays, for several days continuously, need not destroy, or even apparently retard the development of, bacteria in a perfectly transparent nutritive solution. As a matter of fact, development in one case (Exp. VI.) went on most rapidly in the one of three bottles, which had been exposed continuously for the longest time. If variation of temperature was not the determining cause of the different reaction shown by these three samples of bacterialised solution, then I know not how to explain that difference.

Dr. Downes, however, not being satisfied with my criticism of the conclusions arrived at by himself and Mr. Blunt, has forwarded to this Society the short communication just read. With reference to that communication, I must first say that the suggestion offered that I could not have seen the text of the papers in the *Proceedings of the Royal Society* is not correct; and the exactness of my references and quotations ought to have shown that I had read them. With the arguments used to show that my conclusions were not well founded, and that theirs were not open to criticism, I need not take up much time. I have found, in agreement with Dr. Downes, that an inoculated solution, exposed to light coming through red glass, becomes turbid sooner than a similar solution cultivated under yellow glass, and that it may remain long transparent under exposure to light reaching it through blue glass; but it does not seem to me of necessity to follow, that the mixed rays in white light, even of great intensity, must be destructive. I have also tested the comparative temperature of solutions, in bottles cased in tinfoil and naked, and have not found it uniformly higher in the former, when both are exposed to the sun. I can easily understand, in fact, that bottles or test-tubes, wrapped all over in foil or any other covering, and standing on a hot surface, such as a windowsill on which the sun's rays strike, may be better protected by the wrapping from the heat of the surface on which they rest than others not so wrapped. The temperature attained under these circumstances will depend, in fact, more on the height of the column of fluid than on the mere difference of wrapping or no wrapping. The high *à priori* method which Dr. Downes adopts in his communication is, I venture to think, not quite appropriate in an inquiry, in which direct experiment is applicable, and can, indeed, alone be conclusive. An illustration of the danger in applying this method may be taken from the first paper of Messrs. Downes and Blunt (*Proc. Roy. Soc.*, 1877, pp. 499, 500). They found that, of tubes containing urine exhausted with a Sprengel pump, those which were insolated became turbid sooner than those which were encased. This experiment may not have proved that insolation favours the development of bacteria, but it surely may be taken as showing that insolation *per se* is not excessively destructive.

I may have been wrong in attributing too much influence to an elevated temperature *per se*; but I must still insist that Messrs. Downes and Blunt gave too little consideration to it as at least a disturbing element, recognising it only as a condition favourable to development.

In my previous paper I did not venture to deny to direct sunlight any influence whatever inimical to the development of bacteria, though I did not think that that inimical influence was established by the experiments described. I have felt it incumbent on me to repeat, with variations, the investigations previously reported, and though perhaps even less disposed than I was then to consider light a mere neutral factor, I am still compelled to repeat that bright light, and even direct insolation, need not prevent the development of bacteria in nutritive solutions. A short account of one or two experiments, out of a considerable series, will suffice to show both methods and results:—

Exp. I. Five one-ounce phials were charged equally with about a dram and a half of inoculated Cohn's solution, and plugged with cotton wadding. Three were suspended outside of a window, receiving the direct rays of the sun for the greater part of the day. Of the three, one was wrapped in brown paper, the others left uncovered. One bottle was left standing outside uncovered on the stone windowsill, and one was placed for comparison on a shelf in a tolerably well-lighted room, the sun's rays falling on it for an hour or so in the afternoon. This was on 12th February, the day being very hot. The 13th was cool and cloudy, the 14th bright and warm; and on the 15th, which was also bright and very hot, the solution in the bottle kept inside was already opalescent in the morning, the wrapped suspended one likewise opalescent later in the day, both rapidly becoming quite milky. The other three were still transparent. On 2nd March both of the exposed suspended bottles began to show a slight milkiness, which by the 8th had increased to complete opacity. Even at this last date the one left standing on the windowsill uncovered was still quite transparent. The general results of this mixed experiment were —first, that a solution exposed to diffused light, and even to some extent to the direct rays of the sun, developed bacteria as quickly as that contained in a bottle carefully wrapped in paper; and, secondly, that bottles suspended in the sun showed full development of bacteria, though at a later date, while one which had been standing on a hot window sill continued to be quite transparent. The amount of light was not greater in the latter case, but the temperature attained in the sun was considerably higher; and I cannot think of anything but this difference of temperature which could have brought about the different results. The actual difference in the temperature of the solutions, in bottles standing and suspended, is very considerable, since I found that, with the thermometer at about 118 degs. Fahr. in the sun, fluid in the bottom of a bottle, standing on a window-sill beside it, rose readily to 108 degs. Fahr.; while fluid in suspended bottles, whether naked or covered with tinfoil, rose only to 98-102 degs. Fahr., when the thermometer marked as much as 125-132 degs. Fahr.

The difficulty I have experienced in carrying out comparative tests lay in preserving uniformity of temperature, with varying intensity of solar light. I tried first to get over the difficulty in the following way:—

Exp. II.—Two bottles, each containing two drams of inoculated solution, were suspended inside but just behind the glass of a high window, on which the sun fell nearly all day. One was wrapped in paper, the other exposed. This was on 19th February at two p.m., the day being bright but cool. The 20th was cloudy in the afternoon, the 21st bright and warm, and on the 22nd the solution in both was distinctly opalescent, though most markedly so in the covered one. On the 24th both were quite milky, but still the bacterial growth was most marked in the wrapped bottle.

The doubt was whether the more rapid development in the covered bottle was due to the protection from the light, or to the more uniform temperature preserved by the paper wrapping. I therefore varied the conditions in the following way :—

Exp. III.—Three small thin phials were half filled with inoculated solution, and suspended just inside of a window, as in the last experiment, on 6th March at noon, the day being bright and warm. One of them was not protected at all from the sun ; the second was shielded from its rays by a small piece of thin white paper put between it and the glass of the window ; while the third was more fully protected by means of a larger piece of thick brown paper. The 7th was bright and very hot ; the 8th warm, but cloudy after the morning. On the 9th, at 9 a.m., both the protected bottles showed slight opalescence, which steadily increased, though without noticeable difference in them. Only on the 11th was there slight cloudiness in the exposed bottle, which became distinct on the 14th ; and on the 19th, after several very clear, hot days, it was quite milky and crusted. It may seem that the influence of the direct rays of the sun in retarding development is here quite apparent. That the retardation may in part have been owing to that I am not prepared absolutely to deny ; but it is also evident that the unprotected bottle was also exposed during the day to a higher temperature than the others, and possibly also to a slightly lower temperature during the night, and thus to greater fluctuations, both upwards and downwards toward unfavourable extremes. I have not been able to devise any arrangement whereby a nearer approach than in this case could be got to uniformity of temperature with varying intensities of light. I claim, however, to have again shown clearly, in opposition to the conclusions of Messrs. Downer and Blunt—

(1) That the brightest diffused light is not inimical to the development of bacteria ; and (2) that full exposure to the sun's rays is not destructive to bacteria or their germs, when precautions are taken, as by suspension, against exposure to too high degrees of temperature.

I cannot add that such exposure to the sun's rays in no way retards development, but I must express the conviction that retardation may generally with equal propriety be ascribed to extremes of temperature associated with the insolation.

Art. III.—*On the Caves Perforating Marble Deposits, Limestone Creek.*

By James Stirling, F.L.S.

[Read 12th April, 1883.]

During a recent examination of some marble deposits at the head of the Murray River (Limestone Creek), it occurred to me that a few measurements and observations on the interior of the caves by which these deposits are perforated might prove interesting. The following descriptions and diagrams are the result of such examination:—

Topography of Limestone Creek Valley.

Forming the most southern source affluent of the Murray, the Limestone Creek presents many important physiographical features. The southern and eastern watershed line is formed by the Great Dividing Range, culminating on the east in the rugged Cobboras mountains, 6025 feet above sea-level; while the western watershed line is formed by a high lateral range at a mean elevation of 4500 feet above sea-level. The general direction of the course of the Limestone Creek, from its source in the Dividing Range to its confluence with the Indi or Hume River, is north north-easterly, and the area of its catchment basin about 240 square miles.

Most of the small tributary streams have their source runnels in fine grassy upland flats, on the crests of the ranges forming the watershed lines, but as they near the parent stream traverse deeply eroded gorges in the mountain flanks, frequently forming cataracts and waterfalls of great beauty. This is more particularly the case with the eastern affluents, which are much shorter than the western.

The view obtained when descending the valley from the west, on the main route from Omeo to Maneroo, N.S.W., is very grand and impressive. Away to the north, just discernible in the distant horizon, looms the snow-capped peaks of the culminating ranges of the Australian Alps, Mount Kosciusko, and the Bugong Ranges, over 7000 feet above sea-level; in the middle distance rises the coned peak of Mount Pilot, 6020 feet; to the east tower the serrated rocky ridges of the Cobboras mountains, 6025 feet; while intervening and winding amid bold, wooded ranges lies the gorge formed by the Limestone Creek valley. Along the course of the stream are a series of richly grassed open flats, backed in many places by low bluffy spurs, giving in their undulating contour and other appearances unmistakable evidences of calcareous deposits *in situ*.

Geological Structure.

The eastern watershed (with the exception of the locality hereinafter mentioned as Stony Creek) is composed of masses of porphyries, fragmental and compact, the former from grains as fine as sand to blocks weighing many tons; while the western watershed is made up principally of slates, and interbedded bands of whitish marble and dense blue limestone. The slates merging on the western watershed line into a class of schistose rocks, bearing a strong resemblance to the metamorphic schists of the Omeo District.* Although the Limestone Creek may generally be said to have eroded its course along the contact of the sedimentary rocks with the porphyries, yet the latter, in the lower part of the stream, have been cut through, leaving precipitous banks on either side.

In order that the stratigraphical relation of the porphyries to the sedimentary rocks may be better understood, the following sectional notes and diagrams are given. The section was determined from personal observation, and crosses the Limestone Creek valley at right angles to the course of the stream.

Starting from the level of Marengo Creek (an eastern affluent of the Mitta Mitta), and proceeding easterly, we have, first, a mass of granitiform rock exposed on the bed of Marengo Creek; ascending Mount Pendergast coarse metamorphic schists, gneissic in character, are seen, showing apparently a vertical dip. As the crest of the range is reached these rocks become more micaceous, full of thin quartz seams, and corrugated along the line of strike, which is here seen to be N. 20′W. Descending towards the Limestone Creek some upland alluvial flats are passed over, with

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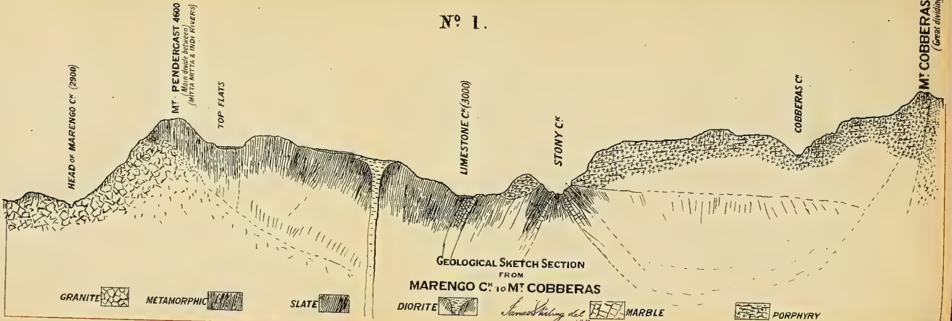
* "The Diorites and Granites of Swift's Creek, and Their Contact Zones." By A. W. Howitt, F.G.S. *Royal Society of Victoria*, pp. 9 to 15.


Nº 1.
HEAD OF MARENGO CK (2900)
MT PENDERGAST 4600
(Main divide between)
(MITTA MITTA & INDI RIVERS)
TOP FLATS
LIMESTONE CK (3000)
STONY CK
COBBERAS CK
MT COBBERAS 6025
(Great dividing range)
GEOLOGICAL SKETCH SECTION
FROM
MARENGO CK TO MT COBBERAS
GRANITE
METAMORPHIC
SLATE
DIORITE
James Stirling del.
MARBLE
PORPHYRY

here and there, on the crests of the dividing ridges, contorted schistose rocks protruding. These are both argillaceous and silicious in character, and generally finely laminated, showing a dip of from 70° W. to vertical at N.N.W. At lower levels a mass of diorite is met with, presenting in the weathering rounded boulders traces of its igneous origin. The soil formed by the disintegration of the latter is shown to be very fertile by the rich carpeting of grasses at this place. So far as I could judge from the altered indurated appearance of the rocks at contact, this mass has been protruded, or rather intruded, from deep-seated sources along the line of section, and not, as might be suggested, either interbedded with the sedimentary rocks, or the remnant of a once larger mass intruded elsewhere. The rock appears to be a mixture of felspar and hornblende principally. On the spurs descending the valley of the Limestone Creek the normal Silurian slates are seen, inclined at high angles, generally 70′ to W., and vary in colour from yellow to bluish grey—soft, yellowish sandstone, and micaceo-argillaceous slate, thin bedded or finely laminated. On the creek flats are deposits of tertiary gravels, frequently auriferous, and which may hereafter be profitably sluiced for gold. Several of the western tributaries of the Limestone Creek are also auriferous, and one, Slaty Creek, contains titaniferous ironsand with cassiterite.* On the east bank of the creek is a bluffy outcrop of what appears to be thin-bedded blue limestone, the beds varying from a few inches to as many feet thick, and inclined at an angle of 70′ to W., with strike to N.N.W., in fact, parallel with the slates with which they are interbedded. These apparent blue limestones, however, when broken, exhibit a crystalline, somewhat saccharoidal texture, and vary in colour from milky white to shades of light grey, and are found to be more or less full of thin yellow seams parallel to the bedding planes. The quality of this marble, on an analysis of hand specimens, seems good, yielding a small percentage of earthy matter, and a large percentage of carbonate of lime; yet even where the beds are thickest these seams would probably deteriorate from the commercial value of the deposit. Whether these seams are in any way due to the percolation of surface waters holding colouring matter, such as one of the oxides of

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* *Geological Survey of Victoria*, Vol. IV., p. 189.

iron, limonite, $H_6 Fe_2 O_9$, in solution; or represent thin seams laid down during the deposition of the calcareous sediments, and which have not been obliterated during the processes of consolidation by which it is probable these beds were metamorphosed from marine limestones into crystalline marbles, I am unable to decide ; although, from the evident regularity and parallelism of the seams and their continuousness, together with the facts noticed when examining the structure of the marble in the interior of the caves, it is probable that the latter is the more correct explanation of their origin. The apparent thickness of this marble bed when crossed by the line of section does not exceed 250 feet. To the east the slates again appear, but, at contact with the marbles, very much contorted along the line of strike. Crossing an eastern affluent of the Limestone Creek (Painter's Creek), the porphyries are first seen, and the change is marked both in regard to the character of the soil and the vegetation.

On examination the rock is found to have a somewhat granular felspathic base, in which are scattered numerous irregularly-shaped patches of felspar, the dimensions of which may generally be about a quarter of an inch by an eighth of an inch in width. On ascending the hill side similar rocks are to be found, nearly to the first summit, but in places becoming more compact.* On descending towards Stony Creek similar rocks are met with, until at lower levels the slates again appear, presenting the same strike and dip, and without any more than the normal state of alteration as seen generally on the eastern watershed near the marble deposits. On a small spur abutting on Stony Creek are seen the deposits of fossiliferous blue limestone from which specimen No. 1 was taken.

At lower levels a tributary of Stony Creek—Round Mountain Creek—has laid bare another narrow band of finely laminated slates, which are succeeded by the Stony Creek marbles, consisting of rather amorphous or thick-bedded masses of whitish, greyish, pinkish, and variegated marbles, as seen in specimens Nos. 2, 3, 4, and 5.

In one place a ridge of undenuded porphyry remains overlying the marble deposits, as shown in sketch ; while on

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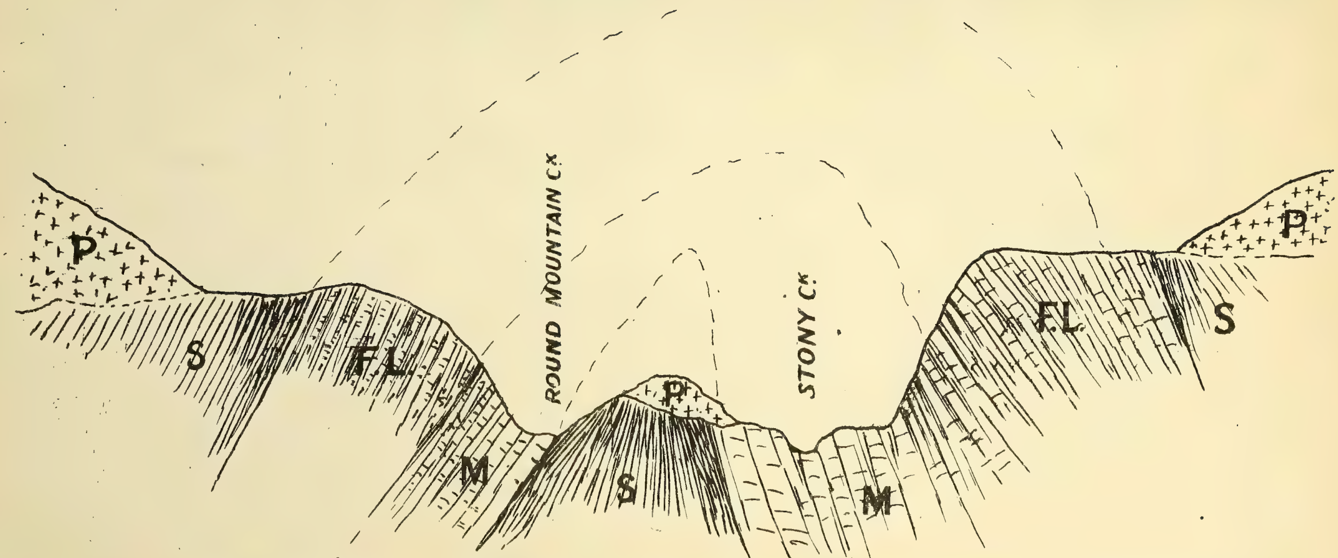
* *Progress Report, Geological Survey of Victoria*, 1876, p. 196. A. W. Howitt, F.G.S.

No 2.



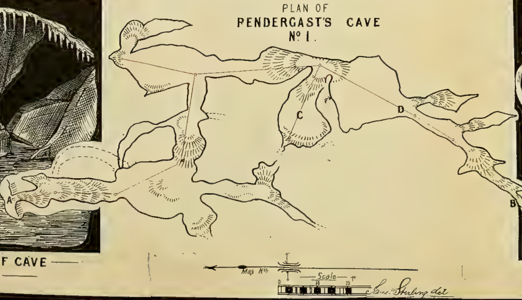
P. PORPHYRY. S. SLATE. F.L. FOSSILIFEROUS LIMESTONE. M. MARBLE.

INTERIOR OF CAVE

at D

Nº 3.

INTERIOR OF CAVE
at D



INTERIOR OF CAVE
at C.

the eastern bank of the creek the marble beds are capped by blue unaltered limestones containing fossils (molluscs).

In ascending the steep and rugged ranges to the east, the porphyries become more compact and silicious, having a greyish or reddish felsitic base, with small translucent quartz-crystals, patches of pink-coloured felspar and fragments of other rocks, the whole forming a breccia-like mass, as seen in specimen No. 6. On the summit of Mount Cobboras, and on the rocky-crested ridges near it, the rock masses weather into vertical layers with a northerly strike. Descending the eastern slopes of Mount Cobboras, the porphyries previously described give place to salmon-coloured quartz-porphyries, almost granitic in structure and weather in rounded masses.

EXAMINATION OF CAVES.

CAVE NO. 1.—PENDERGAST'S CAVE.

The first examined is that perforating a marble deposit near the Limestone Hut (an out-station of Mr. James Pendergast, of Mount Leinster). For reference this may be called Pendergast's Cave. In examining the ground plan of this cave (Diagram 3), it will be seen that it traverses generally the line of strike of the strata. This is the case with most of the caves examined, and would appear to indicate their origin to be by percolation of water from the adjoining creeks. What I mean by this is that the present water channel of the Limestone Creek, although in some cases at a lower level than the orifices forming the entrances to the caves, originally stood at a much higher level, and washed the bases of the limestone bluffs; then, percolating along the lines of strike, gradually eroded a channel to a lower level; and, owing to the calcareous mass being traversed by joints and lines of shrinkage, the water charged with carbonic acid gradually decomposed the hard crystalline masses, and by the further mechanical action of silt and small stones eroded a larger passage. The action of rain water from above, acting similarly by its carbonic acid, derived from the decomposing vegetable matter covering the calcareous deposits, would probably form many of the curiously-shaped holes and crevices seen on the surface.*

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* *Vide* Boyd Dawkins' *Cave Hunting*, p. 53.

The entrance to this cave is fully twenty feet above the level of the Limestone Creek, and is exceedingly narrow. The difficulty encountered on entering is, however, amply recompensed for by the pleasure experienced when the interior beauties are brought into view—pendent crystalline stalactites of innumerable forms of beauty stud the ceiling, while the floors and sides, in addition to numerous stalagmital pillars, are here and there fretted with a rich deposit of glittering calcitic crystals. The rough sketch is a faint endeavour to portray the characteristic cave scenery.

In many places the floor is made up of thick deposits of silt, covered by a thin stalagmital coating; while in others the original silt has been removed, leaving a thin floor of stalagmite.

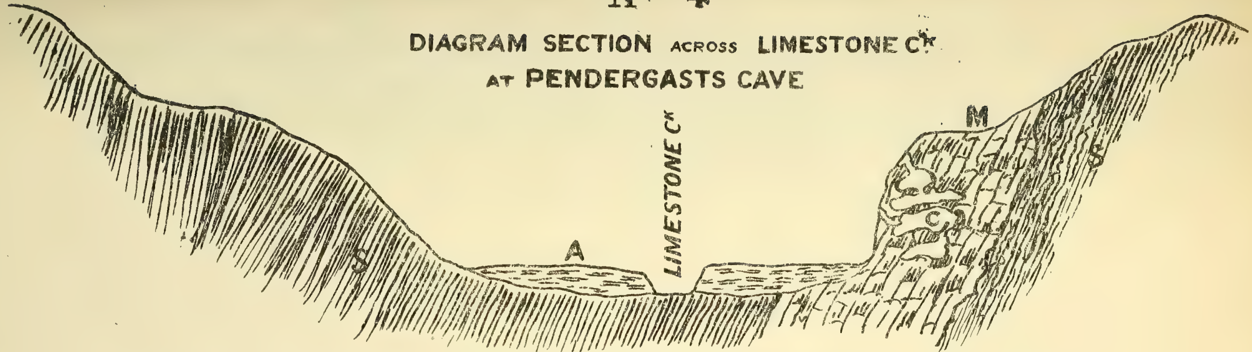
In many places where fissures exist to the surface from the uppermost cavern, the sides of the latter are covered with a mass of soft, milky-white substance, fully three inches thick, which I cannot describe better than by calling it calcareous froth. The substance hardens upon exposure to the external air, and is most abundant after a heavy rainfall, when the interior of the cave is in a moist condition. The marble, where examined on the sides and roof of the cave, although the bedding was more obscure and apparently of greater thickness than seen on the weathered surface, yet still retained the objectionable yellow seams discernible at the surface. The only fossils obtained in the vicinity of this cave were impressions of encrinites, too obscure for palæontological identification. A section through the caves, and the deposit in which they are situated, gives the features shown in Diagram No. 4, and in following the deposit along the line of strike the beds are seen to be flexured to a considerable extent, and narrow at their extremities to thin bands of corrugated calcareous shale, as in Diagram 4.

Cave No. 2.—Sheean's Cave.

This is, perhaps, the largest cave in the series, and is situate at the base of an extensive bluff of marble on the western side of Limestone Creek, about half-a-mile below Pendergast's Cave (see sketch). The general direction of the cave conforms to the existing drainage system of the Limestone Creek, and is nearly parallel with the strike of the beds themselves. Where the ramifications are rectangular to the general direction, they are, I think, produced by the

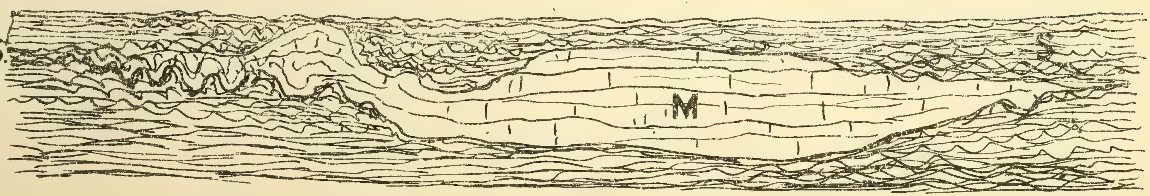
Nº 4

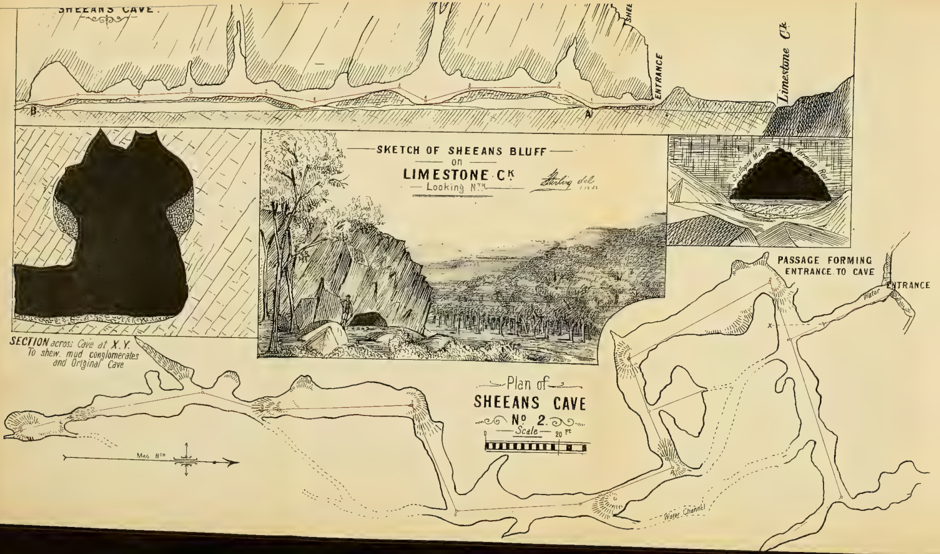
DIAGRAM SECTION ACROSS LIMESTONE Cᴷ
AT PENDERGASTS CAVE



S. SLATE A. ALLUVIUM & TERTIARY GRAVELS. M. MARBLE. C. CAVES.

M. MARBLE. S. SLATE. C.S. CALCAREOUS SHALE.




SHEEANS CAVE.
ENTRANCE
Limestone Ck
B
A
SKETCH OF SHEEANS BLUFF
on
LIMESTONE Ck
Looking Nth
Stirling del
Scalloped Marble Forming Roof
SECTION across Cave at X.Y.
To shew mud conglomerates
and Original Cave
PASSAGE FORMING
ENTRANCE TO CAVE
ENTRANCE
Water
X
Y
Plan of
SHEEANS CAVE
No 2.
Scale
0
20 Ft
MAG Nth
Water Channel

percolation of acid-laden waters from the interior—*i.e.*, as the main channels became choked up by the accumulation of débris, silt, and gravels, etc., the rushing waters caused by an annual flood would endeavour to find a passage along the lines of joint or shrinkage. At present the water traverses from A to B (see plan), and from B finds its way through narrow or flattened orifices to lower levels, re-entering the Limestone Creek about 200 yards below the entrance to the cave. The roof of the entrance, and for some distance inward (about 20 feet), consists of a mass of whitish marble beautifully scalloped by the action of running water. The entrance is very nearly on a level with the Limestone Creek, from which it is distant about 70 feet, and separated by the alluvium and an accumulation of débris (see plan). After the first 33 feet are traversed the narrow entrance passage gives place to a large chamber, from which start various ramifying passages. Those through which the water runs are narrower than that which I have shown traverse lines. The floors of 2 to 3, 4 to 5, and 7 to 8 are simply masses of soft and hardening silt with, in some places, stalagmital covering. These present many favourable spots for fossil hunting, but owing to the limited time at my disposal I could not undertake any examination. However, the plans and sections submitted may prove useful as a basis for further examination by any one disposed to undertake such interesting work. Many of the roof fissures extend almost up to the surface of the deposits, quite 60 feet in some places, and their sides are frequently covered with stalactical drapery of every conceivable shape and of very beautiful appearance. The rate of accumulation of these stalactites depends, apparently, on two principal causes—viz., the quantity of percolating water holding carbonate of lime in solution, and the rate of evaporation of the carbonic acid from the surface of each drop of water, the latter depending upon the temperature, accessibility of the air, and other conditions. During my last visit to Pendergast's Cave, No. 1 (there had previously been a rather heavy rainfall), the stalactites were covered at their extremities with bright, clear drops of water, some indeed were dripping, and there was also a visible increase in the quantity of matter I have denominated calcareous froth. It is probable, therefore, that the rate of stalactital growth depends largely on the seasons, a wet season being most favourable. The lines of bedding are well seen in the interior of the cave, although frequently covered with reddish and yellow earthy sediment. Throughout this cave, at about 6 feet above the present bottom and water-level, are masses of mud conglomerates, with waterworn pebbles and boulders from ½-inch to 3 inches in diameter, and made up of the porphyries and slates which exist *in situ* on the surrounding hills. These mud conglomerates evidently are the undenuded remnants of what was for a long time the original deposit forming the floor of the ancient cave, and may yet be found to contain fossils of scientific value. I have indicated their position on Diagram No. 5. The beds, where visible within the cave, seem to be much thicker than on the weathered surface, and are still full of the parallel earthy seams before referred to.

TEMPERATURE OF THE CAVES.

During two visits I made some observations on the temperature of the caves examined. On the first occasion, in August, 1882, when the surrounding hills were covered with snow, the thermometer at the entrance to caves Nos. 1 and 2 stood at 50° Fahr.; at a distance of 100 feet within the caves it rose to 58° Fahr. During November of same year the thermometer at entrances registered 62°, and at the same place as before, within the caves, it fell to 54°, thus giving a difference of 8° between the external and internal air in each case. This seems to agree with the result of observations recorded elsewhere, "that the air in caves is generally of the same mean temperature as that of the district in which they occur, and consequently cool in summer and warm in winter."* For instance, during August, the minimum degree of cold registered during a severe frost at the Limestone Creek was 20°, or 12° below freezing point, while in November the maximum registered was 80°. Taking the mean of these observations as an approximate mean annual temperature, we have 50°, which I anticipate is about that of the regular mean temperature of the caves, and also that of the Limestone Creek valley in which they are situated. Of course this determination is not to be taken as strictly correct, as a more extended series of observations are required to ascertain the mean temperature of the place, and it is probable that the maximum and minimum heat is greater and less

* Boyd Dawkins' *Cave Hunting*, p. 71.

than that recorded, but from the altitude and latitude of the place it is not improbable that this approximate determination may be found to be correct within reasonable limits, the latitude of the caves being about 37° 7′, and the altitude 3000 feet above sea-level.

Cave No. 3.—Dry Cave.

This is situated close to No. 2, in the same bluff, and is probably connected with it by narrow orifices. The interior caverns are more lofty, and the stalagmital floors quite dry, the scenery being similar to No. 2 Cave, and the general direction parallel to the strike of the beds it perforates. The entrance is very flat, and at a higher level than No. 2.

Stony Creek Caves.

These are, so far as I could examine them, unimportant; flat, low-roofed orifices, through which the flood-waters of Stony Creek find their way, and are of limited extent, being apparently younger than the Limestone Creek caves. And in regard to the latter, it is probable that they are not greater than Pliocene age, and have been hollowed since the partial denudation of the once superincumbent porphyries, for, as previously stated, the mud conglomerates within the caves are made up of rounded waterworn fragments of the rocks found *in situ*. I was unable to find anywhere in the whole series of calcareous deposits evidences of cavities which might have existed and have been filled up by mineral constituents during any consolidation of the mass prior to the deposition of the porphyries. There are certainly numerous small veins of calc spar, but no break in the general continuity of the beds. The greater hollowing out of the caves on the Limestone Creek are, I think, to be accounted for by the more lengthened periods of exposure to subaërial influences and the percolation of acid-laden waters; the Stony Creek calcareous deposit having been more recently laid bare by denudation of the porphyries. So far as a superficial examination would enable me to judge, I think the marbles at this place will prove of considerable commercial value, the texture and colour being excellent, and the beds more homogeneous than at the Limestone Creek. However, this is a matter for determination by commercial enterprise, and outside the objects of this paper.

In concluding this sketchy article on the caves, a few remarks on the beds they perforate may be interesting. It has been shown with reference to the Limestone Creek marble beds that the surface outcrops, and also those within the caves, are intersected with thin yellow seams parallel to the bedding planes, and it is conjectured that these seams can hardly be due to the percolation of surface waters holding colouring matter in solution, because of their regularity and parallelism. Whether the intense subterranean heat, which it is probable caused the metamorphism of the calcareous sediments into crystalline marbles, has obliterated all traces of bedding at a depth, and so produced a homogeneous mass of saccharoidal marble, I am unable to suggest; but in regard to the origin of the marbles the evidences are, I think, in favour of their having assumed their crystalline form during shrinkages in the earth's crust at the close of the Silurian or at the beginning of the Devonian periods, when the whole series of sedimentary rocks were inclined at high angles—*i.e.*, folded and bedded together by the dynamic and metamorphic agencies of nature—and, after long-continued periods of subaërial or subaqueous denudation, were again submitted to the influence of plutonic forces, during which the fragmental porphyries which at present rest on the upturned edges of the sediments were deposited. That the latter are the results of either subaërial ash, or subaqueous tuff, grouped round such probable volcanic centres as Wombargo and Cobboras mountains,* is, I think, evident enough from their lithological character and their stratigraphical position. It is hardly probable that the deposition of the porphyries over the palæozoic sediments would cause such extensive metamorphism of the calcareous beds; in fact, the proof that such is improbable is seen at Stony Creek, for here the unaltered fossiliferous beds are in direct contact with the overlying porphyries, while the crystallisation of the rock masses appears to increase with the depth below the surface.

In my examinations of the Stony Creek marble beds I was fortunate in finding some fossils, which Professor M'Coy has been good enough to examine, and has identified one shell, *spirigina reticularis,* which he states is one of the few

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* *Vide* A. W. Howitt in ***Progress Report, Geological Survey of Victoria,*** 1876, p. 200.

fossils common to the Devonian and Silurian systems. He also states that some crinoidal stems—which are very abundant in the Stony Creek beds—are apparently "Actinocrinus," and that there is a small undescribed species of Atrypa and a species of Beyrichia. He also remarks that the evidence points to these specimens being either Upper Silurian or Lower Devonian, the geological interval between these two being very small. Among many highly scientific problems arising out of an examination of the rock masses in this rugged portion of our Australian Alps, that which relates to the metamorphism of the sedimentary rocks into crystalline schists is, perhaps, one of the most important. Of the relations between the palæozoic sediments of the Limestone Creek and the regional metamorphic schists of the Mitta Mitta source basin, I shall, I hope, have more to say when dealing with the geological structure of the Indi River and the Mitta Mitta source basin. The facts elicited in this paper may pave the way for more extended observations and determinations in that respect.

THE ROCKS OF NOYANG.

