TRANSACTIONS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR THE YEAR 1870.

SYDNEY:
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1871.

ROYAL SOCIETY

OF NEW SOUTH WALES.

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OFFICERS FOR 1870.

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President:

HIS EXCELLENCY THE RIGHT HON. THE EARL OF BELMORE.

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FUNDAMENTAL RULES.

Objects of the Society,

1. The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

President.

2. The Governor of New South Wales shall be *ex officio* the President of the Society.

Other Officers.

3. The other Officers of the Society shall consist of two Vice-Presidents, a Treasurer, and two or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers.

4. The Vice-Presidents, Treasurer, Secretaries, and the six other Members of Council, shall be elected annually at a General Meeting in the month of May.

Vacancies during the Year.

5. Any vacancies occurring in the Council of Management, during the year, may be filled up by the Council.

Fees.

6. The entrance money paid by members on their admission shall be One Guinea; and the annual subscription shall be One Guinea, payable in advance.

The sum of Ten Pounds may be paid at any time as a composition for the ordinary annual payment for life.

Honorary Members.

7. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, or distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions, they may attend the meetings of the Society, and they shall be furnished with copies of transactions, and proceedings, published by the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

Confirmation of Bye-Laws.

8. Bye-Laws proposed by the Council of Management shall not be binding until ratified by a General Meeting.

Alteration of Fundamental Rules.

9. No alteration of or addition to the Fundamental Rules of the Society shall be made, unless carried at two successive General Meetings.

BYE-LAWS.

Ordinary Meetings.

1. An Ordinary Meeting of the Royal Society, to be convened by Public Advertisement, shall take place at 8 p.m., on the first Wednesday in every month, during the last eight months of the year. These Meetings will be open for the reception of contributions, and the discussion of subjects of every kind, if brought forward in conformity with the Fundamental Rules and Bye-Laws of the Society.

Council Meetings.

2. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Contributions to the Society,

3. Contributions to the Society of whatever character, must be sent to one of the Secretaries, to be laid before the Council of Management. It will be the duty of the Council to arrange, for promulgation and discussion at an Ordinary Meeting, such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society,

Ordinary Members.

4. Candidates for admission as Ordinary Members to be proposed and seconded at one of the stated meetings of the Society. The vote on their admission to take place, by ballot, at the next subsequent meeting; the assent of the majority of the Members voting at the latter meeting being requisite for the admission of the Candidate.

New Members to be notified of their Election.

5. Every Member shall receive due notification of his election, together with a Copy of the Fundamental Rules and Bye-Laws of the Society.

Introduction of New Members to the Society.

6. Every Candidate duly elected as Member should, on his first attendance at a meeting of the Society, be introduced to the Chair, by his proposer or seconder, or by some person acting on their behalf.

Annual Subscriptions, when due.

7. Annual Subscriptions shall become due on the first of May for the year then commencing. The Entrance Fee and first year's Subscription of a New Member shall become due on the day of his election.

Members whose Subscriptions are not paid to enjoy no privileges.

8. Members will not be entitled to attend the Meetings or to enjoy any of the privileges of the Society until their Entrance Fee and Subscription for the year have been paid.

Subscriptions in arrears.

9. Members who have not paid their subscriptions for the current year, shall be informed of the fact by the Treasurer. If, thirty days after such intimation, any are still indebted, their names will be formally laid before the Society at the first Ordinary Meeting. At the next Ordinary Meeting, those whose Subscriptions are still due, will be considered to have resigned.

Expulsion of Members.

10. A majority of Members present at any Ordinary Meeting, shall have power to expel an obnoxious Member from the Society, provided that a resolution to that effect has been moved and seconded at the previous Ordinary Meeting, and that due notice of the same has been sent in writing to the Member in question, within a week after the Meeting at which such resolution has been brought forward.

Admission of Visitors.

11. Every Ordinary Member shall have the privilege of admitting one friend as a Visitor to an Ordinary Meeting of the Society, on the following conditions:—

1. That the name and residence of the Visitor, together with the name of the Member introducing him, be entered in a book at the time.
2. That the Visitor does not permanently reside within ten miles of Sydney, and,
3. That he shall not have attended two meetings of the Society in the current year.

The Council shall have power to introduce Visitors, irrespective of the above restrictions.

Management of Funds.

12. The Funds of the Society shall be lodged at a Bank, named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

Audit of Accounts.

13. Two Auditors shall be appointed annually at an Ordinary Meeting to audit the Treasurer's Accounts. The Accounts as audited to be laid before the Annual Meeting in May.

LIST OF MEMBERS

OF THE

Royal Society of New South Wales.

Adams, P. F., Surveyor General.
Allen, George, the Hon., M.L.C., Toxteth Park, Glebe.
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Allwood, Rev. R., King-street.
Allerding, F., Hunter-street.
Armstrong, Walter Dickinson, Macquarie-street.

Barker, Thomas, Maryland, near Liverpool.
Bell, Edward.
Bedford, Edward, Castlereagh-street.
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Beilby, E. T., Macquarie-street.
Bell, William, Pitt-street.
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Berry, Alexander, North Shore,
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Bode, Rev. G., Macquarie Street.
Boyd, Dr., Lyons' Terrace.
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Brereton, Dr., O'Connell-street.

Campbell, The Hon. Charles, Pine Villa, Newtown.
Cape, W. F., Pitt-street.
Cane, Alfred, Stanley-street.
Clarke, Rev. W. B., St. Leonards, North Shore.
Cox, Dr. James, Hunter-street.
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Cracknell, E. C., Telegraph Office, George-street.

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Croudace, Thomas, Lambton.

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Deffell, G. H., Elizabeth-street.
Docker, Joseph, the Hon., M.L.C., Australian Club.

Elliott, F. W., Pitt-street.

Fairfax, John, *Herald* Office.
Fairfax, J. R , *Herald* Office.
Faithful, G. E., Australian Club.
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Francis, Judge.
Fraser, Collin, M.P., Australian Club, or Bannockburn, New England.

Gardiner, Martin, C.E., Gordon Terrace, Liverpool-street, East,
Garran, Dr., Andrew, Phillip-street.
Goodlet, J., 124, Erskine-street.
Gowlland, John, R.N., North Shore.
Goodchap, Charles, Civil Service Club,
Graham, Rev. John.
Gray, Samuel W., Wollumben, Tweed River, *via* Cassino.

Halloran, Henry, Colonial Secretary's Office.
Hale, Thomas, Exchange.
Hill, F. W., General Post Office.
Hill, Edward, Rose Bay. (Life.)
Hill, Rowland, Joint Stock Bank.
Holden, G. K., Land Titles' Office.
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Hovell, Captain, Goulburn.
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Jones, Dr. Sydney, College-street
Josephson, Judge, King-street.

Kean, William, Union Club.
Krefft, Gerard, Museum, College-street.

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Leibius, Dr. Adolph, Royal Branch Mint.
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Macarthur, the Hon., Sir William, M.L.A.
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Manning, John Edye, Circular Quay.
Mansfield, G. A., Pitt-street.
Mayes, Charles, Pitt-street.
McDonnell, William J., George-street.
McDonnell, William, George-street.
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Miles, Charles, 54, Upper William-street.
Mitchell, D. P , Cumberland-street.
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Morell, G. A., Phillip-street.
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Nathan, Charles, Macquarie-street.

Paterson, Dr., Elizabeth-street, North.
Paterson, Hugh, Macquarie-street.
Pell, Professor, Sydney University.
Phillips, Captain, Pacific Insurance Company.
Pilcher, Charles Edward, King-street.
Prince, Henry, George-street.

Ramsay, Edward, (life) Dobroyde.
Reading, E., Phillip-street.
Reed, Howard, Pott's Point.
Renwick, Dr. Arthur, Elizabeth-street.
Richardson, A. H., George-street.
Roberts, J., George-street.
Roberts, Alfred, Castlereagh-street.
Rolleston, Christopher, Auditor-General.
Ross, J. G., 193, Macquarie-street.
Rowe, Thomas, Pitt-street.
Russell, Henry, Sydney Observatory.

Scott, Rev. William, (life) Warden of St. Paul's College.
Scott, J. H. L., Civil Service Club.
Senior, F., George-street.
Smith, Professor, M. D., Sydney University.
Spencer, Walter W., Pitt-street South.

Tebbutt, John, Junr., Parramatta.
Thomson, E. Deas, the Hon., M.L.C., C.B.
Thomson, Professor, Sydney University.
Thompson, James, Treasury.
Thomson, H. A., Pitt-street.
Tooth, Frederick, Parramatta-street.
Tucker, William, Clifton, North Shore.
Tunks, William, M. P., North Shore.
Twynam, E., Goulburn.

Walker, William, Windsor.
Ward, R. D., North Shore.
Watt, Charles, Parramatta.
Walker, P. B., Telegraph Office, George-street.
Wallis, William, Bank Auction Rooms, George-street.
Weigall, A. B., Head Master, Sydney Grammar School.
Williams, Dr., Macquarie-street.
Williams, J. P., New Pitt-street.

CONTENTS.

ANNIVERSARY ADDRESS,

Delivered 25th May, 1870, by the Rev. W. B. Clarke, M.A., F.G.S., &c., Vice-President.

GENTLEMEN OF THE ROYAL SOCIETY,—

Some remarks towards the close of last year's Address indicated a hope, that on the present occasion my place would be filled by a younger and more active member of our body.

But, having received from the Council an intimation, that some inconvenience may arise, unless I again venture into the field, I propose to notice a few of the topics which it may be advisable to consider at this first meeting of a new year.

We may, I believe, congratulate each other on the fact elicited by the Treasurer's Report, that we are not in debt, which, as times go, may be held to be a condition of comparative prosperity. But we are still unable to meet certain demands which must be met, if we would carry out the views which on former occasions have been spoken of.

Our Volume for the session of 1868 is now published; but it lacks an abstract of our discussions, and contains no illustrations. These will, however, be necessary for the Volume of 1869, now in the press, and others may be required in subsequent years.

In some of the Scientific Societies at home, the funds are supplemented by the authors of communications, when the papers are of a nature to require considerable expense.

It has occurred to myself, to be charged in this way for a lithographic plate, appended to a paper describing some portion of the geology of New South Wales, and for that plate, I paid more than £12 sterling. Of course I was allowed such copies of the plate as I required.

It strikes me, that unless our Exchequer obtains an increase, we shall have to follow the example of our friends at home; but it must also be borne in mind, that, unless some arrangement is made by which such an expense can be justified, either a contributor or the Society itself may be a loser in another way.

It will be readily understood, that the ordinary printing of some communications may be of such an intricate character, that our expenses may even, without illustrations, be much enhanced. It appears to be, therefore, deserving of the attention of the Council, in what way a difficulty of the kind is to be encountered. And when I recall the subjects which were discussed during our last session, I feel assured you will not consider the remarks just made otherwise than as directed to the advancement of the Society. To do full justice to some of the papers presented to us, would require an amount of illustration which our funds would not justify, though it may do an injustice to the authors, to refuse them the advantage.

I would go further and say, that a Goverment grant of a moderate kind would be usefully and constitutionally expended in assisting our exertions to perform what I am satisfied we are performing, a very important service to the community. The papers read in 1869 will justify this opinion.

In the list are some excellent communications entirely dedicated to Colonial interests, and by enumerating them with the divisions to which they belong, we find there were under the following heads:—

On Law...	1
Mathematics	4
Telegraphy	1
Geology	1
Metallurgy	2
Meteorology	3
Ethnology	3

Titles of the Same.

1. Opening Address, by Rev. W. B. Clarke, M.A., V.P., May 12th.

2. "A Review of the Progress of Lands Titles, Registration in New South Wales," by G. K. Holden, Esq. May 12th.
3. "Analytical Solution to Sir William Hamilton's Problem, on the inscription of closed *n gons in any quadric*," by Martin Gardiner, Esq. June 2nd.
4. "Important new theorem in the Geometry of three dimensions," by Martin Gardiner, Esq. June 2nd.
5. "An Exposition of the American Method of Levelling for Sections—its superiority to the English and French Methods as regards actual field practice, and subsequent plotting of the Section," by Martin Gardiner, Esq. June 2nd.
6. "On the Electric Telegraph between England and India, and how to connect the Australian Colonies, with the Telegraphic Systems of Europe and America," by E. C. Cracknell, Esq. July 14th.
7. "On the Geological Structure of the country around Goulburn," by Professor Alexander M. Thomson, D. S. August 5th.
8. "On the Origin and Migrations of the Polynesian Nation, demonstrating their discovery and progressive settlement of the Continent of America, (Part 1,) by the Rev. J. D. Lang, D.D. November 3rd.

Continued in Part II on November 3rd.
And in Part III on December 8th.

9. "Improved Solutions to Important Problems in Trigonometrical Surveying," by Martin Gardiner, Esq. October 6th.
10. "On the Water Supply of Sydney from George's River and Cook's River," by Charles Mayes, Esq. November 17th.
11. "On the Results of the Chemical Examination of Waters for the Sydney Water Commission," by Professor Smith, M.D. November 17th.
12. "On Gold Refining by means of Chlorine Gas," by F. B. Miller, Esq. (Sydney Mint.) December 1st.
13. "On a New Apparatus for reducing Chloride of Silver," by Dr. Leibius, (Sydney Mint). December 1st.
14. "Remarks on Tables for calculating the Humidity of the Air," by H. C. Russell, Esq., Government Astronomer. December 8th.

I do not know whether any previous session of this, or of the previous Philosophical Society, has ever exhibited a heartier desire to turn the channel of our thoughts more freely towards practical results, than the last; and the thanks of our body generally are due to those members of it, who laid before us their able researches in the various branches of Science and Literature which they have cultivated, for such advancement of the claim which this Society has to the respect and support of the community

No one can justly accuse us of wasting our time in idle speculations realising nothing of lasting value, who looks down the list which I have read to-night. I trust I shall be pardoned if I dwell for a moment on one or two of them, especially that which has suggested a reference in another direction.

It is but a duty to my friend Professor Thomson (without intending, however, anything invidious in the selection of his paper), to say, that he has done himself great credit by his survey of the County of Argyle, of which I can speak with some kind of authority, having myself examined and reported on considerable portions of it on various occasions.

Yet, that is not the motive which induces this reference. I would wish to point out what is a desideratum in the future geological mapping of the colony. It is a well-known remark, that where Topography is deficient, Geology depicted must be imperfect. Unless the physical features of a district are faithfully delineated, it is impossible to assign accurate boundaries to the various formations. It is not the business of the geologist to undertake the work of the ordinary surveyor; any more than belongs to a house-painter to form the frame work of the doors and windows he is called on to decorate.

The work of Geology, therefore, is hindered in these colonies, by want of carefully defined features of the country; in saying which, I mean to infer no *inaccuracy* in that work which has been so well performed in the various Survey departments.

In the course of correspondence with gentlemen employed in Geological surveying, I have met with continual allusion to what is wanted by them. In all truth it must be said, that many of the maps of different parts of Australia are altogether blanks, and yet the 19 Counties map of Sir Thomas Mitchell (with some few errata), and some other charts from the same office by his successors, show what can be done in the colony.

At this time a geologist in France, a friend of my own, is engaged in making a Geological map of the World; but, it is easy to perceive, that the boundaries in various countries will, of necessity, be very much distorted.

When, however, a Government geologist has to make a Topographical survey before he commences his appropriate duties, he loses time, incurs the displeasure of the public who always want men to run before they can walk, and finally brings upon himself the undeserved charge of not "earning his salt."

There is no doubt, that an influence of this kind operated in the case of the late survey of Victoria, which has been abandoned; an example followed, I regret to say, in Queensland, to the Government of which I had the privilege of recommending two excellent surveyors who, in spite of topographical difficulties, have done some admirable work. The only Official Survey now going on is in Western Australia, to the Government of which I had the further privilege of recommending the gentleman who was employed originally in the survey of Tasmania now also abandoned.* I am inclined to suspect, that, although much has been accomplished in those Colonies, more would have been done had full Topographical feature charts previously existed. We are, therefore, entitled to anticipate great results from the Trigonometrical Survey, that has been commenced under the auspices of the Astronomer of New South Wales, whose report we look for with much anxiety. I would further wish to speak with great respect, of the efforts made by the present Surveyor-General, to encourage the study of Geology among the younger officers of his department by attaching to it a museum and library of reference and by recommending their attendance on the lectures at the University.

It will be remembered, that after Dr. Thomson had read his paper on Argyle, some discussion took place respecting the

* Mr. C. Gould, to whom reference is made, was succeeded by Mr. Brown, formerly on the Survey of Victoria.

character of certain granitic rocks which I endeavoured to explain as the result of transmutation. The idea of seeming *stratification* in such rocks, was a novelty to some who spoke on that occasion. It may serve the purpose of fuller exposition, to mention, that since that discussion Professor Montagna's observations have been made known. In his work, published at Naples in 1869, the author proposes a new theory of "*Metamorphism founded on the fossilisation of animals and plants.*" He states that he has discovered in granite portions of coal-measure Lepidodendron, and in porphyry and serpentine *L. sexangulare.* Casts of Asterophyllites and Stigmaria have been also found by him in all kinds of the rock named. If (as he suggests) a new arrangement of rocks, according to such discoveries, is to be brought about, Geological science may be hastening to a development which will cast many long-cherished theories to the winds.

DISCOVERY OF DIAMONDS IN NEW SOUTH WALES,—OPINIONS AS TO THEIR ORIGIN.

Connected with coal plants in transmuted deposits, there has arisen another enquiry amongst ourselves, as to the probable origin of the Diamond. How has the Diamond been produced, and to what Geological formation does it belong, are questions which have had various replies. Although we may not be able to solve the mystery, it may, perchance, be not uninteresting to review the statements that have been put forth by different authorities, now the public mind in Australia is excited by accounts of increasing discoveries of the precious gem in New South Wales.

It appears that I did not miscalculate, when, in 1860, I headed a notice of five diamonds that had come into my hands, *New South Wales a Diamond country* ("Southern Gold Fields," p. 272); for, up to the present time, several thousands have been brought to light. In some valuable papers by Mr. Norman Taylor, and in a report of similar character by Prof. Thomson of our University, may be found a clear exposition of the phenomena presented in the diamond field at Two-mile Flat on the

Cudgegong River, which these gentlemen have recently explored and described.*

The opinions expressed by them are to the effect, that the Diamond district is limited to the presence of an ancient drift deposit covered generally by basaltic rocks, and that when found in the river bed, or in alluvial soil, the diamonds are frequently scratched and broken, whilst in the drift alluded to they are found intact. And at the points where they are thus found in the river bed, they are so found in consequence of the tailings of the miners having been washed thereto.

The river having changed its course, the area referred to is merely an alluvial space at one of those points.

The general formations of more ancient date in the vicinity, are considered to be Upper Silurian traversed by greenstone, with overlying carboniferous beds as outliers of more extended strata. Mr. Norman Taylor has suggested, that the Diamonds have been in some way derived from the carbon in the Coal measures. Opinions as to the derivation of Diamond from vegetable matter by a process of distillation, somewhat like that to which coal is due, and even from animal matter capable of supplying carbon, have been long held by certain philosophers.

Considering the facts glanced at before,† relating to the transmutation of rocks by heat and other agencies, the formation of Diamond in the humid way does not appear to me an extravagant supposition. But, on examining the sand or deposit in which the Cudgegong Diamonds are found, I was struck with the amount of minute gems, such as zircon, topaz, sapphire, corundum, spinel, pleonaste, &c., which compose the finely sifted material in which gold is also found; and Mr. Norman Taylor dwells on the circumstance, that the Diamond is not only associated with the gold (as in most other foreign localities), but with those gems which are held to have had an igneous origin,

* A paper subsequently read before the Royal Society, will be found in the present Volume.

† "On the Transmutation of Rocks in Australasia," by Rev. W. B. Clarke, M.A.; read before the Philosophical Society of N.S.W., 10th May, 1865, (T. P. S. p. 266).

occurring as they do in rocks which are so denominated; and in some cases (I may add) in true lava of modern volcanos.

But, before I go further into this question, I must digress, in order to explain, that though Diamond is thus associated, on the Cudgegong and on the Macquarie, as at Suttor's Bar, yet there are in my knowledge hundreds of spots throughout the length and breadth of Australia, where the same gems are found in as great abundance, often of much larger proportions, with or without gold and without a trace of the existence of Diamond. I have found them myself in this way in a variety of places in this and the neighbouring colonies, in an area which I do not exaggerate, when I call it a hundred thousand square miles; and within the last year I have received thousands of such gems from correspondents and visitors who have consulted me, without finding among them more than a few Diamonds and but ten independent of the present produce from Two Mile Flat and Suttor's Bar.

Those ten were found not far from Bingera, and are the first fruits of a new locality. They were accompanied by zircon, larger than any found with Diamonds on the Cudgegong, but also with very small crystallisations of the same mineral and quartz. The friend to whom I am indebted for the examination of these Diamonds, is encouraging a search for more. I may add, that I have seen no Diamond from Cudgegong exactly resembling those from Bingera.

I have received also two Diamonds said to be found near Kangaloon, on the Mittagong Range; but, as many other minerals which are probably not indigenous there, have also been forwarded from the same neighbourhood, I have much hesitation in accepting the statements made.

A further announcement was made to me in 1870, of Diamonds on the Darling, a few miles from Fort Bourke, but on examining a large collection of the pebbles consigned to the Commercial Banking Company as "Diamonds" and "precious stones," I found that they were all varieties of silica [quartz, jasper, agate, chalcedony,] with small highly polished fragments of fossil wood and other drift.

Probably no other person has had more experience of this kind than myself, for I have at times been almost overwhelmed with applications, personally or in writing, upon the subject. Dr. Thomson has also had his own experience of similar occupation, and, in many instances, is well able to confirm my statement.

One might almost fancy, that colonists were going mad in the search for Diamonds; and yet one digger confessed to me, that from the labour of six men employed for six years, he had only obtained three Diamonds which were of small size.

Without wishing, then, to dishearten any diligent man who is, whilst anxious to serve himself, doing his utmost to develop the resources of the country, it is surely only right to warn any who have only their personal labour and privations to look to, against embarking in a search which, to be successful, requires ample means, union of energies and machinery.

Moreover, the Diamonds hitherto found have been but of little commercial value; and as to the other gems, I believe they have realised scarcely any sale at all. Capital and time and contrivances may, however, hereafter meet with a successful find.

Some of the inquirers as to Diamonds, have deserved a less encouraging reception than this. It is with no unkind feeling that I mention (merely to show the speculative character of the present *furore*), that amongst the stones forwarded for examination, have been found pieces of common glass, portions of chandeliers or bottle-stoppers, and some of these have been disguised by grinding and colouring by paint.

With what object, persons supposed to hold respectable positions in life, could have condescended to such a device, merely to give trouble to those who have voluntarily given their time and experience to oblige them, is difficult to imagine. It seems to me to be an unworthy reward for wasted patience, and, not unfrequently, unreturned postage stamps and other expenses.

Many times have pebbles of quartz—such as the one rendered famous by the Townsend imposture—been forwarded, in the hope that they would be pronounced Diamonds; but I am persuaded, that, save in the Townsend case, there has been no intention to deceive in that way, and that the senders were merely under wrong impressions. A real digger has no object in imposture. Such cannot be said for the glass-grinders, who were sometimes more transparent than the material they had manipulated.

So much for this episode. Let us now go back to the Diamond, and endeavour to ascertain some particulars relating to its history.

On the Cudgegong there are five principal places where the mineral is found. They occur at various depths from the surface, greenstone in some instances having caused the formation of unequal hollows for the collection of drift. The intrusive rock follows the strike of the older rocks, which is about N. 25° W.

The older drift has been since covered by a basaltic flow, which in turn has suffered from the denudation that has spread the drift, so producing a younger drift, to which Mr. Norman Taylor assigns the term Newer Pliocene, in contrast with the older. This designation is, no doubt, due to his Victorian practice. The basalt he compares with that of the Coliban River in Victoria, which from my own personal knowledge of that locality, I can confirm.

The Carboniferous rocks have not furnished much detritus to the older drifts; but such occurs abundantly in the river bed. A still more recent wash of drift occurs on the present surface.

Mr. Taylor very properly presents to notice a difficulty which has been hinted at already.

If the Diamonds were derived from the Carboniferous rocks, why are they not found in the river bed, except where the tailings of the miners have been washed in? From all the evidence arrived at, the newer drift is derived from the older, and with them is associated a cement of quartz and altered rock held by a yellowish green silicate of iron and hydroxide of iron, from hand specimens of which I have myself taken gold. Mr. Taylor says it contains Diamonds also.

Many of the pebbles, which are of quartz and very hard flinty altered rock, have long attracted my attention, on account of the glaze or polish which they wear. They have exactly the outward coating which distinguishes so many of the surface pebbles found in the very heart of the interior of Australia, traversed by Sturt, M'Kinlay, and Burke and Wills. What may have been the way in which these pebbles have been polished, is not easy to be discovered. Iron sand, or, better still, perhaps gem sand, in violent motion, may have been the agent, since we know granite rocks in sandy deserts are polished by sand-flows far from water. It has been suggested, that the polish arises from the action of silicated water, as the hollows in the pebbles are as smooth as the general surface. But they are only in the condition of the greatest part of the surface drift all over the interior of New Holland. Unless, therefore, we assume, that a flood of silicated water has covered the greater part of New Holland, we cannot so explain the phenomenon.* If, on the other hand, the gems and the iron belong to the basaltic rocks, and if these are younger than the cement, such an explanation can only be accepted in connection with a much more distant origin for the pebbles than any local strata. The older drift, therefore, cannot have a local origin.