BY

A. W. HOWITT, F.G.S.

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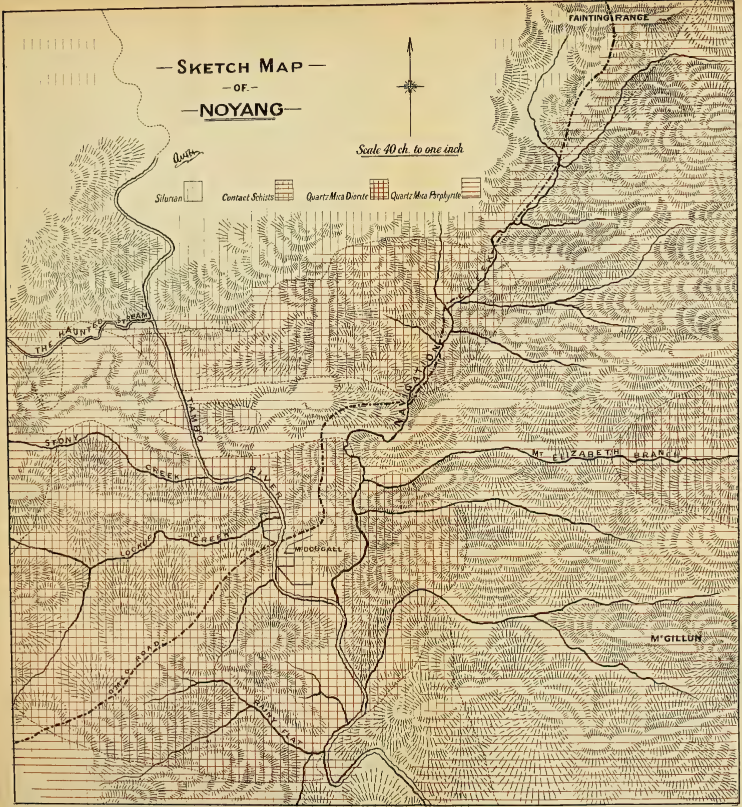
SKETCH MAP
OF
NOYANG
Scale 40 ch. to one inch
Silurian
Contact Schists
Quartz Mica Diorite
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FAINTING RANGE
THE HAUNTED STREAM
TAMBO RIVER
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LOCKUP CREEK
MCDOUGALL
MCGILLUN
OMEO ROAD
RAINY FLAT

Art. IV.—*The Rocks of Noyang.*

By A. W. Howitt, F.G.S.

[Read 10th May, 1883.]

I.—Introduction.

In a former paper I made the statement that I had observed, when tracing round the boundary of regional metamorphism at Omeo, the constant recurrence near it of tracts of intrusive igneous rocks.* The rocks which I described in that paper formed one of those areas; those which I am now about to describe constitute another.

Noyang, strictly speaking, is the native name of the place where the road from Bruthen to Omeo first crosses the Tambo River; but I have applied it, as it is locally used, to the whole tract delineated upon the sketch map which is attached to this paper.

In examining this locality it seems at first sight that the regionally metamorphosed schists of Omeo do not extend so far south as the northern boundary of the intrusive rocks of Noyang; but a more extended examination of the country to the north of that boundary, as far as Ensay, has caused me to see that the limits of the regional schists must probably be extended to the northern slopes of the Fainting Range. I am not now prepared with the evidence necessary to determine this question; indeed, it would be beyond the scope I have set myself in this paper, and may well wait until I have prepared, by an examination of others of the detached intrusive areas which border the regional schists, for a consideration of the latter.

It will be observed that in this paper I have followed the terminology and classification established by Professor Rosenbusch in his "Physiographie der Massigen Gesteine," and lately presented by him, in a more systematised form, in

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* "The Diorites and Granites of Swift's Creek." *Transactions of the Royal Society of Victoria*, Vol. XVI., p. 19.

a communication to the *Neues Jahrbuch.** In order to avoid confusion, and to connect the terms I here use with those which I made use of in former papers, I shall, where a difference exists, note the synonym in a footnote.

II.—Physical Geography and Geology of the District.

The tract of country which I have mapped takes in the valley of the Tambo River for three miles above and two miles below the crossing at Noyang.† To the east it includes the slopes of Mount Elizabeth Range, and to the west those falling from the watersheds between the Tambo River, Shady Creek, and the Haunted Stream. Mount Elizabeth is the culminating point of a great and rugged mass of mountains which fill in the fork between the Tambo and Tambarra Rivers to the extent of about one hundred square miles. This mountain rises to near 3000 feet above sea-level. At its northern extremity it descends steeply into a comparatively low-lying basin, worn out of the metamorphic schists and the intrusive rocks. Its steep and rugged ridges fall to the west into Navigation Creek, and to the east into a tributary of the Tambarra River; to the south the mountain separates into a number of great spurs covered almost wholly with nearly impenetrable scrubs, the haunts of a few wild cattle, and almost untrodden by the foot of man.

The part which I have examined and mapped forms but about one-fourth of the one hundred square miles covered by this mountain and its spurs; but, having seen its northern, eastern, and some parts of its southern sides, I think that my examination gives a fair sample of the whole.

The Mount Elizabeth chain stands in the contact of three great formations. To the north it is bordered by the extreme outliers of the regional schists; to the west there is the great recurring series of lower palæozoic slates and sandstones, with quartz veins in which are most of the gold workings of Gippsland; to the east is the extensive tract of country occupied by the various intrusive rocks of the Buchan and

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* N. J. M., 1882, Vol. I., Part II., p. 1.

† I am under great obligation to the kindness of Mr. A. Black, the Assistant Surveyor-General, and to Mr. W. H. Gregson, the Land Officer at Bairnsdale, for supplying me with tracings of official surveys of much of the Noyang locality. The remainder I have filled in from rough surveys made during the examination of the rock formations.

Snowy River districts, with their associated fragmental formations, tuffs, and lavas; and finally, to the south, the course of the Tambo River separates the lower palæozoic sediments to the west from a great extent of intrusive igneous rocks to the east.

III.—The Igneous Rocks.

The particulars which I shall detail in these pages as to the igneous rocks of Noyang admit of my now saying that they are members of a series which is precisely analogous to that of which granitite is the crystalline-granular type. In this the characteristic felspar is orthoclase, while in the Noyang series it is a plagioclastic felspar, and very frequently albite. The complete analogy between the two groups of rocks will be better seen when I come to the description of the varieties of igneous rocks at Noyang.

(*a.*) *The Quartz-Mica-Diorites.*

Almost the whole of the south side of the Tambo River is occupied by light-coloured crystalline-granular quartz-mica-diorites. They do not, however, extend up the course of the Tambo River for more than a mile above the Noyang crossing, where they adjoin a great mass of quartz-mica-porphyrite, of quartz-porphyrite, and of quartz-granophyrite, which there crosses the river and extends for several miles to the west along the course of the Haunted Stream. On the eastern side of the Tambo, at Noyang, these quartz-mica-diorites extend towards Mount Elizabeth for some distance, and there also adjoin porphyritic varieties of rocks of the same series. These porphyritic rocks have cut across the crystalline-granular quartz-mica-diorites, have sent out great masses into them, and also many strong dykes across them even far into the adjoining sediments. Higher up the course of a stream having its source in part of the Mount Elizabeth Range, and near the localities I have just mentioned, there are again large masses of a crystalline-granular character, which differ, however, in so far that they seem to be somewhat younger in period of formation than the quartz-mica-diorites which I have described, and are also comparatively wanting in the basic minerals (magnesia-iron-mica and amphibole) which characterise them. Some of these rocks might be classed as the analogies of the "micro-granitites." To the south-east the quartz-mica-diorites terminate at well-marked examples of crystalline and schistose hornfels in respect of which they are intrusive.

The quartz-mica-diorite is much decomposed over a large tract of country, which is worn into rounded ridges and rather flat gullies. Elsewhere it stands out in torlike masses, and is well seen in the river course where the excessive floods in the last fifteen years have laid it bare in innumerable places. In its fresh condition it is a hard and somewhat tough rock of a light colour.

I now proceed to the results of the microscopic and chemical examination of these rocks.

The sample which I selected as typical occurs at the crossing of the Tambo River at Noyang. The structure of the rock is wholly crystalline-granular, and the constituent minerals have been formed in the order in which I now describe them:—

1. *Magnetite* in rectangular crystals. It occurs mostly in the mica and amphibole crystals, and more rarely adjoining them.

2. *Magnesia-Iron-Mica* (*Haughtonite*). This mica occurs in very irregularly-bounded crystals or groups of crystals. The outlines, whether seen in sections parallel or perpendicular to the basal cleavage, are most irregular, often running out into narrow protuberances or retreating into deep hollows. In places portions are detached, being either parts of cleavage plates separated from but still accordant with the main mass, or else in other cases broken up into numerous small flakes and scattered at random in the adjoining spaces filled by quartz. The other constituent minerals, amphibole, felspar, and quartz, conform themselves to the outlines of this mica, and the first is associated with it, not merely adjoining, but occasionally more or less enveloped by it.

At first sight it seemed to me that, in places, the felspar crystals were partially surrounded by the mica as a later production; but further examination has satisfied me that this is only apparently the case, and arises through the mica crystals having in some cases been partially broken, and in others from the felspar crystal either having crystallised in a pre-existing hollow, or having become fitted partly into it during the movements of the magma before it cooled.

This mica becomes translucent in shades of brown, and is in sections perpendicular to the cleavage strongly dichroic in shades of colour from pale yellow to almost black. It is either uniaxial, or having so small an optic-axial angle as not to be distinguishable when examined in the most favourable cases under the microscope by the staurescope. As a rule, it is poor in inclusions. The most frequent are magnetite, but I have met with instances when it contained rather numerous twinned grains of felspar, which had the look of having been broken from larger crystals. Rarely I have observed crystalline granules of quartz. The only other inclusions to be noted are a few apatite needles lying in the basal section, and a few minute colourless prismatic microliths.

The alteration of this mica is almost wholly to some form of chlorite. Scarcely an instance has come under my notice in these rocks—crystalline-granular or porphyritic—in which the mica has not shown traces of chloritisation. The change commences at the exterior, and extends between the cleavage plates towards the centre, and in some cases certain folia are more attacked than others. It may be said generally of all these rocks that their decomposition commences with the alteration of the dark-coloured iron-magnesia-mica, which is so common as to be characteristic of the whole group.

In order to determine the nature of this mica, I separated sufficient for examination from portions of the Noyang rock. It is jetty black in colour, with a somewhat vitreous lustre; rather difficultly separable into thin laminæ, and somewhat brittle, except in the thinnest flakes. Before the blowpipe it fuses rather easily, and becomes magnetic. In warm hydrochloric acid, it decomposes somewhat easily, the silica separating as white scales. The specific gravity I found to be unexpectedly low, viz., 2·81. The quantitative analysis yielded the following results :—

No. 1.—Iron-Magnesia Mica.

	Per cent.	Molecular Proportions.		Ratio.	
Fl	·66	·35			
TiO_2	1·05*	·25	Fl + SiO_2	12·76	2·8
SiO_2	38·66†	12·67			
Al_2O_3	19·00	3·69	R_2O_3	4·48	1·
Fe_2O_3	6·37	·79			
FeO	9·96	2·77			
MnO	·66	·18	RO	8·84	1·9
CaO	1·52	·54			
MgO	10·61	5·35			
K_2O	8·58	1·83			
Na_2O	1·08	·35	R_2O	4·23	·9
H_2O	1·85	2·05			
	100·00				

The bases in this mica are therefore in the following proportions:—

R_2O_3		RO		R_2O
1.	...	2.	...	1.

that is, it belongs to a group which Professor Rammelsberg ‡ classes as the third, including, among other micas, lepidomelane and the haughtonite of Dr. Heddle. § Professor Heddle describes the mica to which he has given the name of haughtonite as occupying a position between biotite and lepidomelane, and he gives the oxygen ratio of the three species as follows:—

	Biotite.		Haughtonite.		Lepidomelane.
SiO_2	21·	...	19·	...	20·
R_2O_3	8·	...	10·	...	15·5
(ROR_2O)	15·	...	12·5	...	7·

The oxygen ratio of the Noyang mica is—

SiO_2	...	19·35
R_2O_3	...	11·25
(ROR_2O)	...	11·36

The relative proportions in which the silica and the sesquioxide and protoxide bases occur in the Noyang mica

* TiO_2 is calculated out as sphene, which occurs with this mica.

† SiO_2 is estimated from the difference.

‡ "Ueber die chemische Zusammensetzung der Glimmer." C. Rammelsberg, N.J.M., 1881, p. 365.

§ "On Haughtonite—a New Mica," by Professor Heddle. *Mineralogical Magazine*, Vol. III., Part XIII., p. 72.

are not quite those which Dr. Heddle assigns to haughtonite. The Noyang mica stands, however, between biotite and lepidomelane, although not equidistant to each. Its physical characters and behaviour before the blowpipe and to hydrochloric acid remove it from biotite, and the relatively small amount of ferric oxide removes it from lepidomelane. It may be, however, considered as representing a compound of three-fifths biotite and two-fifths lepidomelane, and with such a composition its low specific gravity is more in accord.

Although the composition of this mica does not quite agree with that given by Dr. Heddle for haughtonite, it is sufficiently near to justify me, I think, in referring it to that variety of magnesia-iron-mica.

It is convenient at this place to speak of the alteration products of this mica.

Chloritic minerals are so extremely common in these crystalline-granular rocks that they may be looked upon as one of the most characteristic constituents. The rocks which I have examined in thin slices afford plentiful evidence of the manner in which the conversion of the magnesia-iron-micas into chloritic minerals has taken place. Sections of the rock which I have taken for illustration afforded me all stages from the merest alterations in the edges of the cleavage plates to the complete conversion of the mica into a chloritic pseudomorph. Chloritisation is attended by the elimination of ores of iron, which are deposited as magnetite either in the chlorite crystals themselves or in their neighbourhood.

The discussion of analyses given in this paper shows that this mineral is probably in some cases at least of the constitution indicated by the formula—

$$3\ SiO_2 + R_2O_3 + 5\ RO + 4\ R_2O$$

—that is, of chlorite. But the mineral, as might have been expected from its mode of formation, through the alteration of mica and of amphibole—perhaps not always under precisely the same conditions—does not seem in all cases to be of the same structure or composition. The chloritic minerals occurring in the quartz-mica-diorite under consideration I found to be uniaxial, or to have an extremely small optic-axial angle. I could not determine which it was, as no section was precisely parallel to the basal cleavage. In slices perpendicular to that direction it is dichoric in

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shades of bright green. The ores of iron, and perhaps also titanium, which are removed in the alteration of the mica, are not always redeposited in rectangular crystals or in granular masses. I have observed frequently in these chlorite pseudomorphs, that the magnetite (? titanic iron) has been placed in the basal plane as opaque black needles, either singly or in tufts or masses. It is very common for these needles to be arranged in more or less well-marked stellate groups, with rays including angles of approximately, or exactly, 30°. Such arrangements are only visible in sections parallel to the cleavage, while in sections perpendicular to it the needles only show as horizontally-arranged tufts.

The chlorite either fills almost exactly the space formerly occupied by the magnesia-iron-mica or amphibole in the less altered rocks, or in those which have been most altered it fills irregular spaces with cleavable or with radial masses. In many instances flakes of a chloritic mineral are to be found throughout the whole rock.

In selecting a sample of rock from which to extract the chloritic mineral for examination, I necessarily had to choose one in which the process of chloritisation from mica might be considered to be complete. This involved a partly decomposed condition of the rock generally; and I found, probably in consequence of this, that the selected mineral, although carefully extracted and examined under the lens, still contained impurities.

The chloritic mineral formed pseudomorphs after mica (probably haughtonite). Its hardness is 1·5 to 2·, specific gravity 2·785. Its colour is dark green, with a rather pearly lustre in the cleavage plates, and the streak is grey, with a tinge of green. Before the blowpipe it fuses at the edges of thin flakes to a black magnetic glass, and is decomposed easily by sulphuric acid and by hot hydrochloric acid, white scales of silica being set free. In every example which I examined in the process of selection I found minute portions of a colourless mineral so intimately mixed with the mass as not to be separable.

One of the crystals of which I prepared a basal cleavage plate as a microscopic object showed these two different minerals distinctly. One I observed to be green in colour, and of the character which I have described when speaking of the chloritic pseudomorphs after mica; the other a colourless radiating mineral, apparently monoclinic. There was very little more than a trace of free ores of iron in this example. Subjoined is the quantitative analysis:—

No. 2.—Chloritoid.

	Per cent.	Molecular Proportions.		Ratio.	
SiO_2 ...	34·39 ..	1·146	SiO_2 ...	1·146 ...	1·7
Al_2O_3 ...	24·38 ...	·473	R_2O_3 ...	·650 ...	1·
Fe_2O_3 ...	14·17 ...	·177			
FeO ...	1·81 ...	·050	RO ...	·735 ...	1·1
CaO ...	3·80 ...	·135			
MgO ...	11·01 ...	·550			
K_2O ...	1·64 ...	·035	R_2O ...	·767 ...	1·2
Na_2O ...	·95 ...	·030			
H_2O ...	6·32 ...	·702			
	98·47				

Hygroscopic moisture, 1·20 c 212° F.

Unless it were possible to isolate the impurities and to separate and examine each of the two component minerals, no certain conclusions could be drawn as to the real nature of the latter; but it may be possible by calculating the percentage to arrive at an approximation to the truth. The constitution of the rock from which the sample was extracted renders it most improbable that the impurities can be anything else than felspar and quartz; the examination which I have made of the Noyang igneous rocks renders it further most probable that the felspar is albite or an oligoclase very near to it. Thus the impurities may be calculated out, and the remaining molecular proportions should give the constitution of the mixed chloritic minerals. On this basis I have made the subjoined calculation. It raises a strong presumption that the mineral is a mixture of two of the chlorite group, one having the constitution of chlorite and the other of chloritoid. Under the microscope the former is colourless or white, and therefore probably free from iron; the whole of the iron therefore goes to form the latter.

CHLORITOID.

	Si. O_2.	Al_2. O_3.	Fe_2. O_3.	Fe. O.	Ca. O.	Mg. O.	K_2. O.	Na_2. O.	H_2. O.	Molecular Proportions.	Per cent.
	1·146	·473	·177	·050	·135	·550	·035	·030	·702		
Albite	·180	·030	..	..	..	..	..	·030	..	·240	7·90
Chlorite	·078	·026	..	..	..	·130	..	..	·104	·338	7·21
Chloritoid	·594	·417	·177	·050	·135	·409	·035	..	·559	2·376	73·93
Quartz	·294	..	..	..	..	..	..	..	..	·294	8·82
Totals	1·146	·473	·177	·050	·135	·539	·035	·030	·663	3·248	97·86
Differences ..	..	..	..	..	..	·011	..	..	·039	..	..

Disregarding the impurities, this mineral may be considered as composed of nearly 9 per cent. of chlorite and 91 per cent. of chloritoid.*

The molecular proportions of the sesquioxide and protoxide bases in this chloritoid do not agree well with those of other chloritoids, the analyses of which I have been enabled to examine and calculate; † yet the whole mineral, including impurities, gives a formula which accords quite as nearly with that of chloritoid as do those of some of the analyses to which I refer.

This raises a doubt whether those analyses were not also of impure or mixed material. It is to be feared that in too many cases new species of chloritic minerals have been established by analysts on all too insufficient examination, and that mineralogical science has been overburdened with names that will ultimately have to be expunged.

This Noyang mineral, being a mixture, has not even a right to be called a mineral species. It is a mixture of chloritic minerals, and I doubt whether, strictly speaking, I am justified in calling it chloritoid in disregard to the percentage of chlorite it contains.

Amphibole. In these rocks amphibole constantly accompanies, but is subordinate to, the mica. As is the case with the latter, its crystalline planes are rarely observable. It is ragged, eroded, and seems in places to have suffered partial refusion at the edges and corners after crystallisation. Twinning is not very common, but when occurring is according to the ordinary law. The prismatic cleavage is well marked in sections across "c." Measurements of the obtuse angles in several sections gave me 124° 30′, 125° 10′, and 126° 15′. The colours, as seen by ordinary light, are shades of green.

The polychroism of this amphibole is well marked. I found it to vary through shades of yellow and green, and in some cases brown and bluish green. The colours of the three rays and the absorption I found to be as follows in one of the most typical sections:—

$c >$	$b >$	$a >$
dark green	light green	yellow.

In sections which were probably near the clinopinacoid, I found the angle formed by the plane of vibration to be as

* A slight difference would be made if that portion of the felspar which is kaolinised were calculated out. This is so trifling as to be immaterial.

† Dana, *System of Mineralogy, with Appendices to* 1882; Rammelsberg, *Mineralchemie*, 1875; Heddle, *Mineralogical Magazine*, July, 1880.

high, in one case, as 22°, but in the majority of cases between 12° and 20°.

Besides these, which may be considered with some certainty as hornblende, I found occasional instances of a second amphibole of a somewhat different character. The most marked feature, at first sight, was that its crystalline masses included numerous fragments or imperfect crystals of twinned felspars of small size. The outlines of this amphibole are even more irregular than those of the just described hornblende. The polychroism is much less, and the angles formed by the plane of vibration are much higher, being in two good instances, which I measured, 31° 15′ and 35°. Marked features are the indistinctness of the prismatic cleavage, and a somewhat marked very closely placed striation, which seems to represent a separation rather than a cleavage. It seems to me that this mineral stands in the same relation to hornblende that diallage does to augite. It is more subordinate to the hornblende than both are to the magnesia-iron-mica.

The dark-coloured masses looking like included fragments of some rock which are very common in the Noyang quartz-mica-diorites, I found to be crystallisations of, mainly, the more basic minerals. I observed the amphibole to be well crystallised, frequently twinned, and strongly polychroic. The prismatic angles measured in several cases were precisely 124° 30′, taking the mean of several readings. The angles formed by the plane of vibration I found in the highest to be 22°.

Felspars. The felspars of this rock are characterised by being almost, if not all, plagioclase. They are well crystallised, excepting where they have become adapted during growth to the form of some mica or amphibole crystal. The twinning takes place according to the Albite, and also to the Carlsbad law. Sometimes the former alone, but more frequently both conjoined. In some crystals one half of the Carlsbad twin is simple, while the other is compound. Besides these twinned crystals there are some lesser ones which are not twinned. Of these some may be orthoclase, but I found only one which had the optical characters of that felspar.

The mean of a number of measurements of the angle formed by the plane of vibration gave the following:—

OP (001)	$\infty \bar{P} \infty$ (100)	...	$\infty \breve{P} \infty$ (010)
5° 30′	...	15° 45′	

These measurements suggest albite, but are not incompatible with oligoclase; and the discussion of the analysis of this rock causes me to favour the latter view.

A slice from a rock collected on the upper part of the Mount Elizabeth branch gave me favourable sections for optical measurements of the felspars, and I found these to be in the zone $OP - \infty \bar{P} \infty$ between 2° 30′ and 16° 45′. This, again, agrees rather with oligoclase than albite.

Quartz fills in the spaces left vacant by the previously described minerals. It usually is composed of several crystalline granules, and otherwise completely resembles the quartz in other crystalline-granular rocks of a granitic character. I observed as inclusions—(1) Magnetite crystals, (2) laminæ of mica, (3) felspar fragments, and (4) small colourless crystals, apparently monoclinic.

Sphene. This mineral occurs, but not so frequently as might have been expected. The examples which I have observed have been rough crystalline grains; and in only one instance did I observe a well-formed crystal of the characteristic double wedge-shaped form.

Apatite occurs in the usual small and somewhat lengthy prisms.

I carried out a quantitative analysis of a portion of the same rock from which the thin slices were prepared:—

No. 3.—Quartz-Mica-Diorites.

	Per cent.	Molecular Proportions.		Ratio.	
P_2O_5	·22	·03	$= SiO_2$	19·23	4·1
TiO_2	·03	·01			
SiO_2	57·69	19·23			
Al_2O_3	15·65	3·04	$= R_2O_3$	4·64	1·
Fe_2O_3	7·42	·93			
FeO	2·41	·67	$= RO$	4·69	1·
MnO	tr.	...			
CaO	6·92	2·47			
MgO	3·10	1·55			
K_2O	2·37	·50	$= R_2O$	2·52	·5
Na_2O	2·33	·75			
H_2O	1·59	1·77			
	99·73	30·95			

Hygroscopic moisture ... ·34
Specific gravity ... ... 2·779

The alterations which have taken place in this rock make it somewhat difficult to calculate satisfactorily the different mineral percentages. All that can be hoped for, in the absence of more precise knowledge of the composition of the alteration products, is to arrive at a fair approximation. The analysis of the mica affords some light; but I found that on analysis the hornblende would not give reliable results unless that mineral were separated by methods which I had not at command. In the following calculation I have disregarded the small amount of chloritic alteration, and also the minute plates of some micaceous mineral, one of the alteration products of the felspars:—

QUARTZ-MICA-DIORITE.

	$P_2.O_5$.	Ti. O_2.	Si.O_2.	Al_2 O_3.	Fe_2 O_3.	Fe. O.	Ca .O.	Mg. O.	K_2 O.	Na_2 O.	H_2 O.	Total Molecular Proportions.	Total per cent.
	·03	·01	19·23	3·04	·93	·67	2·47	1·55	·50	·75	1·77	30·95	..
Sphene	..	·01	·01	..	..	..	·01	..	..	..	..	·03	·09
Apatite	·03	..	..	..	..	..	·10	..	..	..	..	·13	·50
Soda Felspar ..	..	..	4·50	·75	..	..	..	..	..	·75	..	6·00	19·69
Lime Felspar ..	..	..	1·04	·52	..	..	·52	..	..	..	..	2·08	7·25
Magnesia-Iron-Mica	..	..	3·00	·50	·50	·45	..	1·55	·50	..	·50	7·00	23·10
Kaolin	..	..	2·54	1·27	..	..	..	..	..	..	1·27	5·08	15·30
Magnetite	..	..	..	..	·22	·22	..	..	..	..	..	·44	2·55
Hornblende.. ..	..	..	1·86	..	·26	..	1·86	..	..	..	..	3·98	12·87
Quartz	..	..	6·28	..	..	..	..	..	..	..	..	6·28	18·84
Total	·03	·01	19·28	3·04	·98	·67	2·49	1·55	·50	·75	1·77	31·02	100·19
Differences ..	..	..	·05	..	+ ·05	..	+ ·02	..	..	..	..	+ ·07	..

The analysis thus calculated assigns ·26 Mol. of R_2O_3 and 1·86 Mol. of RO bases to the hornblende. This may represent the truth so far; but it is not likely that these constituents consist wholly of ferric oxide and lime, but that portions of the alumina and magnesia would be included in the amphibole minerals.

Assuming, however, that this calculation sufficiently expresses the composition of the rock as it is, and that the kaolin represents the altered felspars, the following may be assigned as the probable percentage composition of the unaltered rock; and in this I have assumed that the unaltered condition of the felspars was that of an oligoclase of the constitution Al. 3 : An. 1.:—

Oligoclase	48·25
Magnesia-iron-mica	23·49
Hornblende	11·64
Magnetite	2·32
Quartz	14·01
Sphene	·09
Apatite	·50
	100·30

In this rock the ratio of the constituents is—

Felspar, 1·30 ; Quartz, ·42 ; RO Minerals, 1.

(*b.*) *Quartz-Mica-Porphyrites and Quartz-Granophyrites.**

Rocks of this class are confined to the eastern side of the Tambo River, excepting where, above the Noyang ford, a great offshoot of the main mass extends from near Mount Elizabeth to the westward of the river, and along the course of the Haunted Stream. Many strong dykes of these rocks also extend similarly westward, and it might even be said with truth that they radiate from the great central porphyritic masses of Mount Elizabeth. The relations of these quartz porphyrites and granophyrites to the older crystalline-granular diorites may be well seen in Navigation Creek and the Tambo River. They penetrate the latter either as masses, or as parallel or winding dykes. The crystalline-granular rocks are in many places cut off by the porphyrites, but there are also frequent instances where the

* Spherulitic quartz-porphyrite.

former become poor in mica or amphibole, and at the same time acquire a more porphyrite character by the appearance of isolated crystals of felspar or quartz, or of both.

Great portions of Mount Elizabeth, in fact masses which are mountains, are, it seems, entirely composed of such rocks as those I am now considering, and *in situ* they have an extraordinary resemblance to their close analogues, the quartz-porphyries. Rocks of this class are in contact with the sediments over as large an area as are the crystalline-granular quartz-diorites.

I have included the quartz-granophyrites in this section, for the reason that I have as yet found such rocks only as abnormal parts of the quartz-mica-porphyrites. At the Haunted Stream, for instance, the great mass of such rocks at its northern contact with the sediments, has the structure of a granophyrite.

Some of the larger dykes which proceed from the quartz-porphyrite masses across the crystalline-granular rocks also show this structure.

As I have already said, I have not found the granophyrite structure largely developed at Noyang; but it does not follow that it is not to be met with more frequently than I have found it. The area of the quartz-porphyrite rocks is so large, that my examination, which has been specially directed to the area surveyed, has only included it in part.

The results of microscopic and chemical analysis of these rocks are as follow. The first example which I shall describe was collected near the north-western contact in Navigation Creek:—

Under the microscope it shows a micro-crystalline granular ground-mass, wholly composed of felspar and quartz, together with very numerous bladed microliths of a light green colour, and these occur in both felspars and quartz. So far as I could make out from an examination of these minute minerals, I believe them to have been amphibole, but now almost, if not quite, converted into some form of chlorite.

In this ground-mass, and forming part of it, certain of its constituents are porphyritic:—

(1.) Small twinned crystals, or clusters of crystals, of felspars, in which I found optical measurements in the zone $OP - \infty\bar{P}\infty$ min. $= 5°$, and max. $= 15° \; 15'$, and certain simple sections, in which the angle formed by the plane of vibration was 14°. The composition of these twins was according to (*a*) the Albite law; (*b*) the Carlsbad law; (*c*) where the composition face is $\infty \breve{P} \infty$ with interpenetration of twins, so that a double twin is produced in which the two diagonally opposite are optically similar; and (*d*) the Albite law and the Pericline law combined.

(2.) Felspars which are not well crystallised, but which are certainly simple, and in some of which, so far as could be made out from an examination of such minute objects, obscuration occurred where the longer diameter was in accordance with the plane of polarisation of the nicol.

(3.) Very rarely small imperfect crystals of a chloritic mineral. Its characters are precisely those which I shall describe when speaking of the porphyritic minerals of "first consolidation" in this rock. These chlorite flakes are probably the alteration products of such detached flakes of mica as I have observed to exist in the quartz of the quartz-mica-diorite.

(4.) A few minute, colourless prisms, of a tetragonal habit, which polarise brightly, and become obscured when the plane of the nicol is parallel or perpendicular to their prismatic sides. In one instance the measurement of the angle $\infty P \wedge P$ gave me 132°. These crystals are certainly zircon.

The porphyritic minerals of the first consolidation are as follow:—

Felspars. These are compound crystals, usually twinned according to the combined Albite and Carlsbad laws. The edges and corners are mostly rounded off or broken. They also form groups of several crystals, adjoining each other with their fractured ends. The angles of obscuration I found to be in the zone $OP - \infty \bar{P} \infty$ 5° 45′ to 16° 15′. These porphyritic felspars are somewhat altered, being not only kaolinised to some extent, but also full of minute flakes of a pale green colour, a mineral probably of the chlorite group. The optical and physical properties of these felspars may point to oligoclase rather than to albite.

Quartz occurs in more or less perfectly formed but often corroded and fractured crystals, with hexahedral outlines, and their character is precisely that so familiar to observers in the quartz of the quartz-porphyries.

Chloritic Minerals. Besides these there are a number of crystals of a chloritic mineral of about the same size and relative number as those of quartz. These are evidently the alteration products *in situ* of a magnesia-iron-mica, but in not one instance in the slices I prepared of this variety of rock did I find any portions of the original mineral remaining intact. Yet after carefully observing the various stages of alteration from mica to chlorite in the crystalline-granular rocks of this group, I cannot feel any doubt that this also is merely a secondary mineral. It occurs either in more or less well-defined hexagonal or rectangular sections. The former undergo no change of colour or of tint when examined over the polariser alone, while the latter are more or less markedly dichroic. The ray which traverses the crystal in the direction of the axis "c" is almost colourless, while that perpendicular to it is of some shade of green. It is, however, very rare to find one of these chlorite sections homogeneous throughout. The basal section, when examined between crossed nicols, usually shows a more or less wide margin, which behaves like an isotropic or uniaxial mineral when seen in the direction of the optic axis, while more or less of the central part is doubly refracting. The sections perpendicular to the cleavage planes show similar features; the green outside edges of the plates become wholly obscured when their fibrous structure is parallel to the plane of the nicol, while the colourless central parts show strong chromatic polarisation, resembling that of potassa-mica, and in no position are the numerous fibrous aggregates simultaneously obscured, nor could I find any fibres that behaved otherwise than would do those of a triclinic mineral. This suggests a colourless chloritic mineral, perhaps Leuchtenbergite. In the cleavage planes there have been deposited ores of iron and perhaps titanium.

In order to learn something more as to the nature of the porphyritic felspars and of the chlorite pseudomorphs, I digested a slice of this rock with occasional boiling in hydrochloric acid for nearly a month. On then examining it I found that the hydrated iron ores had been removed from the slice, leaving it altogether much clearer and more translucent than before. The chlorite pseudomorphs were somewhat bleached, and some of the folia were more attacked than others, but a great part of the black amorphous substance in the chlorite was unaffected, and could therefore not be magnetite.

The porphyritic felspars were not only not affected, but were much brightened by the removal of minute alteration products; but there was one exception, where part of the porphyritic crystal had evidently been replaced by some carbonate—probably calcite—and had been totally removed, leaving the ragged-edged cavity usual in such cases. The ground-mass of felspar and quartz granules was wholly unattacked.

The result, therefore, of this test has been to show that if any difference exists in the power of resistance against alteration between the porphyritic felspars and the felspar granules of the ground-mass, it is in favour of the latter. We have another instance of the rule that the earlier consolidated felspars are the more basic.

The following is an analysis of this rock:—

No. 4.—Quartz-Mica-Porphyrite.

	Per cent.	Molecular Proportions.		Ratio.	
P_2O_5	tr				
SiO_2	... 72·39	... 24·13	SiO_2	... 24·13	... 8·4
Al_2O_3	... 14·42	... 2.80	R_2O_3	... 2.87	... 1·
Fe_2O_3	... ·56	... ·07			
FeO	... ·30	... ·08	RO	... 1·31	... ·4
MnO	... ·01	... —			
CaO	... ·85	... ·30			
MgO	... 1·85	... ·93			
K_2O	... 1·23	... ·26	R_2O	... 3·42	... 1·2
Na_2O	... 5·93	... 1·91			
H_2O	... 1·13	... 1·25			
	98·67	31·73			
Hygroscopic moisture		·55			
Specific gravity	...	2·632			

Taking the microscopic examination as the basis, the above may be calculated into mineral percentages as follows:—

QUARTZ-MICA-PORPHYRITE.

	Si. O_2.	$Al_2.O_3$.	$Fe_2.O_3$.	Fe. O.	Ca. O.	Mg. O.	K_2. O.	Na_2. O.	H_2. O.	Total of Molecular Proportions.	Total Per cent.
	24·13	2·80	·07	·08	·30	·93	·26	1·91	1·25	31·73	..
Soda Felspar ..	11·46	1·91	..	..	..	..	..	1·91	..	15·28	50·15
Potassa Felspar ..	1·56	·26	..	..	..	..	·26	..	..	2·08	7·25
Lime Felspar ..	·60	·30	..	..	·30	..	..	..	..	1·20	4·19
Magnetite	..	..	·07	·07	..	..	..	..	..	·14	·81
Chlorite	·57	·19	..	·01	..	·94	..	..	·76	2·47	5·25
Kaolin	·28	·14	..	..	..	..	..	..	·14	·56	1·69
Quartz	9·66	..	..	..	..	..	..	..	..	9·66	28·98
Totals	24·13	2·80	·07	·08	·30	·94	·26	1·91	·90	31·39	98·32
Differences ..	..	..	..	..	..	+ ·01	..	..	– ·35	– ·34	– ·35

Estimating the kaolin as representing alterations in the porphyritic felspars, and assuming these to have been of the constitution, Alb. 3, An. 1, we have ·88 molecules of oligoclase to be taken into consideration in deciding upon the probable condition of the unaltered rock; and similarly the chlorite may be calculated as magnesia-mica. The result of such a calculation gives the following as the probable percentage constitution:—

Felspar	63 36
RO minerals	8·18
Quartz	23·48
	100·00

And these constituents are in the following molecular proportion to each other:—

Felspar, 8·61; Quartz, 4·31; RO Minerals, 1.