It is certain, moreover, that if the other gems have been derived from basaltic rocks, and not from the greenstone, of which there is no evidence, the basalt was of an older period than that which now covers the drift, and such older basalt is not traceable. All, therefore, favours the belief that the term drift, implying a driving of material from a distance, is a correct term to apply to the Diamond-bearing deposits; but a question of another kind immediately suggests itself,—Was the motive power of this

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* On comparing some specimens of Cetacean remains and teeth of Carcharodon, brought more than forty years ago from the beach at Felixstow, in the County of Suffolk, (which fossils are certainly older than those in the crag cliffs above, and appear not to have fallen but to have been drifted up from a probably Miocene submarine bed to the eastward.) I recognise the identical *kind* and *degree* of polish on these Tertiary relics as distinguishes the Cudgegong pebbles. This, at any rate, is an interesting fact, and may have some bearing on geological inferences beyond the present use of it. In the superficial local drift above the ferruginous sandstone beds about Sydney, are numerous polished pebbles and fragments of the rock which exhibit an oxidised surface, but the polish in that case is, probably, due to very different agency to that of a *deposit* upon the pebbles, which is the theory of those who regard the Cudgegong pebbles as coated by an infiltration of silica. The Miocene fossils on Felixstow beach have, in the presence of iron, more relation to the Sydney fragments than to the drift pebbles of Cudgegong and the interior—but there, for the present, the comparison rests.

drift, and of necessity of the gold drifts, *fluviatile* or *glacial?* A marine accumulation is not suggested; and no fossil remains, favouring such a solution of the question, have been found. Silicified wood of the Carboniferous age occurs abundantly in the drift; but it must have been silicified long before any Diamond could have been formed from the carbon which the original wood contained, unless Diamonds claim an antiquity as high as that of the Coal measures themselves, or even one higher than theirs. In that case, they must also be drifted, as well as the minerals and rocks that are associated with them.

This may be the final result of our enquiries, but there are many who (as Mr. Taylor does) think the Diamond is a product of chemical forces now in operation, and therefore, it is a strictly local and limited product, not necessarily connected with any Carboniferous beds of comparatively high antiquity. As Magnesite exists in the vicinity, and that is certainly a recent product, arising from the decomposition of the exposed igneous rocks, so infiltration, decomposition, and reconstruction of carbonaceous materials, of whatever age, under the influence of chemical transformation, may be producing Diamonds at this moment, wherever the needful conditions exist.

An author of some distinction, M. Favre, Professor of Geology at Geneva, has turned his attention to this very subject, and as his paper "On Artificial Minerals" may not be generally known, I will refer to it. [It is to be found in the "*Bulletin*" of the "*Société Géologique de France*," vol. xiii., 2nd series.] He therein reviews the experiments which, up to 1855, had been made in the production of artificial Diamonds, and refers to the experiments of M. Jaquelain who had procured from the Diamond a carbonaceous matter having the aspect of coke, and those of M. Despretz who had proved that melted Carbon and melted Diamond are nothing but graphite. This is akin to the idea of Glocker of Breslau, and of others before him, that Diamond is an altered coal. Petzholdt also found in different Diamonds—especially the brown—traces of similar organisation to that of silicified vegetable matter; but Dufrénoy rejects the opinion of Liebig, that they can have a vegetable origin.

M. Favre shows, that of thirty-four minerals found with Diamond (according to the catalogue of M. Denis), consisting of sulphurets, carbonates, oxides, silicates, and native metals, thirty have been artificially produced; and of the thirty, twenty-nine were produced by the aid of volatile chlorides.

If this be the case, though one of the conditions is heat, the argument as to an igneous origin for Diamond, because it is found in association with minerals of igneous origin, must be abandoned or modified.

Ten years later, Professor Göppert, in his work "On the Organic Nature of the Diamond," pointed out, as Jaquelain had done, that it may be turned into coke. He says, that some must have been soft, as they are superficially impressed by sand and crystals; that others contain crystals of other minerals, germs of plants and fragments of vegetation. Hence, it would certainly appear, that the origin of such Diamonds cannot have been igneous, and, I may add, assuredly not more so than those granitic rocks I have already mentioned, that contain Coal measure plants. He states further, in 1868, that he had a Diamond which contained *dendrites*, such as occurs on minerals of aqueous origin; that there are at Berlin, one which contains bodies resembling *Protococcus pluvialis*, and another green corpuscles linked together, closely resembling *Palmoglœa macrococca*. To these supposed Algæ the names have been given of *P. adamantinus* and *Palmogleites adamantinus*. As illustrating the views he takes of these Diamonds, he says, the Metamorphic rocks in which they occur also contain evidences of vegetable fossils, such as *Eozoon canadense;* and that even in some topazes there are traces of organic substances.

A very interesting lecture was delivered by Dr. Percy, *On Chemical Geology*, on 12th December, 1863, before the School of Mines, in which he treats of the formation of Silica; of "*that glorious mineral Corundum*;" of Spinel, and of other gemstones; showing the influence of water, moderate heat, and salts of chromium, and he then adds: "the Diamond will come ultimately, no doubt." There is nothing to show that an igneous origin is attributed to them.

As an item in this enquiry, we may refer to a notice in *Silliman's American Journal* (VI., 110), 1848, by Professors E. and W. B. Rogers, referring to a previous paper, on "A new method of determining the carbon in graphite," (V., 392,) in which the authors show, that "the Diamond may be converted into carbonic acid in the liquid way, and at a moderate heat, by the re-action of a mixture of bi-chromate of potassa and sulphuric acid, in other words, by the oxydating power of chromic acid." The method is much the same, as in the process of oxydating graphite. By this method, they obtained from half a grain of Diamond, an evolution of as much carbon as was nearly equal to what was due to the entire weight of the Diamond.

On the other hand, Sir J. Herschel (Physical Geography) quotes the case of a Bahia Diamond mentioned by Harting, which contained well-formed filaments of iron pyrites, and he infers from the combination of iron and carbon at high temperatures the possibility of an igneous origin for Diamond.

A paper by Messrs. Sorby and Baker was read in 1869, before the Royal Society of London, on the structure of certain minerals, among them Ruby, Sapphire, and Diamond, showing that these gems contain cavities entirely or partially filled with a liquid, probably condensed carbonic acid, as well as with crystals—that some Emeralds contain a strong saline solution with cubic crystals, probably of chloride of potassium, and that the black specks in Diamonds (such *e. g.*, as those seen in our Cudgegong mineral) are really crystals, which are sometimes surrounded by contraction cracks, a black cross appearing under polarized light. The authors conclude, that the Diamond does not afford positive evidence of a high temperature, though not opposed to it.

That its structure has great peculiarities has been shown by the changes produced in a yellow Diamond by heat. This stone was exhibited by M. Frémy to the Académie des Sciences at Paris in 1866, when it was seen to become rose-coloured by the application of heat, returning to its proper tint on cooling. It is said to be the first instance of such a phenomenon. But, on turning to the 7th Report of the British Association, it will be seen, that in 1837, Sir David Brewster pointed out that the Diamond possesses strata of different refractive powers; and he uses this as a strong argument for its vegetable origin—the changes of refraction, and, consequently, the density in parts and hardness in the same crystal, being due to the action of the gases imprisoned in an expansive mass.

If we now consider the relations of the Diamond to the rocks in which it is found, we shall see how great or how little is the dependence upon *them* for its origin.

A statement was made in "Nature," February, 1870, p. 363, respecting the finding of a Diamond in *granite* in the neighbourhood of Prague. It is described as exceeding in hardness the Brazilian diamonds. It was suggested to be Zircon, but this Dlaschkowitz stone appears to be a veritable diamond. Its occurrence in *granite* was also mentioned in the Chemical Journal. The statement came from Professor Schafarik, who sent it to the Bohemian paper "*Politik.*" On such authority it was received but not believed as authentic.

It was not till I found mention of it in an Italian publication that I discovered the mistake that had been committed. In a notice, under the head "*Scoperta di Diamanti in Boemia,*" in No. 6 of the *Bollettino* of the *Reale Comitato Geologico d' Italia*, published in June, 1870, p. 175, we read "Fecesi questa scoperta sul finire dello scorso anno nelle vicinanze di Dlazkovic, villaggio posto tra Bilin e Lobositz, in Boemia, dove existe un giacimento di sabbie *Granatifere* lavorate per l' estrazione dei *piropi*, varietà di *granato* di un bel color rosso. Commista al prodotto della lavatura di queste sabbie, rimarcossi dai lavoratori una piccola pietra sconosciuta, durissima, e di color giallo-verdastro, che sottoposta ad esame si riconobbe essere un piccolissimo *diamante* del peso di 57 milligrammi ed in forma di esaedro a spigoli rotundati. *Dopo* di quest' epoca *altri diamanti* di simil fatta si ritrovarono, benchè assai di rado in *quelle sabbie granatifere* Quantunque sia questa scoperta di ben poca importanza, pure crediamo bene di segnalarla, essendo indubbiamente questo il *primo giacimento diamantifero che in Europa siasi trovato.*"

From this we learn that these diamonds were *not found in granite*, but in a *garnetiferous sand*, which is a new fact for *Europe* but not for the supposed origin of diamond in a plutonic rock. I have quoted the original words to prevent mistakes as to the meaning.

DIAMONDS IN BRAZIL.

Brazil seems naturally to claim our first attention. It has been found that in a certain Brazilian rock called *Itacolumite*, diamonds have been found *in situ*, and, therefore, all diamonds are assumed to have been derived in a similar way, wherever a rock imagined to be Itacolumite exists.

In 1846, Professor Shepherd, of South Carolina (A. S. J. II., 253) announced the extensive development of the rock in that State, and he gives a figure and description of a diamond from gold washings in that formation.

In Brazil, however, they occur in great numbers, in the lower Itacolumite beds.

According to Humboldt this rock belongs to the very oldest sedimentary deposits.

So far as my own observation has gone this rock does not occur in New South Wales, and even in Brazil, as I will show, diamonds are not confined to it. My friend Mr. Ulrich, late of the Victorian Survey, says the same of the sister colony, and assures me he had very good opportunities of satisfying himself by examining the Brazilian specimens at the last International Exhibition at Paris. Humboldt (*Essai Gèognostique Paris*, 1820, *p.* 89), includes Itacolumite in the quartz rock series parallel with his primitive clay slate.

Von Cotta places it among the crystalline schists, and describes it as a fine-grained micaceous talcose or chloritic schist, *sometimes* flexible, holding occasional quartz pebbles with magnetic iron and gold, as well as diamond. According to Eschwege, it passes into *Itabirite*, which belongs to the Red Hæmatitic group. Other writers include it with "Mica Schist," "Quartz of the mica slate," and "Elastic sandstone." Heusser and Claraz consider it a "granular quartz," sometimes bearing quartz veins with pyrophillite lime.

Eschwege says it attains in Brazil a thickness of many thousand feet, ranging for hundreds of miles.

The North Carolina species lies between limestone and clay slate. It is said that it occurs in Portugal, Spain, and on the Rhine. But this is doubtful. On the whole, it may be held to be a transmuted sedimentary rock—a friable quartz or sandstone.

M. Damour *(Bull. S. G. de France xiii.*, 2nd Ser., p. 543) mentions the occurrence in Brazil of diamond bearing sand, near Bahia, containing numerous minerals and ores, and states that the diamonds often contain spangles of gold in their cavities. He enumerates 32 mineral species, among them very minute rhombohedral dodecahedrons of garnet of a topaz yellow colour; a similar occurrence to that of Two Mile Flat, noticed by Mr. Norman Taylor, where *brown* garnets of the same form occur.

M. Damour suggests, in relation to the statements of M. Favre (referred to above), that the occurrence of the same minerals with diamond in different countries would throw some light on the formation. I may add that this is the principal reason which induces me now to enter so fully into this discussion.

Mr. Taylor instances as many varieties as M. Damour; but the so-called gems in the list given by the latter are confined to Quartz, Zircon, Garnet, and Tourmaline; Ruby, Sapphire, and Corundum being absent, and Euclase having been since added. The metals seem to predominate.

There is according to M. Claussen, another solid matrix of diamond in Brazil, which he calls *Itacolumite sandstone* (a secondary red sandstone), which overlies the crystalline beds, and once had an enormous development; to its denudation he attributes a considerable portion of the materials forming the mixed erratic diamond-bearing deposits; but in this he finds neither gold nor platinum. M. d'Archiac gives a very clear abstract of Claussen's remarks in his *Progrès de Géologie* (II., 379-383).

In the province of Matto Grosso, at the waterparting of the basins of the Amazon and Parana Rivers, a little south of 14° S. latitude, and at an elevation of some 1200 feet above the sea, is the diamond field of the Sierra Diamantina.

But the most important field in a geological, if not commercial view, is that which, ranging at a distance full 900 miles S.E. of the former, stretches through the province of Minas Geraes, between 16° and 26° S. latitude, and even comes down to the coast at San

Joao do Barro, where, in 1850, a chance washing of the underlying schist disclosed the presence of many diamonds. The deposit is not confined to the beds of rivers or ravines, but covers the slopes and tops of the hills. This deposit ceases exactly at the boundary of the bituminous beds of the coal measures of St. Catherine.

Is this, then, I would ask, any indication of the origin of diamond in Carboniferous rocks? If so, ought not those rocks to contain diamond?

In the north part of Minas Geraes, Jurassic calcareous formations cover the red sandstone, and these are in turn subordinate to gypseous marls and rock salt. Yet in the ravines, cut down to the sandstone, through the overlying beds, diamonds are found, *i.e.*, *above* the Carboniferous formation.

Moreover, in 1839, diamonds were discovered in the Psammite of Serro de Santo-Antonio de Grammagoa *imbedded* in the rock, whereas in the preceding Itacolumite sandstone they occur between the plates of mica, just as garnets occur in mica-schist. The edges of these are *rounded*, whilst in the Psammite the angles are *uninjured*, proving that the transmutation of the sandstone into Itacolumite has also affected the diamond crystallisation. For a long period the red Psammite and the secondary Itacolumite sandstone have been regarded as the sole matrices of diamond, whence it has been derived by the detrital erratic deposits; but since then, it has been found in the true Itacolumite subordinate to the talc schists with quartz.

The diamonds in the derived deposits are more numerous the nearer the deposits are to the solid rocks.

The detrital beds are classified according to their character.

Thus *Groupiara* is a drift not due to the present system of drainages. *Burgalho* or *Gurgalhoa* consists of superficial fragments of underlying rock. The decomposed schist of the latter is called *Barro.* A sandy mass between these is spoken of as *Terra.* Another bed of granular Itacolumite is known as *Pizarro;* but all belong to the decomposed rocks.

Cascalhao represents the sand, clay, and pebbles in the beds of rivers, torrents, lakes, and of the hollows in their courses through the solid rocks. *Tahoa-canga* or *Tapahan-canga* is what we call in Australia *cement.*

The Cascalhao of the old watercourses goes by the name of *Guipara;* that at the heads of rivers *Tabuleira;* and the partly rounded pebbles of the present streams are denominated *Corrido.*

The assemblage of all the minerals associated with the diamond is, according to Heusser and Claraz, from whom the last four terms are taken, called "*the formation.*"

We learn further from these authors that though diamond belongs undoubtedly in Brazil to Itacolumite and Metamorphic schist, yet it is not so, necessarily; for the Itacolumite mountains do not always contain diamond, and in that of Itacolumi itself none are found.

The minerals seem to follow a choice as to their matrix and associations. Thus Anatase occurs with sub-oxide of iron—Rutile and Brookite. Euclase is found with Topaz, in a whitish clay of decomposed rock.

Specular iron ore, rutile, black tourmaline, hyaline and smoky quartz are associated. Topaz (sometimes "rotten") is abundant, but is no longer, in comparison with euclase, an object of search.

Ores of tellurium, as well as sulphur, occur in some localities. In the crystalline schists crystals of lime, arragonite, magnetic iron pyrites, copper pyrites, manganese ores, and chromate of lead are met with. Scorodite and pseudomorphs of the same also occur in the schists and in the "*tapahan-canga.*" Amethyst is found in veins in schists and gneiss, whilst Chrysolite, Cymophane, and green Tourmaline collect in the Cascalhao of the crystalline schist rivers.

Mr. Heuland, in 1823, exhibited to the Geological Society of London (*Transactions, second series* 1, p. 119) a diamond in cascalhao surrounded by Scorodite (a cupreous arseniate of iron), which I do not see in M. Damour's lists, but which was found by Eschwege; and Dana says it encrusts quartz and beryl, and is found in Victoria with gold and Arseno-pyrites. Of the latter mineral Mr. Ulrich gives three localities. It has not yet been found on the Cudgegong. But Schorl rock does occur there, and in the sands of Bahia, at Diamantina, in Minas Geraes; and this mineral there called *Feijao*, as well as Hydrophosphate of alumina, is considered an indication of diamond.

It is stated by Mawe (*Travels in Brazil*) that the mines of Cerro-do-Trio annually produced, between 1801 and 1806, to the amount of from 20,000 to 25,000 carats, and that the weight of those sent to the Treasury in Rio Janeiro was 115,675 carats.

As an encouragement to diamond seekers in this colony may be mentioned that numbers of the Brazilian crystals are so small that four or five make only a grain, so that it takes sometimes seventeen to twenty to weigh a carat. There are rarely in the course of the year more than two or three of the latter weight, and it takes two years to find one of 30 carats; so that when a negro workman found one of $17\frac{1}{2}$ carats, called an *octavo*, he was crowned with flowers, conducted in triumph to the manager, fresh clad, and set at liberty. This is reported by Malte Brun (*Précis* iii. p. 293). Dr. Thompson has ascertained that up to 12th January, 1870, 9-10ths of the diamonds at the Two-mile Flat weighed less than a carat, and that 497 together weighed 120 carat grains; but as they were different in size, the average is assumed at one carat each, the largest being $1\frac{3}{8}$ carats. One, however, had been found weighing $5\frac{5}{8}$ carats.

These facts are interesting as correlating, so far as is known, the prospects of this colony and those of Brazil.

To prevent reference to it hereafter, I may mention now that a new and valuable work on precious stones ("*Handbuch der Edelstein*") was published in Vienna last year by Dr. Albrecht Schrauf. I found a notice of it in the *Quarterly Journal of Science*, for January, 1870. In it is given a formula for calculating the value of diamonds, which tested by the price actually paid for the Sancy stone (£20,000), taking the weight at 53 carats, and the price of the first carat at £15, and which is near to the theoretical result (£21,862 10s. 0d.), appears to be tolerably correct. It is this:—

$$\frac{m}{2}(m+2)\,a = \text{value},$$

where m is the number of carats, and a the value of one.

I have already noticed some of the facts stated by Messrs. Heusser and Claraz.

There are one or two others which may be quoted by way of relieving the dryness of these details. But I would mention that much compact information is given by these authors, in relation to their physical and geological researches in the interior of Brazil, in Dr. Petermann's *Mittheilungen* (1859. Heft. xi.).

The previous and following quotations are taken from a paper read before the Geological Society of Berlin. Herodotus, we remember, tells (III., 102) a ridiculous story, repeated by authors as late as the sixteenth century, of gold being brought up by ants as big as dogs that guarded it when obtained, and pursued the man that took it from them; but Messrs. Heusser and Claraz tell a far more probable story of diamonds having been found among the little pebbles with which some "worm-like insects" cover their tubular coverings—a fact quite paralleled by the Phryganea of Auvergne, which covered their indusiæ with the shells of *Bulimus atomus* or a small *Paludina*, forming strata which cover nearly 800 square miles, and are from eight to ten feet thick. (*Scrope, Central France, p.* 11.)

There is, however, another statement of even greater interest. In the Cascalhao are found fragments of quartz shaped like an anvil. These were used as earrings by the ancient inhabitants of Brazil. One of these ornaments was found in Cascalhao that had never been disturbed, in a dry watercourse, covered by 18 feet of vegetable soil, on which many fine palm trees were growing. Arrow heads and bones were also found with it. This Cascalhao must, therefore, be comparatively recent, or the race to whom such implements belonged must have been very ancient.

According to M. Hockeder the first diamond in Minas Geràës was discovered in the year 1827. But I believe Brazil was known to possess diamond just a century before. The effect was much like that which takes place in Australia when a new lead is discovered. The gold workings were all deserted by what is called here "a rush," and the greatest excitement followed. Mr. Hocketer's memoir, though now little known, made also a stir at the time. [*Ueber des vorkommen der diamantem.*] There are other documents referred to in the *Bull: Soc. Geol. de France.* (xiv. 232; i. 19; ii. 659.)

Further particulars relating to the diamond beds of Brazil may be found in a paper by M. Pissis in the journal just cited (*Tom.* xiii).

One passage seems to bear upon certain facts observable in Australia. He says, "to these stratified rocks we must add compact Diorites, which show themselves abundantly distributed on the surface, sometimes forming long lines of hills, sometimes simple *mamelons* in which the matter appears to have been poured out in the manner of basalts, producing long sheets which cover the last beds of the limestones, whether siliceous or schistose." He then goes on to speak of the sandstones which underlie the limestones, and which are to be regarded as the true matrix of the diamond. "Thus, of all the rivers of the province of St. Paul those only which flow over the *sandstones* are diamond bearing." And instancing the Rio Guarahi, he says it leaps over the escarpment where it forms several cataracts, cutting through the various beds of Sandstones and Psammites, and it is only below the cascades that you begin to find diamonds, a similar remark to that of M. Claussen in relation to the Coal measures.

Other facts worthy of mention may occur in Captain Burton's work on the "*Highlands of Brazil*," but as I have never yet seen a copy of that work, I have not referred to it.

DIAMONDS IN INDIA.

We may now turn to another quarter. India was renowned as a diamond country long before Brazil; Tavernier mentions diamonds in 1642.

In 1814, Dr. Heyne published some tracts on India, in which he described the diamond mines of Southern India, showing that a conglomerate caps the Cuddapah Hills; and he adds, wherever diamonds are found they are in alluvia and recent deposits in which the rounded pebbles are so numerous as to produce the conglomerate character.

In 1832, Mr. Cullinger published in a Calcutta periodical—"Gleanings in Silence"—some notes on the geology of the country between Saugor and Mirzapore, in which he mentions the occurrence of diamonds in solid sandstone underlying chlorite slate, and also in a ferruginous agglomerate, of which he gives several localities.

Mr. Newbold in a paper that may be found in the *Athenæum* of 11th of June, 1843, has described the diamond-bearing gravel of Cuddapah, in Bundelcund, a little south of Golconda.

It holds rounded pebbles of trap, granite, schists derived from beds twenty to forty miles distant, quartz, jasper, silex, sandstone, and limestone of the vicinity. In it are broken or rolled diamonds; and as the diamond beds are occasionally covered by *Regur*, or black cotton soil (which is also not uncommon in Australia), I consider they are of the same age as the older drift of the Cudgegong. But when these materials are cemented at the upper part by *Kunkur*, which is a tufaceous carbonate of lime (very common in some parts of Australia), diamonds are *never* found. In the Nizam's territory, such cemented beds contain bones of the Mastodon.

In the fifth volume of the second series of "*Transactions of the Geological Society of London*" is a valuable memoir "On the fossils of the Eastern portion of the great Basaltic district of India," by the late Mr. Malcolmson, which was read in November and December, 1837. In it he alludes to the Cuddepah diamond mines, in the neighbourhood of which is abundance of basalt. He gives also a sketch of the position of the diamond sandstone of Bangnapilly, which is horizontal, vertically jointed, resting on schistose beds underlain by stratified limestone, and surmounted by a diamond-bearing breccia, which is not interstratified, but is a mixture of sandstone and other rocks, rounded and angular. On the opposite side of the valley, according to Colonel Cullen, the sandstone is replaced by a sharp ridge of trap, and on the descent the schist and limestone were found to be capped by a quartzose sandstone. Besides the diamond conglomerate, seams of rock crystal occur, and fine white quartz charged with galens and with specular, micaceous and pyritous iron. The slates are occasionally flinty or jaspideous. The base of the whole is the granite of the Carnatic, and this rock is penetrated by many dykes of greenstone. In the diamond sandstone, magnetic iron and corundum are met with. The fossils in the argillaceous limestone are of fresh water origin.

Mr. Malcomson opposes the idea of Major Franklin, that the diamond rocks belong to the Saliferous deposits of England. In this part of Bundelcund, greenstone follows the strike of the so-called grauwacke in the bed of the Nerbudda River, and basalt forms the overlying strata, another analogy with the Cudgegong diamond district.

Mr. Broderip considered the rocks to be Jurassic, and scarcely distinguishable from the white Lias of Bath.

As to the saliferous beds, Mr. Malcomson says, there is not a rock formation in India from granite to recent alluvium in which salt does not exist; and he further states, that the sandstone, covering 800 miles of latitude and 400 of longitude, is everywhere above the limestone which Captain Franklin calls *lias*.

In 1853, Mr. Carter, in his "Summary of the Geology of India," (*Bombay Asiat. Soc.*, 1854,) also adopts the view that these Bundelcund diamond rocks are Jurassic.

D'Archiac (*Progrès*, vii., 644,) repeats Carter's statements, and puts the diamond-bearing conglomerate *with a note of interrogation* above the Punnah sandstone, and much above the Carbonaceous shales of Kuttra.

I would here wish to remark that these beds must be distinguished from those which hold *Glossopteris*, and which paralleled with the African Karoo beds, Mr. Tate (Q. J. XXIII.) in 1867, considered Triassic, whilst Dr. Oldham, the experienced and able Superintendent of the Geological Survey of India, agrees with me in assigning them to a Palæozoic epoch.

But inasmuch as coal may exist in the Jurassiac or Triassic, as well as Upper Palæozoic formations, the proximity of a coal-bearing formation to the diamond rock leaves the question as to the origin of diamond in such a formation just where it was.

Since the establishment of the Indian Survey, under its present enlightened Superintendent, the Messrs. Blandford and Mr. Theobald have explored large tracts of India, and have given their opinion, in which Dr. Oldham concurs, that the Nagpur, Damoodah, and Talcheer, as well as other Bengal coal-fields, cannot be younger than Permian. (*Mem. Ind. Surv.*, i., 82.) These beds in the Damoodah group hold many species identical with those of our New South Wales coal districts, including the outlying patches on the Cudgegong.