Another example of a rock of this group I found as a dyke crossing Navigation Creek below the junction with it of the Mount Elizabeth branch. In its least weathered portions it is hard, compact, of a pale slate colour, and of a flinty appearance. With the lens there are visible here and there minute cleavage planes of felspar and glassy-looking granules of quartz.

Under the microscope I found it to have a micro-crystalline-granular ground-mass of quartz and felspar, in which were a few porphyritic crystals, and here and there slight traces of yellow basis. In this ground-mass there are innumerable bladed microliths of some chloritic mineral. These lie at all angles in the rock, are bent, twisted, and often ragged at the ends, and are of a pale green colour. The constituents of this ground-mass show in places traces of radial structure. The porphyritic crystals are rare and of the subjoined kinds:—

(1.) A single large porphyritic crystal of triclinic felspar, in which the two compound halves are composed of plates which are not continuous throughout. The optical angle of obscuration on each side of the composition face of the Carlsbad twin I found to be nearly 17°.

Three small compound twins are probably of the second order of consolidation.

(2.) The porphyritic-quartz crystals are also very rare, there being only two, and these are both much rounded and eroded at the edges.

Both the felspar crystals and the quartz I found to be surrounded by a margin of crypto-crystalline ground-mass, which gradually passed into the micro-crystalline-granular structure of the major part of the slice.

(3.) A few small chlorite pseudomorphs after magnesia-iron-mica are scattered through the ground-mass. The character of this mineral is precisely that already described.

This rock, therefore, clearly has been a quartz-mica-porphyrite, in which the porphyritic characters are only slightly marked, and in which the RO minerals are almost absent. It nearly represents the ground-mass of such a rock as that already described as typical of this group.

The following analysis and calculation of the mineral percentage is of a sample of this dyke :—

No. 5.—Quartz-Mica-Porphyrite.

	Per cent.	Molecular Proportions.		Ratio.	
P_2O_5	tr.	—			
SiO_2	77·66	25·89	= SiO_2	25·89	10·5
Al_2O_3	12·30	2·39	= R_2O_3	2·47	1·
Fe_2O_3	·61	·08			
FeO	·17	·05	= RO	·47	·2
CaO	·16	·06			
MgO	·73	·36			
K_2O	·19	·04	= R_2O	2·80	1·1
Na_2O	6·96	2·25			
H_2O	·46	·51			
	99·24	31·63			
Hygroscopic moisture		·33			
Specific gravity		2·634			

The following may be taken as the probable composition of this rock calculated into its component minerals :—

QUARTZ-MICA-PORPHYRITE.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.	Total Molecular Proportions.	Total Per cent.
	25·89	2·39	·08	·05	·06	·36	·04	2·25	·51	31·63	..
Soda Felspar ..	13·50	2·25	..	..	..	..	..	2·25	..	18·00	59·04
Potassa Felspar ..	·24	·04	..	..	..	..	·04	..	..	·32	1·12
Lime Felspar ..	·12	·06	..	..	·06	..	..	..	..	·24	·83
Magnetite	..	..	·02	·02	..	..	..	..	..	·04	·23
Chlorite	·30	·04	·06	·03	..	·47	..	..	·40	1·30	3·00
Quartz	11·73	..	..	..	..	..	..	..	..	11·73	35·19
Totals	25·89	2·39	·08	·05	·06	·47	·04	2·25	·40	31·63	99·41
Differences ..	..	..	..	..	..	+ ·11	..	..	— ·11	..	+ ·17

This rock may be assumed to have had the following composition, if we assume that the alumina and the magnesia in the chlorite represent the mica:—

Felspar	61·50
RO minerals	3·10
Quartz	35·40
	100·00

And on this basis the molecular proportion would have been—

Felspar, 12·5 ; Quartz, 7·9 ; RO Minerals, 1.

Quartz-Granophyrites. The rocks which I have selected as illustrations of this subdivision of the group are the following:—

(1.) Contact of the quartz-porphyrite mass with the sediments at the Haunted Stream.

In the slices of this rock which I prepared I found but very little of a ground-mass such as that which I have described in the quartz-mica-porphyrites, but that which there is precisely resembles it in being a minutely fine-grained compound of felspar and quartz. The far greater part of that which in kindred rocks would go to form this ground-mass is here aggregated into radial spherulitic masses of felspar and quartz, which either form the whole or surround some central object, or are disposed in irregular groups round it. These central objects are in some cases quartz, in others felspar crystals, or even chlorite, which, however, cannot be regarded as an originally formed constituent. The structure of these spherulites is not usually regular, but may be described as being built up of several groups of radial crystals. In some few the optical accordance of the various parts is such that a more or less perfect black cross is observable by polarised light in the spherulite as a whole, but in most cases this is not the case, and there are independent portions of several discordant crosses in the whole. The quartz-crystals which form the centres of these spherulitic masses are precisely such as are found in the quartz-porphyrites. The felspars are all plagioclase, and are often fractured. In some cases I have observed two or three felspar fragments forming the nucleus of a spherulite. One very large instance I observed to be built up of four concentric portions. The centre was a large somewhat rounded crystal of quartz, having several of the characteristic sinuses; this was followed by a rather narrow envelope of felsitic basis; the third envelope was of radial masses of the usual spherulitic composition. The whole mass was surrounded by a very fine-grained crystalline compound of felspar and quartz, in which there were a few small radial spherulites.

Throughout the compound ground-mass are innumerable small, lengthened green or brown microliths, some bent or twisted, or with forked ends. They occur more frequently in the spherulitic than in the micro-crystalline-granular parts of the rock. So far as I could observe their direction of extinction forms a small angle with the longer diameter. This suggests that they are amphibole, and the original condition of the chlorite microliths which I have found to be so numerous in the ground-mass of the quartz-mica-porphyrites of this locality.

In this ground-mass are porphyritically (1) crystals of quartz, (2) crystals of plagioclase, (3) a few examples of chlorite pseudomorphs after magnesia-iron-mica. All these porphyritic crystals are of the character of those I have described as occurring in the quartz-mica-diorites.

(2.) A dyke crossing the road north of Noyang.

This dyke cuts across the quartz-mica-diorites about a mile from the ford, and is probably a continuation of one of the strong dykes which have been laid bare by floods in Navigation Creek, possibly even of the dyke which I have examined and analysed, as recorded on page 25.

In this sample the main mass is micro-crystalline-granular. In it are distributed small prisms of plagioclase and granules of quartz. Besides these there are spherules isolated and in masses. Some of these are composed only of radiating long and very narrow prisms; others are radiating bundles of fibres surrounding a central crystal of quartz or felspar; and others are formed of a radial hemisphere placed against a felspar crystal.

(3.) Rock at the ford at Noyang.

This rock is composed wholly of felspar and quartz. The constituents of the ground-mass are arranged in radial aggregates. When such an aggregate is placed in a certain position as regards the plane of polarisation, one or other of the constituents becomes wholly obscured at the same time, and the second constituent stands out in strong contrast. This structure, therefore, assimilates to that which is called "micro-pegmatoïde" by MM. Fouqué and Lévy. These spherulitic aggregates very often touch each other, while elsewhere they are so far apart as to admit the interposition of crystals of plagioclase or micro-crystalline masses of quartz and felspar. In some few instances imperfectly formed crystals of felspar form the centre of the aggregates; more rarely these latter are arranged in the manner described as "structure pegmatoïde." Quartz does not occur in this rock porphyritically.

No mica or amphibole is present, nor any alteration products which would indicate their former existence.

(c.) *Quartz-Porphyrites.*

These rocks are so intimately connected with the quartz-mica-porphyrites that they might with propriety have followed them in this description; but as I have considered these intrusive rocks in the order in which I believe them to have been formed, the quartz-porphyrites in their most typical examples find their place here.

These rocks I have observed as dykes cutting across the older igneous rocks. At a certain part of the course of the stream which is known as the Mount Elizabeth branch, it leaves the crystalline-granular quartz-mica-diorites of its upper valley, and flows over successive masses of breccias, of black vitreous-looking porphyritic rocks, of quartz-mica-porphyrites, and of masses and dykes of milk-white, close-grained quartz-porphyrites. These last I believe to be the youngest of the whole group, with the exception of the black, vitreous rocks (felsophyrite). It seems to represent the magma of these older rocks freed from the basic constituents which in them go to form the mica, amphibole, and magnetite.

I now give the results of microscopic examination and chemical analysis of these white quartz-porphyrites. The samples were collected from two localities :—

(1.) A slice prepared from this sample I found to be composed of felspar and quartz. In places the former showed a tendency to crystallise out in definite forms, showing that it had a slight priority in order of formation; but although these imperfect crystals showed twinning, I could not obtain any measurements of the angles formed by the planes of vibration in the twin halves. In the ground-mass there was one porphyritic crystal of plagioclase, but, unfortunately, the greater part of it was lost in preparing the slice. A few rare and slight traces of hydrated iron ore completed the composition of this rock.

(2.) This slice much resembled the last described, but in the ground-mass of quartz and felspar I observed several crystals of quartz of the kind so commonly found in these porphyrites. There were also some porphyritic crystals of felspar, which were so much kaolinised that all that can be said of them is that they were plagioclase. Finally, there were some slight traces of chlorite and much more hydrated iron ore distributed through the whole rock than in the other example.

It was unfortunate that this sample was the one which I selected for analysis, and which, being the more porphyritic, and the more altered by decomposition, of the two, was less well suited for the purpose I had intended.

The rock when examined in a hand sample has a compact, nearly milk-white appearance, with here and there slight ferruginous stains, and a few small quartz-crystals can be made out.

In the subjoined analysis the silica was not directly determined.

No. 6.—Quartz-Porphyrite.

	Per cent.	Molecular Proportions.		Ratio.	
SiO_2	... 78·77	... 26·26	= SiO_2	... 26·26	... 10·3
Al_2O_3	... 12·44	... 2·43	= R_2O_3	... 2·55	... 1·
Fe_2O_3	... ·95	... ·12			
CaO	... ·53	... ·19	= RO	... ·20	... ·08
MgO	... ·02	... ·01			
K_2O	... ·24	... ·05	= R_2O	... 2·53	... 1·
Na_2O	... 6·79	... 2·19			
H_2O	... ·26	... ·29			
	100·00	31·54			
Hygroscopic moisture		·14			
Specific gravity ...		2·614			

The calculation of the mineral percentage may be made as follows:—

QUARTZ-PORPHYRITE

	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.	Molecular Proportions.	Per cent.
	26·26	2·43	·12	·19	·01	·05	2·19	·29	31·54	..
Soda Felspar	13·14	2·19	..	..	..	..	2·19	..	17·52	57·49
Potassa Felspar	·24	·04	..	..	..	·04	..	..	·32	1·12
Lime Felspar	·32	·16	..	·16	..	..	..	..	·64	2·23
Magnesia-Iron-Mica ..	·06	·01	·01	·03	·01	·01	..	·01	·14	·47
Kaolin	·06	·03	..	..	..	..	..	·03	·12	·36
Limonite	..	..	·11	..	..	..	..	·22	·33	1·08
Quartz	12·44	..	..	..	..	..	..	..	12·44	37·32
Totals	26·26	2·43	·12	·19	·01	·05	2·19	·26	31·51	100·07
Differences	..	..	..	..	..	..	..	—·03	—·03	+·07

This rock may be considered as essentially a compound of felspar and quartz. The percentage composition can be taken as follows in the unaltered rock, assuming the kaolin, as before, to represent the alterations in the felspar, and disregarding the hydrated iron ore :—

Felspar	61·91
RO minerals	·47
Quartz	37·62
	100·00

The molecular proportion of these minerals I find to be as follows :—

Felspar, 133·43 ; Quartz, 88·88 ; RO Minerals, 1·

It is to be noted that this rock not only consists essentially of felspar and quartz, but that the felspar is almost wholly albite, it being most probable that the K_2O is here isomorphous with the Na_2O in a triclinic form.

The following comparison of the constitution of the four allied rocks may now be made, and the increasing acidity of magma comes out clearly. The analysis No. 5 may be thought to nearly represent the ground-mass of the porphyritic members of the series :—

	Felspar.	Quartz.	RO Minerals.
Analysis No. 2 ...	1·30 ...	·42 ...	1·
,, No. 3 ...	8·61 ...	4·31 ...	1·
,, No. 4 ...	12·5 ...	7·9 ...	1·
,, No. 5 ...	133·43 ...	88·88 ...	1·

(*d.*) *Quartz-Felsophyrites.*

The locality where this rock occurs appears to have been a focus of igneous activity. It is here that the great mass of quartz-mica-porphyrite extends out westward with its associated dykes, first filling a wide space in the crystalline-granular rocks, and then separating them from the sediments. At this place it is also that the masses and dykes of white quartz-porphyrite have penetrated the older igneous rocks.

The felsophyrite masses seem to me, so far as I could make out in the absence of a detailed feature survey, to fill in a central position in regard to the above-mentioned formations, and to be flanked by masses of breccias, which at first sight have the appearance of being made up of angular fragments of compact porphyrites, but which on examination prove to be really portions of the metamorphosed palæozoic sediments of the district.

It remains uncertain which is the younger formation, the white quartz-porphyrite, or this felsophyrite, but I incline to consider the latter to be the younger of the two.

This rock is intensely hard and flinty in appearance, usually black or greyish black in colour, and shows exceedingly numerous included fragments of other rocks, which give to it a porphyritic appearance. I examined two samples which I collected as probably fairly representing the average character of the rock. The microscopic examination of the two samples gave me the following results :—

The first sample consisted of a very large proportion of a basis of various shades of yellow to brown, and which has undergone felsitic alteration. It shows flow structure in a beautiful manner, not only in the differently shaded bands of varied width, but also in narrow lines of black, opaque granules, or long and narrow black microliths (iron ores) which lie in the direction of the flow. Alternating with these bands of almost wholly basis are others which are crypto-crystalline, and resemble the ground-mass of the fine-grained porphyrites. In these crystalline bands there are, however, strings and patches of basis which show very distinctly when a Klein's quartz-plate is used for their examination. Although the crystalline bands are much smaller individually than those of basis, and in the aggregate do not probably make up more than one-fourth or one-third of the mass, yet in places they swell out to several times their usual breadth, and the individual crystalline grains become at the same time larger. Similarly, the bands of basis swell out and narrow in their course. The manner in which these bands divide and follow round the included fragments is very characteristic.

Included in these bands, but more especially in those of basis, are innumerable minute crystalline grains, some of which are of felspars, which in many cases are twinned.

In this ground-mass, if the term is admissible, are included many much larger fragments—

(*a.*) Angular masses of yellow glass, rendered in places almost opaque by iron ores.

(*b.*) Fractured and eroded crystals of quartz, such as are found in the quartz-porphyrites.

(*c.*) Felspars which are more or less fractured. Almost all of these are twinned. The optical measurements which I was able to effect gave angles between 4° and 19° for the zone $OP - \infty\bar{\bar{P}}\infty$; and in one crystal, which was perfect and simple with the planes $OP - P - \infty P$, I found the angle formed by the plane of vibration with the edge $\infty\bar{P}\infty - \infty\breve{P}\infty$ to be 5°.

The felspars are extraneous to the rock, being merely included fragments, and the optical measurements afford, therefore, very little information except as to the individual crystal in which the measurement was made. The second sample showed, microscopically, a large number of inclusions, and was not so black and flinty in appearance as the other. The colour was a greyish black, and I found the specific gravity to be 2·717. Under the microscope I observed its characteristics to resemble those of the former sample, but the basis to be much less in amount, while the bands containing opaque black bodies, the crystalline bands, and the foreign inclusions were proportionately greater. This rock has the following composition :—Bands of yellow basis, alternating irregularly with bands or streams of micro-crystalline materials. These bands are, as a rule, exceedingly narrow relatively to each other, but in places swell out to bunches, in which are usually contained angular fragments of foreign substances, such as quartz or felspar. In this ground-mass are—

(*a.*) Angular fragments of quartz-crystals.

(*b.*) Angular fragments of micro-crystalline-granular quartz-porphyrite.

(*c.*) Felspar crystals similar to those spoken of in describing the last sample. The most peculiar feature in these felspars is their conversion in some parts almost wholly into a pale green mineral, having the optical characters of epidote. This alteration, or more properly substitution, product also occurs in several flows which traverse the slice.

(*d.*) Two comparatively large masses of fine-grained sandstone are also included. These have precisely the characters of the hornfels produced by the metamorphism of the quartzose sediments of the district.

(*e.*) Finally, traces here and there of some chlorite mineral.

This rock may therefore be described as a felsophyrite, having a ground-mass which, probably, if found free from included fragments, would represent "pitch-stone."

The composition of this rock, being made up so much of extraneous materials, decided me not to take the trouble of making a quantitative analysis, as it seemed that no results of value would be likely to be attained.

The mode of occurrence of these black and vitreous rocks entirely among the crystalline-granular and porphyritic members of the series suggests that they represent the plug of a vent which emitted a lava that included numerous extraneous fragments, partly derived from below and partly from the volcanic dust which had fallen back again into the orifice. The fact that it is from this locality that the quartz-porphyrite dykes and dyke-like masses radiate, lends strength to such a supposition.

(*e.*) *Diorites.*

Traversing the quartz-mica diorites and porphyrites, but not so far as I know in connection with the later igneous rocks, there are numerous dykes which are all marked by a dark greenish colour and a finely crystalline structure. They are good examples of rocks which were formerly all classed as "greenstones," and which, as dykes, are very common in the Gippsland mountains. There is little in their occurrence to show whether they do or do not belong to the series of rocks which I have now described; but they certainly do appear to be more plentiful in the area of igneous rocks than outside of it; and I have observed the same fact elsewhere; for instance, at Swift's Creek, where dykes of very basic character, being mainly amphibole, traverse the quartz-diorites, and are, I think, connected with the intrusive areas of amphibole rocks (Schillerstein) which are the youngest of all the series which, together collectively, constitute the intrusive area at that place. An instance of these dykes occurs at Navigation Creek, in the quartz-mica-diorites. It is about thirty inches in width, and strikes N 55° W. The rock in mass has a dark greenish colour, and weathers with a rough exterior; a fresh surface shows a minutely crystalline structure, and here and there a few small grains of pyrite. Under the microscope, in a thin slice, I found it to be composed as under—

(1.) Felspars which form a network—or, perhaps, more properly, groups—in which several crystals are in juxtaposition with others at various angles. They are much eroded, and more or less filled by alteration products; and of these epidote in granular masses, and of a pale yellow colour, is the most frequent. It often replaces a large part of the crystal. Another alteration product is kaolin. Minute flakes of some chlorite mineral are also very frequent in these felspars. The optical measurements which I was able to effect in a few of the least altered felspars gave for the zone $OP - \infty \breve{P} \infty$ from 3° 30′ to 10° 15′. The crystals are either compounded according to the Albite law, or more rarely simple. The long and narrow forms of these crystals show that the elongation has taken place in the direction of the edge $\infty \bar{P} \infty - \infty \breve{P} \infty$

(2.) Among and between the clustered felspar prisms are numerous crystals showing the usual external angles of amphibole, but having only the faintest traces of prismatic cleavage. In sections which might be considered near the clinopinacoid I obtained measurements of the inclination of the plane of vibration as high as 18° 30′. This mineral is polychroic, the colour of the three rays being, however, in light shades—

c = green ; b = light green ; a = pale yellow.

Associated with the amphibole are numerous rectangular crystals resembling magnetite, but, as some of them are surrounded or partly composed of a somewhat opaque grey material, they may rather be titanic iron, and the grey material leucoxene. The large percentage of TiO_2 shown in the annexed analysis agrees with this view.

Some yellow crystalline grains with rugged surfaces suggest sphene.

Besides these constituents there are, in spaces between the other crystalline minerals, radial masses of some chlorite mineral, which is, however, clearly distinguishable from the other chlorites produced by the alteration of amphibole, and I suspect that it may represent portions of basis.

The sequence of formation of minerals in this rock is not quite clear, but the probability is that the order has been as follows :—(1.) Titanic iron ; (2.) amphibole and plagioclase, these two not differing perceptibly in period of formation.

I subjoin a quantitative analysis of this rock, but, in the absence of more precise knowledge of the composition of the numerous alteration products, I have not found it practicable to calculate satisfactorily the mineral percentages. All that I can say with safety is that the felspar is probably a more basic one than is found in those rocks which I have already described.

This rock was most probably, in its unaltered state, a diorite standing near to the hornblende porphyrites.

No. 7.—Diorite.

	Per cent.	Molecular Proportions.		Ratio.	
P_2O_5	tr				
CO_2	·44	·20	SiO_2, &c. =	26·42	7·
TiO_2	1·39	·34			
SiO_2	47·63	25·88			
Al_2O_3	17·20	3·34	R_2O_3 =	3·79	1·
Fe_2O_3	3·60	·45			
FeO	8·09	2·25	RO =	7·67	2·
MnO	tr	—			
CaO	6·42	2·30			
MgO	6·25	3·12			
K_2O	1·31	·28	R_2O =	4·79	1·3
Na_2O	4·65	1·50			
H_2O	2·71	3·01			
	99·69	32·13			

Hygroscopic moisture, ·73 c 212° F.
Pyrite (FeS_2) ... ·53
Specific gravity ... 2·893

(*f.*) *Diabase.*

The only instance which I have met with of a rock which did not belong to the diorite group is that of a strong dyke traversing the quartz-mica-diorites near the junction of the Mount Elizabeth branch with Navigation Creek. Examined in a thin slice, I found it to have the following composition :—

(1.) Iron ores in crystals showing rhombic sections, and all more or less surrounded by a grey, somewhat obscure, material (leucoxene).

(2.) Plagio-felspars extended in the direction of the brachypinacoid, and compounded according to the Albite law, more rarely the Pericline law in interposed lamellæ. I could not obtain any satisfactory measurements of the inclination of the plane of vibration. The larger crystals have their edges and corners rounded off.

(3.) Pale yellow augite in ill-formed crystals and groups of crystalline grains. Some of this augite has been converted into a pale green chloritic mineral, and much more into a very pale yellow epidote. In several cases there are crystals remarkable for being partly composed of felspar and augite, the latter being interposed so that the axis "c" coincides in each case, and the angles formed by the plane of vibration in the two minerals are diverse and characteristic of each.

I observed one solitary instance of a very small brown-coloured and dichroic section of a mineral having the prismatic cleavage of amphibole. It was almost surrounded by a chloritic alteration of augite, and may itself be an alteration product of that mineral.

(4.) Prisms of apatite plentiful.

There is no great improbability that a rock such as this should appear among the most basic of the rocks of an area such as Noyang. This dyke occurs under just the same conditions as dykes of the more basic diorites, and the main distinction between it and them is in the more elongated character of the felspars, and the occurrence of augite instead of hornblende.

This rock terminates the series which I have collected to illustrate the igneous rocks of Noyang. The whole series is parallel to that of which the quartz-porphyries are characteristic, the only difference being in the preponderance, in the Noyang group, of a soda felspar, and in the other of a potassa felspar. The presence of albite, or of an oligoclase standing very near to it, as the characteristic felspar of this series is peculiar; and it is interesting to observe that, taking the crystalline-granular rocks as the starting-point, there is a decrease in basicity from an oligoclase to albite, and at the same time a more marked decrease in the general basicity of the rock by the disappearance of the Mg Fe minerals, so that at the end of the series the white quartz-porphyrites are composed almost wholly of albite and of quartz.

IV.—The Sedimentary and Metamorphic Rocks.

The igneous rocks which I have now described form, in the aggregate, a great mass which has left the traces of its intrusion in the changes produced in the physical and molecular condition of the sediments with which it came in contact.

The normal strike of the Silurian sediments of the district may be taken as about N 30° W, but I find that in the neighbourhood of this intrusive mass the strike of the sediments has been diverted to nearly east and west. This is not an isolated case, for I have observed the same deflection of the normal strike adjoining intrusive areas at Swift's Creek, Dargo Flat, and other places in Gippsland. This shows the enormous disturbance of the earth's crust which accompanied the extravassation of the once molten masses.

This deflection of the strata east and west is observable at Shady Creek, about three miles from the contact. The dip to either hand is so slight that, practically, the beds may be looked upon here as vertical. The alteration observable in these alternating sandstones and slates is an induration generally, and a slightly spotted appearance of some of the more fine-grained beds. Narrow veins of quartz, with traces of chlorite, are very frequent. From this point, in going southwards, the sediments soon resume their normal appearance, and no igneous rocks reappear, the Silurian strata disappearing at a distance of about ten miles underneath the marine tertiaries. To the north the sediments become more and more altered into contact schists as they approach the Noyang area.

I prepared several slices from samples collected at Shady Creek, and also from the northern side of the range of hills across which the old line of road leads to Noyang.

Shady Creek.—I found a sample of one of the fine-grained beds to have the following composition:—The slice was prepared parallel to the bedding. It is mainly composed of overlapping more or less rounded plates of a colourless or faintly green mineral. In places where these plates are seen edgeways, they are twisted, bent, ragged edged, and very slightly dichroic, and where numerous form what may not inaptly be called a "foliation." When the rock is examined between crossed nicols, these plates behave like sections of a uniaxial mineral, and this comes out much more clearly when a Klein's quartz-plate is used. The characters of this mineral suggest strongly that it is chlorite. In this mass are numerous small grains of quartz, and a considerable amount of black granular material, which is probably carbonaceous.

A second slice I prepared from one of the coarse-grained sandstones of Shady Creek. The ground-mass of the rock is composed of materials precisely similar to those of the last described sample, that is, mainly of a chloritic mineral and minute grains of quartz; but there are, in addition, a few large flakes of muscovite mica. The only microliths are a few very small, stout, colourless prisms, and a few yellow granules, and some carbonaceous material. In this "paste" there are very numerous angular fragments of quartz, and angular and rounded fragments of felspar. These fragments are of such size, as compared to the remainder of the rock, as to give it a pseudo-porphyritic aspect.

The quartz is such as is found in the crystalline-granular granite rocks, and contains numerous and very minute fluid cavities. Some of the fragments of felspar have all the appearance of orthoclase, others are plagioclase, and in one fragment of the latter I observed the angle formed by the plane of vibration in either side of the twin composition face to be 40°.

Besides the fragments of quartz and felspar which form the greater part of the rock, there are also several rounded fragments which are yellow in colour, contain iron ores (magnetite?), and are isotropic. They have, in fact, exactly the appearance of a volcanic glass, which I believe them to be. There are also some fragments of green tourmaline, and a good deal of brown iron ore generally distributed through the slice. This rock has therefore been formed from the detritus of igneous rocks, which were probably developed both in crystalline and vitreous forms. The examination of a rock such as this suggests that an investigation of the most coarse-grained of the Silurian beds of Victoria might, perhaps, give some insight into the nature of the still older formations of which at present, so far as I am aware, nothing is known. At any rate, it seems that in Gippsland those formations on which the Silurian sediments were laid down, and from whose waste they were most likely formed, have completely disappeared during the metamorphic and plutonic processes to which the palæozoic rocks have been subject.

I prepared several other slices, which did not afford me any special points of interest, being either the same as, or intermediate to, the above.

Northern Side of Shady Creek Range.—The first sample which I examined has, in the hand specimen, a finely-foliated structure, and a silky lustre on the bedding planes or foliations, and also a few slightly marked spots like incipient "nodules." Under the microscope I found this rock to be composed as follows:—

(*a*) Foliations of almost colourless thin overlapping plates, which react as a uniaxial mineral.

(*b*) Foliations alternating with (*a*), composed of the first-mentioned colourless uniaxial mineral, together with flakes of a brownish yellow mica, which in places predominate almost exclusively.

(*c*) Black granular material, most of which I judge to be carbonaceous—possibly some may be magnetite. This is heaped together in places.

Another slice prepared from a sample which was not so markedly foliated, I found to be composed almost entirely of the chlorite-like mineral, with here and there isolated flakes of colourless mica (muscovite ?). These were disposed in two directions, so as to produce a net-like effect in the slice. I observed herein also a few stout short prisms of green tourmaline, and much carbonaceous material, and some hydrated iron ore.

In none of these samples did I observe the thorn-like microliths which are so plentiful in some slates.

In proceeding up the course of the Tambo River from the Noyang ford, the contact of the igneous and sedimentary rocks is found at the junction of that river and the Haunted Stream. In following up the Tambo from this point the appearance of contact metamorphism decreases, until the hornfels rocks gradually are replaced by highly inclined alternating sandstones and slates of much the normal appearance and strike. In selecting a sample for examination I endeavoured to choose one which should be as much as possible in an unmetamorphosed condition; for, at a short distance northward, the formations again show change, and this time gradually assume a character which places them with the regionally metamorphosed schists of Omeo.

The beds from which I selected a sample had a strike of N 55° W. I found them fine-grained and fissile; in colour a dark green, but in all cases slightly spotted by the peroxidation of their iron. A thin slice which I prepared did not, however, bear out the impression I had received from an inspection of the rocks in position. The uniaxial colourless chloritic mineral which is so common a constituent of many of these fine-grained rocks was almost absent, and its place was taken by another colourless micaceous mineral, in rounded plates, with often ragged edges. This mineral, although biaxial and somewhat resembling muscovite, does not polarise with the brightness of that mineral, which also exists in small amount in the same rock. The double refraction of this mineral is rather weak.

A large part of the rock is made up of minute quartz grains. In addition to these constituents there is hydrated iron ore, and much black granular material, which is not affected by long digestion in hydrochloric acid, but is removed by ignition of the slice, and which, therefore, is carbon.

The following analysis is of part of this sample, and the calculation of the percentages has been based upon the microscopic examination:—

No. 8.—Slates.

	Per cent.	Molecular Proportions.	Ratio.
P_2O_5 ...	·23 ...	·03	
SiO_2 ...	62·30 ...	20·71	SiO_2 = 20·71
Al_2O_3 ...	19·22 ...	3·73	R_2O_3 = 3·95
Fe_2O_3 ...	1·80 ...	·22	
FeO ...	4·01 ...	1·11	
CaO ...	·44 ...	·16	RO = 2·75
MgO ...	2·95 ...	1·48	
K_2O ...	3·60 ...	·77	
Na_2O ...	2·07 ...	·67	R_2O = 3·06
H_2O ...	2·36 ...	2·62	
	98·98	31·50	

Hygroscopic moisture, ·40
Specific gravity ... 2·727

SLATES.

	P_2O_5.	Si. O_2.	Al_2O_3.	Fe_2O_3.	Fe O.	Ca O.	Mg O.	K_2O.	Na_2O.	H_2O.	Sum of Molecular Proportions.	Sum of per cents.
	·03	20·71	3·73	·22	1·11	·16	1·48	·77	·67	2·62	31·50	..
Apatite ..	·03	..	..	..	..	·10	..	..	..	..	·13	·51
Limonite ..	..	..	..	·22	..	..	..	..	..	·33	·55	2·10
Muscovite ..	..	2·08	1·04	..	..	..	..	·52	..	·52	4·16	14·50
Chloritoid ..	..	2·69	2·69	..	1·11	·10	1·48	·25	·67	1·77	10·76	33·99
Quartz ..	..	15·94	..	..	..	..	..	..	..	..	15·94	47·82
Totals ..	·03	20·71	3·73	·22	1·11	·20	1·48	·77	·67	2·62	31·54	98·92
Differences	..	..	..	..	..	+·04	..	..	..	..	+·04	..

This calculation shows a probability that the remainder, after providing for the muscovite-mica on the basis of ·52 Mol. of K_2O, gives a chloritic mineral of the constitution 3 SiO_2, 3 R_2O_3, 3 RO, 3 R_2O, with a surplus of 15·94 Mol. of SiO_2 for the quartz. This rock, therefore, has the following percentage composition, disregarding the apatite and the limonite:—

Chloritoid	35·29
Muscovite	15·05
Quartz	49·66
	100·00

And the micaceous minerals are, to quartz, very nearly in the molecular proportion of 1· to 1·

Near the contact of the quartz-mica-porphyrites and the sediments at the Haunted Stream, about two miles from the Tambo River, I found fine-grained beds resembling those just described, and, as in the other case, alternating with sandstones. The dip was here N 10° W at 80°. I found this rock to be made up in great measure of the uniaxial chloritic mineral which I had before observed in the Shady Creek rocks, together with muscovite, which here again was disposed in two directions, producing a net-like appearance. Together with these were some quartz grains and ores of iron, magnetite, and brown iron ore.

In the same neighbourhood, but somewhat nearer to the Tambo River, I found the sediments more metamorphosed. One which I examined I found to be of the following composition:—(1) Angular grains of quartz, with a few minute fluid cavities; (2) brown mica in small flakes; (3) a little colourless mica, perhaps muscovite.

At the junction of the Haunted Stream with the Tambo River, I found the contact schists well developed. For some half mile up the river the schists are traversed by joints dipping east at about 25°. At the contact itself the bedding planes of the sedimentary rocks are almost obliterated, but where I could make it out I found the bedding to be at high angles on a strike east and west. The schists are traversed by a number of strong porphyritic dykes. I observed inclusions in the quartz-mica-diorites at the immediate contact, which somewhat resembled the dark-coloured patches which are so common in these rocks. These, however, were true inclusions of foreign rocks, and not merely aggregations of the more basic elements of the diorites. I examined a slice prepared from a dense black fragment included in the quartz-mica-diorite at the immediate contact. I found it to be a metamorphosed sandstone, exactly similar to some occurring at Swift's Creek. It was composed of (1) quartz grains, (2) muscovite, (3) biotite. I have placed these in the order in which they are relatively as to amount. The only peculiarity in this sample is that the biotite mica is, in places, almost wholly aggregated together, leaving other spots free from it. Besides these three principal constituents, there were numerous minute flakes of brown mica scattered throughout the whole slice, and of such minute size as to be little more than mere microliths.

In order to compare, if possible, the most altered with the least altered rocks, I selected an example of a finely crystalline hornfels, which seemed to nearly represent the less altered rock which I have examined and analysed (No. 8). Of this I prepared slices, and carried out a quantitative analysis.

Under the microscope I found it to consist of the following minerals :—(1.) Angular quartz grains, with their longer diameters approximately parallel. (2.) Biotite mica in brown ragged flakes, forming foliations, but also scattered through all the rock. This mica is dichroic in shades of brown. (3.) A colourless mica, in long rectangular flakes, having the characters of muscovite. (4.) A chlorite mineral in small aggregations, filling-in spaces in the mass ; it is pale green, and not sensibly dichroic. (5.) Brown iron ore ; and (6.) a few small prisms of tourmaline.

The subjoined is the quantitative analysis of the same rock:—

No. 9.—Hornfels.

		Per cent.		Molecular Proportions.				Ratio.
P_2O_5	...	·16	...	·02				
SiO_2	...	61·92	...	20·60	=	SiO_2	...	20·60
Al_2O_3	...	20·74	...	4·03	=	R_2O_3	...	4·31
Fe_2O_3	...	2·28	...	·28				
FeO	...	3·90	...	1·08	=	RO	...	2·38
MnO	...	·17	...	·05				
CaO	...	·42	...	·15				
MgO	...	2·19	...	1·10				
K_2O	...	2·28	...	·49	=	R_2O	...	3·97
Na_2O	...	3·51	...	1·13				
H_2O	...	2·12	...	2·35				
		99·69		31·28				

Hygroscopic moisture ·92
Specific gravity ... 2·738

The subjoined calculation of the mineral percentages agrees with the results of the microscopic examination, with the exception that the combined water is in excess, and that there is a small deficiency in the alumina. These discrepancies are probably due to analytical inaccuracy.

HORNFELS.