The Indian surveyors show that the Mahadeva sandstone (or Bangnapilly rock) surmounts the Damoodah beds, believed to be Permian, and that the Talcheer group, which underlies them rests on gneiss, hornblendic gneiss, schist, and quartz schist; and in the Mahanuddi River to the southward of the Talcheer coal-field, which runs through the basic formations, a small amount of diamonds has been found. Where the Talcheer beds meet the hornblendic rocks by a fault on the Takiria River, and in the Ouli which flows to it from the Mahadeva rocks, gold is occasionally found.

North of this region the great Vindhyan rocks stretch across the country north-north-easterly, being the upper of three groups resting on gneiss and granite. These are described in the second volume of the "Memoirs of the Survey," by Professor H. B. Medlicott; and both he and Dr. Oldham give good reasons for placing the Vindhyan series in connection with the Damoodah, or Coal measures of the Talcheer field, and therefore they are far removed from the Bangnapilly beds, belonging to the Mahadeva group to the southward.

Mr. Medlicott shows that the diamond beds are not all of one age, and instances the mines at Punnah, 600 or 700 miles north of Cuddapah, which he places close to the junction of the lower and middle groups of the Vindhyan series, at the northern edge of the Rewah tableland, in the shales, to which latter group they belong. This at once places them far below any possible Jurassic or even Triassic strata.

The Punnah diamond diggings occupy not more than twenty acres. The diamonds are found in a conglomerate belonging to relics of old spurs and outliers of the tableland. Fine grits among red and green shales, and a few beds of sandstone, constitute the strata.

At Kumerea (another field), the diamond bed is in an incoherent ferruginous sandy earth, of variable thickness and undecided position. To the east it is modified, and near Bridjepur it consists of two feet of conglomeratic sandstone, resting on strong beds of sandstone, and is worked at the surface. The "kukra," or diamond bed, is sometimes an incoherent ferruginous and sandy earth, variable in thickness and position as as are the beds with which it is associated. It appeared to Mr. Medlicott to be somewhat of a puzzle where to place the conglomerate among the regular beds, and he considers the ferruginous element to be subsequent to the deposition. The beds thin out and thicken remarkably. The natives seem to have ascertained the limits of the diamond area, owing probably to the beds dying out. The base of the hills has not been tried.

As to the origin of the Diamond, he does not think the stratum in which it is found is its native bed. He saw no diamonds *in situ*, but, from what he learned of the labourers, "*the diamonds came as pebbles with the rest.*" Quartz pebbles of any kind are rare. The most prominent pebbles are subangular red and white shale, and of what Franklin calls "green quartz," which is elsewhere described by Mr. Medlicott as "glazed or semi-vitrified sandstone." Pieces of the calcareo-siliceous bottom rock, of the size of boulders, occur also. One of the workmen confirmed his opinion, that the occurrence of these pebbles indicated the presence of the gem, and that "*they themselves contained diamonds, and were broken up*" as ore or, rather, as gangue.

In a section just north of the mines, twenty feet of regular beds of cherty and compact limestone rest on fifty feet of alternating sandstone and shale, based on rich sienite; the cherty and jaspery condition of some of the more vitrified beds is shown by another section to be due to a "modifying influence." It is supposed that these beds are the sources of the boulders in the diamond conglomerate.

Besides these diggings, the great majority are said to be alluvial.

On the Rewa escarpment, in the Vindhyan region, they are at the heads of valleys descending from the plateau, where kunkery and lateritic clays pass into a mixture of clay, gravel, and boulders, increasing to great angular blocks of sandstone, between which the diamonds are found. Diggings occur also on the slopes. In one place men were seen removing twelve feet of dark brown clayey sand to get at the boulder bed, the base of which is richest.

"The limited distribution of the transported diamonds was more puzzling" to Mr. Medlicott than that of the rock. He thinks there are indications beyond the area that is worked.

The conclusion is, that the open valleys of Rewah are not altogether due to atmospheric and river action; the whole must have been under water when these diamonds were washed into their position. "If," says the author, "the diamond is but a pebble in the conglomerate," then, on the other hand, there is every chance of further discoveries, "since quartz grains of similar size with the diamonds are abundant, and there are other sufficient proofs of the recent submergence of the country. (p. 75.)

In the above references, there is not as clear a relation as was given in connection with Brazil; but the geology of the region is not in some respects so settled as to determine exactly where, in relation to other countries, the Vindhyan rocks of India belong. Enough, however, has been produced to show that the Mahadeva beds are younger than the Damoodah, which clearly correspond with our own Upper coal-measures, and that the Vindhyan beds were faulted and elevated and denuded before the deposition of the Talcheer beds that are still lower than the Damoodah.

Under such circumstances it follows that there is probably no very close connection between diamond beds in India at distant localities, and very little to justify the supposition that all, if any, of the Indian diamond deposits can be exactly synchronous with older Pliocene.

I have not yet mentioned two very important and interesting memoirs, by Messrs. Hislop and Hunter, published in the 10th and 11th volumes of the Quarterly Journal of the Geological Society, on the geology of the Nagpur territory. Differing in opinion from them as to the age to which they assign what they term the great Jurassic formation, which extends over enormous areas and comprises the Coal-fields of Central India and Bengal, I would still accept their statements with the greatest respect. They regard the base of the Peninsula as formed of gneiss, granite, sienite, pegmatite, mica schist, and quartz; but these are not all of anterior date to the sedimentary formations.

Over these occur the Coal-bearing rocks, the upper part of which are the sandstones, partly transmuted, which have been already alluded to, and which other authorities regard as the source of the diamond.

Over these beds comes the lower trap rock, which is compact beneath and vesicular at the top, with cresting patches of nodular trap. These traps enclose in places a thin sedimentary formation of Tertiary age, which has an uninterrupted range of 1050 miles in one direction, and of 660 miles in the other. Its age has relations with the Eocene of Europe. Notwithstanding the order presented in various parts of this large region, the authors consider the various trap rocks as all younger than these beds, the lower having in fact been the younger. The trap, they hold to have flowed into and over and to have altered the lowest of these tertiary beds, which were deposited in a series of great lakes of no great depth.

Above the trap another series of beds occurs, the lowest of which is *Laterite*, a well-known term to those who are conversant with Eastern Asiatic geology. In this, the authors state, occur the diamond mines east of Nagpur. They dispute the assertion that the diamonds belong to the transmuted sandstones below the trap; and say that at Weiragad (about 80 miles S.E. of Nagpur) there is no sandstone, but quartzose metamorphic rocks only. At that place the diamonds occur in a lateritic conglomerate which overlies the sandstone in other places, and in which ferruginous cements occur formed from the detritus and boulders of adjoining formations; and this they hold to be the diamond conglomerate. It is therefore assumed to be younger than the overlying trap formation. Above comes in a series of deposits, the lowest of which is brown, the middle red, with existing fluviatile shells, land shells, and bones of mammalia (which Professor Owen has since determined to be those of buffalo and antelope); tusks of a large animal were also found in the brown clay. The uppermost deposit of all is the Regur or black cotton soil, in which Kunkur is mixed. Bones of oxen and sheep are found in it.

Messrs. Hislop and Hunter consider these *Black and Red* clay beds to belong to the *Post-pliocene* formations; the *Brown clay* to the newer Pliocene.

Assuming these Nagpur deposits to be correctly placed, diamonds of India are still, according to evidence collected from other authorities and already considered, traced to a conglomerate which may be more recent than our basalts on the Cudgegong, but may not be more recent than those at Ballarat; but which seems to have derived its pebbles and boulders from Palæozoic and Metamorphic and ordinary igneous rocks; *laterite* itself covering rocks alike of every older epoch. Occurring as this detrital *covering* does all over India, and having the same relative position to all kinds of rocks, and at all heights up to that of at least 8000 feet above the sea, the idea of diamond belonging to it as its actual source is not sustainable.

In asubsequent paper (Q.J.G.S., vol. xvi.) the Rev. S. Hislop, one of the authors, considers the Intertrappean Tertiary bed as lower Eocene, producing good fossiliferous evidence for this opinion; and shows that the Mahadeva or Bangnapilly sandstone is about the same age, in which Dr. Oldham seems to coincide. (*Memoirs of India*, vol. 1, 171.) Hislop's views have not been thoroughly received by other geologists; and doubts have been expressed as to whether the trap or basaltic formation of India is not all of one age.

If compared with the Cudgegong Diamond deposits, the older of which, and from which the younger is derived, underlies the trap (basalt), it will be seen there is a difficulty to be reconciled with respect to each; and if the diamond conglomerate of India be lower Eocene, that difficulty is complicated by assuming that the Cudgegong deposit is Pliocene.

On reviewing the whole evidence I am inclined to believe that unless they are much younger than the Pliocene, or Pleistocene epochs, in fact of recent origin, they must be considered as drifted from rocks older than the Carboniferous. As they everywhere exist in limited areas, it would also be a fair inference that as there is no want of carbon, and similar agencies must operate over enormous regions, the limited range of diamond is a strong argument against its recent production. If the facts advanced by several of the authorities whom I have quoted are received, then diamond must have undergone processes similar to those that have resulted in the formation of gems, of which there is no dispute as to probable age.

It is remarkable, how silent observers in general in India are as to the multiplicity of such gems and other extraneous minerals in the Indian diamond regions. Yet Mr. Carter names Quartz, Jasper, Lydian stone, Epidote, Micaceous iron, Garnets and Corundum, derived from rocks of different ages.

There is another interesting locality near Gungpur, on the northern frontier of Orissa, on a river running to the Bay of Bengal, north of Kuttak; but I have no accurate knowledge of its history.

To these remarks on Indian diamond beds, I have only to add that, in 1867, I had the honour of a visit from an officer of the Bengal army, whose official position gave him great opportunities of acquaintance with the country, and who came to this colony on a tour of inspection, to examine our railways and coal-beds, and from him I learned that the Vindyhyan conglomerate is chiefly made up of Jasper, Chalcedony, Specular iron, and a green rock, which latter lies *en masse* on granite; that the diamonds are of all colours—rose, yellow, brown, black, and *pale green*—which last being the favourite, or national colour of the followers of Mahomet causes the green diamond to find a ready sale, whilst the others are neglected. In size they are that of a hazel nut, or larger. But, he added, that in the diamond districts the people are wretched; they think and talk of little but diamonds, which they often swallow if not watched.

DIAMONDS IN RUSSIA.

Russia is a country in which diamonds are also found, but sparingly, as near Bissersk and Chrestovodsvingensk in the Ural chain; the detritus in which they occur being made up of angular fragments of chloritic, talcose and quartzose rocks. The former of these places was mentioned in 1831 in the "Gornoï" Journal of Petersburg; and in 1839 Baron von Meyendorf stated to the Geological Society of France that diamonds had been discovered in two different localities, and that they had been found in a microscopic form in native Iridium which had been brought to Paris. (Bull. II., 314.)

The first Ural diamond was found at Bissersk in 1829 after Humboldt's visit to Count Polier; three others were found afterwards in that year. In 1830 other three were found. M. Karpoff, a mining officer, shortly after was deputed to carry on the search, and four were discovered, which are described as colourless, diaphonous, smooth and very bright with 42 triangular facets. One was broken in two.

Thirty-seven others were taken, the last in July 1833, from the Adolphskoi Mine and were used by the Countess Polier in decoration of her church images. One weighed $\frac{3}{4}$ of a carat. Their forms showed from 12 to 42 curved facets, smooth and sparkling. In 1831, however, a few were found in the gold land of M. Medjer near Ekatherinburg. One was given to the Institute of Mines by his son, after the father's death. It was a rhombhoidal dodecahedron with rounded edges and translucent, weighing $\frac{5}{8}$ of a carat. (*Bull. Geol. Soc. de France*, IV., p. 100, 1833.) The information here given was received from Count de Cancrine, Russian Minister of Finance.

Sir Roderick Murchison, in 1841, saw forty diamonds from the Adolpskoi rivulet; but as the gold found with them did not pay, no further search was made for diamonds. Three other localities have also been named, ("*Geol. of Russia and the Ural*, 1845," *p.* 641,) in two of which one diamond and in the third two diamonds were found.

Sir Roderick considers that the Itacolumite of Brazil occurs in various parts of the Ural, where it was detected by Colonel Helmersen, and adds what seems to bear upon certain conjectures previously mentioned. He says:—"We may add that as Carbonaceous grits of the Devonian and Carboniferous periods exist, it is very easy to conceive how these masses, like other sediments to which we have previously alluded, have been transmuted into the quartzose micaceous schists which occur in the Chain, and how the diamonds have been derived from them and deposited in the auriferous gravel." (p. 482.)

Finally, I may remark that Osm-iridium found on the Cudgegong occurs in three places near the Ural, as well as in South America and in Canada, in gold diggings with which diamonds are, as we have seen, generally associated. Moreover, Cinnabar found on the Cudgegong is also associated with the diamond detritus of Brazil; and as the mode of its occurrence is precisely that in which it presents itself in the Gilbert gold-field of North Queensland (as I learn from Mr. Daintree), and also in that most wonderful gold-field on the River Thames in New

Zealand (as Dr. Hector has stated), as well as in Otago, *i.e., not in lodes* but as a member of *drift deposits*, there is a sort of union between these and other regions in which the diamond is found. Drift or alluvial Cinnabar is not less remarkable than drift diamonds; and I believe at present no lode has been detected.