	P_2O_5.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.	Total Molecular Proportions.	Total per cent.
	·02	20·60	4·03	·28	1·08	·05	·15	1·10	·49	1·13	2·35	31·28	..
Apatite	·02	..	..	..	..	..	·06	..	..	..	..	·08	·33
Limonite ..	..	..	..	·08	..	..	..	..	..	..	·16	·24	·78
Lime-Mica ..	..	·22	·22	..	..	..	·09	..	..	·09	·04	·66	2·36
Potassa-Mica ..	..	·98	·49	..	..	..	..	..	·49	..	..	1·96	7·861
Magnesia-Iron-Mica ..	..	6·92	3·36	·10	·83	·05	..	·85	..	1·04	·69	13·84	47·57
Chlorite	..	·30	..	·10	·25	..	..	·25	..	..	·40	1·30	3·46
Quartz	..	12·18	..	..	..	..	..	..	..	..	..	12·18	36·54
Total	·02	20·60	4·07	·28	1·08	·05	·15	1·10	·49	1·13	1·29	30·26	98·88
Differences ..	..	..	+·04	..	..	..	..	..	..	..	–1·06	–1·02	–·81

The lime-mica which is here indicated may perhaps be included in the minute scaly aggregates. Disregarding the small amount of apatite, considering the ferric hydrate as extraneous, and including the small amount of chlorite with the mica, we have the following composition of the rock:—

Micaceous minerals	62·63
Quartz	37·37
	100·00

—the micaceous minerals being, to the quartz, in the molecular proportion of 1·46 : 1·

The Omeo road from Noyang follows, for some distance, the contact of the sedimentary and igneous rocks along Navigation Creek. The alteration here is mainly an induration, thereby producing a hard flinty-looking rock, differing in appearance somewhat from the normal hornfels. On examining a thin slice, I found it to consist almost entirely of grains of quartz of different sizes, even down to mere dust. With this there was a very little brown mica. Many of the larger quartz masses were not only compound, but increased in size by secondary quartz which, also generally diffused through the rocks, gives it its indurated appearance. At the foot of the Fainting Range, however, the quartz-mica-porphyrite mass has produced much more marked effects—that is, if one can be quite sure that the alteration is wholly due to its influence, and not in some measure to previous metamorphism; for it is on the northern side of this range that the schists commence to assume an appearance which is more like that of the less metamorphosed members of the regional schists, than those contact rocks which I have described herein.

At the summit of the Fainting Range the sedimentary rocks have a wrinkled schistose structure, the bedding vertical on a strike of N 70° W. This character is maintained down the range southwards to near their contact with the quartz-mica-porphyrites, where the dip of the schists is to N 10° E at 75°. They are penetrated at this place by several large dykes proceeding westward from the igneous mass.

I prepared several samples from this contact, and I found them to be somewhat peculiar forms of hornfels. One sample was composed mainly of angular quartz grains, set together with only slight traces of bedding in a material which had been altered to a micaceous mineral in aggregates of minute, brightly polarising scales. Besides this there were also well-marked flakes of muscovite. Throughout this rock there are numbers of the minute oval or rounded brown and colourless microliths, which I have found very frequently in the most altered of the quartzose hornfels rocks. I treated a slice of this rock with hydrochloric acid, with occasional boiling, for a month. I found the ores of iron removed, the scaly micaceous aggregates dull and evidently much acted on, but the muscovite and the minute microliths were quite unaffected. The scaly aggregates are probably of some chlorite mineral.

Another sample I found to be a foliated rock, the mass of which was composed of a micro-crystalline-granular aggregate, having the appearance of a mixture of quartz and felspar, associated with a colourless or pale green micaceous mineral. In this mass I observed angular quartz grains, some of which were fractured, so that the parts were no longer optically in accord with each other. Surrounding all the larger quartz grains, I observed a margin of secondary quartz, which was not always in accord with the nucleus. In examining these quartz grains, it seemed singular that the oval or rounded microliths, which are probably mica, are often within the quartz substance. Their formation thus in the substance of a quartz grain seems at first sight inconceivable. The observation that these quartz grains consist of an original centre, and a subsequently deposited exterior, removes the difficulty, and shows that these mica-microliths could have been formed during the metamorphism of the rock, and then sealed up by the secondary quartz. With these quartz fragments were also pieces of felspar—angular fragments lying with their longer diameters according to the foliations. I am unable to decide whether or not to consider these as examples of the regeneration of felspars from sedimentary material. Their peculiar appearance, and their manner of arrangement favours this, and indeed there is no *a priori* reason that I know of against such a regeneration in contact schists; but the fact remains that such instances are of extreme rarity.

In following down the Tambo River from the Noyang ford, the contact between the igneous rocks and the sediments is found where Rainy Flat Creek joins the river. The sediments at that place are converted into well-marked varieties of quartzose and micaceous hornfels, such as those which I have already described. The hornfels has a dip to S 10° E at

67°, and is traversed by two systems of well-marked joints, one dipping N 60° E at 30°, and the other S 55° E at 42°, and these are so marked that it requires an examination of the texture of the rock to determine that they are joints, and not bedding planes.

The metamorphism of the sediments continues for several miles down the valley of the Tambo River, showing the neighbourhood of the intrusive rocks, which then reappear in a somewhat peculiar form as a crystalline-granular compound of quartz and felspar, almost wholly devoid of mica or hornblende. The composition of these rocks is that which, under favourable circumstances, might have consolidated as a quartz-porphyrite, such as are seen near Noyang.

I prepared some slices of these rocks, and I found them, as their appearance in the field had indicated, to be composed essentially of felspar and quartz, with very slight traces of a brown magnesia-iron-mica. The felspars were of three kinds: one highly compounded according to the combined Albite and Carlsbad laws, and with small angles formed by the plane of vibration with the composition face, in one case so small as almost to coincide with the twin plane. The second felspar was evidently orthoclase, and was kaolinised. The third felspar was microcline. A little chloritic mineral is distributed through the whole rock.

The quartz in this sample fills in large spaces, and is remarkable for the numerous microliths it contains. Many of these are of some chlorite mineral, some are ores of iron, and some have even the appearance of felspar fragments. Fluid cavities were not numerous.

Another sample which I collected at a further distance I found to be less quartzose, more felspathic, and to be also entirely free from mica. The felspars were in large tabular crystals, which had slightly interfered with each other's growth. The best crystallised appeared to be oligoclase, and the least well-formed were microcline.

V.—Conclusion.

The age of the Noyang intrusive rocks must remain somewhat uncertain. All that can be stated with any degree of certainty is that they are younger than the goldfields series of North Gippsland, and therefore probably younger than Lower Silurian. The geological structure of the district, and the relations of the palæozoic formations in it, cause me to believe that these intrusive masses date from the great age of plutonic disturbance that embraces the close of the Silurian and the greater part of the Devonian period. Thus the formation of these rocks would have taken place in an age which, in Gippsland, was one of great volcanic activity.* The occurrence of dykes and masses of quartz-porphyrites radiating from the same place where subsequently other masses of felsophyrite rocks (lavas) appeared, together with breccias, suggest that this spot formed one of the vents of a palæozoic volcano, whose site is now indicated by the great mountain mass of the Mount Elizabeth Range. It is not at all improbable that the enormous masses of ejected volcanic materials between Noyang and the Buchan River, some of which are within a distance of fifteen miles of the place I describe, may have in part been derived from this source.

The igneous rock masses of Noyang, as a whole, cover a far larger area than that which I have mapped and described, and are encircled, and I doubt not were once wholly enveloped, by the more or less altered Silurian sediments. These have evidently been subject to violent strains and compression, so that the bedding now lies in places at more than 45° to the normal strike of the district. These disturbed sediments have been invaded by the igneous rocks, which have not only truncated their horizontal extensions and have sent into them dykes and masses, but have also melted off and absorbed an unknown amount of the vertical extension downwards of the folded and compressed strata.

The igneous rocks which at Noyang thus intruded into the sediments varied as to their structure, but they all belong, with one exception, to the same petrological group, although formed at different and successive parts of the same period over which the invasion and metamorphism of the sediments extended and the subsequent cooling and crystallisation took place. The igneous rocks of Noyang must be considered as a whole. The several varieties of rock have been, no doubt, produced at different times, but these times have been merely parts of a great series of periods of activity and quiescence, and the difference in the composition and structure of the rocks thus formed must necessarily have depended in great

* "The Devonian Rocks of North Gippsland," *Progress Report, Geological Survey of Victoria*, Part III.

measure on the continuously varying conditions thereby produced.

In considering what may have been their origin and the mode of their formation, it is evident to me that an explanation which disregards the influence of those contact sediments which have been absorbed into the mass of the crystalline rocks will be partial and incomplete.

The microscopical examination of the igneous rocks of Noyang brings out clearly one marked feature, viz., the decreasing amount of the Fe Mg minerals in the succeeding formations. The occurrence of more basic rocks as dykes at the close of the process is a small feature when compared to the whole. The analyses which I have given also show this decreasing amount of RO bases, and this is most marked in the latest of the quartz-porphyrites, which is essentially composed of albite and quartz alone.

Two explanations might be given of this decrease of basic minerals in succeeding rocks. It might be suggested that the successive emissions of rocks of less and less basicity represent the residues of the original magma from which the RO bases had crystallised out as magnetite, mica, or amphibole, and that thus the latest rocks represent the more acid residuum. But this view fails to account for the amount of sediments which have certainly been absorbed, and suggests that the earlier and more basic rocks owe at least some of their basic compounds to the sedimentary materials which have been absorbed. An inspection of the analyses Nos. 3, 4, 5, and 6 shows that absorption of rocks of such a kind would certainly add a comparatively large increase of the RO bases to the igneous masses. To see what might be the result of such a process, I have calculated and subjoin results on the assumption that equal portions of a magma of the constitution of the white quartz-porphyrite (analysis No. 6) and of a sediment (analysis No. 7) were combined. Such a magma would have a mean composition as given below:—

HYPOTHETICAL COMBINED ROCK.

	$Si. O_2$.	$Al_2 . O_3$.	$Fe_2 . O_3$.	Fe. O.	Ca. O.	Mg. O.	K_2. O.	Na_2. O.	H_2. O.	Molecular Proportion.	Per cent.
Molecular Proportion	23·505	3·080	·170	·555	·175	·745	·425	1·425	1·455	31·535	..
Soda Felspar ..	8·550	1·425	..	..	..	..	..	1·425	..	11·400	37·410
Lime Felspar ..	·350	·175	..	..	·175	..	..	..	..	·700	2·440
Potassa Felspar ..	1·200	·200	..	..	..	..	·200	..	..	1·600	5·570
Mica	2·580	1·290	..	·205	..	·440	·225	..	·420	5·160	17·436
Amphibole	·485	..	..	·180	..	·305	..	..	..	·970	2·713
Magnetite	..	..	·170	·170	..	..	..	..	..	·340	1·972
Quartz	10·340	..	..	..	..	..	..	..	..	10·340	31·020
Totals	23·505	3·090	·170	·555	·175	·745	·425	1·425	·420	30·510	98·561
Differences ..	..	+ ·010	..	..	..	..	..	..	—1·035	—1·025	..

This would give a proportionate amount of—

Felspar, 2·1; Quartz, 1·6; RO Minerals, 1.

This shows that such a compound as the above might, in consolidation, crystallise in the form of one of the rocks belonging to the Noyang group; and a compound formed by the fusion of different proportions of the igneous magma and the sediments might produce any one of them.

Such fusions have taken place in the Gippsland area, at the close of the Silurian age, to an enormous extent, and the influence of the absorbed sediments on the invading igneous magmas cannot be overlooked.

It seems to me that such possibilities, in the formation of igneous rocks, have not yet been sufficiently regarded by petrologists.

Art. V.—*On the Occurrence of Bacteria (Bacilli) in Living Plants.*

By T. S. Ralph, Esq.

[Read 10th May, 1883.]

In these days of germ-theory and of research after bacteria discoverable in the tissues of animals, and supposed to be elements of disease in some form or condition, and when we are called on to become familiar with such terms as these—Sphæro-bacteria, Micro-bacteria, Desmo-bacteria, Filo-bacteria, and Spiro-bacteria, Bacilli and Micro-cocci; and then some of their results, as Bacteruria and Pathogenous-bacteria, in relation to a whole host of maladies, and the question of mutability of bacteria, it may not be without interest to bring before the notice of the scientific mind that bacillus (a sub-genus of bacterium) is to be detected in living plants.

A few years ago there was a notice in the *Journal* of the Royal Microscopical Society of England to this effect, that bacteria had been found in the crushed tissues or cells of plants; and the question was asked, as this had been noticed by some foreign observers, Have any investigators in England observed, or encountered, the same objects?

To this day, so far as I have been able to ascertain, no further information has been accorded, save that bacilli have been noticed in the tissues of decaying or dying plants in a moist condition, leading us to suppose that these organisms may be direct promoters of the decay of such vegetals.

The interesting part of my communication lies in this: that living bacilli can be shown in the living cells of what appears to be a healthy vallisneria, and I have also found them in the cells of another water-weed—*i.e., Anacharis alsinastrum.*

As far as I have been able to ascertain, these organisms (bacilli) can be readily detected in the square cells of the surface of the leaf, intermixed with chlorophyl grains, but soon gravitating to the lower portion of each cell. They appear to be confined to these superficial cells, and are with difficulty to be traced in the deeper-seated larger ones of the plant. On two occasions I have distinctly seen a bacillus occupying the central portion of a large cell in which cyclosis was going on. On account of the greater density of the protoplasm moving along the walls of the cell, I suppose the bacillus could not enter the current, the lesser specific gravity of this organism preventing it occupying any portion of the stream which was of greater density than itself, hence its steady continuance in the central or calm region of the cyclosis.

Now come questions:—What relation do these bacilli bear to the host, or plant, in which they are found? Are they vegetals, living in commensalism with it? Are these organisms vegetal or animal in their life character? Do they await the dissolution of the cell contents in order to complete further destructive changes? Or do they conduce to the fermentative or zymotic change of the chlorophyl and starch grains occupying the cells in which they are found?

These are not useless questions to be asked; and, if solved, possibly their solution may tend to explain or set at rest some of the vexed and disputed points which have presented themselves regarding disease germ-cells and their presence in the animal economy.

Although bacteria and bacilli have been familiar to me for some fourteen years, and I have noticed them in animal tissues undergoing decomposition—in the blood of man, in the blood of puerperal cases (certainly, only at times of illconditioned health), in the renal secretion quite recently passed—yet, strange to say, although the cells of vallisneria have been examined by me hundreds of times, the presence of these organisms has hitherto escaped observation, or been overlooked. I account for this from this circumstance —that the bacilli are minute; they occupy, chiefly, external cells; are intermixed with cell contents; and, lastly, they gradually gravitate to the lowest portion of the cell in which they are to be found, so that the examination of a leaf which has been lying for some time flat on the table will fail to afford evidence of their presence, as they have sunk behind or below the starch and chlorophyl grains in the cell.

There is, however, another feature for consideration. The plant on which I have been experimenting—and you have before you specimens of it, and they look healthy—has been under confinement or cultivation for a period of three or four years; and I have also, in examining specimens of leaves living in an open pond, found no bacilli, and we have therefore to consider the conditions of life to which my specimens of vallisneria have been subjected, *i.e.*, in the summer season to a temperature at times, as I have ascertained, of 100 degs. Fahr., and a less depth of water than natural.

The plant as I have seen it in Sydney possessed leaves five to six feet in length, with more than an inch in breadth, and of such thickness that it was easy to cut slices edgeways off it, each slice having an upper or a lower edge of outside cells on the right and left of the observer, so that the central larger cells can be fully exposed for viewing the cyclosis going on in them, besides which it is easy to split the leaf into two layers for the same purpose.

The greater size of the cells and the easy mode of manipulation conduce very favourably to the examination of this phenomenon, compared with the cells of the European variety of this plant, as I pointed out in my recent visit to England, when I introduced a few living specimens of our Australian form for the special benefit of my colleagues in microscope research.

It will be well to pursue the conditions of life which have surrounded my specimens. For instance, the pond plant has a darker area in which it grows; the light supplied to it under natural conditions reaches it mainly from above, whilst lateral supply is materially lessened. Compare, for instance, this biological condition with that which has obtained with my tank plant. A large glass vase, of less than two feet in depth, and light pouring into it in the open air and surrounding the plant at all angles; and not only so, but a greater variation in the temperature of the water in which it lives, for, I suppose, no pond water would rise 100 degs. Fahr., nor, indeed, over the average temperature of the surrounding earth at a depth of one foot below the surface. The factor of extreme light, with advanced amount of heat, may be an important one in aiding the development or, perhaps, of introducing the bacteria into the system of the plant.

I may add that my plants, with this exception—*i.e.*, the presence of bacilli—appear to be healthy. They throw up male florets and long peduncles of female flowers, and, moreover, are clean-looking compared with their less civilised and favoured fellows of pond-life. These appear to me, to sum up at present, all the known biological conditions.

But, to return, What is the true nature of these organisms?

First of all, it seems to me that we are not dealing with true vegetal forms in some instances, and that there are objects which possibly have been placed in the category of organised life which are really chemical combinations, and not specific plants or animals. Supposing that at this point of the organic world we are able to differentiate between these two forms—animal and vegetal—what functions, however, do these organisms which we have been considering subserve? They are widely spread or distributed, and they lead us to surmise that they tend to the production of further decompositions of the tissues in which they are found. Fermentation of ordinary materials is familiar to us, and here, in some degree, I think we are warranted in accepting their presence as needful to this end. I will adduce another instance of their presence, and also of the mode by which they seem to be brought into activity, and this is in accord with the phenomena of their presence in superheated living specimens of vallisneria, and their comparative, if not their total, absence from those specimens which have not been exposed to superheat or light conditions.

I have found bacteria in abundance in tea leaves after infusion for tea-drinking. Now tea when prepared by the grower is allowed to heat or commence fermentation, and this process is suddenly arrested by the operator at a certain point, requiring great judgment in its exercise, and the tea leaf is dried, so that the process of fermentation ceases. So their presence seems to have been called forth by the abundant action of heat. I have not been able to examine the tea leaf under natural conditions, in order to ascertain the presence of these bodies; but in the leaf of a camellia, which is an ally of the tea plant, I have found some bacteria. I have now little doubt that they are largely distributed in the vegetal world. But the evidence afforded us of their presence in the living cells of vallisneria is most satisfactory in this respect; that without manipulation their presence can be determined, and, so far, we are certified that their presence is not the result of outside contamination, as might be urged when they are found in the crushed cells of plants. There is, besides, another point of interest, namely, that ensilage, or the process of forming fodder by subjecting green vegetable matter, as grass and trefoil, &c., to immediate pressure from the field, in order to form it into cattle food, is dependent on the presence of bacteria forms let loose, and that perhaps owing to the facility of these organisms to be let loose may depend the success or failure which attends this newly imported process of fodder preparing.

In conclusion, I have no intention of discrediting the action of bacteria forms as disease germ-cells if regarded as disease promoters through derived chemical poisons. There may be also a question to be settled. Are they different in their organic characters, further than or beyond the inducted poison which they appear capable of transmitting? Their chemical constitution may enable them to present differences in colouring under the use of dyes.

These considerations lead me to think and suggest that we should not dissociate the study of the animal economy from that of the vegetal. In this last we have placed before us the leading physiological phenomena of the organic world to study in their simplest form, and if duly examined and recorded will, I believe, enable us to carry a thread of continuity from the vegetal forms into the animal organic, always, however, remembering that there has been a differentiation in the production of the higher, as compared with the lower, forms of existence.

Art. VI.—*Modern Fireproof and Watertight Building Materials.—Traegerwellblech and Asphalt.*

By Peter Behrendt, C.E.

[Read 10th May, 1883.]

Mr. President and Gentlemen—

The subject of the paper which I have the honour to offer for your consideration this evening must be viewed from two standpoints.

The first has in view the anomaly which is apparent in the manner in which large warehouses are being carried out around us. With massive walls of masonry, which give to the exterior a stately and noble appearance, the interiors are fitted up with staircases, floorings, and partition walls of the most combustible materials. The question of insurance alone is thus affected in a marked degree.

The second involves the consideration of sanitary measures and precautions against the insidious influence of damp.

Actuated by a conviction that these matters merit the most earnest consideration, I shall now proceed to describe, from diagrams and other suitable illustrations, some building materials of comparatively recent invention, which I have reason to believe are not yet before the public in this part of the world, and which, I hope to convince you, fulfil all the requirements calculated to bring about a desirable and much-needed reform in the whole art and process of building.

The building material I shall speak first about is of a very ingenious character; it is fireproof, and a covering and bearing material at the same time. I shall use further on its German name,

Traegerwellblech,

which means a bearing corrugated-iron plate. Traegerwellblech was first used in Belgium as a material for bridge plates, but having only very flat corrugations its bearing strength was in no proportion to its price. The material now known on the Continent of Europe under the name of Traegerwellblech is an invention of Messrs. Hein, Lehmann and Co., of Berlin, who succeeded in inventing a machine which corrugates the iron plates in a cold state. Those drawings by which I shall explain the application of this material are partly copies of designs of Mr. A. Lehmann, partly designed by myself.

As you see from Fig. 1, Traegerwellblech is a corrugated-iron plate, of which the corrugations possess the characteristic of being greater in depth than in width, and whereby each corrugation is formed by perpendicular pieces with semicircular undulations, so that the whole forms a connected series of semicircular curvatures, connected by the intervening iron beams. Traegerwellblech thus represents all the essential features for withstanding a load, since it offers the greatest moment of resistance with a minimum of deadweight. Subsequent to the conflagration of the Kaiserhof Hotel, in Berlin, in 1875, Traegerwellblech was largely used in the process of restoration for the landings, staircases, corridors, and partition walls, especially in lieu of brick arching between iron girders, which, on account of unequalised expansion, had ill withstood the effects of fire, and collapsed.

The *Zeitschrift für Bauwesen*, the leading German journal for architecture and civil engineering, issued by the Minister of Public Works, expresses itself as follows (page 169, year 1877):—"The opportunity thus afforded for exhibiting Traegerwellblech in the dual character as a fireproof medium and as a bearing construction for the massive walls, seems to point to the probability of the usefulness of this material to purposes in the architectural constructions, and its application can be highly recommended," and further on calls particular attention to the state of brickwork arching between iron girders. "The flat brickwork arching between iron girders withstood the fire badly; the unyielding bonding of the bricks became detached from the expanding iron beams, the collapsing material, meeting with no resistance, fell in, and the vaulted spaces were thus deprived of all protection from fire."

Traegerwellblech plates are made in lengths up to 15 feet, the breadth varying from 1 foot 6 inches to 2 feet 2 inches; the thickness of the iron is between one and five millimeters. (19—10 B.W.G.)

The curvilinear Traegerwellblech plates are more advantageous than the straight ones in this respect, that they are capable of withstanding eight times the load of the latter.

The curved Traegerwellblech plate rests on the lower flange of the girder, the supported ends are walled up, the whole is then filled with ashes, sand, or clay, and levelled over, and the floor laid down, which may be composed of cement, asphalt, brick, or wood.

A ceiling of Traegerwellblech, straight or arched, is not only in conformity with all the exigencies demanded for this part of an architectural structure, but it leads to the construction itself of ceilings to the highest degree of perfection. It is light; it is a bearing and space-covering construction at the same time; it requires very little height, by which the walls can be lower and therefore cheaper; it is fireproof, and can be used to ventilate ceiling and rooms. Compared with wooden ceilings, it is cheaper by its durability; it is absolutely cheaper than brick arched ceilings, for which it is the most reasonable substitute in all buildings where the by-laws require a fireproof covering of rooms.

These four drawings (Figs. 2—5) will explain the different kinds of Traegerwellblech ceilings which have been carried out in factories and private buildings.

A further adaptation of Traegerwellblech is to be found in fireproof staircases. The plates are laid in inclined planes from one landing to another, the risers are formed up with brick, and the treads are finished off with wood. For wood may be substituted marble slabs, as, in certain instances, has been the case. This drawing (Fig. 6) will give a good idea of such a Traegerwellblech staircase.

For fireproof curtains in theatres the Traegerwellblech is the only material which satisfies all the conditions requisite to establish it as a truly reliable safeguard against fire, by which Traegerwellblech curtains, moved by hydraulic pressure, are now applied to all the important theatres in Germany. Mr. Seipp, of Berlin, who has devoted much time and study to this matter, constructs these curtains as shown by Fig. 7.

The stronger Traegerwellblech plates, that is to say, those of 11, 10, 9 B.W.G., have been most profitably employed as bridge plates.

Figs. 8, 9, and 10 show the construction of Traegerwellblech roofs. The remarkable feature of these roofs and domes is their being free from any rafters and purlins; only tierods are required if the walls be not strong enough to resist the horizontal thrust. The vertical iron you see in the plan is mere thin hoop iron to keep the tierod in a horizontal position. Such roofs have been carried out up to a span of one hundred and twenty feet. They have a parabolic form; the rise is generally one-fifth of the span, and they are provided with louvres in intervals of three or five feet. For small spans up to twenty-five feet our light Colonial corrugated-iron roofs are cheaper than these Traegerwellblech roofs; but for roofs over factories, or railway stations with large span, they are highly to be recommended.

As far as I am aware, the Dutch Government has ordered gatekeeper cottages of Traegerwellblech for their colonies. Considering that such cottages would stand a bush fire, especially if covered with stone-paper outside, which would also make a good ventilated cool wall, it should be worth while trying such cottages for our country stations.

All Traegerwellblech plates are either varnished or zinc-coated, not galvanised.

Messrs. Palmer, Scott and Co., who are the agents of the manufacturers, Hein, Lehmann and Co., and Mr. Mephan Ferguson, who has acquired the right to carry out all constructions of Traegerwellblech in Victoria, have kindly sent specimens of this material for your inspection.

I shall now proceed to the second part of my paper, to

Watertight Building Materials.

I use this term advisedly, since I am aware that it is apt to sound somewhat strangely to English ears. It has been adopted, however, after mature deliberation, by the profession, and signifies absolute imperviousness to moisture.

I shall not, on this occasion, refer to the pernicious influences of damp dwellings, nor shall I enlarge on the waste of capital in the multiplication of ill-considered and defective structures. Suffice it for me to enumerate the several quarters from which buildings are exposed to the attacks of moisture :—

1. Rain, and consequent percolation from above;
2. Absorption from the atmosphere, consequent on the hygroscopic innate qualities of the material employed;
3. Absorption from below the surface of the ground.

Various devices have been resorted to, and many are the substances that have been put to the test in repeated attempts to solve the problem of protecting buildings against the inroads of moisture from the three sources I have named; notably among them are copper, lead, zinc, iron, glass, cement, and asphalt. From among these asphalt, with various combinations of other substances, has proved hitherto the best protection; and I may note, in passing, that, not to mention other firms, that of Messrs. Büsscher and Hoffmann have made the manufacture of watertight building materials of asphalt a speciality.

The advantages possessed by this latter material are, briefly, these :—

1. Asphalt is not absorbent, and capable of resisting the action of water in so far as our present purpose is concerned.

2. Its elasticity and homogeneity renders it capable of being laid in successive layers, like a diaphragm over irregular surfaces.

3. Notwithstanding its ready adaptability to combine with almost every known building material, experience proves that no danger of disintegration is to be apprehended from differences in expansion and contraction in the mass protected by this medium.

The following are the several varieties of this form of asphalt as at present prepared for building purposes :—

Carbon de pierre (stone pasteboard);
Asphalt felt;
Asphalt plates;
Asphalt bricks.

The material called carbon de pierre, stone-paper, or stone pasteboard (German, Steinpappe), was invented by Dr. Faxe, a gentleman of the Swedish Navy, who flourished in the last century. During the first half of the present century, Dr. Gully, an eminent Prussian engineer, and Mr. Büsscher, the father of the proprietor of the factory I have made mention of, made that material a subject of earnest study in Sweden and Finland, and eventually matured the project for its manufacture in Germany.

The carbon de pierre is used in the following manner :— To the purlins are spiked boards, and upon these boards, in distances of 3 feet 4 inches, are nailed battens of triangular section—thus △ ; the intervening spaces between these battens are laid with separate sheets, the edges of which lie against the sides. The continuity of the covering is effected by securing strips of the same material over these divisions in the manner indicated, and finally the whole is treated with asphalt in a fluid state.

A quite modern construction is the wood-cement roof. The purlins have only a slope of 1 foot to 25 feet; they are covered with boards well-tongued and grooved. Over the boards is sieved sand $\frac{1}{4}$-inch thick, then follow three layers of paper. This is a sample piece, each layer brushed carefully with fluid asphalt. After this being done, the whole area of roof is filled in, 6, 12, and more inches, with coarse gravel and good soil on top.

Fig. 11.—Here are given delineations of the various roofs in vogue—brick roof, slate roof, corrugated-iron roof, and stone-paper roof. You will observe that, apart from the moderate cost of the latter, a considerable further saving is effected on account of the low pitch which this material renders possible.

Fig. 12 shows the stone-paper roof as adapted to sheds. Should exception be taken to its dark colour, I may mention that this might be varied to any extent by treating with ordinary lime-wash.

Fig. 13 represents the so-called wood-cement roof, applied to private residences and to warehouses. In the former it permits of a perfectly flat roof, which can be utilised as a flower garden, whereby the charms of the hanging gardens of Semiramis, so celebrated in ancient history, may be enjoyed at the present day; also, and especially in the latter case, the entire enclosed space is available for the storage of goods and for other rooms. That these rooms are fireproof, with regard to fire in the neighbourhood, is to be taken for granted. If, instead of wooden joists and boards, iron girders on curved corrugated iron be employed, as has been done for the roofs of the Imperial Printery in Berlin, this kind of roof may be considered absolutely fireproof.

The asphalt felt has its origin in England. It is produced from cotton and other textile waste with an admixture of pitch in a fluid state. It has not proved particularly successful, and its application seems to be limited to the securing of ridges and for the preliminary coverings of roofs.

Asphalt plates consist of layers of asphalt alternated with laminæ of some coarse fibrous materials. This combination was known to the ancient Egyptians and Babylonians. It fell into desuetude, however, with many other arts and inventions, and has only been resuscitated forty years ago. Referring to our illustrations, Fig. 14 gives two different modes of uniting the asphalt plates; in most instances the method x will be found to suffice. The plates generally have a length of 12 feet, a width of 2 feet 8 inches, and a thickness of $\frac{1}{4}$ to $\frac{1}{2}$ inch. The overlapping joints are firmly united by means of asphalt in the fluid form, and the entire exterior surface is treated in the manner previously indicated.

Fig. 15 shows a method of applying the plates in order to get dry rooms in fortifications.

Fig. 16 shows a section trough and a portion of a bridge. I cannot restrain, in passing, from making a brief reference to the great necessity of protecting the bearing surfaces of these important and costly structures from the effects produced in many ways from the penetration of water.

Fig. 17 shows in what manner a cottage in a low-lying locality may be insulated from moisture.

Fig. 18 shows a brick-kiln protected in like manner. This insulation is very important in this case, in order to get well-burned bricks.

Fig. 19 shows in which way any foundation may be protected by the interposition of a substratum of this invaluable material.

Fig. 20 depicts the roof of a cotton factory made of the asphalt plates as a precaution against fire. The entire roof-area forms a permanent water reservoir. Should fire arise in any part of the building, the quenching of it is palpably a matter of instantaneous accomplishment.

Asphalt bricks.—This item may be dismissed with the remark that, with the exception of watercourses and fortifications, asphalt bricks meet with little favour. The cost of freight will prohibit their use here, and I much doubt their ever attaining to any marked degree of popularity, although they could be employed with great advantage for grain stores.

Having thus brought the functions of two new and genuine kinds of building materials under review, I trust to have awakened sufficient interest in your minds to encourage their introduction in this town. Investors have a right to expect that the best available known means shall be adopted to ensure a dry and fireproof building; and the community in general have a right to demand the framing of such by-laws as shall bring about a radical change in the present mischievous system in force of running up dwelling-houses which, from their great susceptibility to damp, are the source of many dreadful diseases.

In support of the theory here advanced I may, in conclusion, aptly quote the opinion of an eminent English authority. Mr. Chadwick, Commissioner of the International Exhibition at Paris, in a report to the British Government thus expresses himself:—"There is yet another reason why the construction of walls in common brick or soft stone should be abandoned, namely, from the facility with which these materials absorb and retain moisture. The brick ordinarily in use in England is capable of absorbing 1 lb. weight of water. Thus a small cottage having walls one brick in thickness will be composed of about 12,000 bricks. These afford the united capacity of absorbing 1500 gallons, equal to 6000 quarts or $6\frac{1}{2}$ tons of water, which in its turn will require 3 tons full measure of fuel to evaporate."

As it will be impossible to abandon bricks altogether in favour of concrete buildings, which Mr. Chadwick has in view, we should at least employ methods by which the dangers of dampness can be either prevented or reduced to a minimum.

APPENDIX.

In order to make this paper more useful for the professional Engineer and Architect, I thought it advisable to add a table of the bearing strength of the various Traegerwellblech plates now in use.

The tests, of which the following data are the results, were carried out under the superintendence of Royal Engineers and Architects in Berlin.

I. Bridge Plate.

Plate No. 14, 3 feet long, tested by hydraulic pressure.

$22\frac{1}{2}$ tons caused a bending of 3″
$28\frac{1}{2}$ „ „ „ $5\frac{1}{2}$″
29 „ „ breaking.

II. Flooring Plate.

A curved Traegerwellblech plate, No. 2, 11 feet span, 1′ 2″ rise. The plate broke when loaden with 2800 lbs. of pig iron per superficial foot.

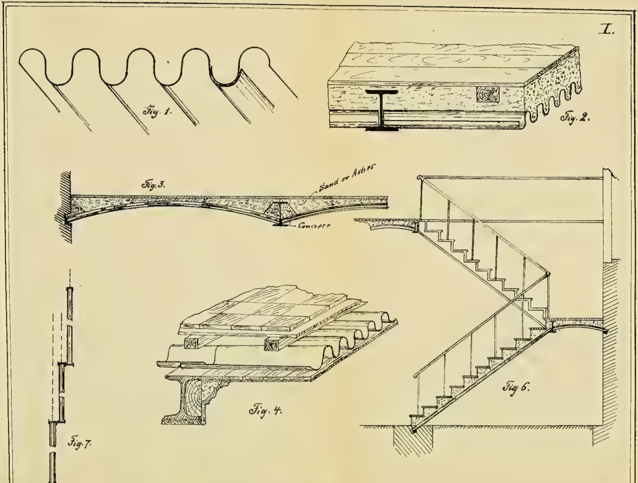
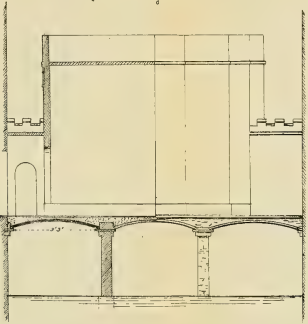
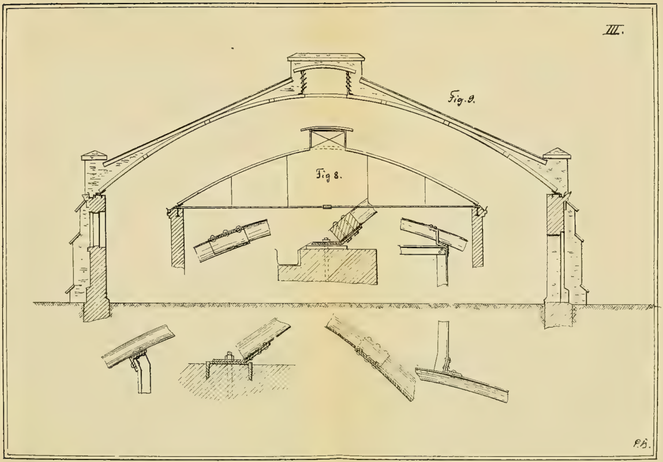
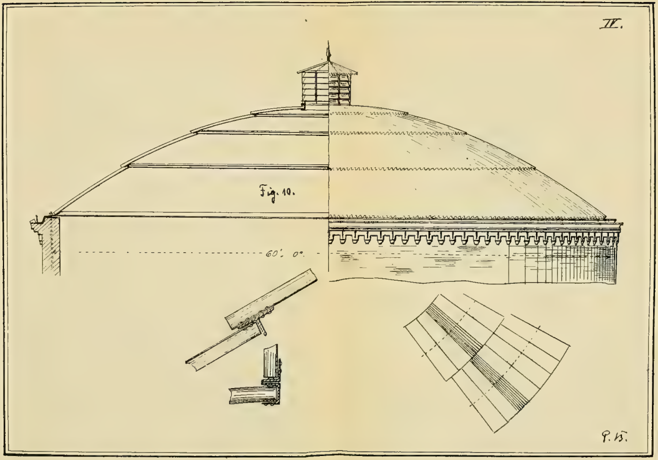

I.
Fig. 1.
Fig. 2.
Fig. 3.
Sand or Ashes
Concrete
Fig. 4.
Fig 6.
Fig. 7.
G. B.

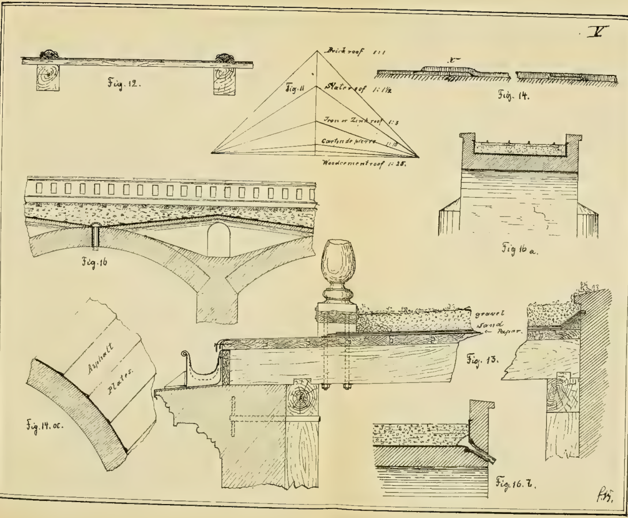
Fig. 5.