In California Cinnabar is said to be brought up by *Solfatara* action. (*Phillips in Phil. Mag., Dec.* 1868. *p.* 431.) It may, therefore, be that the Cudgegong mineral is due to the action of former hot springs. The account given by Mr. A. Phillips respecting the "Chemical Geology of the Gold Fields of California" in the paper cited above, justifies the further inference that Silicated waters may also have operated in coating and cementing pebbles and fragments of rocks at Cudgegong as they have done in California. He even shows, that quartz veins holding gold and coloured by pyrites, as well as auriferous pyrites itself, have been formed in recent times by the action of aqueous solutions.

DIAMONDS IN BORNEO AND AFRICA.

There are but two other countries to which I need refer, Borneo and Africa.

In the *southern* ravines of the Rotos Borneo chain, which is composed of Serpentine, Diorite, and Gabbro, which run north and south, there is a deposit of red clay with fragments of quartz, in which spangles of gold, magnetic iron, platinum, and also *osmium* and *iridium* are met with, the whole reposing on Serpentine. In this clay, on the *western* slopes, diamonds are found over fragments of Sienite and Diorite, and with the ores above-named. Black quartz with pyrites and plates of platinum are *there* the indications of diamond and, according to M. Louis Horner, this quartz belongs to the Serpentine. (*See d'Archiac*, ii., 333.)

So varied, yet, to some extent, so consistent with each other, are facts connected with the history of the diamond. That its mode of production in all countries may have been the same is very probable; but that origin, it must be said, obtains little illustration from the various geological conditions with which it is associated. Perhaps this very variety, whilst setting dogmatism at defiance, may serve as encouragement to the close observation of practical prospectors.

Of African diamonds we have only heard much of late. Knowing that they are generally found with gold, and that Africa contains numerous auriferous regions, it might have been anticipated that diamonds would have had a greater celebrity in that vast country, forming a quarter of the globe, than they have had in modern times.

But though Heeren has shown that there was a considerable trade among the ancient Carthaginians in diamonds brought from the interior of Africa, the only record I can find in modern times of the existence of diamonds in that part of Africa, is of three shown at the Exhibition of the produce of Algiers. They were found in the Goumel River, in the province of Constantine, and were given up in payment to M. Peluzo, the Sardinian consul at Algiers, by an Arab who wished to know their value, saying that they were found in the sand of the Goumel River, with gold. One of these is deposited in the School of Mines at Paris; the second was purchased by M. Brongniart for the Museum of Natural History; and the third by M. de Drée. The Arab had several others. M. Rozet says, however, that he had acquaintance with the jewellers of Algiers, and had never heard of diamonds found in the province. The facts stated are on the authority of M. Dufrénoy and the Secretary of the Geological Society of France. (IV. 164, VI. xv.)

In Southern Africa diamonds were reported to have been discovered in 1867. After the announcement of the new find, Mr. Gregory, a well-known London mineralogist, who went to Africa on behalf of the great diamond merchant, Mr. Emanuel, sent to the editor of the *Geological Magazine* (December, 1868) an article denying the statement and declaring it a "hoax," "imposture," or a "bubble scheme." To this Dr. W. G. Atherstone, F.G.S., a resident of Graham's Town, Cape of Good Hope, replied (May, 1869) refuting the charge, and declaring that twenty-one diamonds were known to have been found either on private or Government land, and thirteen of these were bought by persons of credibility, one of them the Governor of the colony, and another by a lapidary. Dr. Atherstone contradicts Mr. Gregory's account of the geology of the district, the latter asserting that all the rocks are igneous or their derivatives, and the former declaring that the rocks are fossiliferous, of the *Dicynodon* beds (which by the way brings them into relation with some of our Australian rocks); and that Mr. Wyley (an accepted geological authority) had, years before this controversy, shown that there was an intimate relationship with the Indian diamond region of Bangnapilly, and that Dr. Shaw had described the African district in the *Graham's Town Journal* of the 20th January, 1869, pointing out also the same resemblance.

In the "Journal of the Society of Arts," of the 13th February, 1869, is a list of the diamonds by Mr. Chalmers; who, as well as Mr. Radcloff, a Missionary, asserts that one of them was found near Pniel (No. 7 of the list), by a Griqua.

Mr. Gregory, in answer to this reply, explains some personal remarks of his own, and admits the existence of Dicynodon relics but *south* of the district alleged by Dr. Atherstone. And thus stood the matter till 1870. It now appears, that diamonds have been found in vast quantities and that many magnificent and valuable stones have been disinterred. They are found on the surface of a calcareous conglomerate near the frontier of the Orange River territory, and are said to vary in weight from 6 to 13 carats, some of them reach 150 carats. The diamonds are accompanied by garnet, topaz, and other hard minerals.*

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* The locality is at Pniel on the Vaal River opposite Klipdrift (the territory of the chief Waterboer), distant about 800 miles from Cape Town, where the weather is fiercely hot from all December to all March. It is much nearer to Port Elizabeth eastward of Cape Town, the distance being about 496 miles. But the difficulties in travelling are great. In November 1870, about 10,000 men were employed. Without mentioning an opinion as to the alleged value of the diamonds found, I may append here an extract from the *Mauritius Commercial Gazette* of 18th November which is not without interest.

"The latest telegraphic advices from the diamond-fields is that "at Hebron they are picking them up at the rate of sixty diamonds per week." And at Gonggong, or a little below that place, one man has found two diamonds, one valued at £40,000 and the other at £80,000. Of ordinary sized diamonds reports come in daily. A man has just found a ten-carat one on an abandoned kopje (hillock). Another, Mr. H. S. Jones, son of an auctioneer of Cape Town, has unearthed one of 26 carats, worth about £8000. This he obtained after ten days' work. He is on his way back to town to dispose of his find, while a man who worked with him, named Lance, who came here from St. Helena, remains, and continues working the claim in his partner's absence.

The territory which is ascertained to be diamondiferous now fully extends over 100 miles. As to the possibility of its exhaustion, to speak of that, competent judges say is to speak of an event which may occur next century, or perhaps a century hence.

It may be as well to state here that diamonds have occasionally been found in our sister colony of Victoria, and have been recorded by my friends, the Rev. Dr. Bleasdale, Mr. Ulrich, and Mr. Brough Smith, the latter of whom, in his recently published valuable official work on the "Gold-fields of Victoria," mentions sixty small diamonds of little value from Beechworth, taken out of, or near to, the usual "wash dirt" of the diggers, varying in weight from one-eight to two carats and a half.

In 1865 fifteen more diamonds were also procured from the Woolshed diggings.

It is said also, that some small diamonds have been found at the Echunga gold-field S. E. of Adelaide, in South Australia.

At the present time, therefore, New South Wales is the diamond colony of Australia.

I fear, Gentlemen, in thus exhausting the subject of the diamond I have exhausted your patience as well; but I have been anxious to collect from every available source, in the course of my own reading and observation, all that bears upon our new

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The following is a *résumé* of the known shipments since the beginning of September last :—

NUMBER AND VALUE OF DIAMONDS SENT FROM THIS PORT.

1870.	Diamonds.	Value.
Sept. 14th.—Per R. M. S. Roman	496	£15,000
„ 29th.—Per R. M. S. Norseman	387	15,500
Octr. 15th.—Per R. M. S. Northam	67	8,850
„ 31st.—Per R. M. S. Saxon	110	4,230
Novr. 13th.—Per R. M. S. Celt	1240	22,255
Per post	26	1,300
	2326	£64,135

Last week we had intelligence by telegraph of some very large "finds." The report was that one of 150 carats had been found; one of 117 carats, and several others ranging from 12 to 18 and 25 carats. With regard to the two very large ones, I prefer to take the announcement with caution; but as to the smaller ones, I do not for a moment doubt they were really obtained. A personal friend of mine found one of them weighing 15 carats. At the same time there need be no unnecessary scepticism about the matter. Large finds are kept very close; but it is very well known for all that, diamonds of immense size have been found. When I say "of immense size," I mean above 100 carats up to nearly double that weight. The 88 carat one found by Wheeler arrived yesterday in town. It is in the keeping of the Standard Bank, which institution has made a large advance upon it, and to which it is entrusted for disposal in Europe. Irrespective of this monster, the mail steamer Celt will take home on Saturday nearly 2000 diamonds, valued at a large amount."

colonial industry, that the matters thus brought together may be an assistance to persons anxious to investigate the curious circumstances connected with the most mysterious of our minerals.

It seems to me, however, that whatever may be richness of some of these distant countries which have been spoken of, there can be no reason to doubt that the gifts of the Creator to this country, in which we are sojourners, are abundant, and are equal in many respects, if not superior in some, to those which His providence has showered so liberally on the lands of the stranger. May we be induced to make a good use of them!

COAL IN INDIA.

The references that have been made in the preceding part of this Address to the Carboniferous rocks of India naturally induce a desire to say a few words respecting their recent development.

A new Coal-field, intermediate between the Diamond districts, and of the age of the Upper Damoodah, has within the last year been determined in Central India, after long examination and strong convictions of its existence on the part of Mr. Medlicott. It lies south of Nagpore and north of Hydrabad. It will be of great use to India, and may, perhaps, have an indirect influence on the present import of Australian coal. An area equal to two square miles south of the river Wurdah is said to contain a thickness of 14 feet of coal, not deeper than 100 yards below the surface, and easy of access; whilst to the north of Wurdah there is even a greater distribution of the mineral.

What renders this discovery interesting to ourselves is, that it is unquestionably of similar age to our Newcastle coal; and that it is capable of supplying for at least thirty years a quantity equal to what India now yearly supplies from her other coal-fields, which is 600,000 tons, the exact amount exported from Newcastle in the year 1867. And yet it is said this very sum is only equal to the produce of a single English colliery.

FOSSILS IN LORD HOWE'S ISLAND.

During the past year an expedition (*quasi* scientific) was sent out to Lord Howe's Island. Having had an opportunity of examining the rocks collected, I have been enabled to see that the Island belongs to a system of formations common to many Pacific islands, with the geology of which I am somewhat familiar. Howe's Island consists of a mass of igneous rock rising abruptly out of the ocean to the height of upwards of 2800 feet, having on its lower portions a deposit of elevated coralline sandstone, in which are embedded the shells of a Bulimus and what were supposed to be its eggs. These have since been determined to be those of a Gecko.

By the favour of Dr. James C. Cox, I have had the opportunity of seeing another Bulimus, which occurs semi-fossilised in similar deposits in the Isle of Pines; the shell, in each island respectively, being of still living species. The shells of the living Bulimus, in Howe's Island, do not differ from the embedded shells.

It has been said that no reptiles exist in the island; but Dr. McDonald, of H.M.S. Herald, who reported on the island and the little group of rocks and reefs that belong to it, states that two snakes and a lizard do exist there. This has been partly confirmed by the Gecko eggs. Certain it is that he distinctly mentions one as a *land snake;* the other, of course, may have been a Hydrophis, as it was on the low reef on the west side, which connects the horns of the curve formed by two extremities of the island. Since the return of the expedition, I have received an additional proof that the coral sandstone contains other relics of animal life besides Bulimus.

About four or five feet above the sea level on either side of the island, Mr. Leggatt, who placed these fossils in my hands for inspection, found numerous bones which have not yet been fully determined as to their character. The late Dr. Foulis, in an account of the island sent to the Government, mentions the existence of bones of the turtle; but it is possible some of these bones may turn out to be those of birds. At present I content myself with suggesting that there is much to do before the natural history of this little group will have been exhausted. Mr. Moore, one of the recent explorers, has given an account of the botany, and dwells on the existence of a flora there which is only partially Australian, and more nearly resembles that of Norfolk Island. Yet in the latter the peculiar tree is the well-known Pine, whilst a huge Banyan or Ficus is the distinguishing plant of Howe's Island.

It is this plant which has induced the belief that Howe's Island belongs to a wider area now submerged.

I confess I have always held the opinion that the east coast of New South Wales formerly extended more to the eastward; and as soundings are known to exist between it and New Zealand, that the ancient land that once existed in the open space suffered the same change that affected the base of the Barrier Reef farther to the south. This, however, is certain, that if there has been subsidence, there has also been elevation in various islands to the eastward of Australia, as I showed many years ago in relation to Lifu Island in the same region as the Isle of Pines. And on reference to Sir Charles Lyell's arguments "On Insular Floras and Faunas," (*Principles ii., ch. 41*,) we may see what can be said on the opinion, that such islands as Howe's were raised out of the ocean by successive eruptions from great depths during periods of slow elevation.

The collections I have examined of the rocks in that group exhibit nothing of any great antiquity, a fact also established by the existence of continuous life in the Bulimus which is found fossilised in the beds of detritus and marine relics that have been, and are being, now still further raised above the sea level by the process of leisurely elevation, such as is exhibited by the present surface, the extension of the western beach seawards and by a similar gentle rising on the opposite Australian coast, as about Moreton Bay.