Fireproof Bridge with Showroom. – Virg. Tobac: Fabr.
by Mr. Oakden, Architect.


III.
Fig. 9.
Fig 8.
P.B.


IV.
Fig. 10.
60'. 0".
G. B.


V
Brick roof 1:1
Fig. 11
Slate roof 1:1½
Iron or Zinc roof 1:3
Carton de pierre 1:10
Woodcement roof 1:25.
Fig. 12.
Fig. 14.
Fig. 16 a.
Fig. 16
gravel
sand
Paper.
Fig. 13.
Asphalt
Plates.
Fig. 14. a.
Fig. 16. b.

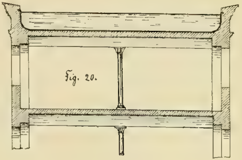


Fig. 20.

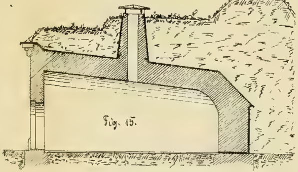


Fig. 15.

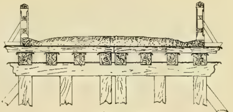


Fig. 16. c. Wooden Bridge.

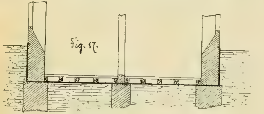


Fig. 17.

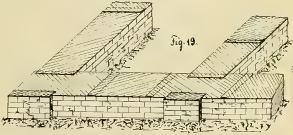


Fig. 19.

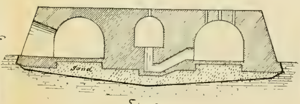
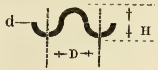


Fig. 18.

P. B.



No.	H	D	d	Plates. Length	Plates. Width	Weight. lbs. sq.yard.	Equally distributed load per super. foot at a free bearing length of lbs. 3′	4′	5′	6′	7′	8′	9′	10′	11′	12′	13′	14′
	″	″	″															
0	1.80	3.60	0.04	14′ 6″	2′ 3″	22	334	189	120	84	62	48	37	31	24	22	18	15
1	2.00	3.60	0.04	14′ 6″	1′ 11″	24	394	222	142	99	73	55	44	35	29	25	21	18
2	2.40	3 60	0.04	14′ 6″	1′ 8″	28	526	296	190	132	97	74	58	47	39	33	28	24
7	2.80	3.60	0.04	14′ 6″	1′ 8″	30	672	378	242	170	123	95	74	60	50	42	36	31
8a	3.20	4.00	0.04	14′ 6″	1′ 6″	32	870	490	313	217	160	122	97	78	65	54	46	40
8c	3.20	4.00	0.06	14′ 6″	1′ 10″	47	1297	742	468	324	238	182	144	117	96	81	68	59
8d	3.60	4.00	0.06	14′ 6″	1′ 10″	52	1568	882	565	392	291	221	174	141	111	98	83	72
9	3.20	4.00	0.08	14′ 6″	1′ 10″	63	1719	967	620	430	315	242	191	155	128	110	91	79
9a	3.60	4.00	0.08	14′ 6″	1′ 10″	69	2070	1164	745	517	380	291	230	186	154	129	110	95
10	3.20	4.00	0.12	9′ 6″	2′ 2″	95	2548	1433	917	637	468	360	283					
11	3.20	4.00	0.16	8′ 6″	2′ 2″	126	3362	1722	1103	765	562	430						
13	4.00	4.00	0.12	9′ 6″	1′ 10″	113	3673	2066	1322	919	675	516	408					
14	4.00	4.00	0.16	8′ 3″	1′ 10″	150	4850	2728	1746	1212	890	700						
15	4.00	4.00	0.20	6′ 6″	1′ 10″	187	6010	3381	2164	1500								

N.B.—Nos. 0, 1, 2, 7, 8a, 8c, and 8d are straight and curved; the other Nos. straight only.

Art. VII.—*Incandescent Lamps for Surgical and Microscopical Purposes.*

By Robert E. Joseph, Esq.

[Read 10th May, 1883.]

I claim your attention for a short time to-night to bring under your notice two of the latest adaptations of the incandescent lamp for use in scientific research—namely, for surgical and microscopical purposes.

The use of electricity for producing light for surgical purposes by heating inferior metals was attempted in 1851, 1853, 1854, and 1856 by various scientists. In 1867 Dr. Bruck, dentist, introduced an electric light apparatus for the use of surgeons, &c., and a little later a Dr. Mullot, in France, made a number of experiments in this direction, but with apparently very little success, all the apparatus having been so cumbersome to handle.

Trouvè, in 1879, introduced a more perfect apparatus, using platinum wire, flattened in the middle, and kept in a state of incandescence by means of a "Plante" secondary battery. This, however, appears to have been only partially successful.

The chief causes of failure in the cases mentioned arose, doubtless, from the use of troublesome and expensive apparatus, rendered necessary by the employment of a metal raised to incandescence with the unavoidable over-heating and constant fusion of the wire. In the apparatus now brought under your notice the metal wire has been replaced by a carbon filament enclosed in a vacuum, and with ordinary care there is very little danger of over-heating or breaking it, some of the ordinary Swan lamps having been in use for 2000 hours.

In the *British Medical Journal* for 27th January, 1883, which I have no doubt has already been seen by many of our members, there is a paper on "The Illumination of Internal Cavities by Means of the Electric Light," by Dr. Oliver and J. B. Payne, from which I will merely read the following extract:—

"*Mr. Payne's report.*—Leiter's arrangement contains an electric lamp in which platinum wire is heated by means of battery power, and rendered incandescent. The arrangement I made is of a much simpler construction, gives a perfectly pure light, and develops less heat. It consists of an electro-plated outer tube nine inches and a half long by eleven-sixteenths inch external diameter, glazed at one end with a stout piece of plate-glass, made perfectly secure and tight.

"A Swan's electric lamp is used—the filament of which is carbon, and rendered incandescent by means of battery power. It is hermetically sealed in a glass shade; and water, conveyed to and fro through very small brass tubes, is made to circulate round the lamp. The light from this lamp is perfectly pure, and exhibits the conditions of things in their true and natural colour. For prolonged observation I should prefer to use either a Grove's or Bunsen's battery, but in the demonstration just referred to four cells of a modified Léclanche battery were employed, and answered admirably. It is advisable to have as great a pressure as possible for the water supply, so as to ensure perfect circulation, and for this I suspended from a hook fixed near the ceiling of the room a tin can containing water, connecting it with the brass tubes by means of lengths of India-rubber tubing."

Dr. Lodge gives an account of an operation he performed with the use of the apparatus just described, and appears to have been impressed with its value.

For examining the mouth and throat the small Swan lamp appears most valuable, and it is also likely to prove a useful accessory for dentists, and to replace the somewhat cumbersome mirrors in use by them. A very small amount of battery power is required to obtain the necessary illumination. Probably in the surgery a form of "Gravitz battery," such as Sir William Thompson's, or a modified Léclanche, would be the most convenient, but where space is an object a small bichromate battery will give good results for a short time. The modified Léclanche exhibited will last without any attention, except adding a little water now and then, for at least twelve months, and will always be ready for use. It has, however, the drawback of polarising quickly, and therefore the lamp must not be kept in use for more than three or four minutes at a time without giving the battery a similar period for rest. Probably in many instances this form of battery would be sufficiently effective. For portable purposes, a small form of bichromate battery would be the best, and would give a light lasting from twenty minutes to over an hour, according to the amount of solution that the cells were capable of holding. The next use to which the small incandescent lamp has been recently and successfully applied is to the microscope.

Mr. C. H. Stearn, who has been associated with Mr. Swan during the whole of his experiments with incandescent lamps, has just introduced several forms of lamps and apparatus for the purpose, and I cannot do better than to quote from a paper read by Mr. Stearn before the Royal Microscopical Society in January last.

"The length of the incandescent filament is $\frac{1}{10}$th of an inch; its diameter, $\frac{1}{166}$th of an inch; and its superficial area, about $\frac{1}{535}$th of a square inch. Two Bunsen cells, or four Léclanche's, are sufficient to render them fully incandescent; but for general purposes it will be best to use an additional cell, regulating the intensity of the light by means of the adjustable resistance attached to the base of the microscope.

"As the duration of the lamps is in an inverse ratio to the temperature at which they are maintained, it is desirable that the most intense light that the lamp will give should only be employed for a very short time, when a special effect is required—such, for instance, as for purposes of micro-photography. If the lamp is at other times used no brighter than is necessary to obtain a white light, and the current turned off when observation is not going on, the lamps will last a very long time, as experience has shown that a life of more than 2000 hours of continuous and brilliant incandescence is frequently exceeded by Swan lamps. It is possible to obtain a light of $2\frac{1}{2}$ candles from the tiny surface just mentioned, with an electro-motive force of $3\frac{1}{2}$ volts, and a current of $1\frac{1}{4}$ amperes. It would, however, at a safe temperature, give a light equal to one candle.

"As the source of light is almost a point, and the lamp can be brought very nearly into contact with the slide, a higher degree of obliquity of the illuminating rays can be obtained than by almost any other method; and hence black-ground illumination is shown with great beauty, and many of the diatoms display diffraction colours with unusual splendour.

"The resolution of test objects becomes very much simplified, as most of them can be resolved by the lamp alone, without any accessory apparatus."

I think it must be evident that the incandescent lamp must soon replace all other forms of lamps for microscopes. There is very little difference between the trouble of setting up and trimming the oil lamp usually employed and that of filling a small battery for use, whilst the difference in the quality of the light obtained would be a considerable gain to the microscopist. The battery to be used is the same as for the lamp for surgical purposes, and the particular form to be used must be regulated according to circumstances.

Whatever form of battery be used, it is always advisable to insert an artificial resistance in the circuit, so arranged as to be able, by turning a handle, to increase or diminish the light. This is especially desirable when using a battery which polarises easily, as at the commencement, with the battery fresh, there might be a risk of breaking the carbon filament, whilst, as the battery polarised, the light would gradually diminish in intensity. By means of the adjustable resistance the intensity of the light can be kept at a fixed standard for a considerable length of time, whilst by starting with a considerable resistance in circuit, and then gradually reducing it, there need be no danger of injuring the lamp by excess of current. Two forms of lamps are shown to-night —one on a stand to replace the ordinary lamp only; the other, and smaller one, is mounted on a stand with universal attachment, but, as can be readily seen, it could quite easily be attached direct to the microscope. Mr. Stearn suggests the use of three lamps permanently fitted to the microscope stand—one above the stage, one on the sub-stage, and one below for use with the polariscope; each lamp being controlled by a switch, could be turned off and on at pleasure. This, of course, would be a very perfect and convenient arrangement, but not economical; and probably an attachment, proposed by Mr. J. B. Payne, that can be readily fitted to either the stand condenser or to various parts of the stage with a small clamp, will find greater favour with microscopists.

ART. VIII.—*On Germs of Blennorrhagia.*

Translated by MR. RUDALL, F.R.C.S., from an Original Paper by DR. ECKLUND, of Sweden.

[Read 10th May, 1883.]

Art. IX.—*Notes on Hydrology.*

By G. R. B. Steane, Esq., C.E.

[Read 14th June, 1883.]

The subject which I have the honour to submit to you this evening, Hydrology, is a very extensive one; but I purpose referring only to the subject of rainfall, more particularly the rainfall in Sandhurst, and some of the results of my own observations during a long residence there.

Rainfall is, I believe, the most capricious of the elements, as it is governed or influenced by so many varying forces, and the laws which govern it are most complex. The general laws which govern it are being studied, and it is anticipated that some of them may be generalised, so that though it may be impossible to govern the rain, yet we may in the future be better enabled to prepare for the inevitable.

The object with which I have observed rainfall has been, primarily, its effect in causing floods, and to arrive at reliable data for providing for it. With that object in view I constructed a simple recording rain-gauge, consisting of a cylindrical gauge, into which rain from a known area was conveyed. A light metal float actuated a couple of pencils which recorded the rainfall, first on a drum which revolved in an hour, and secondly on a drum which revolved in twenty-four hours. After a heavy fall of rain it was an easy matter to scale off the quantity that fell in any period of time.

Rain, as is well known, is water which has been evaporated carried by currents of air and condensed by cooling. Air has the power of absorbing varying quantities of moisture increasing with the temperature. Hence a cube foot of air at 32° can absorb $3\frac{1}{2}$ grs.
at 86° „ „ 14 grs.
at 140° „ „ 56 grs.
and so on, so that if warm air, saturated, is cooled it will discharge water, and it is well known that the greater the heat the more rapid the evaporation.

The movements of the winds which carry these vapours have been most ably explained very recently by our esteemed President.

We will briefly consider under what circumstances rain falls generally. First, the air must be laden with moisture and must necessarily be warm, and to obtain that moisture it must come over extensive areas of water—the ocean. On coming in contact with cooler currents of air, cooler lands and trees, the moisture is condensed in the form of rain, and also when warm air, saturated with moisture, is mixed with a cooler air also saturated a discharge of moisture takes place, but to a very small extent. Where the vapours are carried inland until they come in contact with high mountain ranges, there the moisture is thrown upwards and is condensed, and the air which is then cooled passes over the mountain range with less moisture in it and in a state to absorb moisture instead of discharging; and it is found to be almost universal that the coast-line of continents is wet, and inland is dry, more particularly if the coast is bounded by mountain ranges.

It is found to be the case in India, where the south-west monsoons, which blow towards the north in summer (the sun being north of the equator), are laden with moisture from the Indian Ocean come in contact with the Western Ghauts, and the bulk of the moisture is discharged at about the height at which the clouds float. At one station there—Mahabulshwur—the rainfall for an average period of five months per annum is 245 inches, upwards of 20 feet; in 1849 it amounted to 338 inches; 10 to 13 inches often fall in one day, and as much as 130 inches in a month. The quantity rapidly falls off at a higher elevation, and also lower down, that is, above and below the average height of the line of cloud flotation; but on the eastern side of the mountain, only 11 miles distant, at another station—Paunchgunny—the average is only 50 inches per annum; and further east is the Deccan (or dry country), where the rainfall is only from 16 to 20 inches. This is, I believe, the most remarkable instance of the decrease of rain when intercepted by mountains. Then, at the head of the Bay of Bengal, Calcutta, being low, receives 60 to 80 inches per annum, but in some parts of the Himalayas, north of Calcutta, the rainfall is said to amount to as much as 600 inches per annum. The same rule holds good in Great Britain. The moisture from the Atlantic is condensed in Westmoreland and Cumberland at from 80 to 150 inches, whereas on the east side it varies from 18 to 24 inches per annum.

The same rule holds good with regard to Europe, as we recede from the Atlantic—Greenwich, 24 inches; Paris, 23 inches; Vienna, 19 inches; St. Petersburg, 15 inches

Catherineburgh, 12 inches; Barnaval, 9 inches. The same rule holds good with regard to the coast of America; and the same rule applies also to Australia. In New South Wales the coast rains from Antony and Clarence Rivers to Botany average about 50 inches, whereas inland it ranges from 10 to 16 inches per annum. In South Australia—at Mount Lofty, 42 inches; Charleston, 34 inches; Cape Borda, 27 inches; Bullaranga, 32 inches; Adelaide, 21 inches, near the coast; but inland, in the valley of the Murray, it ranges from 10 to 15 inches, and inland towards Stuart's Creek it is from 6 to 10 inches only.

Then again at Southport, near the coast, on the Overland Telegraph route, the rainfall is about 90 inches; further inland, Daly Waters, 35 inches; and further again, at Charlotte Waters, only 10 inches.

In Victoria our heavy rains are between the coast and the dividing range, and the lightest are on our north-west plains.

Taking the rainfall for last year, the heaviest, 60 inches, is at a place called Beenak, in the Yarra basin, hemmed in by a kind of horseshoe of mountains, with the open end facing south-westerly towards the sea. Then at the dividing range near Woodend, 49 inches; Blackwood, 43 inches; Macedon Nursery, 31·6 inches; Bungaree, 32·9 inches. Then along the coast—Portland, 30·3 inches; Warrnambool, 25 inches; Otway, 30 inches; Wilson's Promontory, 38·7 inches.

Then to the northern side of the dividing range there is a marked reduction—Castlemaine, 24·7 inches; Crusoe, 24·6 inches; Sandhurst, 21·6 inches; Heathcote, 23 inches. Further on the reduction is still more marked—Whroo, 19·7 inches; Elmore, 19·7 inches; and Echuca, 14·3 inches. If we start again, at Maldon, with 22·9 inches; Inglewood, 18 inches; Boort, 16·7 inches; and Kerang, 13·1 inches. Still again, on the Wimmera—Stawell, 18·1 inches; Horsham, 14·6 inches; Dimboola, 10·9 inches.

We have the sea to the south-east, south, and south-west of us. South-east winds bringing moisture are carried over the Australian Alps and mountains of Gippsland, condensing much of its moisture before it reaches us, and still more by the time it reaches the Sandhurst district. Moreover, they come down on us from cool elevated regions to a warmer climate, particularly in summer. Then winds from the south and a little east of south are comparatively cold, and do not carry so much moisture as the more easterly or westerly winds. The winds from the south are cool to start with; they come across the high lands of Tasmania, part with a portion of their small amount of moisture there; more moisture is collected in the Straits, which is condensed between Melbourne and the dividing range about Blackwood and Macedon; and the last few drops are squeezed out about Mount Alexander and the Big Hill Ranges, arriving at Sandhurst a cold dry wind, so that rain is never by any chance received there with a south wind. Often have I seen the sky with every appearance of rain, but no matter how threatening with a south wind no rain is received, excepting possibly a very few drops at the commencement. Not only is there no rain, but the sky becomes perfectly cloudless. The south-west winds arrive laden with moisture comparatively warm over the least mountainous portion of our colony, and it is from that direction most of the heavy rains are received in Sandhurst during the winter.

It appears to me that in summer time the moisture is brought from the sea with south-west winds; finding the land warm it is not condensed, but is carried inland over the plains into Central Australia, gathering more moisture by being more heated. The vapours then return with north-east, north and north-west winds from a hot to a cooler locality, and when deflected upwards by the first heavy timber or high lands are condensed in heavy storms of short duration.

Elevation has also an influence on the amount of rainfall, which may be easily understood if we bear in mind that the vapour of water is lighter than air at the sea-level. This vapour is invisible; when it changes into clouds it is changed partially into water. It is not known thoroughly how the clouds are supported; there are several theories on the subject. Nevertheless we know that clouds carrying large quantities of moisture generally float several thousand feet above the sea-level, and the greatest amount of rain may naturally be supposed to fall at that elevation, decreasing in higher and lower elevations. This has been noticed particularly on the Ghauts in India.

Clouds sometimes attain an altitude of upwards of 20,000 feet, but they cannot possibly carry much moisture.

Respecting seasons of floods and droughts, the knowledge of the general laws is at present very limited. Mr. Todd, of South Australia, has pointed out that years of drought are observed to be years of mean higher barometric pressure, and has shown that in South Australia the seasons of drought and floods follow in some sort of cycle. Mr. Russell, of New South Wales, appears to attach some weight to a nineteen-year cycle. I believe I am correct in stating that in England, where they have the advantage of a very extensive range of observations, no satisfactory cyclic series can be arrived at; and I have never heard Mr. Ellery's opinion respecting Victoria.

Some years since I was under the impression that we had a cycle of seven years, for the following reasons:—In Melbourne, 1842 was a wet year and a year of floods; 1849 the wettest in white man's time; 1856, 1863, 1870, periods of seven years, and very wet years—viz., 1842, 31 inches; 1849, 42 inches; 1856, 30 inches; 1863, 36 inches; 1870, 33 inches; 27 inches being the average; but to upset the seven-year idea, 1875 was the wet year, with 33 inches, and 1877, which ought to have been wet, only supplied 24 inches; so I gave up my long-cherished idea in disgust, and the nineteen-year theory will not apply. The dry years are much more irregular. For a period extending from 1840 to date, excepting a few years (1851 to 1854, no records), the driest seven years have been—1865, 15·9 inches; 1868, 18·2 inches; 1879, 19·2 inches; 1843, 21·5 inches; 1859, 21·8 inches; 1862, 22·0 inches; 1866, 22·4 inches.

The wettest seven years—1849, 42·2 inches; 1863, 36·4 inches; 1870, 33·7 inches; 1848, 33·1 inches; 1875, 32·8 inches; 1872, 32·5 inches; 1842, 31·1 inches.

The number of wet days in a year varies greatly—from 107 days in 1866 to 165 days in 1863.

In Sandhurst the average rainfall for twenty years is 21·7 inches, varying from 10·9 inches in 1865 to 38·3 inches in 1870. The rains are fewer, and of shorter duration, as a rule, than in Melbourne—in 1877, 64 days on which rain fell; 1876, 65 days; the greatest number being 132 days, in 1863, the average being about 99 days a year.

RAINFALL, SANDHURST, 1861 to 1882.

Average	...	21·73	inches per annum	
Least rain	...	10·95	,,	in 1865
Most rain	...	38·36	,,	in 1870
Rain=Average	...	21·74	,,	in 1867

Seven years over average and twelve years under.

On examining monthly rainfall I find there was—

No rain	1	month	in	1865
„	1	„		1878
„	1	„		1880

43	months	under ½ inch			
35	„	½ inch to 1 inch			
78	„	1	„	2 inches	
52	„	2 inches to		3	„
28	„	3	„	4	„
6	„	4	„	5	„
6	„	5	„	6	„
4	„	6	„	7	„

1 month over 7 inches, which was Oct., 1870.

During the same period—

Upwards of	1 inch	fell in	24	hours	59	times
„	2 inches	„	24	„	10	„
„	3 „	„	24	„	5	„
„	2 „	„	48	„	17	„
„	4 „	„	48	„	1	time, March 15th and 16th, 1878.

Our rains are heavier than Melbourne, but not so heavy as Sydney, and they are heavier still in Queensland.

I believe the heaviest rain of short duration in Melbourne was 10th March, 1877, when 1 inch fell in 15 minutes; rate, 4 inches per hour.

At Ballarat, February or March, 1876, 1·81 inch fell in 20 minutes; rate, 5·43 inches per hour.

At Sandhurst, of which I have any record, 12th December, 1875, ·5 inch in 5 minutes; rate, 6·0 inches per hour.

At Sydney, August, 1878, 1 inch fell in 6 minutes; rate, 10 inches per hour.

The heaviest 24 hours' rain recorded in—

Sandhurst,	3·67	inches,	occurred 16th March, 1878
Melbourne,	3·10	„	„ 9th December, 1860
Beechworth,	6·00	„	in 30 hours, occurred 31st Aug., '75
Sydney,	20·41	„	occurred 15th October, 1844, when 5·4 inches fell in 2 hours.
Adelaide,	3·15	inches,	on 4th April, 1860

The following are also a few exceptionally heavy rains—

Townsville (Qld.)		20	inches in	3 days, 25th Feb., 1877
Sydney	...	1·72	„	30 minutes, 6th Feb., 1878
„	...	10·88	„	48 hours, 7th Feb., 1878
„	...	7·00	„	4 hours, 5th April, 1882
Adelaide	...	7·8	„	10 days, June, 1848

In England—

Greenwich	...	1 inch in 15 minutes, 25th July, 1852		
Wandsworth	...	2·17 inches in 2 hours, 12th June, 1859		
Southampton	...	2·05 „	2¼ „	26th Sept., 1859
Neville { Holborn, London		4·00 „	1 „	1st Aug., 1846
Neville { Highgate „		3·50 „	1 „	„ „
Neville { Greenwich	...	·95 „	1 „	„ „
Westminster, Vauxhall, and Lambeth	...	4·00 „	3 „	„ „
Nottingham	...	3·25 „	1 „	13th Aug., 1857
Little Bridge	...	·68 „	4½ min.,	29th Sept., 1855

Average Yearly Rainfall.

Sydney	...	51·46 inches
Melbourne	...	27·13 „
Sandhurst	...	21·73 „
Adelaide	...	21·09 „
England	...	38·00 „
London	...	24·00 „
Ireland	...	36·00 „
France	...	31·00 „
Spain	...	22·00 „

The following are some of the heaviest rates per hour of rainfall in Sandhurst, for various short periods since 1877—

Minutes—	1	2	2½	3	4	5	6	7	15	18½	20	25	30
9th Feb., 1878 ...	-	-	-	-	-	-	-	-	2·88	-	2·68	-	2·00
26th Feb., 1880 ...	-	-	-	-	-	-	2·8	-	-	-	-	1·28	·90
21st March, 1880 ...	-	-	3·6	-	-	2·8	-	2·6	-	1·78	-	-	-
26th October, 1882	4·8	4·3	-	3·8	3·4	3·0	2·5	2·4	-	-	-	-	-
28th Nov., 1882 ...	6·3	5·7	-	5·5	5·1	4·7	-	4·2	-	-	-	-	-

Rainfall, 4 a.m., 22nd April, 1882, to 3 p.m., 24th April, 1882, 3·66 inches; heaviest in 1 hour during the same period, ·66 inch.

Heavy Falls in Sandhurst in various short Periods.

					Rate per hour.
31st Dec., 1863	...	3 inches in	3½ hours	...	·85 inches
8th Feb., 1864	...	·83 „	1 „	...	·83 „
7th Sept., 1870	...	·75 „	15 minutes	...	3·00 „
14th March, 1874	...	·46 „	24 „	...	1·15 „
13th Feb., 1875	...	·55 „	10 „	...	3·30 „
12th Oct., 1875	...	·50 „	5 „	...	6·00 „
11th Feb., 1877	...	2·50 „	75 „	...	2·00 „
11th Feb., 1878	...	1·13 „	90 „	...	·75 „
19th Oct., 1882	...	·40 „	5 „	...	4·80 „

The following is a list of the mean number of wet days per month in Sandhurst for 20 years ending 1881; the mean monthly rainfall; mean intensity per wet day; the maximum and the minimum :—

Month.	Mean wet days.	Mean rain. Inches.	Intensity per wet day. Inches.	Maximum per month. Inches.	Minimum per month. Inches.
January	4·25	1·44	·33	3·75	·0
February	3·95	1·46	·34	6·36	·01
March	5·10	1·46	·31	6·10	·06
April	8·15	1·79	·22	5·21	·35
May	10·25	2·02	·20	3·84	·37
June	11·40	2·54	·22	6·24	·26
July	11·50	1·89	·15	4·29	·14
August	12·85	2·15	·16	5·23	·26
September	10·65	2·24	·21	5·85	·27
October	9·30	2·34	·24	7·63	·17
November	6·40	1·48	·23	6.47	·00
December	5·25	·94	·18	4·90	·01

Mr. Ellery has kindly supplied me with the following list of rainfalls at Melbourne :—

			Rate per hour.
1859—June 14	·57 inches	in 1 hour	·57 inches
1860—Sept. 8	·50 „	1 „	·50 „
Dec. 9	3·10 „	12 „	—
1861—Jan. 31	2·37 „	11 „	—
Mar. 19	1·00 „	3 „	—
1862—Dec. 8	·48 „	25 minutes	1·15 inches
1863—Oct. 12	·85 „	12 hours	—
Nov. 22	·96 „	8 „	—
1864—Mar. 2	1·18 „	30 minutes	2·36 inches
April 12	1·10 „	12 hours	—
1867—April 6	·86 „	12 „	—
1870—Jan. 3	1·08 „	4 „	—
Jan. 25	1·52 „	12 „	—
1871—Feb. 7	1·89 „	9 „	—
Aug. 8	1·30 „	9 „	—
Nov. 22	·62 „	15 minutes	2.48 inches
1872—Nov. 19	·43 „	20 „	1·29 „
1877—Mar. 10	1·00 „	15 „	4·00 „
April 21	1·76 „	7 hours	—
1878—Mar. 15	2·12 „	12 „	—
1882—Dec. 5	1·25 „	1 „	1·25 inches

I fear that by this time I must be wearying you with statistics, and as I am not a professional lecturer, and consequently lack the art of making figures pleasant, I will as rapidly as possible draw to a close.

The value of a knowledge of the rainfall in all its varying phases is of special use to the engineer. By knowing the heaviest monthly, weekly, daily, and hourly rain, and also the maximum fall for still shorter periods, he is better enabled to calculate the necessary sizes of bridges, culverts, and water conduits. Of course other data are also necessary, such as the nature of the surface and subsoil, the general inclination of the ground, and the state of the surface.

The method adopted generally for fixing the dimensions of bridges over large rivers, viz., gauging the velocity and obtaining numerous cross-sections of the largest known floods will not apply to artificial watercourses, and is, in my opinion, unreliable when applied to the partially dry creeks of Australia, for the reason that the channels generally vary very greatly, the sectional area being in some cases very much larger at one spot than probably a short distance lower down. Furthermore, information of this kind is generally unreliable. Excessively high floods may be caused by obstructions which were not noted by the observer subsequently removed. Information of this kind is necessary, but it is equally necessary that something of the local hydrology should be also known and applied.

In my opinion, to estimate the requisite waterway at a certain point, it is necessary to know the area and form of the watershed; next the levels to find the time it will take the first drop of water to travel from the greatest distance to the culvert or bridge; then to know what proportion of the water soaks into the ground, and what portion is held back, and the rainfall.

As an illustration, suppose an area of five acres, and the greatest distance the water has to travel ten chains, and assume the nature and inclination of the surface to be such that nine-tenths of the water flows off at the maximum period, and the water travels the ten chains in six minutes, we must then know the heaviest rain that falls in six minutes; for it is evident that if the storm only lasts four minutes the rain will have ceased for two minutes before the extreme particle of water will have reached the culvert—hence the flood will not be a maximum. Should the rain be uniformly heavy for eight minutes, it is also evident that the flood will arrive at its maximum in six minutes, stay so for two minutes, and then subside. In

Sydney we find that one inch fell in six minutes on one occasion. One inch on ten acres will supply 36,300 cubic feet, nine-tenths of which is 32,670 cubic feet. Again, suppose the inclination of the culvert, when of the proper size, to be such that the water will flow when full six feet per second, then the maximum discharge will be when the most distant particle, together with particles from every portion of the area, has reached the culvert—hence the area required will be fifteen feet sectional area of waterway, or one and a-half feet per acre, and it could not be larger.

Now, if we assume a river five hundred miles long, area, say, fifteen thousand square miles, say two hundred hours for water to travel, and one-half held back, then the maximum flood will be after two hundred hours' continuous rain; less would not make a maximum, and more would only maintain the maximum. Suppose the heaviest two hundred hours' rain to be five inches, and velocity of flood ten feet per second, we should then have—

$$\frac{\overset{\text{c. ft. per Sq. Mile.}}{2{,}300{,}000} \times \overset{\text{Sq. Miles.}}{15{,}000} \times \overset{\text{Inches.}}{5}}{200\text{ hrs.} \times 3600\text{ secs.} \times 10\text{ ft. per sec.}} \times \frac{1}{2} = 12{,}000\text{ sq. ft.}$$

$$= \tfrac{4}{5}\text{ sq. ft. area per square mile.}$$

A chalk or sandy basin may absorb the whole of a heavy rain.

I will conclude with the observed maximum discharge in cubic feet per minute per square mile of several rivers and watercourses, partly from Beardmore and other sources.

Area of Watershed.	Name.	Maximum discharged per minute per square mile.
600,000 square miles	Nile at Cairo ...	36 cubic feet
886,000 „	Mississippi ...	67 „
180,000 „	Ganges at Benares..	428 „
3,890 „	Severn at Gloucester	193 „
3,086 „	Thames at Staines	129 „
4,570 „	Shannon at Killaloe	960 „
35,000 „	Rhone at Avignon	592 „
20,000 „	Garonne ...	1,110 „
900 „	Ardeche, 1857 ...	18,888 „
71 „	Loch Katrine ...	2,094 „
98 to 100 „	Ireland ...	544 to 900 „
100 „	Coliban, Victoria..	6,000 „
$15\frac{2}{3}$ „	Bendigo Creek ...	15,400 „
$\frac{1}{10}$ „	Hargraves St., Sdst.	56,000 „

Exhibiting enormous differences.

Art. X.—*Astronomical Notes.*

By R. L. J. Ellery, F.R.S.

[Read 14th June, 1883.]

Art. XI.—*On Iron Girders.*

By Professor Kernot, M.A.

[Read 12th July, 1883.]

Art. XII.—*Schöne's New System of Sewage.*

By Mr. Blackett.

[Read 9th August, 1883.]

Art. XIII.—*Notes on the Dressing of Tin Ore.*

By J. Cosmo Newbery, B.Sc.

[Read 9th August, 1883.]

During the past five years numerous tin-bearing lodes have been discovered in this and other Australasian colonies. The mines have been opened and expensive machinery erected, but the results in many instances have been disappointing to the investors. A great many samples of these ores have passed through my hands for assay and report, and I have come to the conclusion that, in part at any rate, the disappointment has been due to the want of a proper consideration of the question of how best to extract the ore from the gangue or associated mineral matter. This is especially the case where the gangue is a hard quartzose or granitic rock. According to the general custom, these ores are reduced to fine sand in the ordinary stamping battery, such as is used to reduce our auriferous ores. The latter, of course, require to be crushed very fine, so that the small particles of gold may be beaten out and separated from the quartz; but in the case of these tin ores this fine crushing reduces the brittle tin stone to a slime, while the hard tough rock with which it is associated is being converted into sand. With this result the separation of the tin ore becomes a matter of very great difficulty, for we have forgotten the cardinal principle of ore-dressing, which is, that the ore shall not be broken finer than is absolutely necessary to separate the rich mineral from the gangue or accompanying rock, and it would be well, I think, to remind those who are engaged in this work of the following general principles of ore-dressing:—

"1. Absolute perfection in separation according to specific gravity cannot be arrived at, chiefly on account of the irregularity of the various grains to be operated on.

"2. The more finely divided the stuff to be treated, the greater is the amount of labour and care required, and the more imperfect the separation.

"3. The reducing machinery may be considered the most perfect which produces the least quantity of stuff finer than that which it is intended to produce.

"4. It is necessary, in determining the degree of fineness to which a mineral should be reduced, to consider the metallurgical value of the ore contained in it, and set against this value the loss which will probably be incurred, together with the labour and expense attendant on the manipulation.

"5. The vein stuff should be reduced to such a degree of fineness that the largest proportion of 'deads' (worthless mineral) and clean ore should be obtained by the first operation, thus saving labour and preventing the loss incident to a finer subdivision of the ore and more extended treatment.

"6. The apparatus or plan of dressing may be considered the most efficient which, with stuff of a given size, allows at an equal cost the most perfect separation and of the proper separation of stuff of nearly equal specific gravity. The average percentage to which the clean ore is to be brought and the highest percentage to be allowed in the waste being determined, it is evident that the more perfect the degree of separation the greater will be the amount of clean ore and castaways (worthless mineral) obtained in each operation, and the quantities of middles or stuff to be reworked will be diminished.

"7. We may further consider a great improvement in dressing operations, such apparatus or plan of working as will allow, without a disproportionate increase in the cost, of the equally perfect separation of fine and coarse stuff. This will be of especial benefit in the case of finely disseminated ore, which is necessarily obliged to be 'reduced to a great degree of fineness.' Perhaps I should apologise for repeating the A B C of ore-dressing, but I fear that it has been forgotten by many, and that until it has been relearnt many good mines will continue to give poor returns."

The treatment I propose for these hard ores, which consist of very tough quartz, with more or less feldspar, mica, tourmaline, and tin stone, is (1) Calcination, in heaps or kilns; (2) crushing in an ore or stone-breaker; (3) disintegration; (4) classification of disintegrated ore by a series of sieves; (5) concentration of the classified ore.

I can, perhaps, best illustrate the success of this treatment by giving the actual results obtained from a quantity (about half a ton) of very hard ore from the Ben Lomond district, Tasmania, kindly given for the trial by Mr. J. E. Dobson, at my suggestion, and in the interest of Mr. C. W.

Chapman, of Hobart. The work of calcining, crushing, and disintegration was conducted under the immediate supervision of Mr. Rees Davis, the well-known engineer.

The stone was calcined, without previous breaking, in a kiln belonging to the Victorian Patent Freestone Company, and was found to be rendered very friable; even the finest ore could be easily separated from the quartz and other minerals. The ore was then passed through one of Hope's stone-breakers, at the rate of about half a ton in rather less than five minutes.

The result of this was—

	Class in p. c.	P. c. of Tin Ore found.	P. c. of free Tin Ore in Sand under $\frac{1}{4}$-in. diameter.
1. Coarse, roughly-broken Ore	56·0	—	—
2. $\frac{1}{4}$ to $\frac{1}{10}$-in. in diameter	22·0	4·28	2·04
3. $\frac{1}{10}$ „ $\frac{1}{20}$ „ „	15·5	13·77	4·95
4. $\frac{1}{20}$ „ $\frac{1}{40}$ „ „	2·5	29·7	1·78
5. $\frac{1}{40}$ „ $\frac{1}{60}$ „ „	2·5	39·5	2·37
6. less than $\frac{1}{60}$-in. „	1·5	37·0	1·84
			12·98

This 12·98 per cent. of clean tin ore gave on assay 69 per cent. of pure tin, which would be equal to 8·99 per cent. on the ore reduced to less than $\frac{1}{4}$-in. in diameter.

Owing to the want of suitable sieves, the whole of the ore from the stone-breaker was sent to the disintegrator, instead of sending only those portions, Nos. 1 and 2, which contain attached or enclosed tin ore.

The disintegrator used was one made by Mr. Buncle as a bark mill. The rate of disintegration was as nearly as possible 1 cwt. of ore per minute, but even this rate and the time taken by Mr. Hope's stone-crusher is only approximate; the feeding was done by hand from bags, and was irregular. With a proper regular feed the work would be done with much greater rapidity.

From the disintegrator we obtained the following sizes of material:—

Grains over $\frac{1}{10}$ of an inch in diameter ...	13·5 per cent.
Between $\frac{1}{10}$ and $\frac{1}{20}$ „ „ ...	30·0 „
„ $\frac{1}{20}$ „ $\frac{1}{30}$ „ „ ...	14·0 „
„ $\frac{1}{30}$ „ $\frac{1}{50}$ „ „ ...	18·5 „
„ $\frac{1}{50}$ „ $\frac{1}{100}$ „ „ ...	11·0 „
Less than $\frac{1}{100}$ „ „ ...	13·0 „

Mr. J. L. Morley washed (without further crushing) a portion of each of these classes, and obtained the free tin ore, which he smelted, and has given me the following table of results :—

Mesh of Sieve holding ore.	Per cent. of class.	Per cent. of tin in each class.	Per cent. of tin on the whole ore.	Per cent. of return of tin in each class.
$\frac{1}{10}$ inch	13·5	*none, nearly all quartz*		
$\frac{1}{20}$ „	30·0	3·81	1·14	10·40
$\frac{1}{30}$ „	14·0	9·65	1·35	12·30
$\frac{1}{50}$ „	18·5	18·9	3·52	32·05
$\frac{1}{100}$ „	11·0	23·62	2·57	23·40
Ore passing thro' $\frac{1}{100}$ inch	13·0	18·9	2·40	21·85
	100·0		10·98	100·00

These results show that in this operation we can at once get rid of 13·5 per cent. of worthless material, while we are classifying the remainder into grades of equal-sized grains, from which the clean tin ore may be separated with ease by any of the washing processes. I should mention that the average assay of this ore made by my assistant, Mr. Adams, was 11 per cent. of tin, so that Mr. Morley's return of 10·98 per cent. of tin shows the separation to have been almost perfect.

This process is not suited to clayey ores, or ores associated with hydrous minerals, such as brown iron ore, but with quartzose or granitic ores I have no doubt that when compared with the results of the ordinary crushing and dressing plants it will be found to return much more and better dressed ore for the smelter, a higher yield of metal, smaller requirements in space for machinery, less washing water, and lower working cost.

The ore classified by the sieves may be treated by dry concentrators, a point of some moment in many districts where water is scarce, or has to be brought long distances.

Art. XIV.—*Descriptions of New, or Little Known, Polyzoa.*

Part V.

By P. H. MacGillivray, M.A., M.R.C.S., F.L.S.

[Read 9th August, 1883.]

In the present communication I propose describing some forms of Retepora, and giving a list of all the Victorian species known to me.

In this genus the appearance of the cells varies so much, according to age and other circumstances, that the specific determination of fragmentary or imperfect specimens is frequently very difficult and sometimes impossible. Those enumerated here are well-marked, and have definite characters by which I think they can almost always be certainly recognised.

The habit of growth is not usually of very great value. Of our Australian species, however, several can be recognised at a glance, as *R. monilifera* (normal form), *R. granulata*, and *R. porcellana*. *R. munita*, *formosa*, and *aurantiaca* are very similar in form, but the latter is known by its colour. *R. tessellata*, *fissa*, and *avicularis* are not easily distinguished from each other without a lens. *R. phœnicea* is at once known by its permanent red colour. Important characters are derived from the form of the mouth, the structure and situation of the avicularia, the appearance of the ovicell, and in a less degree from the more or less massiveness of the zoarium, and the proportion in size of the fenestræ to the interspaces. The ovicell in many species is very characteristic. In *R. serrata* and *avicularis* it is filled in, smooth, and without any special markings; in *R. phœnicea* the lower part is occupied by a peculiarly-shaped plate, curving downwards and backwards; in *R. fissa* and *aurantiaca* there remains a permanent vertical slit, sometimes closed, but always marked; in *R. carinata* this slit is filled in to form a keel; in *R. formosa* it is occupied by a granulated vertical band, dividing below to form a similar band on each side above the aperture; in the various forms of *R. monilifera* the ovicell is similarly marked, the band in *umbonata* ending above in a sharp umbo; in *R. tessellata* it is not perfectly known, those I have examined, which agree with Hincks' figure, being evidently immature, but it is probably entire, and without special marks.

In the "Proceedings of the Literary and Philosophical Society of Manchester for 1878," Mr. Waters published a short but very suggestive paper on the use of the opercula in the determination of the Bryozoa. I regret not having been able to procure this paper until quite recently, when the author kindly sent me a copy. Busk, who also had not seen it until long after its publication, has lately figured the opercula and other chitinous organs in a paper on the "Challenger" Celleporæ, and shown that they are of great specific value.* I have examined these parts in all our Reteporæ, and find that in many they are very characteristic —in fact, it would be possible to identify most of the species by an examination of the opercula alone. A reference to the figures will show their variations. There can be no doubt that in other genera, especially those in which the real structure of the mouth is so apt to be obscured by the growth of the peristome or the deposition of calcareous matter, the examination of the opercula will give most valuable aid in the discrimination of the species. Whether they will afford characters of higher value must be doubtful until a much larger series has been examined. They have been prepared in the manner adopted by Busk. A fragment is treated with dilute nitric acid for the removal of the calcareous matter, carefully washed in water, soaked in picro-carmine, which stains the chitinous parts yellow, and then teased out with needles in a drop of glycerine. Figures of all the forms are appended.

I am indebted to Mr. Hincks and Mr. Waters for specimens of the European species for comparison.

Full details of all our species, for which the drawings are being lithographed, will shortly be published in Professor M'Coy's "Decades."

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* *Journal of Linnæan Society*, October, 1881.

R. monilifera, M'G.

(*R. monilifera,* P. H. MacGillivray, *Trans. Phil. Instit., Vict.,* 1860; Hincks, *Ann. and Mag., Nat. Hist.,* May, 1878.)

Polyzoary foliaceous, variously convoluted. Fenestræ oval, narrower than the interspaces. Cells separated by narrow raised lines, convex, smooth or granular. Primary orifice arched above, straight below or hollowed, or with a sinus. Secondary orifice with a sinus in the lower lip, permanently open or becoming closed in whole or in part, at one side of which is generally a small oval avicularium. Usually an elliptical avicularium on the front of the cell, and others of various forms on different parts of the polyzoary. Ovicells prominent, rounded or pyriform, with a beaded or granular band above the orifice, from which extends upwards a similar vertical band. Dorsal surface vibicate, granular.

This abundant species presents several forms so marked that it may be doubtful whether they ought not to be considered as species. In all, however, the mouth has essentially the same structure, a fissure in the lower lip of the peristome, with a small avicularium at one angle of the opening. This fissure is sometimes closed by the complete or partial coalescence of the opposite sides, leaving only a loop-shaped mark or the lower end remaining perforated by a round foramen. The angle supporting the oral avicularium is frequently much produced forwards. The other avicularia are extremely various. There is generally an elliptical one on the front of the cell, and forms with semicircular mandibles are common. On the inner edge of many of the fenestræ, one or more are found with long, narrow mandible closing in a rostrum which has a sharp tooth on each side towards the point. These open horizontally inwards. In all, the ovicell is prominent and marked by a beaded line immediately above the orifice, from the middle of which a branch extends vertically upwards. In *sinuata* the upper part of the vertical band frequently projects considerably forwards, in *munita* it occasionally ends in a sharp spine, while in *umbonata* it ends at the base of a large sharp umbo. All intermediate forms may be observed. The general form of the operculum is similar, although somewhat modified in the different forms. In the typical form it is thinner, more mitriform, and constantly presents a peculiar dendroid marking, which also occasionally occurs in *sinuata,* but not in the others. The peculiar large, jointed spines seem to be confined to the typical form, *sinuata* and *umbonata;* at least I have not seen them in *munita.*

Form *monilifera.*

Polyzoary expanded, foliaceous, closely plicated, usually much broader than high. Fenestræ rounded or elliptical, much narrower than the interspaces. Mouth at first with the lower margin entire or with a slight notch; as growth advances, the peristome of the lower lip is much produced, retaining a deep narrow notch, at one angle of which a small avicularium is produced. Ovicells prominent, the beaded line broad, the extension upwards slightly clavate and reaching nearly to the upper edge.

This common form is confined to shallow water. On the framework of the wooden pier at Queenscliff it forms large masses, almost dry at low tide. The mode of growth is characteristic. The polyzoary is closely plicated, forming numerous narrow calycles and cavities, expanding widely from its attachment and sometimes, either from a single zoarium or the confluence of several, forming masses six to nine inches wide and two to four or five inches high. The fenestræ are generally much narrower than the interspaces. In the youngest marginal cells the shape of the mouth varies, the lower edge being straight, hollowed, with a small central sinus, or with a deep lateral one. As growth advances, a narrow central sinus is formed in the peristome. On one angle of this a small avicularium is usually developed. Occasionally this angle is much produced forwards, bearing the avicularium on its summit. Sometimes the angles of the sinus coalesce, leaving a rounded foramen, and occasionally this also is obliterated. There is usually an elliptical avicularium on the front of the cell, towards the upper part, either vertical or oblique, sometimes nearly central, but oftener to one side. In some specimens numerous other avicularia are present, often on calcareous elevations. The mandibles are of various forms, pointed, spatulate, or semicircular; one of the last frequently situated above a fenestra. The beaded line of the ovicell is thick, the vertical part extending to its summit, where its clavate extremity is occasionally slightly elevated. Small oval or elliptical avicularia are scattered irregularly over the back, sometimes with triangular mandibles, and occasionally one of the latter of a large size is found at the base of a fenestra.

In young cells there are frequently two long, hollow, jointed spines articulated at the upper margin of the mouth. In older cells, and occasionally in younger ones, there is an enormous spine on one side articulated to an elevation of the peristome. These spines are of peculiar structure (as pointed out by Hincks), consisting of segments narrower at the base, expanding upwards, and each segment fitting into the one below somewhat like the joints of an Equisetum.

Variety *sinuata.*

Polyzoary much convoluted and contorted, thick. Fenestræ rounded, narrower than the interspaces. Mouth with a deep and wide sinus in the lower lip, on one angle of which is a large oval avicularium. Ovicell prominent, the vertical band thickened and frequently, especially in older cells, slightly elevated. Back vibicate, dense, granular.

This variety, which attains a size of about 2 inches by 1 to 1½, is usually found surrounding the narrow stems of black algæ. The polyzoary is much thicker and denser than in the normal form. The sinus in the lower lip is much wider and deeper, and the oral avicularium is larger. The jointed spines, which are commonly present, are of great size; the lower joint is very long, the succeeding much shorter. The ovicells are broader, and the vertical beaded line is frequently elevated towards its upper extremity. The avicularia are usually very numerous, and are often raised on calcareous eminences. They vary much in shape, and are frequently broadly spatulate. The back is densely granular, the vibices little prominent, and the avicularia very few.

R. monilifera, form *umbonata.*

Polyzoary foliaceous, expanded, or convoluted. Fenestræ elliptical, narrower than the interspaces. Cells quadrate or ovate, those towards the edges separated by much-raised margins, surface granular, glassy. Mouth sloping obliquely backwards; in young cells lower lip nearly straight or hollowed, entire, thin; in older with a loop-shaped notch, at the angle of which is an avicularium. This notch is frequently bridged over, leaving a small foramen, which also is sometimes obliterated. In the latter case the lip is thickened, and at its junction with the lateral margins projects slightly, giving origin to slender, jointed spines; in many of the older cells the spines are very thick and telescopic in appearance, and are frequently confined to one side. The avicularia are very varied, semicircular, spatulate, and pointed; and there is frequently a semicircular one above a fenestra, and also often one with a long, narrow mandible closing in a bidentate rostrum, opening horizontally inwards on the edge of a fenestra. Ovicell prominent; the vertical band ending in the base of a sharp, smooth, umbonate process. Back strongly vibicate, with numerous small, round avicularia, especially about the edges of the fenestræ.

A small form distinguished by the much-raised margins of the younger cells and the peculiar umbonate process on the ovicell. These characters are usually so marked that they might seem sufficient to constitute a new species. In some cases, however, the umbonate process scarcely exists, and the vertical band is little more prominent than in *sinuata*. Young cells of *munita* also not uncommonly have the edges considerably raised.

R. monilifera, form *munita*.

Polyzoary expanded, foliaceous, convoluted to form large cavernous or calyculate masses. Cells separated by narrow raised lines, surface granular. Peristome expanded forwards with a loop-shaped mark in the centre of the lower lip, closed or perforated below, on one side of which is an avicularium. Small oval avicularia on the front of the cells, and various others scattered in different parts. A very large avicularium, with either a semicircular or very long triangular, pointed mandible, above the upper angle of most of the fenestræ. Ovicells with the beaded line narrow. Back granular, vibices well-marked, elliptical avicularia more abundant about the edges of the fenestræ.

Mr. Hincks, in his valuable paper on Retepora, has already proposed the varietal name of *munita* for this form. The largest specimen I have is $2\frac{1}{2}$ by 3 inches, but as all my other specimens are incomplete, I have no doubt it attains a considerably greater size. The convolutions of the polyzoary form large calyculate or funnel-shaped cavities, and are not closely plicated, as in the form *monilifera.* The peristome is usually much elevated forwards, with a loop-sharped mark or occasionally a fissure, on one angle of which is a small avicularium. This avicularium is very frequently absent. It is also sometimes very much elevated on a production of the peristome. There is occasionally a thin spine at each side of the mouth above, but I have never seen the large jointed spines found in the other forms.

Two varieties are distinguishable. In the one, *lunata*, the supra-fenestral avicularium has the mandible semilunar or semicircular and very large, and the loop of the peristome is usually imperforate. In the other, *acutirostris,* which is also usually altogether stouter, the supra-fenestral avicularium has an enormous pointed mandible, and the peristome of the lower lip is usually perforated. Occasionally both forms of large avicularia occur on the same specimen.

R. formosa, n. sp.

Polyzoary expanded, twisted and convoluted so as to form large funnel-shaped compartments. Fenestræ rounded or oval, narrower than the interspaces. Cells elongated, raised and expanded above, separated by distinct raised lines, surface minutely granular. Mouth sloping backwards, narrowed below, the thickened lateral margin uniting at an acute angle with the raised cell-margin; the lower lip straight, with a minute notch. Usually an elliptical avicularium directed vertically or obliquely on the front of the cell towards the middle or to one side. Ovicell large, prominent, a small beaded band on each side above the aperture, meeting at an angle in the middle, and extending vertically upwards to end in a slightly clavate extremity. Posterior surface strongly vibicate, granular, and with numerous elliptical or rounded avicularia close to the edges of the fenestræ. Operculum expanded upwards, slightly contracted below, higher than broad.

Port Phillip Heads, 10 to 18 fathoms.

This beautiful species in the appearance and size of the polyzoary resembles the *munita* form of *R. monilifera.* It is, however, at once distinguished by the form of the mouth, which slopes backwards, and is wide above and contracted below. The lower lip is straight, and has usually a minute rounded sinus, and is destitute of oral avicularium. The slightly thickened sides of the mouth unite at an acute angle with the elevated margins of the cells. The operculum is also of a very characteristic shape, in correspondence with the form of the mouth. Besides the avicularia on the front of the cells and those on the back of the polyzoary, there are frequently one or more with long pointed mandible opening horizontally inwards on the edge of the fenestræ. There is also occasionally an avicularium with a semicircular mandible above a fenestra in front.

R. carinata, n. sp.

Polyzoary expanded. Fenestræ elongated, narrower than the interspaces. Cells ovate, broad, separated by narrow raised margins. Mouth (primary) with the lower lip entire, or (secondary) with a deep sinus at one side and a large avicularium towards the base of the prominent peristome; operculum rounded above, hollowed below, broader than high. On the inner margin of the fenestræ, slightly in front, several avicularia with long pointed mandibles directed vertically from before backwards. Ovicell sub-immersed, pyriform, with a vertical sharp ridge slightly bulbous at its upper extremity. Dorsal surface granular, traversed by slightly raised vibices, and with a few rounded avicularia about the edges of the fenestræ.

Port Philiip Heads.

The only specimen I have seen is quite perfect, and forms a waved, somewhat fan-shaped expansion seven-eighths of an inch wide by about three-fourths deep. It is of a beautiful orange colour. The cells are mostly broad, prominent, tubercular, and glistening. The mouth is broad, arched above, and in the youngest seems to be entire and straight below or slightly convex. The peristome is rapidly developed on the lower lip, projecting as a plate with a deep notch at the angle of the mouth on one side, and receding gradually from this to nearly the level of the opposite angle, but without any notch at that side; the margin is frequently finely serrated. There is a considerable, prominent avicularium below the lower lip, with the broad mandible directed upwards and usually inclined to the angle formed by the sinus. There are also other round or elliptical avicularia scattered in various parts, and numerous avicularia, with long narrow mandibles closing in bidentate rostra, close to the edge of the fenestræ. Similar avicularia occur in some other species, but in these, so far as I have seen, they always open horizontally inwards, while in the present they are directed across the edges of the fenestræ. The vertical slit, the closure of which gives rise to the ridge on the ovicell, is still in some instances slightly open towards the upper extremity.

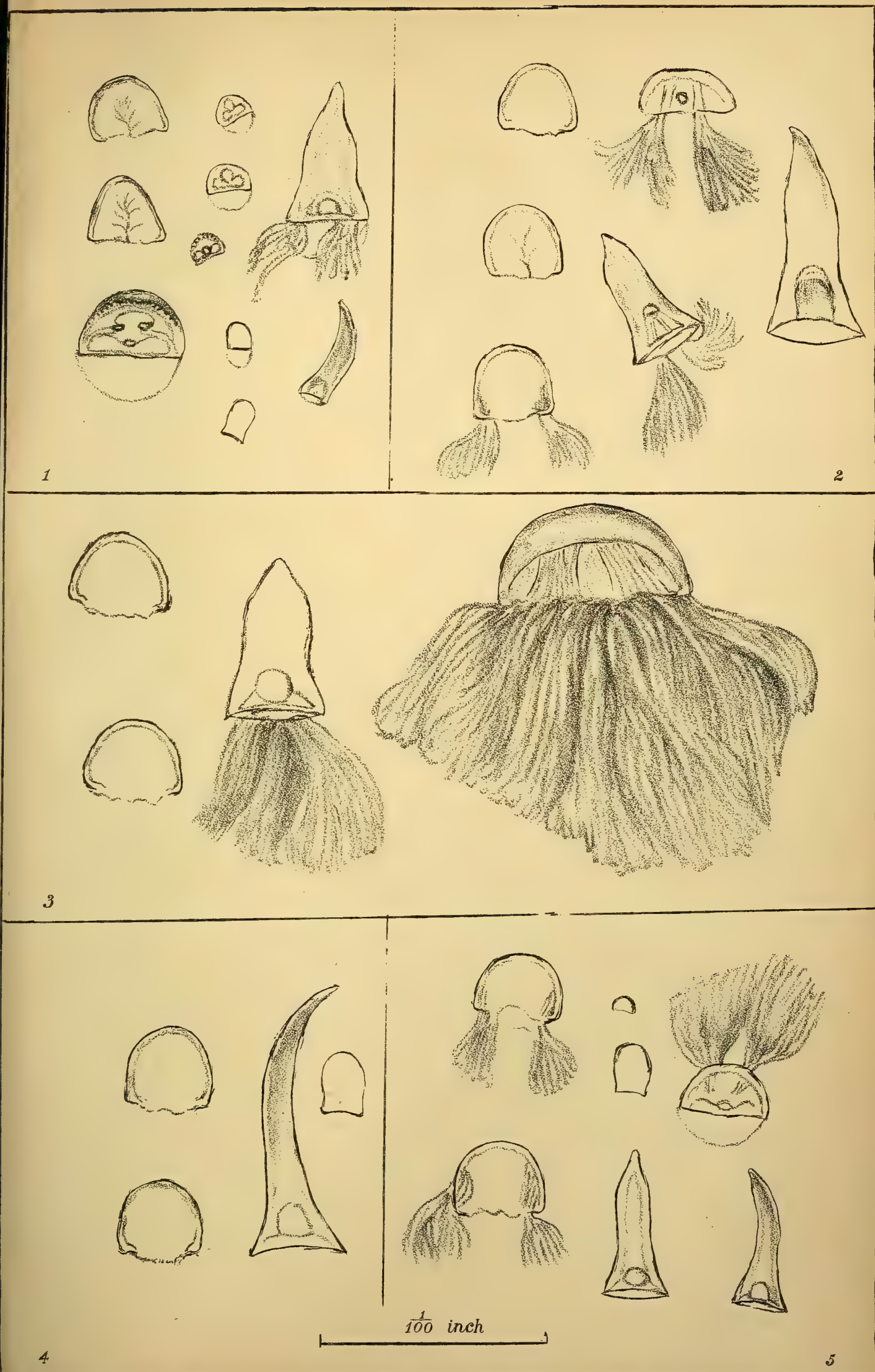
R. fissa, M'G.

The description and figures of this species given in my last paper were taken from the original specimen, which is of considerable size and well calcified. I have a number of other specimens with the fenestræ more elongated, the interspaces narrower, the cells longer, and the peristome very much produced, of the true position of which I was doubtful. I am now satisfied that they belong to the same species, and I believe that they are identical with Smitt's Floridan, *R. marsupiata,* although they do not altogether correspond with his description, and that they are probably the Australian form referred to *R. cellulosa* by Busk and Hincks.

In this form the fenestræ are large, elongated, and wide, the interspaces narrow, with one to four rows of cells. The cells are long, narrow, separated by well-raised margins. The peristome is much produced, curved forwards, with a nearly circular aperture opening upwards. From the centre of the lower lip a shallow groove, with slightly raised edges, extends vertically downwards; immediately below this, or slightly to one side, is usually an avicularium with a bluntly-triangular mandible directed downwards and tilted somewhat forward. The lower lip on either side of the groove is smooth or sometimes serrated. The edges of the groove occasionally meet to form a tube either extending the whole length or confined to the lower end. Occasionally the small avicularium is enormously developed with a large triangular mandible. There are also sometimes other avicularia. In some cells the avicularia are entirely absent. The ovicells are rounded with a vertical slit. In different specimens a complete gradation may be seen to the structure of the typical *R. fissa.*

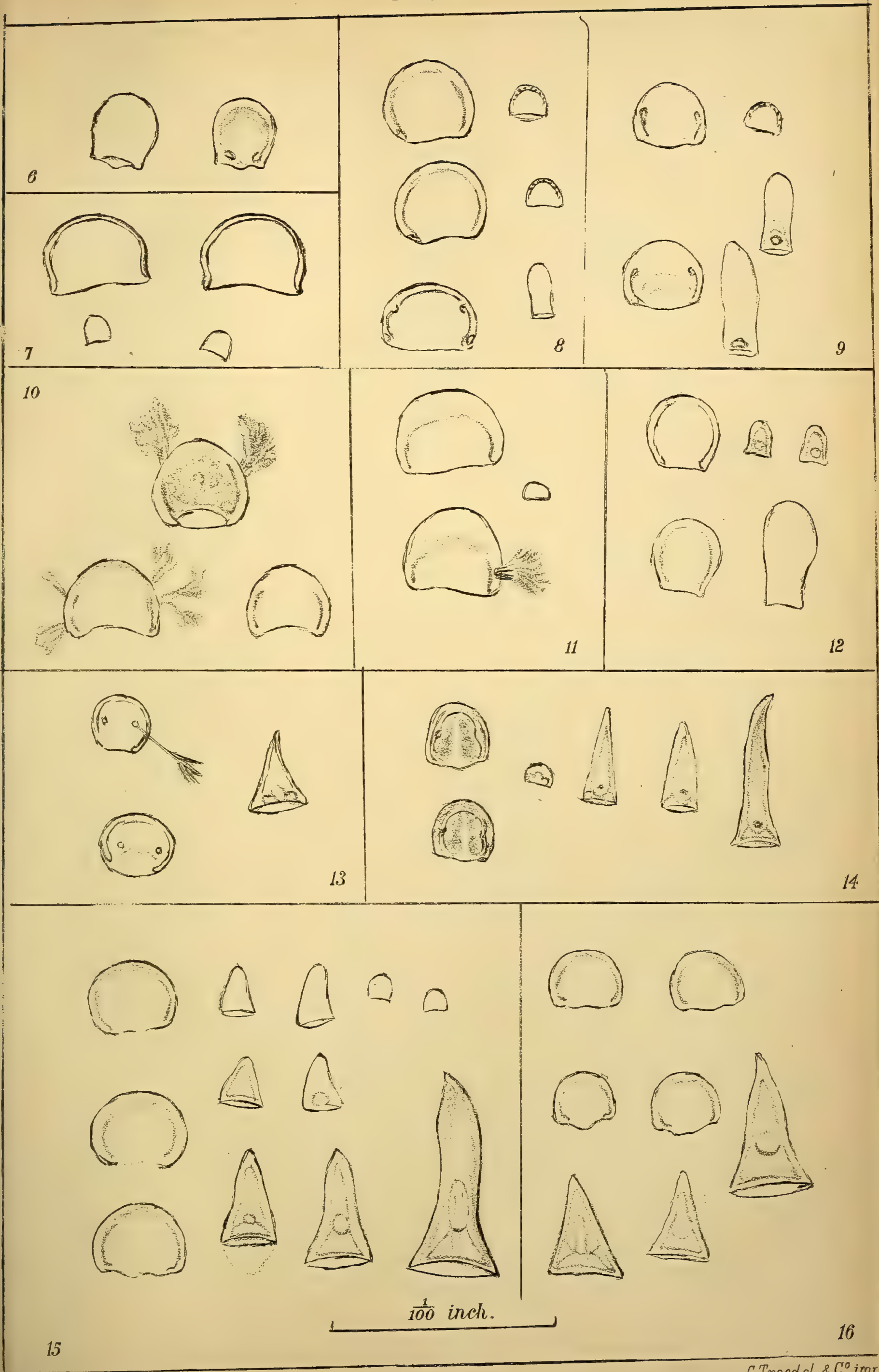
The Victorian species of Retepora with which I am acquainted and to which all my specimens may be referred are :—

R. monilifera, M'G.
  Form *monilifera*, M'G.
    var. *sinuata*, M'G.
  Form *umbonata*, M'G.
  Form *munita*, Hincks.
    var. *lunata*.
    var. *acutirostris*.
R. formosa, M'G.
R. aurantiaca, M'G.
R. carinata, M'G.
R. granulata, M'G.
R. fissa, M'G.
  (? = *marsupiata*, Smitt.)
R. porcellana, M'G.
  (= *robusta*, Hincks.)
  var. *laxa*.
R. avicularis, M'G.
R. tessellata, Hincks.
R. phœnicea, Busk.
R. serrata, M'G.



P. H. M^c G del & lith. C. Troedel & C^o imp.

Plate II.



P.H.McG del & lith.

C.Troedel & Co. imp

Plate III.

P.H.M^c G del & lith. 1/100 inch C.Troedel & C^o imp.

Explanation of Figures.

Plates I. and II.

Opercula and Chitinous Appendages.

Fig. 1. *Retepora monilifera.*
Fig. 2. *R. monilifera,* var. *sinuata.*
Fig. 3. *R. monilifera,* form *munita,* var. *lunata.*
Fig. 4. *R. monilifera,* form *munita,* var. *acutirostris.*
Fig. 5. *R. monilifera,* form *umbonata.*
Fig. 6. *R. formosa.*
Fig. 7. *R. aurantiaca.*
Fig. 8. *R. porcellana.*
Fig. 9. *R. porcellana,* var. *laxa.*
Fig. 10. *R. carinata.*
Fig. 11. *R. granulata.*
Fig. 12. *R. serrata.*
Fig. 13. *R. phœnicea.*
Fig. 14. *R. tessellata.*
Fig. 15. *R. fissa.*
Fig. 16. *R. avicularis.*

Plate III.

Fig. 1. *Retepora monilifera,* young cells. Fig. 1*a*. Adult cells. Fig. 1*b*. Portion showing ovicells.
Fig. 2. *R. monilifera,* var. *sinuata.*
Fig. 3. *R. monilifera,* form *munita,* var. *acutirostris.*
Fig. 4. *R. monilifera,* form *munita,* var. *lunata.*
Fig. 5. *R. monilifera,* form *umbonata.* Fig. 5*a*. Young cells. Fig. 5*b*. Ovicell in *profile,* to show the umbo.
Fig. 6. *R. formosa,* young cells. Fig. 6*a*. Older cells and ovicell.
Fig. 7. *R. fissa,* var. *marsupiata* (?)
Fig. 8. *R. carinata.*

Art. XV.—*Electric Lighting for Mines.*

By Mr. R. E. Joseph.

[Read 11th October, 1883.]

Having for some months past been engaged in arranging several appliances for the electric illumination of our gold mines, I have made a few notes on the matter which I hope may be of interest.

Although at first sight the work of lighting a mine and its workings, both above and below, may appear to be a comparatively easy matter, a careful examination as to the conditions required for its successful maintenance in working order will show that it is not so, and that a system which would prove satisfactory in ordinary places might be extremely unsuitable for mining purposes.

Most of our mines require artificial light on the surface-works all night, and for the underground workings both day and night each week, with scarcely any cessation. The surface-lights are used to illuminate the engine and boiler-house, winding plant, changing house, smithy and brace, and, where crushing plant exists, the battery house and its engine.

Where gas has been available it has been used to a certain extent for the above-named purposes, but as gas in all country districts is high in price it forms a heavy item in the working expenses, consequently we find that the general illuminant used is oil, kerosene, and candles. Neither of these agents gives a good light, and all of them have serious disadvantages which should preclude their use except under most exceptional circumstances.

Oil and kerosene lamps require constant attention; they have to be trimmed and the oil renewed daily, and unless provided with glass chimneys they smoke and are offensive; if chimneys be used, there is a constant breakage, and thereby expense. Candles are, it is true, easily managed, but the light they afford is too feeble for the purposes required on the surface as fixed lights, consequently we see them carried about from place to place, lighting up small areas as required, with, as may be expected, the accompanying waste from the draughts of air. But the most serious disadvantage arising from the use of any of these agents is the danger of grease mixing with the gold or any of the appliances belonging to it, grease of any sort being a source of trouble, and causing a great waste in the recovery of the gold during the process of amalgamation. In the underground workings generally the principal lights used are oil-lamps at the plats or entrance to the drives, and candles in the crosscuts, levels, and backs. As a rule, a mine has either too little or too much air—that is to say, some of our mines are so badly ventilated that in certain parts a candle will not burn, whilst in other mines the draught of air is so great that it is difficult to keep the candle alight, and under these circumstances about half the candle is wasted by the grease running away. An examination of nearly all our mines shows at once that the arc-light would be unsuitable for surface works and unworkable for below ground, where there are few places large enough to hang an arc-lamp. Most of our drives and levels are some six or seven feet wide, about the same height, and varying from two hundred to eight hundred feet in length; consequently they require a number of small lights only. Above ground arc-lights might be used, but as a number of them would be required (all the places to be lighted being detached), it would be an expensive method not only in its first cost, but in its maintenance. It, therefore, became obvious that the incandescent system of electric light would prove the most suitable for all conditions and circumstances.

In designing and carrying out an electric-light installation at a mine, two or three points require careful consideration.

Deriving an electric current from a dynamo machine, which must be kept in motion during the whole time a light is required, it was found necessary to provide a motor independent of the mining plant.

Where water-power is not available a small steam-engine, of a good working type and sufficiently large enough to do the maximum amount of work required of it, must be provided. This auxiliary engine can, of course, be supplied with steam from the regular boilers in use, thus involving no extra outlay for firing.

Little need be said about the engine—any kind or make will answer, provided it be of an economical type with respect to its steam supply; but it was found an advantage to fit on an extra fly-wheel to ensure its steadiness in running, and special large lubricators to feed the oil for a length of time without stopping the engine. The dynamo machine used is of a special type. Running constantly both day and night, its working parts require to be durable, the armature not too large and heavy, and the speed not too high.

The current it furnishes must not be of too high an electromotive force, for if any shock were felt on taking hold of any bare wire there would be an aversion on the part of the miners to handle or use any of the apparatus, whilst the machines in use have been so arranged that the electromotive force will remain nearly constant, and thus maintain to the same degree of brightness either one or its maximum number of lights without altering the speed of the driving engine.