Whether Howe's Island, attaining as it does to an elevation equal to the height of many parts of the Australian Cordillesa, may have been one of the sources, whence flowed the great basaltic streams that cap so many points of the mainland, it would not be easy to demonstrate; but there does not appear to be any discrepancy between the ages that have been assigned to those lava flows and to the islands on which Lyell has commented.

As a further proof that we have much to learn as to the continuance of certain species from a somewhat earlier epoch into the present (which is the case with the Bulimi of Howe's

Island and the Isle of Pines), I may mention an announcement made by Professor Owen about three months ago, that he had received from Queensland with the remains of *Diprotodon* (a Pleistocene animal) fragments of a crocodile, similarly fossilised, which he has determined to be identical with the species of that animal still existing in the Queensland rivers—a fact similar to the fresh-water shells of living species attached to the Diprotodon bones. Crocodile's teeth similarly fossilised I sent home to Professor Huxley some years since, collected from the neighbourhood of Peak Downs, by Mr. A. Gregory.

As to Howe's Island Dr. Macdonald has shown that the coral sandstone has undergone an elevation in the middle of the island, producing a saddle-formed ridge distinct from the lower horizontal beds of the same rock which was probably produced by a paroxysmal heaving similar to that which I pointed out must have been the case in Lifu.

During the last year, also, I was enabled to announce in the local papers and in the Geological Magazine (VI. 383), the important fact that a femur of a bird allied to, if not incidental with the Dinornis or ancient Moa of New Zealand, has beeu disinterred from the depth of upwards of 180 feet in drift and under lacustrine deposits, on Peak Downs, in Queensland, thus proving another link in the chain of evidence to show that all through the southern lands in the Eastern hemisphere flightless birds have existed, of which a living bird in Howe's Island is another example.

And if it be true that the New Zealand Moa is still living (or is only recently become extinct), we have a similar fact to that illustrated by the occurrence of the living and fossilised Bulimi before-mentioned.

The Bulimi in the Pacific Islands appear to be as distinct in species as are the flightless birds in genera and orders between New Zealand, Bourbon, and Madagascar; and now we have the gap somewhat filled up by the Peak Downs bird, which is an ancient example of what we have in the Emeu of this colony, the Cassowary of the Solomon Isles, and the Ostrich of Africa, so that, as before said, there is, despite the differences, an apparent oneness of design in the structure of certain inhabitants of the separated lands of the Southern hemisphere.

It is perfectly clear that birds incapable of flight could not have passed by the use of their wings, from island to island, nor could they have partaken in the ordinary character of the migrations of birds.

We can only surmise that these Southern lands had once a connection now no longer in existence, or that they have from the beginning remained separate and distinct, each with its peculiar and independent creation.

I must confess that so far as I understand the received explanation of the formation of the Barrier Reef, or comprehend the existence of peaks like that of Mount Gower in Howe's Island, it appears to me that neither could have been formed without an older base and support of rocks than are now visible ; and that although the productions of either belong to the present, that present extends backwards in time to what may be called the past.

Those who are interested in such enquiries will find some very striking illustrations of the subject in the 2nd vol. of *Wallace's Malay Archipelago*, published in 1869, in which he assigns reasons for the former connection with Africa of the Malayan Archipelago. As, however, in that case Australia as well as India is excluded, it is, nevertheless, maintainable on similar data, that other connections in the Pacific may have existed between the present insulated tracts of dry land which must have bridged over many great spaces now occupied by the ocean.

Elsewhere (*Remarks on Sedimentary Formations of New South Wales*) in 1867, I suggested that the older Australian deposits are repeated in New Zealand, &c. Dr. Hector has since then (*Lectures on Mining*, 1869) by a very ingenious device, placing an outline of New Zealand on a map of Australia, *adjusted to the same meridian*, shown that the gold-fields of the former tally with those of the latter in the same *re-arranged general latitudes in which the character of the gold as to the proportions of silver agree ;* so confirming the previously expressed idea with additional emphasis, (*See Trans.* N.Z. Inst., II., p. 366, *issued April*, 1870), and the comparison holds good from the Ovens River and Gipps's Land to Rockhampton.

SUPPLY OF WATER. FLOODS. CLIMATE.

With a few words on another topic I will conclude. I refer to the Water Commission, to the evidence before which I contributed several facts relating to the elevations in the districts from which it has been proposed to obtain a supply; and as I had myself reported on a supply for Paramatta nearly thirty years ago, and afterwards, in 1850, was the chairman of the Artesian Well Board, I am not stepping out of my way in noticing this subject.

Nature seems this year to have given us a further insight into her operations. And, in consequence, we have the seeming inconsistency of a body of scientific gentlemen seeking a supply of water; and a portion of the same Commissioners employed in seeking how to get rid of a superabundance of it. Of course there is no actual contradiction. It is Sydney that wants the supply; Maitland that wants to get rid of one.

Now, touching the former, I have been confirmed recently in my previous views, that it is to *tanks* and *reservoirs* that we must look for our domestic supply. The millions upon millions of tuns that have been running away uselessly, or doing damage, during the last few months would have been sufficient, if properly stored, to have sufficed for many years for a greater population than we have at present. The valuable data in the report of the Commissioners for dealing with this question of supply will not, assuredly, be thrown away; and it is only a matter of cost that has to be considered, if their scheme is to be adopted.

This very question is attracting attention at home, and in the last number (brought out by the mail on the 16th instant) of the *Journal of the Royal Agricultural Society of England* (Vol VI., No. 11, p. 268), are some calculations showing the practical value of private tanks and public reservoirs, in an excellent paper "On Village Economy," communicated by Mr. J. Bailey Denton, C.E. But private individuals need not allow the bounty of Providence to be wasted, if they would, by a very simple contrivance, store it for use. Yet very few do this, confining themselves to periodical interludes of alternate complainings of droughts and deluges, and doing nothing whatever to help themselves.

Similarly, with an utter regardlessness to the "laws of nature" of which we hear so much, men go with their flocks and herds to dwell in places, from which, as a rule, they are sure to be swept away by such floods as those which have of late desolated many parts along our river beds, balancing in their minds, or not as the case may be, that what they lose in one way is gained in another though not always by the sufferers.

The main body of a great flood destroys much of the property that is on its immediate border; but *the backwaters* of the same flood spread over the more distant flats a rich manure brought down from the hills as a compensation for its ravages elsewhere. The ancient inhabitants of such places as the Pomptine marshes in Italy built their dwellings out of the reach of miasma, though once, before the sea invaded them, they were fertile tracts and thickly inhabited. And to this day the people who farm the Campagna only visit it for the sake of needful husdandry, returning from its pestilential atmosphere to the higher lands. Not one of these, I verily believe, would have had the folly to dwell in a *River bed* liable to a repetition of floods week after week; though it must be admitted that the older settlers, continue to occupy the sites of towns, that were exposed, but at long intervals (many centuries), to the ashes and lava streams of Vesuvius, as the remains still testify.

Certainly, after the disasters of Gundagai in 1851, and of the Hunter and Hawkesbury in 1870, it would be a merciful interference of Government to prevent any fresh formation of townships in such perilous places as many that could be named; for instance, on the Shoalhaven River many houses have been erected on a sandy deposit, itself produced by floods, and forming the actual bank of the river.

No doubt, it is a noble act to assist nature by engineering skill to carry off the torrents that have had their original channels disturbed and blocked up by careless occupiers of the soil, and it is generous and praiseworthy to relieve distresses that are even brought on by inconsiderateness; but it would be far better to prohibit the possibility of such risk, than to look calmly on whilst the people take their own way of running into mischief.

The meteorological conditions ought to be known well enough at present to require no such comment as this.

But it appears there are seasons when the ordinary eccentricities of the climate are greatly exaggerated by combinations of phenomena that taken together are irresistible.

When we hear of a flock of sheep, numbering several thousands, swept away without warning from an upland pasture in which no regular stream or channel exists, as was the case lately in the North; or when we hear of a thousand head of cattle enclosed in a paddock near a river level, from which the person in charge would not release them, though warned of the coming deluge, and of poor, helpless families surrounded in the night by roaring torrents, deep as the roofs of their solitary habitations, it is quite clear that the labours of our Relief Committees and the supply of seed wheat are very insufficient measures for the final preservation of people from such calamities. *Excelsior* should be the only motto for the occupier, whilst the lands of the owner are getting the periodical top-dressing Providence brings about by means of Inundation.

Connected with the *morale* of this topic are some considerations associated with the more special objects of our gatherings here; and inquiries are suggested which at the present moment can only partially be answered, though a full explanation may be hazarded ere long.

Everyone has noticed the peculiar conditions of the present period,—Earthquakes, interrupted electric and magnetic forces, displays of the Aurora, Sun spots, irregular Gales, absence of hot winds, sudden Storms, Tropical rains,—disturbing the usual order of summer weather, yet dressing the ground in a mantle of verdure which rivals the freshness of an English spring.

We may not be able to explain it all just yet; but when the time arrives we shall probably learn that a great disruption of ice has, within a year or so, taken place from the Antarctic barrier.*

A south wind during November was the prevailing wind, though, as we learn from the tables of my colleague the Astronomer, a N. E. wind prevailed that month for ten years preceding.

With this upper wind were combined lower temperature, greater humidity, heavier pressure of the atmosphere, and more abundant rains than were recorded during the same ten years. When these conditions are taken in relation to the tropical current that sets along our shores, from the heated volume of which has been a great evaporation over an unusually wide-spread surface, we can understand how the cool heavy air above pressing upon the lighter moist strata below may have produced unusual condensation, which, in the production of the rains, has caused those occasional *heats* which were so remarkable in the intervals of the more boisterous stormy gales which we have experienced.

There has been a great disturbance of the ordinary electrical atmospheric status of the air; and without taking into account any local or incidental occurrences—such as the influence of the telegraphic wires or the iron rails now stretching across the colonies, which must have affected in some degree the electric state of the atmospheric strata near the surface, or of the peculiar state of the sun—we may conclude that the present is a period when we are naturally incited to enquire whether we are living at the commencement, or middle, or end of a Cycle in the terrestrial and meteorological movements of Nature.

After an examination, long ago, of many thousands of phenomena, I came to the conclusion that at certain intervals or

* Since this was written, I have had my attention drawn to an announcement on the part of the Hydrographer of the Admiralty, of which I had no previous knowledge respecting the *fact* that Icebergs were dangerously prevalent on the Cape Horn Route in November 1869 and for several months before, and I have also received intelligence, that the Swedish Expedition to Spitzbergen had in 1868 met with Ice in an unusually disturbed condition, heavy drifts blocking the coasts, and betraying a disruption. It is not improbable therefore, that my conjecture as to one cause of our present extraordinary seasons in Australia may have been correct. [Jan. 31st, 1871.]

multiples of them nearly the same meteorological occurrences took place.

I am informed by a close observer, that the year 1819 was distinguished by just such a season as this—that was immediately after a great disruption of ice in the Arctic regions which produced just such changes as we have experienced here. Of course we cannot know what took place in the Antarctic regions at that time. But having observed that in this part of the world occurrences are noted at about six months' date from the time of similar occurrences in the Northern hemisphere, it is not without a show of reason that one might conclude that the irregularities of 1819, which was a marked year in this hemisphere, may have nearly corresponded with those of the same years in the other hemisphere. And if so, this year, at an interval of fifty-one years (a multiple of 17), satisfies the period in question.

It may be said, that in all this there is little else than conjecture, and that we have no right to make application of events in such a way.

But if the planting of Hawthorn hedges in England is known to have produced some climatical effects; if the clearing of forests in Poland, and of the summit of St. Vincent in the West Indies, are also known to have produced dryness to a surprising degree, depriving, in the latter case, the vegetation of the mountain top of the power of condensing water from the trade-wind ; if, too—what I can testify to from my own observation of of what I saw there—*paragrêles* (which are nothing more than posts at certain intervals, just like telegraph posts,) when placed in the vineyards of the Canton de Vaud, in Switzerland, convert the once destructive hail to snow, thus protecting the vines; so, I think our clearing of the Australian forests (any great tree of which produces daily a great amount of electricity), and our continuous lines of electric posts and wires, and the iron lines of our Railroads, must have some effect in the transference and spread or collection of that atmospherical Electricity which is in connection with those grander and more universal combinations which enter into the formation of our climate.

It may be also reasonably believed that the usual Trade winds of the Tropic have recently had a more than usual southern range.

If, however, but little weight be attached to such considerations, they may, perchance, direct the thoughts of inquirers into a channel which may lead eventually to something more satisfactory than theory.

We are all so much interested in our climate, that it can never need apology even for failure in attempting to explain its phenomena. Without the belief that it is possible to *prevent* the ravages of a flood, we may still anticipate the time when Common sense, Science, and Nature shall all unite to advance the prosperity of the country.

It should be the consolation of every mind that is rightly constituted, that He who gave this lower world to us His dependants; who impressed upon its organism laws that cannot by us be abrogated, gave us, at the same time, permission to investigate these laws and authority to turn them all to our advantage.

But if men will go into deserts where there is no surface water to be had, without the appliances to bring it from below; if they will persevere in defying the floods, and expecting to dwell safely in the midst of their channels, do not let them complain that the world has been made as it is, or that they cannot with impunity defy the power by which Nature is governed, whilst neglecting to see that even floods have their uses, and that Deserts are not as waterless as they appear.