Too much care cannot be exercised in carrying out this portion of the work, for it must be recollected that the apparatus will be left in charge of those who probably know nothing whatever of electrical matters, and who could not, therefore, know where to look for or to rectify even the slightest fault which might occur. But with properly constructed apparatus and a little training, no difficulty has been experienced by the engine-drivers employed in the mines in maintaining the dynamo machine in an efficient condition.

The surface and underground lights are kept on two circuits, and under the control of two switches. All the lights are enclosed in outer globes of thick glass, the dirt and dust about the places necessitating a covering for the lamps which could be cleaned and handled roughly. In the crushing-rooms flexible springs are used to suspend the lanterns, it being found that the constant vibration to which the lamp was subjected caused the carbon loops to occasionally break off.

Each lamp is controlled by a separate switch and a safety cut-out, whilst a protecting wire guard is necessary in places where the lamp is liable to be struck with quartz or implements. From the engine-house to the shaft overhead conducting wires are used, not necessarily covered with insulating material. These wires end in an iron junction-box, having a main fusible cut-out. Down the shaft the current is lead by an insulated cable constituting the leading wire, and enclosed in a galvanised-iron pipe of suitable conductivity which serves for the return lead. Copper strips soldered over the joints of the pipes ensure an electrical connection. At each plat an iron junction-box is provided, having a safety cut-out leading to the branch wire for the cross-cuts and levels.

These branch wires are smaller but similar to the main, being also enclosed in iron pipes, which serve as the return wire. At suitable intervals iron boxes are provided, containing a cut-out and coupling by which the lamp can be easily attached.

Each lamp enclosed in an outer glass lantern with protecting wire guard has some 10 feet of flexible conducting wire attached to it, provided with a coupling for attachment to the junction-box. The lantern can then be suspended on the iron tubing in any desired spot. The iron junction-boxes are placed along the cross-cuts and levels at spots selected, and are in excess of the number of lamps in use at one time. It takes but a few seconds to change a lamp from one spot to another; and where required extra lengths of flexible wires are provided, with couplings at each end, so as to lead a lamp to a distant point. The lamps at the plats are not joined to the branch leads, but direct and through its own cut-out to the main wires. Thus any interference owing to an accident or fault to any of the leads in the levels will not affect the platlights, which are important ones to keep constantly alight.

By using leather washers for the covers of the junction-boxes and lamps, it will be seen that the whole system is waterproof, and that the lights will burn, even though the mine should be flooded and the conductors and lamps be under water.

This is a matter of the utmost importance for alluvial workings, where accidents from the inrush of water are by no means unfrequent. In such cases the value of having a light which cannot be extinguished should be highly estimated.

Another important use for the electric light is at the brace, where the light is exposed to the weather. In the case of kerosene lamps, on a stormy night it is very difficult to keep them alight, and then only at the expense of several chimneys.

The electric lamp at the brace is enclosed in a lantern, having a reflector to throw the light on the ropes and skip only, and controlled by a cut-out and switch fixed in a convenient part of the brace. Twelve months' experience with the working of the light at one of the Sandhurst mines has proved conclusively that with the precautions before mentioned no difficulty whatever can arise in any part of the system, and that the incandescent lamp is more economical, reliable, and affords a better illumination than any other available method.

Art. XVI.—*A New Form of Darkfield Illumination Micrometer.*

By R. L. J. Ellery, F.R.S.

[Read 11th October, 1883.]

Art. XVII.—*Notes of an Interesting Fact in Connection with the Early History of the Electric Telegraph.*

By Mr. Ellery, F.R.S.

[Read 15th November, 1883.]

It is no new thing to say that the one who, by intellectual process or rational experiment, makes a discovery seldom reaps the benefit either as regards reputation or more substantial results. The man of science or the patient investigator is nowhere in the race, as compared with the man of business; and so it often, almost always, happens that the discoverer is forgotten, while those who, ghoul-like, turn his brains to account are the only ones who reap the reward and are remembered. This is because men like Faraday, and many more, are not business men; their life is spent in inquiring of nature's forces and nature's laws, and giving the results for the benefit of mankind, and not in learning and following the more popular ways of money-making. The instance I am about to refer to is a case in point. Let us think for a moment what a mess we should be in if we were suddenly deprived of the electric telegraph, or electricity, as a means of communication at a distance, and we may perhaps form some sort of an idea of what we owe to those early workers who laid the foundation-stones of this great and universal benefit. Nevertheless, one, and, as it now seems likely, the first, who by his discoveries made the electric telegraph a fact has been hidden among us for over thirty years, scarcely known except as a country surgeon, and certainly never till now recognised as one to whom the gratitude, if nothing else, of the whole civilised world belongs for his investigations into the applications of electricity and magnetism, which are now considered by competent authorities to have constituted those first important steps which rendered all subsequent details of the electric telegraph an easy task. From some articles and correspondence in the *Electrician*, it is pretty clear that Dr. Edward Davy (who was known by some of us thirty years ago as superintendent of the Assay Office in Melbourne, was one of the founders of the Philosophical Institute, the parent of this Royal Society, and now resides at Malmsbury, following his profession as a medical man) must be regarded, in virtue of his most important discoveries, exhibitions of working models at Exeter Hall, and his invitation to carry out his electric telegraph on the Great Western line in England, the real first inventor of the electric telegraph. The history, in brief, seems to be this: As early as 1836 Davy conceived the possibility of an electric telegraph, and appears to have had an excellent knowledge and thorough grasp of the properties of electricity. He had been educated for the medical profession, and took his diploma at the Royal College of Surgeons in 1828. He then seems to have taken up the business of an operative or analytical chemist; and we have heard of several chemical instruments invented or improved by him. During this time (about 1835) he seems to have made some investigations into electricity; and in 1836 the possibility of using the electric current for telegraphic purposes suggested itself to him, and he matured a method, which he patented in 1838, as already stated. Wheatstone and Cooke patented in 1837, and afterwards actually carried their needle telegraph into operation, and obtained its adoption on the railway lines of Great Britain. Davy, who had matured his plan and exhibited working models before this time, contested unsuccessfully the granting of the patent. Perhaps from the want of means, or perhaps for lack of the commercial afflatus, so often absent in scientific men, yet so essential to the substantial success of a discovery or invention, Davy failed to carry his telegraph into practical use, and eventually we hear of his having come to Australia in 1839. His connection with the early discovery of the electric telegraph was forgotten; nor does he ever seem to have in any way resuscitated the matter until his work is referred to in Mr. Fahie's papers on the early history of the electric telegraph, published lately in the *Electrician.* Although Wheatstone and Cooke succeeded, and Dr. Davy did not, does not alter the fact that to the latter we are decidedly indebted for discoveries which eventually resulted in the perfection of both what are known as the needle and Morse systems. To those interested in this subject, I may state that copies of Dr. Davy's work and inventions can be seen in the *Electrician,* Vol. XI., Nos. 8, 9, 10, and 11 of this year. There is, however, one paragraph taken from his letters and communications which is interesting and prophetic. It is in a postscript to a letter to his father, dated July, 1838. Speaking of a suggestion that had been made to the effect that Government would scarcely allow such a powerful instrument to be in the hands of individuals, he says :—"I know very well the French Government would not permit it except in their own hands. But though I think our Government ought, and perhaps will, eventually take it upon themselves as a branch of the post-office, yet I can scarcely imagine that there would be such absurd illiberality as to prohibit or appropriate it without compensation." Again in 1838 Davy wrote :—"I cannot, however, avoid looking at the system of electrical communication between distant places, in a more enlarged way, as a system which will one of these days become an especial element in social intercourse. As railways are already doing, it will tend still further to bring remote places in effect near together. If the one may be said to diminish distance, the other may be said to annihilate it altogether, being instantaneous." There is a ring of prescience in these words, uttered as they were forty-five years ago, before a mile of telegraph wire had been erected, except the single mile he constructed himself for experimental purposes in Regent's Park; and although, so far as is known, the idea of submarine communication was at that time scarcely dreamt of, Davy, in his "Outline Description of His Improved Electrical Telegraph," refers to and describes an insulated conductor or "cable" for such a purpose. This Society will, I am sure, feel proud to know that it may rank among its founders the name of Edward Davy, the almost forgotten pioneer and inventor of the electric telegraph, and at the eleventh hour to do what honour to him it may be within its province and power to do.

Art. XVIII.—*Notes on the Rainfall Map recently Issued by the Government of Victoria.*

By Mr. Ellery, F.R.S.

[Read 15th November, 1883.]

The subject of rainfall is one of great importance to almost every community, and perhaps to none much more than to Australia, where "prosperity" or "poverty" is almost synonymous with its plenteousness or its paucity. There is, therefore, a constant anxiety in the public mind regarding the prospects of rain or of wet and dry seasons, and a widespread interest in the monthly and annual amount of rain that falls on the various areas of which settled Australia is composed. No amount of knowledge of this subject nor any human interference are likely to tangibly affect the amount of rain which nature provides for these regions; but an accurate knowledge of the amount provided, and its distribution both as regards area and time, are of the utmost importance and value, as showing on the one hand how much may naturally be expected to fall over any particular area or areas, and when; and, on the other, the provisions necessary to turn what does fall to the best account. Over a large part of the littoral areas of Australia rain falls every year on an average equal to that in the neighbourhood of London; but it is not so equally distributed over the year as in that place. Moreover, England generally, by reason of the immense influence of the "Gulf Stream," possesses an extremely humid climate, while Australia, for the most part, is extremely dry. Although, therefore, the actual rainfall be the same, these differing conditions make up a vastly different climate. With our dry atmosphere the same amount of rain does not "go near so far," and it has been gradually forced upon us that to make it go far enough for our needs we must not allow it to flow back to the sea without spreading its beneficence a little more widely over our thirsty but otherwise prolific soil. To obtain a good knowledge of our assets in this respect, the Governments of all the colonies have for some years past been spreading rain gauges over Australia, and gathering statistics from many hundreds of places, and the number is largely increased every year. Already a very fair idea of the rainfall of various districts can be formed, and most valuable information on the subject obtained. To place this before the public in a clear and comprehensible manner has been one of the chief aims of the several colonial astronomers and meteorologists upon whom the collection of rainfall statistics devolves. Mr. Russell, of Sydney, has for two or three years past compiled a map showing the rainfall at each rain-gauge station in the year by means of a *black circle,* the diameter of which indicates the amount. Mr. Todd, of Adelaide, adopts a somewhat similar plan; but until now I have not taken any steps in this direction, principally on account of the cost of carrying out a really satisfactory method of doing so. Last year, however, a request was made in Parliament that a rainfall map of Victoria should be prepared, and the Government concurring, and undertaking to provide the necessary cost, I at once set to work. Some meteorological maps lately issued by the French Government, and a valuable little work published in America, entitled, *Distribution of Rainfall Over the Globe,* suggested to me an admirable method of graphically representing the amount and distribution of rain over the colony, as far as statistics were available, by grades of one colour. These methods, however, were expensive, involving a separate printing for each colour, but it was suggested by Mr. William Slight, the engraver of the Survey Department, that by a careful system of etching and toning a similar and equally good and distinct effect might be produced in one printing. Just at this time our fellow-member, Mr. W. Culcheth, who, since his residence in Australia, has taken a very practical interest in all matters pertaining to rainfall, irrigation, &c., submitted a sketch map he had prepared from statistics obtained from the Observatory, showing by different rulings the amount and distribution of rainfall over Victoria. This map was very carefully traced out, and I at once adopted it as the basis of the new rainfall map. Indeed, I may state that Mr. Culcheth had displayed such care and judgment in outlining the areas that it was found unnecessary to alter them, except in a very few instances, and to a trifling extent; and I must here acknowledge my indebtedness to this gentleman for the substantial help his tracing afforded me. The production of nine effective tones in one colour by etching and tinting was a very tedious and laborious undertaking, but the result is one of which the officers of the engraving and lithographic branch of the Survey Office, who took immense interest and pains in the work, may well be proud. This method of grading, being once accomplished, is available for any future maps, so that for next year's map the work will be trivial as compared with this first one. The map consists of the new map of Victoria, combined with the south part of New South Wales and the west part of South Australia, upon which is printed in blue colour nine grades or tones, each grade being confined within certain irregular curved outlines or boundaries, forming a somewhat arbitrary limit to the areas, over which the rainfall was 5 to 10, 10 to 15, 15 to 20, and so on up to 50 or more, inches per annum. It must be remembered that these curved outlines have been put in with a somewhat free hand, and they must not be taken as strictly representing a margin beyond which the rainfall is 5 in. more or less than within it. Nevertheless, as the contour of the country, some topographical knowledge, as well as rain-gauge statistics, have been taken into account in tracing them, they may confidently be assumed as sufficiently near for all practical purposes. There are two or three prominent facts displayed by this map :—1. That the greatest rainfall takes place on the coast lines or on the summits of the high ranges, especially near the coast. 2. That the areas immediately in the lee of these ranges have a markedly lessened rainfall. 3. That, were it not for the mountain ranges, it appears probable the amount of rainfall in the southern and eastern portions of Australia would decrease gradually from the coast line to the central regions of the continent. It is proposed to issue a similar map every year; and I hope the one for the current year will be ready by February. It would be very interesting to have a map showing the average rainfall for many years, but the materials available for one to show an average five years are, I fear, as yet somewhat too meagre.

Art. XIX.—*The Return of the Pons Comet.*

By Mr. Ellery, F.R.S.

[Oral communication 15th November, 1883.]

Art. XX.—*The Recent Red Sunsets.*

By Mr. Ellery, F.R.S.

[Oral communication 15th November, 1883.]

I have received a good deal of correspondence in reference to the recent peculiar sunsets, which it appeared have been seen in many other parts of the world, and have created a great deal of interest. I have received a letter from Mr. Bosisto, reporting the fact that, when about seven hundred miles from the Straits of Sunda, the vessel on which he was a passenger passed through a floating mass of pumice dust and ashes, with an occasional charred tree. Similar volcanic *débris* had been reported by other ships. I have received several letters giving different theories of the sunsets. One theory which has appeared in the papers was that so much matter has been taken up outside of the earth's surface as to form another moon. This peculiar sunset has been noticed all over the Southern Hemisphere; and a very unusual state of the upper atmosphere has certainly existed in the Northern Hemisphere, for we have news of a green sun in India frightening the people out of their lives, and this has been attributed to volcanic action. Mr. Moncure Conway told me that in coming through the tropics from America in September the passengers were astonished at seeing the sun assume a steel-blue colour, which it retained all day long, and that on one occasion it was quite green at the time of setting. These appearances are not remarkable, and are not uncommon in the Arctic regions. The green sun was fully accounted for by aqueous vapour in different forms in the atmosphere. It has been said by some writers lately that the sun, if looked at through the steam issuing from the funnel of a steam-engine, would appear green, but I have never tried that experiment. There is no doubt, however, that the sun did assume all kinds of curious colours under different atmospheric conditions. I have myself seen it looking as described by Mr. Conway, a steel-blue, when there was a hazy horizon. It has been stated by Mr. Lockyer that the sunsets are owing to the volcano in the Straits of Sunda. I think we might all rest satisfied that that will not explain them at all. If the volcano in the Straits of Sunda caused the sunsets, then it has been able to alter the state of the atmosphere all round the world. The effect could not be caused by volcanic dust, because the sunsets have continued such a length of time, and the dust will have been precipitated long ago. Hydrogen would not produce anything like a red sunset. I have only to say, in the first place, that the sunsets are not very remarkable. I have seen far more wonderful ones in other parts of the world, and no notice has been taken of them. In the Mediterranean I have seen a red sky three hours after sunset; and we all know what grand sights are sometimes witnessed in the tropics. There is nothing unusual in the sunsets, except perhaps that they are a little uncommon in these latitudes, and have lasted a little longer than usual. What is rather singular is that above the yellowish or deep orange tinge there has been a distinct purple region. That is not very often seen. Still it is explained by the fact that all these beautiful sights morning and evening are due entirely to the prevalence of vapour in the higher regions of the atmosphere. Indeed, any day during the occurrence of these red sunsets it has been possible by careful examination with an opera glass to see that the atmosphere was not quite clear of cloud. The trace of a slight filmy cloud could just be seen, and there has evidently been vapour high up in the atmosphere for a considerable time past; in fact it could always be seen on the clearest day. I believe therefore that the sunsets are simply due to the presence of vapour in an unusual quantity, and for an unusual length of time for this season of the year. I do not believe the volcano has anything whatever to do with the phenomena. The pumice-stone no doubt came from the Straits of Sunda, but I do not think the red sunsets did. The earthquake and the sunsets happening to occur about the same time, people have connected them.

Art. XXI.—*The First Discoverers of the New Hebrides.*

By Mr. A. Sutherland, M.A.

[Read 15th November, 1883.]

Art. XXII.—*Descriptions of New, or Little Known, Polyzoa.*

Part VI.

By P. H. MacGillivray, M.A., M.R.C.S., F.L.S.

[Read 13th December, 1883.]

Discoporella reticulata, n. sp. Fig. 1.

Zoarium orbicular, bordered, convex; cells connate, radiating in uniserial rows of irregular length; peristome with the outer border produced, pointed, and entire; centre of zoarium occupied by large shallow cancelli, separated by narrow raised walls; a single or double row of smaller rounded cancelli between the rows of cells.

Port Phillip Heads.

I have only a single specimen of this species, which seems quite distinct from any previously described. The most distinctive character is the number and large size of the shallow cancelli in the centre of the zoarium. There are no spines to be seen in the interior of any of the cells or cancelli.

Discoporella pristis, n. sp. Fig. 3.

Zoarium irregular in shape, bordered, adnate or partly free and raised at the edges; cells irregularly distributed; mouth elliptical, peristome entire, divided, or usually produced into a long point with a series of fine spines on one or both sides; interstitial cancelli rounded, irregular in size and distribution, frequently finely denticulate round the orifice.

Port Phillip Heads. Found also by Mr. J. B. Wilson.

The distinguishing character of this species is the peculiar development of the peristome, which in many of the cells is produced on one side into a long pointed process, one or both sides of which is armed with a series of sharp spines or teeth, giving the whole a marked resemblance to the beak of a sawfish. In many cells, where this prolongation is absent, there are several sharp, slender spines round the edge of the mouth. The cancelli are round, usually with the edge denticulate; but it is frequently difficult in this, as in some other species, to say what are cells without peristome and what cancelli. In some specimens portions of the zoarium are covered by a thin, calcareous, perforated pellicle, which also occurs in several other cyclostamata, attention to which was first, I believe, called by Mr. Waters in his paper on the "Bryozoa of the Bay of Naples."

Discoporella echinata, n. sp. Fig. 4.

Zoarium usually orbicular, bordered; cells arranged in irregular rows or confused; peristome produced, entire, notched, or divided into several processes; numerous long, fine spines growing irregularly from the surface of the cells; cancelli numerous, rounded, denticulate at the orifice (as also usually are the cells).

Port Phillip Heads. Found also by Mr. J. B. Wilson.

I have some doubt whether this may not prove to be a variety of Busk's *D. fimbriata*, from which, as usually seen, it differs chiefly in the numerous spines springing from all parts of the cells, which give it a very distinctive appearance. These spines also spring from other parts of the zoarium.

Fasciculipora bellis, n. sp. Fig. 2.

Cells in small, cylindrical, erect fascicles, mostly opening at the summit by prismatic orifices; one or two series opening lower down, the upper of these frequently partly separated and their orifices reaching to the same level as those of the chief mass of the bundle; surface minutely punctate.

Port Phillip Heads.

A small and very beautiful species, of which I have only seen one specimen. In this there are six or seven fascicles spread over a small calcareous nodule, and connected by a calcareous punctate or perforated crust. When viewed vertically they suggest a resemblance to a composite flower on the end of its pedicle.

Fasciculipora fruticosa, n. sp. Fig. 5.

Zoarium branched, the main branches mostly horizontal, with numerous short branches turned upwards, the secondary branches consisting of bundles of cells, all opening terminally by closely packed prismatic orifices; surface punctate, longitudinally faintly sulcate and (especially in older parts and on the back) transversely corrugated.

Port Phillip Heads.

This species is closely allied to *F. ramosa* (D'Orb), of which also I have a small specimen, found by Mr. Maplestone at Portland, but from which it is evidently quite distinct, the branches being much more slender and containing fewer cells. Some of my specimens form dense, shrub-like tufts almost an inch in diameter.

EXPLANATION OF PLATE.

Fig. 1. *Discoporella reticulata*, natural size. Fig. 1*a*. The same magnified.

Fig. 2. *Fasciculipora bellis*, natural size. Fig. 2*a*. Side view of one of the bundles magnified. Fig. 2*b*. Vertical view of the extremity of the same.

Fig. 3. *Discoporella pristis*, natural size. Fig. 3*a*. A portion magnified. Fig. 3*b*. A small portion more highly magnified.

Fig. 4. *D. echinata*, natural size. Fig. 4*a*. A portion of the same magnified.

Fig. 5. *Fasciculipora fruticosa*, natural size. Fig. 5*a*. Portion of the same magnified.

Art. XXIII.—*Electricity as a Motive Power on Railways.*

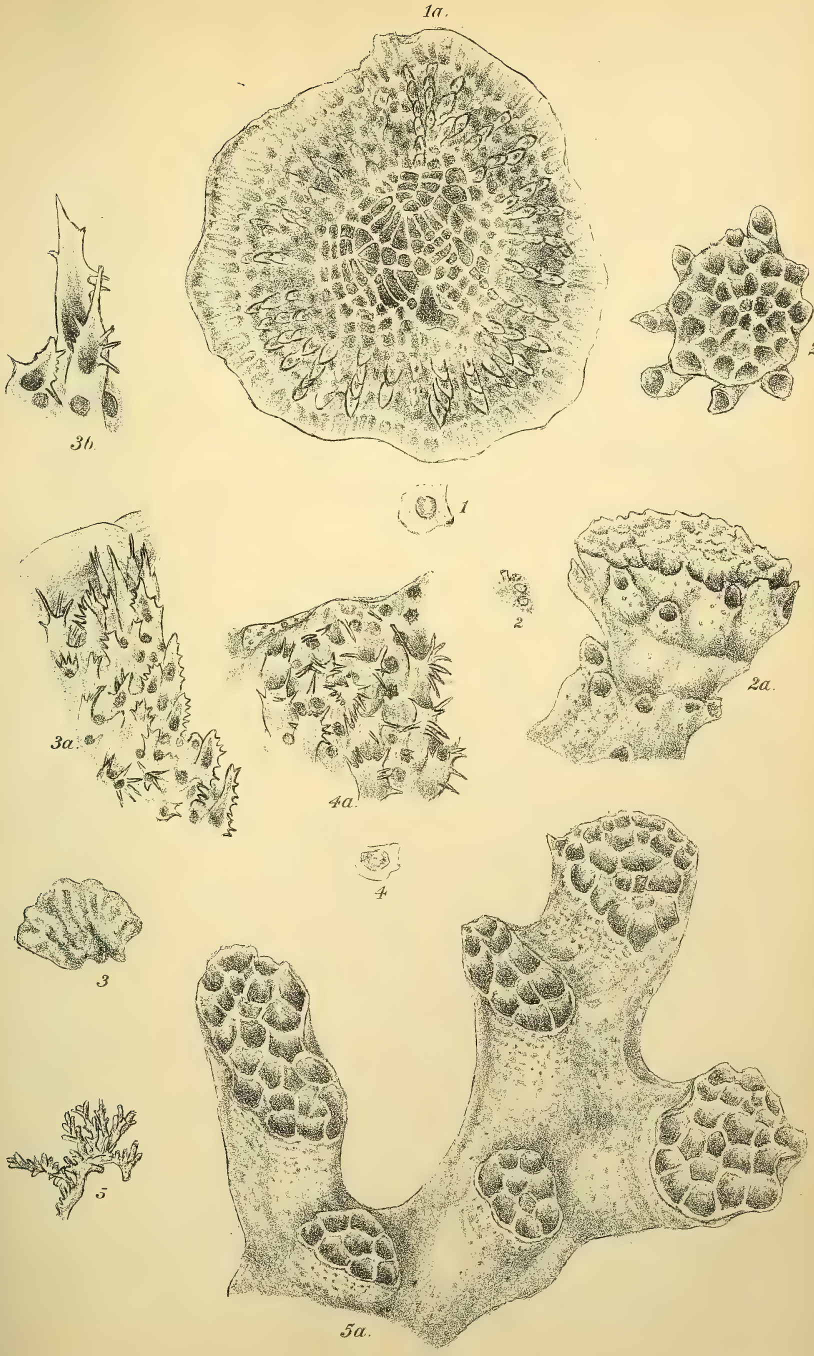
By Mr. G. W. Selby, Jun.

[Read 13th December, 1883.]

Art. XXIV.—*Gas as a Motive Power.*

Professor Kernot, M.A.

[Read 13th December, 1883.]



P. H. M^c G del & lith.

C. Troedel & C^o imp.

Obituary.

GEORGE MANLEY HOPWOOD, F.C.S., F.I.C.

Died 23rd July, 1883.

George Manley Hopwood was born at Plymouth in 1846. While still very young he lost both his parents, and was taken under the care of a distant relative in Edinburgh ; she and her husband, the Rev. Mr. Rowbottom, adopting him and treating him with the utmost kindness. His education was obtained at the well-known school—the Edinburgh Academy, and on its completion he was apprenticed to a druggist of Edinburgh. Here his taste for chemistry received some little encouragement, and he devoted himself to the study of the science. As a step towards the prosecution of chemistry as the business of his life, he engaged as assistant to Dr. Stephenson Macadam, of the Surgeons' Hall, Edinburgh, brother of one of the founders of this society. Here he worked at analyses for commercial purposes, and became expert in the chemistry of manures and agricultural products. When about twenty years of age he joined Dr. Angus Smith, F.R.S., of Manchester, where he not only gained a further insight into general analytical work, but also took part in some of Dr. Smith's researches on the cattle plague, and the air of mines. He rose to the position of chief assistant in Dr. Smith's laboratory. He then associated himself with Mr. Edward Hunt, B.A., of Manchester, in researches for technical purposes, especially on the nature of dyes. He was apparently just entering on a department of inquiry in which he might have won a distinguished name, when failing health forced him to leave England. He landed in Melbourne in 1873, and spent some time in recruiting his greatly weakened constitution. The Victorian climate suited him so well that he determined to stay here, and obtained a position in the Mining Department, there being then no opening in his own profession. But ere long he received an appointment as assistant in the Assay Department of the Mint ; he was also made assistant to Mr. Geo. Foord, for the examination of gas for the City of Melbourne. He was at various times employed by the Government for the Department of Agriculture, and was one of the chemical experts at the Melbourne International Exhibition.

He died at Hawthorn on 23rd July, 1883. Mr. George Foord thus speaks of him:—"He was characterised by patient and modest industry, watchful attention, and earnest zeal. He had accumulated a considerable store of special knowledge in connection with industrial and commercial chemistry, and excelled in the neatness and method of his work."

SUETONIUS HENRY OFFICER.

Died 26th July, 1883.

Suetonius Henry Officer was the third son of Sir Robert Officer, of Tasmania, and was born at New Norfolk, in that colony, in the year 1830. He was sent to Edinburgh for his education, and was destined for the Navy, but after entering a military school for a short time he followed the bent of his own inclination, and returned to the colonies, where he and his brother founded a fine station on the River Murray. For many years his life was the busy and enterprising one of a pioneer squatter, but he reaped the fruits of it in gathering a fine freehold property round him. He had always been of a scientific turn, and devoted much of his attention to the question of irrigation and rainfall; for nearly twenty years continuously he forwarded to the Sydney Observatory daily observations of the rainfall and of the height of the River Murray. His arrangements for the irrigation of his own lands were ingenious, and he did his best to impress on his neighbours the desirability of adopting similar means of turning their dry lands into green pastures. He was extremely interested in the question of acclimatisation, and took a large share in the practical work necessary in carrying it on. He was the first to acclimatise the ostrich in Australia, and by the sacrifice of time, labour, and money he had the satisfaction of seeing the industry settled on a lucrative basis. He was in his later life devoted to astronomy, and had a fine telescope, with which he did a little amateur work. In 1881 he gave up the personal superintendence of his station, and fixed his residence in Melbourne, but his health was then too much broken for him to attend the meetings of our Society, or to undertake any work for us.

A brief illness terminated a life of useful industry on the evening of the 26th July, 1883. Though not in any strict sense of the word a scientific man, he had the happy faculty of making scientific work a relaxation and amusement amid a busy life; and of turning that knowledge, whose acquisition gave him so great a pleasure, into a means of profit and advantage to his neighbours and the whole community.

1883.

PROCEEDINGS.

ROYAL SOCIETY OF VICTORIA.

ANNUAL MEETING.

March 13*th*, 1884.

Present, the President (in the chair) and 40 members and associates.

The Report and Balance-sheet for 1883 were read and adopted, as follow :—

"*Report of the Council of the Royal Society of Victoria for the Year* 1883.

"Your Council has again the pleasure of reporting the termination of a very satisfactory year. In the number of its Members, in its finances, in the scientific activity of the working portion of its Members, it has been throughout the year in a flourishing condition; but there is reason to regret that so small a number are to be found among the list of contributors, for many who have both the ability and the opportunity seldom or never add to the real work of the Society by the contribution of Papers.

"During the year we received for our library 91 volumes and 547 parts of scientific publications, issued by learned and scientific bodies throughout the world. In exchange, we have forwarded our Annual Volume to 127 societies and institutions.

"The Crown Grant of the land on which the Society's Hall is situated is now issued, and is in the possession of the Society.

"During the year there have been elected 15 Members and 32 Associates. Hyde Clarke, Esq., was elected a Corresponding Member, and Dr. Edward Davy, who has recently been acknowledged as one of the originators of the Electric Telegraph, was elected an Honorary Member.

"The Society contained 22 Life Members, 116 Members, 34 Country Members, 6 Corresponding Members, 9 Honorary Members, and 70 Associates.

"The Council regrets to announce the loss, by death, of four of our Members—Mr. S. H. Officer, of Mount Macedon; Mr. H. M. Hull, of Hobart; Mr. J. H. Horner, of Melbourne; Mr. G. Manley Hopwood, of the Mint, Melbourne.

"During the year, in addition to the Annual Conversazione, the Society held nine Meetings, at which the following Papers were read—

"12th April.—Mr. Stirling, 'Caves Perforating Marble Deposits, Limestone Creek;' Dr. Jamieson, 'The Influence of Light on Bacteria.'

"10th May.—Mr. A. W. Howitt, F.G.S., 'The Rocks of Noyang;' Mr. T. S. Ralph, 'The Occurrence of Bacteria (Bacilli) in Living Plants;' Mr. P. Behrendt, 'Modern Fireproof and Watertight Building Materials—Traegerwellblech and Asphalt;' Mr. R. E. Joseph, 'Incandescent Lamps for Surgical and Microscopical Purposes;' Mr. Rudall, F.R.C.S., 'A Translation of Dr. Ecklund's Paper on Germs of Blennorrhagia.'

"14th June.—Mr. G. R. B. Steane, C.E., on 'Hydrology;' Mr. R. L. J. Ellery, F.R.S., 'Astronomical Notes.'

"12th July.—Professor Kernot, M.A., on 'Iron Girders.'

"9th August.—Mr. Blackett, 'Schöne's New System of Sewage;' Mr. J. Cosmo Newbery, 'Dressing of Tin Ore;' Mr. MacGillivray, M.A., M.R.C.S., 'Descriptions of New, or Little Known, Polyzoa,' Part V.

"11th October.—Mr. R. E. Joseph, 'Electric Lighting for Mines.'

"15th November.—Mr. Ellery, F.R.S., 'Notes of an Interesting Fact in Connection with the Early History of the Electric Telegraph;' 'Notes on the Rainfall Map recently Issued by the Government of Victoria;' 'The Return of the Pons Comet;' and 'The Recent Red Sunsets;' Mr. Sutherland, M.A., 'The First Discoverers of the New Hebrides.'

"13th December.—Mr. MacGillivray, M.A., M.R.C.S., 'Descriptions of New, or Little Known, Polyzoa,' Part VI.; Mr. G. W. Selby, Jun., 'Electricity as a Motive Power on Railways;' Professor Kernot, M.A., 'Gas as a Motive Power.'

"DISCUSSIONS AND EXHIBITS.

"15th March.—Discussion on Professor Nanson's Paper, 'Methods of Election.'

"12th April.—Notes by Dr. Downes and Mr. T. P. Blunt, F.C.S., criticising Dr. Jamieson's Paper on the 'Development of Bacteria.'

"9th August.—Mr. Ellery, F.R.S., exhibited and described a new Personal Equation Apparatus.

"11th October.—Mr. Ellery, F.R.S., exhibited and described a new Darkfield Micrometer for astronomical purposes.

"During the year Section A was resumed, and held four Meetings, at which Papers on Engineering subjects were read and discussed.

"Volume XIX. of the 'Transactions' of the Society was issued to Members in the month of May. Volume XX., containing the Papers read during the year, will be in the hands of Members about April next."

BALANCE-SHEET.

The Hon. Treasurer in Account with the Royal Society of Victoria.

Dr.

	£	s.	d.	£	s.	d.
To Balance from last Balance-sheet				£123	18	2
„ Government Grant—1882–83				200	0	0
„ Do. do. portion of 1883-4				150	0	0
„ Rent and Gas				5	18	1
„ Eighteen Entrance Fees				37	16	0
„ Subscriptions—						
78 Members	£163	16	0			
8 do. (Half-years) ...	8	8	0			
26 Country Members	27	6	0			
1 do. (Half-year) ...	0	10	6			
41 Associates	43	1	0			
25 do. (Half-years) ...	13	2	6			
Arrears	46	14	6			
Commission	0	3	0			
				303	1	6
„ Interest				4	9	4
				£825	3	1

Cr.

	£	s.	d.
By Printing and Stationery	£248	13	7
„ Furniture	58	6	0
„ Books	4	4	0
„ Freight and Charges of Books and "Transactions"	8	15	2
„ Conversazione and Teas	47	1	3
„ Rates	4	13	4
„ Gas and Fuel	4	15	7
„ Repairs, &c.	10	12	6
„ Clerical Assistant	26	0	0
„ Hall-keeper	6	0	0
„ Collector	35	12	5
„ Insurance	3	10	0
„ Fee for Crown Grant of Land	2	0	0
„ Reporting Meetings of the Society	13	10	0
„ Postage	35	8	4
„ Petty Cash, Advertising, and Sundries	7	17	7
	£516	19	9
„ Balance in Bank	308	3	4
	£825	3	1

Compared with the Vouchers, Bank Pass-book, and Cash Book, and found correct.

3rd March, 1884.

JAMES E. GILBERT
ROBERT E. JOSEPH } AUDITORS.

H. MOORS, HON. TREASURER.

STATEMENT OF LIABILITIES AND ASSETS.

Dr. LIABILITIES.	£	s.	d.	ASSETS. Cr.	£	s.	d.
To Three Debentures outstanding	£15	0	0	By Estimated Value of Outstanding Subscriptions ...	£30	0	0
,, Interest unclaimed	12	12	0	,, do. do. Rents due	5	0	0
,, Estimated Amount of other Outstanding Liabilities	5	0	0	,, Hall, Library, Furniture	3500	0	0
	£32	12	0	,, Balance in Bank	308	3	4
,, Balance	3810	11	4				
	£3843	3	4		£3843	3	4

The following Report of Section A was read and adopted :—

REPORT OF SECTION A.

During the month of August, last year, this Section was revived.

The last meeting, prior to this, of which any minutes are recorded was held on the 27th October, 1880.

There are at present thirty-six names on our list of members, while the average attendance is about fifteen or twenty.

Four (4) meetings were held last year, and two have been held during the vacation.

The following papers have been read before the Section, all giving rise to considerable and animated discussion :—

"The Two Forces Mathematical." Mr. T. Wakelin, B.A., New Zealand.

"A New System of Second and Third Class Railways." Mr. P. Behrendt, C.E.

"Saxeby's Magnetic Test." Mr. C. W. M'Lean, C.E.

"The Economic Design of Railway Viaducts." Mr. J. H. Fraser, C.E.

"The Merri Creek Waterpipe." Mr. W. R. Rennick, C.E.

"The Measurement of Magnetism in Connection with Diagrams." Mr. J. Booth, C.E.

"Underground Telegraph Systems." Mr. J. H. Fraser, C.E.

The subjects considered in the papers, and the manner in which they were treated, speak well for the individual exertions of members and the general energy of the Section during the past year.

B. A. SMITH, *Hon. Sec.*

The office-bearers for 1883 were elected for the ensuing year.

The Hon. Librarian announced the receipt of 6 volumes and 108 parts of scientific transactions since the December meeting.

March 15*th*, 1883.

Present, the President (in the chair) and 22 members and associates.

Mr. G. W. Selby and Mr. E. M. James, F.R.C.S., and the Hon. F. T. Sargood, were elected members of the Society; Mr. J. H. Hill, an associate.

A discussion took place on Professor Nanson's paper, entitled "Methods of Election."

April 12*th*, 1883.

Present, the President (in the chair) and 16 members and associates.

Mr. William Bage and Mr. Charles Bage, M.B., were elected associates.

A note by Arthur Downes, M.D., and Thomas P. Blunt, M.A., F.C.S., was read. The authors criticised the result of Dr. Jamieson's experiments on the "Influence of Light on the Development of Bacteria."

Dr. Jamieson, in reply, said that he had made some fresh experiments, and had written a short paper in which he hoped to maintain the position he had assumed. He then read his paper.

In reply to some questions, Dr. Jamieson stated that he had placed small phials with fertilising fluid behind panes in a window of three different colours—red, blue, and yellow. That which was behind the red glass developed bacteria first, then, at a day's interval, that behind the yellow, and after a few days' interval that behind the blue glass; but he had never found the bacteria quite destroyed, or their development altogether suspended, by the influence of any light whatever.

Mr. Ellery said that the general result of Dr. Jamieson's work seemed to make it probable that any retardation in the development of bacteria was due not so much to light as to the accompanying heat; that even Professor Tyndall, in spite of all his skill as an experimenter, had not guarded sufficiently against the occurrence of that source of error.

Dr. Jamieson said he was afraid that the direct question still remained to be answered—"Does exposure to the rays of the sun necessarily kill bacteria?"

Mr. Stirling then read his paper on the "Caves Perforating Marble Deposits at Limestone Creek." Subsequently he exhibited a number of specimens taken from the rocks, to which he referred in his paper.

The President stated with regret that Mr. Edward Howitt had resigned the position of Honorary Secretary, and proposed that a vote of thanks should be tendered him for his long and valuable services. Professor Kernot seconded the motion, which was carried unanimously.

May 10*th*, 1883.

Present, the President (in the chair) and 30 members and associates.

Mr. Frank S. Outtrim was elected an associate.

Mr. A. W. Howitt's paper on the "Rocks of Noyang" was laid on the table, the President remarking that it was at the disposal of any member interested in geological subjects, but that it was too long to be read before the meeting; when printed, members would have an opportunity of reading it for themselves.

Dr. T. S. Ralph read his paper on "The Occurrence of Bacteria (Bacilli) in Living Plants," after which he exhibited under the microscope some specimens of water-plants within whose unbroken cells he considered bacteria to be visible.

Mr. Ellery thought that possibly many of the phenomena of fermentation might be due to the presence of bacterial life. Dr. Ralph said that he had found bacteria in dry tea-leaves, arising, no doubt, from the part fermentation they had undergone in preparing them for the market. Dr. Jamieson expressed some doubts as to the nature of the organisms shown by Dr. Ralph under the microscope; they scarcely agreed with ordinary descriptions of bacteria, and were more likely to be mere organic particles. If they were bacteria within enclosed cells, it was impossible to account for their appearance except on the supposition that spores had entered through minute holes in the walls.

Dr. Ralph then expressed his desire that this line of experiment should be taken up and pursued carefully by independent observers.

Mr. P. Behrendt then read his paper, "Modern Fireproof and Watertight Building Materials—Traegerwellblech and Asphalt."

Dr. Rudall read his translation of a paper on "The Germs of Blennorrhagia."

Mr. Joseph read a paper on "Incandescent Lamps for Surgical and Microscopical Purposes," and exhibited specimens.

June 14th, 1883.

Present, the President (in the chair) and 19 members and associates.

Mr. Outtrim, Mr. Fraser, and Mr. Mills were introduced to the meeting.

Mr. Naylor was elected as a country member; Capt. Rowan and Dr. Louis Henry, as members; and Mr. W. P. Steane, as an associate.

Mr. Ellery proposed that Mr. Hyde Clarke, of London, should be elected a corresponding member of the Society. This motion was seconded by Dr. Neild, and carried unanimously.

The Hon. Librarian reported the receipt of 76 volumes and 154 parts of scientific transactions since his last report.

Mr. G. R. B. Steane read his paper on "Hydrology."

Mr. Ellery said that much importance must be attached to these investigations of the frequency and amount of sudden rainfalls. Such knowledge must be of use to the farmer and to the engineer; but he disagreed from Mr. Steane in the assertion that the rains are brought up by the winds; for, in this country at least, rainfall is either in front of, or behind, great cyclonic movements which come from warmer regions in obedience to laws of which, at present, we know nothing. When such rainfalls take place on the eastern coast they never penetrate into the interior, but those which occur in South Australia often traverse the entire continent. The north-west, west, or south-west are the only directions from which we ever receive rain. In reply to a question, Mr. Ellery said that, as regards the amount of rainfall which actually sinks into the ground, no reliable experiments have as yet been made; such experiments as have been tried were carried on with artificial soils, which, probably, were only inefficient representatives of the natural surface.

After some further discussion, Mr. Ellery exhibited photographs of stars taken by means of the great telescope at the Melbourne Observatory. He remarked that great improvements had taken place within the last two years in the production of these photographs by the discovery of a new process. Mr. Ellery stated a curious fact about these photographs, viz.:—that faint nebulæ could often be photographed with a much less exposure than was required for the larger and brighter bodies. In some remarks about the recent comet, Mr. Ellery said that as it had been visible for eight or nine months continuously, it has been longer visible than any other comet recorded. At its first appearance the nucleus split up into two and subsequently into three little stars; its course was a parabola, whose vertex lay extremely close to the outer surface of the sun.

July 12*th*, 1883.

Present, Professor Kernot (in the chair) and 31 members and associates.

Mr. J. Hill, Mr. W. P. Steane, Dr. Louis Henry, and Mr. John Naylor were introduced, and signed the members' book.

Mr. Charles Rennick was elected a member, and Mr. Hyde Clarke a corresponding member.

Professor Kernot then described some experiments on the strength of iron girders, with reference particularly to the strength of the new Victoria-street Bridge in Melbourne. He stated that these experiments showed that the bridge, as originally designed, was both economical and strong. At the engineering classes at the University there had been made models of different forms of girders, which were subsequently broken down by loading them to the breaking point. The models were made of iron, wood, or cardboard; the first material being the most useful for experiments, the last the most convenient.

The class in every case calculated the weight the model ought theoretically to carry, and the breaking weight usually agreed very closely with the calculation. Three models were exhibited, the first weighing 25 oz., yet breaking with the weight of 208 lbs. This form of girder was common enough in the colony. The second model weighed 21 oz., and broke with a weight of 771 lbs. The third model was an actual representation of the girders used in the Victoria-street Bridge. It was 45 inches long, weighed 34 oz., and broke with a weight of 1627 lbs. A number of models of girders designed by various eminent authorities had been made and tested at the University, but the Victoria-street girder was better than the best of these by more than 30 per cent.

Mr. T. B. Muntz thought that much credit was due to Professor Kernot for this efficient manner of teaching engineering, and also for the valuable results of these experiments.

August 9*th*, 1883.

The President in the chair—Present, 26 members and associates.

Capt. F C. Rowan and Mr. C. F. Rennick were introduced, and signed the members' book.

Mr. R. E. Fletcher and Mr. G. Smibert were elected associates.

The President said that a number of students of engineering at the University were desirous of becoming associates of the Society for the purpose of joining Section A. As the year was advancing, he would propose that the Standing Orders be suspended to admit of their being elected at once ; this was accordingly done, and the following gentlemen were elected associates :—D. C. Askew, T. Murray, A. W. L. Paul, W. R. Rennick, B. A. Smith, G. Wight, A. M. Grant, J. B. O'Hara, W. H. Brockenshire, L. L. Murray, N. E. Phillips, E. Shaw, N. Tyers, F. S. Grove, C. G. V. Williams, G. H. Dunlop, N. J. Noall, E. C. Rennick, E. L. Smith, H. W. L. Tisdall, L. Clark, F. S. Brush.

Mr. Blackett then read a paper on "Schöne's New System of Sewage."

Mr. Kernot said that his first impression on hearing the description of this new system was that it was too good to be true ; it evidences an immense deal of originality and ingenuity in every particular. Mr. Blackett said that Schöne's system had now been in use for two years at Eastbourne, where satisfactory results had been obtained, and the scheme had therefore passed beyond the experimental stage.

Mr. Cosmo Newbery read his paper "Notes on Tin Ore Dressing."

Dr. MacGillivray read his paper, "Descriptions of New, or Little Known, Polyzoa," Part V.

Mr. Ellery said that these polyzoa had been obtained by dredgings near Queenscliff. This paper contained a complete list of Victorian species of Retepora. Dr. MacGillivray exhibited some specimens.

Mr. Ellery exhibited a new personal equation instrument, in which the exact moment of the passage of a mark representing a star across the middle of the field of vision could be accurately recorded electrically on a chronograph. An observer using the instrument records in a similar way his observation of the time of passage; the difference between the two records represents the personal equation of the observer.

October 11*th*, 1883.

Present, the President (in the chair) and 32 members and associates.

A ballot was taken for the election of the following gentlemen, who were duly elected :—Mr. H. T. Tisdall as member, Mr. W. H. Gregson as member, Mr. R. Schäfer as an associate.

The following gentlemen were introduced to the meeting as new associates :—Mr. W. H. Brockenshire, Mr. E. C. Rennick, Mr. B. A. Smith, Mr. G. Wight, Mr. C. G. V. Williams, Mr. A. M. Grant, Mr. L. L. Murray, Mr. J. H. Dunlop, Mr. A. J. Noall, Mr. A. E. Phillips.

Mr. Ellery described and exhibited a new form of Darkfield illumination micrometer for astronomical purposes. He said that wherever micrometers with *wires* or *webs* were used in telescopes for astronomical purposes, it was necessary to obtain artificial illumination of these *wires.* For general purposes the simple illumination of the field of the telescope in the ordinary way was sufficient, in which case the *wires* appeared as black threads on an illuminated ground. But in case of observing very faint objects, and in some of the more delicate observations, such a mode of lighting renders faint objects invisible. It was, therefore, necessary to devise an illumination in which the field should be quite dark, and the wires rendered faintly but distinctly visible. Many micrometers for this purpose had been constructed, but he had seen none thoroughly satisfactory, except such as were too unwieldy and cumbersome. The one he exhibited had lately been constructed in the Observatory workshop, and appeared to possess all the qualities requisite, without being either too expensive or too cumbersome. In describing the instrument he said :—

"This micrometer is of a somewhat novel form. As far as the micrometer box, parallel wire frames, screws, &c., are concerned, it resembles the ordinary parallel wire micrometer of the German form. The principal frame which carries the measuring web is actuated by a screw with 100 threads to the inch, and is 'kept to its work' by a pair of fine spiral springs, one on each side of the screw. The smaller frame carries eight webs, three parallel to the screws and five at right angles to it. This frame is used for adjusting to zero only, and is therefore movable over a very small range by means of a short screw of 100 threads to the inch, also opposed by a strong spiral spring. Three bisecting wires are used to avoid too great a range of the measuring screw. The whole micrometer box is movable at right angles to the optical axis of the telescope by means of a well-made slide, actuated by a screw with 60 threads to the inch, opposed by a strong spiral spring. The eye-piece is made to slide across the field of view on the micrometer box by means of a quick four-threaded screw. The measuring screw has an epicyclical count wheel-head, as well as the divided head proper, so that whole and parts of revolutions of the screw are read at once. The slide for the eye-piece, as well as that for the whole micrometer box, is moved by two milled screw-heads (the eye-piece one being much the smallest), situated at the end of the box opposite the micrometer screw-heads, and is very convenient for manipulation.

"This instrument can be used as an ordinary micrometer with a bright field by using the light from the central reflector in the telescope. It is in the arrangement for dark-field illumination that the principal novelty exists. The micrometer box, with sliding stage, is attached to a piece of tube 4 inches long, terminating in the adapting screw for attaching to the telescope. At right angles to this tube, and about 2½ inches from the micrometer box, is fixed another short tube, somewhat smaller, to carry one of Swan's 2½-candle-power incandescent lamps. The light from this lamp, rendered parallel by means of a lens, falls on diagonal mirrors of silvered glass, and is thence reflected toward the micrometer box, filling an annular space between the outer tube and a smaller short one to prevent stray light entering the field of view. The light then passes through four square apertures at the base of the micrometer slide, two being parallel with the slides, and two at right angles to them. The holes communicate with small rectangular boxes, which conduct the light to four small thin glass mirrors adjusted to reflect the light exactly in the plane of the wires, illuminating both systems symmetrically on both sides.

"There is a small arrangement of shutters for closing the square apertures in the base of the micrometer, and either pair can be closed at will, so that only one system of wires are illuminated if desirable when observing extremely faint objects, or both pairs can be closed if it is desired to use central illumination and a bright field.

"As reading the micrometer heads while observing is often very troublesome, requiring a hand-lamp illumination, and with many observers a lens also, I have obtained a beam of light from the electric lamp for this purpose. In the central stopping of the lamp lens the central half-inch is cleared away, permitting a beam to pass across the optical axis into a small tube fixed exactly opposite to the lamp tube. At the end of this is a prism which reflects the beam of parallel rays upon one side of the micrometer heads to a reflective surface, which illumines the reading part of the heads, so that with a small reading lens fixed to the micrometer, a most comfortable and convenient method of obtaining the micrometer readings is supplied.

"The intensity of the light can be modified by increasing or diminishing the electric current with a simple rheostat of German silver wire, controlled by the same small milled-head screw that is used for diminishing the ordinary lamp light for central illumination."

Mr. Ellery stated that this instrument had been made at the Observatory, and Professor Kernot remarked that it was gratifying to find that the workshops of the Observatory could turn out such excellent work.

Mr. Joseph read his paper on the "Electric Lighting for Mines," and exhibited some interesting apparatus used for that purpose.

November 15*th*, 1883.

Present, the President (in the chair) and 21 members and associates.

A ballot was taken for the election of the following gentlemen, who were duly elected:—Mr. A. S. Way, M.A., as member; Mr. C. T. J. Vautin, as member; Mr. J. D. Ploos van Amstel, as member; Mr. F. Rennick, as member; Mr. Bennett Hull, as member; Mr. A. T. Danks, as associate; Mr. Frederick Smith, as associate; Mr. S. T. Magee, as associate; and Mr. T. W. Fowler, as a country member.

The Hon. Librarian reported that he had received 1 volume and 48 parts of scientific works since the last meeting.

Mr. Ellery said that the remarkable sunsets which had recently been seen all over the southern hemisphere were attracting much attention in the scientific world. The peculiar red glow which accompanies these sunsets first appeared after the great volcanic disturbance at the Straits of Sunda, hence the theory has obtained some currency that this phenomenon is due to extremely fine particles of volcanic dust ejected by the volcano and held in suspension in the upper strata of the atmosphere; but it seems most improbable that such a small volcano should have caused dust, or particles of any kind, to be diffused over the whole of the southern hemisphere. The spectroscopic examination of these sunset glows points strongly to the existence of moisture, in a very rarified form, scattered through the upper regions of the atmosphere. By the ordinary prismatic action of such a layer of vapour the peculiar tints witnessed in these phenomena are readily accounted for.

Mr. Ellery then read a paper entitled "Notes of an Interesting Fact in Connection with the Early History of the Electric Telegraph." He then stated that it was his intention to propose, at the next meeting of the Society, that Dr. Davy be elected honorary member of the Society, as a slight recognition of his valuable services in the discovery of the means of utilising electricity for telegraphic purposes.

Dr. Davy was not the first patentee of an instrument for the use of electricity for telegraphic purposes. Messrs. Cooke and Wheatstone had obtained their patent in 1837, a year before he took out his; but some years previously Dr. Davy had exhibited working models of his inventions. When Cooke and Wheatstone applied for their patent Dr. Davy lodged a *caveat.* The matter was referred to Professor Faraday, who decided in favour of Dr. Davy; but before the contest was properly ended Dr. Davy was compelled by private affairs to leave England, and he abandoned his claim, being deterred by the prospect of expensive litigation. Mr. Ellery considered that Dr. Davy was the first who practically applied electricity to telegraph purposes. That he was the first inventor of the relay, no one who reads the evidence can doubt.

On the motion of Mr. Blackett, a sub-committee was appointed to consider the means to be adopted in recognition of Dr. Davy's great services to the cause of science, that sub-committee to consist of Mr. S. W. M'Gowan, Mr. J. Cosmo Newbery, Mr. C. R. Blackett, Professor Kernot, and Dr. Wilkie.

Mr. Ellery then read his paper on the "Rainfall Map of Victoria for 1882—a Contribution to Australian Meteorology."

Mr. Sutherland then read a paper on "The First Discoverers of the New Hebrides," describing the voyages of De Quiros in search of Terra Australis.

December 13*th*, 1883.

Present, the President (in the chair) and 15 members and associates.

A ballot was taken for the election of the following gentlemen, who were declared duly elected :—Mr. J. L. Morley, as a member; Mr. J. Thorne, as an associate; Mr. M. L. Bagge, as an associate.

The Standing Orders were then suspended, and Major Shakespear was elected a member, and Mr. Adam G. Shaw, an associate; these elections taking place without the usual nomination.

Messrs. Joseph and Gilbert were re-elected Auditors for the ensuing year.

Professor Kernot, as Chairman of the Committee formed to consider the claims of Dr. Davy, reported that, having consulted all the leading works on the subject, they were convinced that Dr. Davy had been instrumental in helping forward the development of the electric telegraph. At the same time, there were so many beside Dr. Davy following out the same line of investigation in 1838, that it was advisable to be cautious in assigning different degrees of merit to the various workers. The chief point in Dr. Davy's favour was that he was the first to form a distinct conception of the relay system. In view of this they advised that, in the meantime, Dr. Davy be elected as an honorary member of the Society, and that, in future, if he felt disposed to put forward any further claim in the matter, the best assistance of the Society should be rendered him. The report of the committee was adopted, and Dr. Davy was unanimously elected an honorary member.

Mr. G. W. Selby, junr., then read his paper on "Electricity as a Motive Power on Railways."

Mr. Behrendt illustrated the economy obtained by electricity as a motive-power by exhibiting a table of the different amount of work obtained for a given sum by the use of electricity and of steam.

Professor Kernot said that an ordinary locomotive weighed about forty tons, which made a great addition to the weight of a train, causing excessive wear and tear on the rails, necessitating the building of expensive bridges, and many other causes of expense in railways; these could all be avoided by the use of electricity. The number of men required on an electric railway was smaller than that required on a railway of the ordinary kind; still Professor Kernot did not think that electricity could be used for railways except in large cities.

Professor Kernot then read his paper on "Gas as a Motive Power."

Dr. MacGillivray's paper on "New, or Little Known, Polyzoa," Part VI., was laid on the table.

Mr. Ellery said that he had received many interesting letters on the subject of the recent red sunsets. He read an extract from one by Mr. Bosisto, who said that, about 700 miles from the Straits of Sunda, the vessel on which he was a passenger passed through a floating mass of pumice dust and ashes, with an occasional charred tree; similar circumstances had been reported by several ships. Mr. Ellery said that a very unusual state of the upper atmosphere seemed to exist in the northern as well as the southern hemisphere, for news had been received that in India the sun seemed green at setting. Mr. Norman Lockyer was said to have stated that these peculiar sunsets were due to the volcanic eruption at the Straits of Sunda; but Mr. Ellery considered that that explanation would not account for the facts. It would be strange if a volcano could alter the atmosphere all over the world. He believed that these sunsets were due principally to the presence of unusual quantities of vapour in the upper atmosphere.

LAWS.

I. The Society shall be called "The Royal Society of Victoria." Name.

II. The Royal Society of Victoria is founded for the advancement of science, literature, and art, with especial reference to the development of the resources of the country. Objects.

III. The Royal Society of Victoria shall consist of Members and Honorary Members, Corresponding Members and Associates, all of whom shall be elected by ballot. Members and Honorary Members.

IV. His Excellency the Governor of Victoria for the time being shall be requested to be the Patron of the Society. Patron.

V. There shall be a President, and two Vice-Presidents, who, with twelve other Members, and the following Honorary Officers, viz., Treasurer, Librarian, and two Secretaries of the Society, shall constitute the Council. Officers.

VI. The Council shall have the management of the affairs of the Society. Management.

VII. The Ordinary Meetings of the Society shall be held once in every month during the Session, from March to December inclusive, on days fixed by and subject to alteration by the Council with due notice. Ordinary Meetings.

VIII. In the second week in March there shall be a General Meeting, to receive the report of the Council and elect the Officers of the Society for the ensuing year. Annual General Meetings.

IX. All Office-bearers and Members of Council, except the six junior or last elected ordinary Members, shall retire from office annually at the General Meeting in March. The names of such Retiring Officers are to be announced at the Ordinary Meetings in November and December. The Officers and Members of Council so retiring shall be eligible for the same or any other office then vacant. Retirement of Officers.

Election of Officers.

X. The President, Vice-Presidents, Treasurer, Secretaries, and Librarian shall be separately elected by ballot (should such be demanded), in the above-named order, and the six vacancies in the Council shall then be filled up together by ballot at the General Meeting in March. Those members only shall be eligible for any office who have been proposed and seconded at the Ordinary Meeting in December, or by letter addressed to one of the Secretaries, and received by him before the 1st March, to be laid before the Council Meeting next before the Annual Meeting in March. The nomination to any one office shall be held a nomination to any office the election to which is to be subsequently held. No ballot shall take place at any meeting unless ten members be present.

Members in arrear.

XI. No Member whose subscription is in arrear shall take part in the election of Officers or other business of the meeting.

Inaugural address by the President.

XII. An Address shall be delivered by the President of the Society at either a Dinner, Conversazione, or extra meeting of the Society, as the Council for the time being may determine, not later than the Ordinary Meeting in June in each year.

Vacancies.

XIII. If any vacancy occur among the Officers, notice thereof shall be inserted in the summons for the next meeting of the Society, and the vacancy shall be then filled up by ballot.

Duties of President.

XIV. The President shall take the chair at all meetings of the Society and of the Council, and shall regulate and keep order in all their proceedings; he shall state questions and propositions to the meeting, and report the result of ballots, and carry into effect the regulations of the Society. In the absence of the President the chair shall be taken by one of the Vice-Presidents, Treasurer, or ordinary Member of Council, in order of seniority.

Duties of Treasurer.

XV. The Treasurer may, immediately after his election, appoint a Collector (to act during pleasure), subject to the approval of the Council at its next meeting. The duty of the Collector shall be to issue the Treasurer's notices and collect subscriptions. The

Treasurer shall receive all moneys paid to the Society, and shall deposit the same before the end of each month in the bank approved by the Council, to the credit of an account opened in the name of the Royal Society of Victoria. The Treasurer shall make all payments ordered by the Council on receiving a written authority from the chairman of the meeting. All cheques shall be signed by himself, and countersigned by one of the Secretaries. No payments shall be made except by cheque, and on the authority of the Council. He shall keep a detailed account of all receipts and expenditure, present a report of the same at each Council Meeting, and prepare a balance-sheet to be laid before the Council, and included in its Annual Report. He shall also produce his books whenever called on by the Council.

XVI. The Secretaries shall share their duties as they may find most convenient. One or other of them shall conduct the correspondence of the Society and of the Council, attend all meetings of the Society and of the Council, take minutes of their proceedings, and enter them in the proper books. He shall inscribe the names and addresses of all Members in a book to be kept for that purpose, from which no name shall be erased except by order of the Council. He shall issue notices of all meetings of the Society and of the Council, and shall have the custody of all papers of the Society, and, under the direction of the Council, superintend the printing of the Transactions of the Society. Duties of Secretaries.

XVII. The Council shall meet on any day within one week before every Ordinary Meeting of the Society. Notice of such meeting shall be sent to every Member at least two days previously. No business shall be transacted at any meeting of the Council unless five Members be present. Any Member of Council absenting himself from three consecutive meetings of Council, without satisfactory explanation in writing, shall be considered to have vacated his office, and the election of a Member to fill his place shall be proceeded with at the next Ordinary Meeting of Members, in accordance with Law XIII. Meetings of Council. Quorum.

Special Meetings of Council.

XVIII. One of the Secretaries shall call a Special Meeting of Council on the authority of the President or of three Members of the Council. The notice of such meeting shall specify the object for which it is called, and no other business shall be entertained.

Special General Meetings.

XIX. The Council shall call a Special Meeting of the Society, on receiving a requisition in writing signed by twenty-four Members of the Society specifying the purpose for which the meeting is required, or upon a resolution of its own. No other business shall be entertained at such meeting. Notice of such meeting, and the purpose for which it is summoned, shall be sent to every Member at least ten days before the meeting.

Annual Report.

XX. The Council shall annually prepare a Report of the Proceedings of the Society during the past year, embodying the balance-sheet, duly audited by two Auditors, to be appointed for the year, at the Ordinary Meeting in December, exhibiting a statement of the present position of the Society. This Report shall be laid before the Society at the Annual Meeting in March. No paper shall be read at that meeting.

Expulsion of Members.

XXI. If it shall come to the knowledge of the Council that the conduct of an Officer or a Member is injurious to the interest of the Society, and if two-thirds of the Council present shall be satisfied, after opportunity of defence has been afforded to him, that such is the case, it may call upon him to resign, and shall have the power to expel him from the Society, or remove him from any office therein at its discretion. In every case all proceedings shall be entered upon the minutes.

Election of Members and Associates.

XXII. Every candidate for election as Member or as Associate shall be proposed and seconded by Members of the Society. The name, the address, and the occupation of every candidate, with the names of his proposer and of his seconder, shall be communicated in writing to one of the Secretaries, and shall be read at a meeting of Council, and also at the following meeting of the Society, and the ballot shall take place at the next following Ordinary Meeting of the Society.

The assent of at least five-sixths of the number voting shall be requisite for the admission of a candidate.

XXIII. Every new Member or Associate shall receive due notice of his election, and be supplied with a copy of the obligation,* together with a copy of the Laws of the Society. He shall not be entitled to enjoy any privilege of the Society, nor shall his name be printed in the List of Members, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligation signed by himself. He shall at the first meeting of the Society at which he is present sign a duplicate of the obligation in the Statute Book of the Society, after which he shall be introduced to the Society by the Chairman. No Member or Associate shall be at liberty to withdraw from the Society without previously giving notice in writing to one of the Secretaries of his intention to withdraw, and returning all books or other property of the Society in his possession. Members and Associates will be considered liable for the payment of all subscriptions due from them up to the date at which they give written notice of their intention to withdraw from the Society.

Members shall sign Laws.

Conditions of Resignation.

XXIV. Gentlemen not resident in Victoria, who are distinguished for their attainments in science, literature, or art, may be proposed for election as Honorary Members, on the recommendation of an absolute majority of the Council. The election shall be conducted in the same manner as that of ordinary Members, but nine-tenths of the votes must be in favour of the candidate.

Honorary Members.

XXV. Members of the Society, resident in Melbourne, or within ten miles thereof, shall pay two guineas annually, Members residing beyond that dis-

Subscriptions.

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* The obligation referred to is as follows :—

Royal Society of Victoria.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of Victoria, and to observe its laws, as long as I shall remain a Member or Associate thereof.

(Signed)

Address

Date

tance and Associates shall pay one guinea annually. The subscriptions shall be due on the 1st of January in every year. At the commencement of each year there shall be hung up in the Hall of the Society a list of Members and Associates, upon which the payments of their subscriptions as made by Members and Associates shall be entered. During July notice shall be sent to Members and Associates still in arrears. At the end of each year a list of those who have not paid their subscriptions shall be prepared, to be considered and dealt with by the Council.

Entrance fees, &c.

XXVI. Newly elected Members shall pay an entrance fee of two guineas, in addition to the subscription for the current year. Newly elected Associates shall not be required to pay any entrance fee. Those elected after the 1st of July shall pay only half of the subscription for the current year. If the entrance fee and subscription be not paid within one month of the notification of election, a second notice shall be sent, and if payment be not made within one month from the second notice, the election shall be void.

Life Membership.

Members resident in Melbourne, or within ten miles thereof, may compound for all Annual Subscriptions of the current and future years by paying £21; and Members residing beyond that distance may compound in like manner by paying £10 10s. Associates on seeking election as Members shall have to comply with all the forms requisite for the election of Members, and shall pay an entrance fee of two guineas.

Durations of Meetings.

XXVII. At the Ordinary Meetings of the Society the chair shall be taken punctually at eight o'clock, and no new business shall be taken after ten o'clock.

Order and mode of conducting the business.

XXVIII. At the Ordinary Meetings business shall be transacted in the following order, unless it be specially decided otherwise by the Chairman :—

- Minutes of the preceding meeting to be read, amended if incorrect, and confirmed.
- New Members to enroll their names, and be introduced.
- Ballot for the election of new Members.
- Vacancies among officers, if any, to be filled up.
- Business arising out of the minutes.
- Communications from the Council.

Presents to be laid on the table, and acknowledged.
Motions, of which notice has been given, to be considered.
Notices of motion for the next meeting to be given in and read by one of the Secretaries.
Papers to be read.

XXIX. No stranger shall speak at a meeting of the Society unless specially invited to do so by the Chairman. Strangers.

XXX. At no meeting shall a paper be read, or business entertained, which has not been previously notified to the Council. What business may be transacted.

XXXI. The Council may call additional meetings whenever it may be deemed necessary. Additional Meetings.

XXXII. Every Member may introduce two visitors to the meetings of the Society by orders signed by himself. Visitors.

XXXIII. Members and Associates shall have the privilege of reading before the Society accounts of experiments, observations, and researches conducted by themselves, or original papers, on subjects within the scope of the Society, or descriptions of recent discoveries, or inventions of general scientific interest. No vote of thanks to any Member or Associate for his paper shall be proposed. Members may read papers.

XXXIV. If a Member or Associate be unable to attend for the purpose of reading his paper, he may delegate to any Member of the Society the reading thereof, and his right of reply. Or depute other Members.

XXXV. Any Member or Associate desirous of reading a paper shall give in writing to one of the Secretaries, ten days before the meeting at which he desires it to be read, its title and the time its reading will occupy. Members must give notice of their papers.

XXXVI. The Council may permit a paper such as described in Law XXXIII., not written by a Member of the Society, to be read, if for any special reason it shall be deemed desirable. Papers by strangers.

XXXVII. Every paper read before the Society shall be the property thereof, and immediately after it has Papers belong to the Society.

been read shall be delivered to one of the Secretaries, and shall remain in his custody.

Papers must be original.

XXXVIII. No paper shall be read before the Society or published in the Transactions unless approved by the Council, and unless it consist mainly of original matter as regards the facts or the theories enunciated.

Council may refer papers to Members.

XXXIX. Should the Council feel a difficulty in deciding on the publication of a paper, the Council may refer it to any Member or Members of the Society, who shall report upon it.

Rejected papers to be returned.

XL. Should the Council decide not to publish a paper, it shall be at once returned to the author.

Members may have copies of their papers.

XLI. The author of any paper which the Council has decided to publish in the Transactions may have any number of copies of his paper on giving notice of his wish in writing to one of the Secretaries, and on paying the extra cost of such copies.

Members to have copies of Transactions.

XLII. Every Member and Associate whose subscription is not in arrear, and every Honorary Member, is entitled to receive one copy of the Transactions of the Society as published. Newly elected Members shall, on payment of their entrance fee and subscription, receive a copy of the volume of the Transactions last published.

Property.

XLIII. Every book, pamphlet, model, plan, drawing, specimen, preparation, or collection presented to or purchased by the Society, shall be kept in the house of the Society.

Library.

XLIV. The Library shall be open to Members and Associates of the Society and the public at such times and under such regulations as the Council may deem fit.

Legal ownership of property.

XLV. The legal ownership of the property of the Society is vested in the President, the Vice-Presidents, and the Treasurer for the time being, in trust for the use of the Society; but the Council shall have full control over the expenditure of the funds and management of the property of the Society.

Committees elect Chairman.

XLVI. Every Committee appointed by the Society shall at its first meeting elect a Chairman, who shall subsequently convene the Committee and bring up its report. He shall also obtain from the Treasurer such grants as may have been voted for the purposes of the Committee.

XLVII. All Committees and individuals to whom any work has been assigned by the Society shall present to the Council, not later than the 1st November in each year, a report of the progress which has been made; and, in cases where grants of money for scientific purposes have been entrusted to them, a statement of the sums which have been expended, and the balance of each grant which remains unexpended. Every Committee shall cease to exist on the 1st November, unless re-appointed. Report before November 1st.

XLVIII. Grants of pecuniary aid for scientific purposes from the funds of the Society shall expire on the 1st November next following, unless it shall appear by a report that the recommendations on which they were granted have been acted on, or a continuation of them be ordered by the Council. Grants expire.

XLIX. In grants of money to Committees and individuals, the Society shall not pay any personal expenses which may be incurred by the Members. Personal expenses not to be paid.

L. No new law, or alteration or repeal of an existing law, shall be made except at the General Meeting in March, or at a Special General Meeting summoned for the purpose, as provided in Law XIX., and in pursuance of notice given at the preceding Ordinary Meeting of the Society. Alteration of laws.

LI. Should any circumstance arise not provided for in these laws, the Council is empowered to act as may seem to be best for the interests of the Society. Cases not provided for.

LII. In order that the Members and Associates of the Society prosecuting particular departments of science may have opportunities of meeting and working together with fewer formal restraints than are necessary at the Ordinary Meetings of the Society, Sections may be established. Sections.

LIII. Sections may be established for the following departments, viz.:— Names and number of Sections.

Section A. Physical, Astronomical, and Mechanical Science, including Engineering.

Section B. Chemistry, Mineralogy, and Metallurgy.
Section C. Natural History and Geology.
Section D. The Microscope and its applications.
Section E. Geography and Ethnology.
Section F. Social Science and Statistics.
Section G. Literature and the Fine Arts, including Architecture.
Section H. Medical Science, including Physiology and Pathology.

Meetings of Sections.

LIV. The meetings of the Sections shall be for scientific objects only.

Members of Sections.

LV. There shall be no membership of the Sections as distinguished from the membership of the Society.

Officers of Sections.

LVI. There shall be for each Section a Chairman to preside at the meetings, and Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to one of the Secretaries of the Society, prior to the 1st of November in each year, a report of the Proceedings of the Section during that year, and such report shall be submitted to the Council.

Mode of appointment of Officers of Section.

LVII. The Chairman and the Secretary of each Section shall be appointed at the first meeting of the Council after its election in March, in the first instance from Members of the Society who shall have signified to one of the Secretaries of the Society their willingness to undertake these offices, and subsequently from such as are recommended by the Section as fit and willing.

Times of meetings of Sections.

LVIII. The first meeting of each Section in the year shall be fixed by the Council; subsequently the Section shall arrange its own days and hours of meeting, provided these be at fixed intervals.

Corresponding Members.

LIX. The Council shall have power to propose gentlemen not resident in Victoria, for election in the same manner as ordinary Members, as Corresponding Members of the Society. The Corresponding Members shall contribute to the Society papers which may be received as those of ordinary Members, and shall in return be entitled to receive copies of the Society's publications.

LX. Associates shall have the privileges of Members in respect to the Society's publications, in joining the Sections, and at the Ordinary Meetings, with the exception that they shall not have the power of voting; they shall also not be eligible as Officers of the Society. Privileges of Associates.

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TRANSACTIONS

AND

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