When about fifteen years ago, the Marabout Arabs of the Sahara saw the fresh waters springing from the wells made by the French Engineers in that once-desolate region—the bottom of a dried-up ocean—in their joy they called one the "*Fountain of Friends*," another the "*Fountain of Blessing*," and a third the "*Fountain of the Resurrection.*"

Without going to the extent of their gratitude, we ourselves may still desire that the labours of our "friends" in executing the duties of their Commission, whether in diverting an inundation or in bringing a supply to our cities and towns, may be hailed as a "blessing" to the community at large.

POSTSCRIPT.

I do not wish this Address to be incorporated in the Transactions of the Royal Society, without a further and regretful reference to the Trigonometrical Survey, mentioned at p. 5.

This work, there alluded to in connection with a promised Report upon it from the then Astronomer, George Robarts Smalley, Esq., F.R.A.S., was unfortunately interrupted by his illness and unexpected death. But seven weeks elapsed between his occupation of the Chair, at my request, on the occasion of the above Address and my officiating at his funeral on the 13th July following.

He was one of the most useful members of our Society, and had often rendered it important services. He had been my colleague as Vice-President from the time when the Society took its present title, and was mainly instrumental in that change of designation.

Mr. Smalley took his degree as B.A. of St. John's College, Cambridge, in 1845, and was afterwards Professor of Mathematics at King's College, London, and Assistant Astronomer in the Cape Town Observatory. He was son of the Rev. George Smalley, Vicar of Debenham in the County of Suffolk, where I remembered him as a boy.

His official position at Sydney, as Government Astronomer, is now being worthily filled by his former Computer, H. C. Russell, Esq., B.A. (Sydn.), whose name appears in the list of contributors to this volume; and to another able member of our Society, also mentioned in the Address, P. F. Adams, Esq., Surveyor-General of N.S.W., has fallen the duty of continuing the Trigonometrical Survey of the Colony commenced by Mr. Smalley. As a native of the same county in England, to which belonged the late Government Astronomer and the present Surveyor-General, this commemoration of their consecutive services becomes to me a somewhat more suitable duty than it might otherwise appear. I have now spoken for myself in relation to the former. But as concerns the Society to which we have belonged, it may be proper to add, that, at the meeting in August, next after Mr. Smalley's death, it was my privilege to submit the following Resolution, which was supported by Professor A. M. Thomson, D.S. (who had been a Student under Professor Smalley at King's College), and unanimously adopted:—

"The Royal Society of New South Wales, at this its first monthly meeting after the death of the late G. R. Smalley, Esq. desires to express its sympathy with his family, and to record on its minutes its regret at his loss, with a deep sense of the valuable services which he rendered to the Society during his connection with it."

W. B. C.

St. Leonards' 28th Feb., 1871.

Art. I.—*On Post Office Savings' Banks, Friendly Societies, and Government Life Assurance, by Christopher Rolleston, Esq., Auditor-General.*

[Read before the Society, June 15th, 1870.]

Amidst the wonderful progress which characterises the age in which we live there is none more beneficial to society than that which has been directed to the amelioration of the condition of the working classes; and, of the efforts made for their benefit, perhaps, there are none more successful than those which have been directed to the promotion of institutions for securing the savings, and assuring the lives of the people. And surely no higher aim can be placed before any man who is in a position of power and influence than that which is promotive of the happiness and well-being of his less fortunate fellow countrymen.

I am not sure that, in so far as regards the important interests involved in the questions proposed for our consideration this evening, we may not take some shame to ourselves, as the inhabitants of the oldest colony of the Australian group, that we have allowed ourselves to be outstript in the race of improvement by our neighbours north and south of us—in Victoria and Queensland.

Savings' Banks are universally admitted to be amongst the most valuable of social institutions, in fostering a spirit of independence, and encouraging a system of provident forethought amongst the industrious classes; but we have not enough of them, and it is with the view of promoting this great social movement that I have selected this subject for discussion in the hope of directing public attention to it.

The Savings' Bank of New South Wales has undoubtedly achieved a high position amongst kindred institutions. Its administration has commanded public confidence in the highest degree, and the institution has been the instrument of inestimable good wherever it has reached. Its funds at the present time exceed a million sterling, and it has accounts open with some 23,000 depositors or thereabouts. We cannot tell the extent of the individual and family happiness involved in these figures, but whatever the extent may be, it comes far short of the requirements of the colony at the present time—nor is it possible for the Savings' Bank, as at present constituted, to supply the want. It is admirable as far as it goes, that is for the metropolis and the large centres of population in which it has branches.

But when we consider that out of the 113 towns and villages enumerated in the Census of 1861, the advantages of the Savings' Bank have only been extended to *sixteen*, we see at once how inadequate is its organization to meet the wants of the inhabitants in the remote and sparsely populated districts, and we are led to the enquiry how are we to reach these people? And how are we to hold out to them inducements to a prudent forethought in providing for the wants of old age, or the claims of widows and children? There are plenty of bush public-houses with their demoralising allurements to swallow up the yearly savings of a poor shepherd, bullock-driver, or bushman. He is often relieved in a night of the earnings of a year; and, poor man, he can hardly help himself, for he does not know where to place his money, or how to invest it; so he drinks and squanders it, and returns to his labour a poorer but not a wiser man—in nine cases out of ten probably to repeat the same folly again. I say, then, we are bound as a Christian community—seeing that we encourage, by our legislation, the temptation under which so many are led to ruin—to do what we can to provide an antidote. Much has been done to extend the blessings of education to the young throughout the length and breadth of the land, and as an adjunct to this we want to provide for the education of the adult—the father that is, or is to be, of the future generation. We want to train him in the ways of industry, temperance, and prudence; and to make of him a better husband, a better father, and a better citizen. And of the means to be taken to bring about this desirable result, perhaps the encouragement of institutions of the kind I have alluded to are the most effective, but we must look for an organization better adapted for our purpose than that of the present Savings' Bank, and where else can we find an organization adequate to the accomplishment of the ends in view but in the Post Office with its five hundred branch offices scattered all over the country. In connection with the Post Office we have a hundred and sixty "Money Order" offices, and wherever there is a "Money Order" office why should we not have a Savings' Bank? We know that in the mother country the Post Office has organised a most successful system of Savings' Banks, and that in the adjoining colonies her beneficent example has been imitated: and why not in New South Wales? Why should we be behind in the race of improvement?

The Imperial system legalises the opening of Savings' Banks at every "Money Order" office in England, Scotland, Wales, and Ireland. It authorises Postmasters to receive any sums of money not less than a shilling, and not more than £30 in one year, or more than £150 in the whole. Interest is paid to the depositor at the rate of £2 10s. per cent., or 6d. in the pound. The process pursued is this: The postmaster enters the amount of deposit in a book which he supplies, without cost, to the depositor, affixing his signature and the stamp of his office to the entry. The deposit is reported the same day to the Postmaster-General; and by return of post the Postmaster-General acknowledges the receipt by sending a printed letter to the depositor. Once in each year—on the anniversary of the day on which the first deposit was made—the depositor should forward his deposit book to the Controller of the Post-office Savings' Bank Department in London, in order that it may be compared with the books of that department, and the interest due to the previous 31st December be posted in it. When a depositor wishes to withdraw the whole or any part of the sum due to him, he has to make application to the Postmaster-General, on a printed form called a "notice of withdrawal," which he can get at any Post-office Savings' Bank. After properly filling up this form, he folds it up and posts it as an ordinary letter, and in return for it he will receive (probably by return of post) a warrant for the amount required by him, payable at the Post-office Bank named by him in the "notice of withdrawal."

A depositor in any Post-office Savings' Bank may add to his deposits at that or any other Post-office Savings' Bank, and may withdraw the whole or any part of them from that or any other Post-office Savings' Bank without change of deposit book. If a depositor should lose his book, he must report the loss immediately to the Postmaster-General, who will supply him with a new one upon receipt of postage stamps to the value of 1s., to pay for the new book. No charge for postage is made on the depositor for any letter passing between him and the Savings' Bank department with regard to his deposits, or to the withdrawal of the same, or for the transmission of his deposit book between him and the Savings' Bank department.

The postmasters and other officers employed in the receipt or payment of deposits are strictly forbidden to disclose the name of any depositor, or the amount of his deposits, except to the Postmaster-General, or his officers appointed to assist in the business.

Deposits may be made—1st, by trustees on behalf of others; 2nd, by minors; 3rd, by married women; 4th, by friendly or charitable societies, or by penny banks.

There are rules also for the repayment of deposits to representatives of deceased depositors, and for the repayment of deposits to depositors who have become insane, or unable to act for themselves. Such are the leading features of the Post Office Savings' Bank system in the mother country.

And now let us see to what extent the system has been availed of by the industrious classes, for whose benefit the movement was designed.

The sources of my information bring me no nearer to the present time than the end of the year 1867. At that period there were 3629 Post-office Savings' Banks in operation. The number of deposits received in that year was 1,592,344, and the amount was £4,643,906, showing an average of £2 18s. 4d. The number of withdrawals was 581,972, amounting to £3,222,800, showing an average of £5 10s. 9d.

The charges of management of this large business amounted to £62,700, or 7d. on each transaction. The number of accounts opened during the year was 264,341, and the number of accounts closed was 155,612. Whilst the number of accounts remaining open at the end of the year was 854,983; and the total amount standing to the credit of these open accounts was £9,749,929, showing an average of £11 8s. to credit of each account.

From the commencement of the system on the 16th September, 1861, to the 31st December, 1867, the total amount of deposits received exceeded twenty millions sterling, and the balance in hand of Postmaster-General at the latter date, applicable to payment of deposits, was £9,915,393.

Later statistics, kindly furnished me by Mr. Black, the Actuary of the Mutual Provident Society, show that at the close of 1868 the depositors numbered 965,154—an increase of over 12 per cent. on the preceding year; and that the balance due to depositors amounted to £11,666,655—an increase of over 19 per cent. on the balances of the preceding year.

Now, when we consider that this vast business is merely a kind of supplement or adjunct to the transactions of the ordinary Savings' Banks under trustees, which at the close of the year 1867 had a credit with the National Debt Commissioners of £36,792,911; and of the Friendly societies, which had a credit of £1,803,478—together, £38,596,389,—we wonder that the Post Office can have found such a wide field of operation as we have seen that it has covered.

We will now glance at the Post Office Savings' Bank system of Victoria, established in the year 1865, and subsequently regulated by the Post Office Statute of 1866, by which the rate of interest upon deposits is fixed at £4 per cent. per annum. The regulations are framed upon the model of those in force in England, and I append to this paper a progressive statement of the working of these Savings' Banks from their introduction in 1865 to the close of the year 1869.

Progressive Statement of the Post Office Savings' Bank in Victoria, from the commencement of the System, 11th September, 1865, to 31st December, 1869.

Year.	No. of Banks.	Deposits No.	Deposits Amounts.	Depositors' Balances.	Average Balance to each Account	No. of Accounts open.
1865	31	4,964	£18,465	£15,468	£7 5 6	2,126
1866	50	25,909	85,381	58,690	8 13 3	6,774
1867	66	37,624	124,633	103,075	9 5 5	11,118
1868	72	45,408	184,115	166,061	11 11 4	14,356
1869	99	51,528	233,412	243,478*	13 12 6	17,866

It appears that 31 banks were opened in the first year, with 4964 deposits, amounting to £18,465 6s. 6d.; that in the year 1869 the number of banks had increased to 99, the number of deposits to 51,528, and the amount to £233,412 14s.; and that at the close of the year there was a sum of £243,478 at the credit of 17,866 depositors in the hands of the Government.

Independently of the Post Office Savings' Banks there are established eleven Savings' Banks in the colony managed by commissioners, in the same way that the New South Wales Savings' Bank is managed by trustees; and at the close of their financial year, on the 30th June, 1869, they had 19,628 accounts open, showing a balance of £735,139 19s. 6d. to the credit of the depositors.

So we see that in a colony one-fourth the extent of ours, having a population one-third larger, and consequently much more densely located, and more easily accessible by the ordinary local Savings' Banks, the Post-office Savings' Banks have found an extensive and profitable field of operation, and placed the benefits of this great social movement within the reach of thousands who otherwise probably would never have thought of laying by one farthing.

Let us now turn to our youngest daughter, and see what Queensland has to offer by way of example. We find an Act passed in 1864 in that colony, "To grant additional facilities for depositing small savings at interest, with the security of the Government for due repayment thereof."

This statute provides for the receiving of deposits not less than five shillings, by police magistrates and others duly authorised. The money to be remitted to the Treasury, and carried to such account as the Governor and Executive Council may direct. Interest to be paid at the rate of £3 15s. per cent.; and by the regulations, deposits are limited to the total sum of £500, exclusive of interest. In the following year a further statute was passed, authorising the increase of the rate of interest to 5 per

* To credit of 17,866 depositors, on 31st December, 1869.

cent. There was also permission given by the first Act to the Trustees of any existing Savings' Banks to hand them over to the Government, and it appears by the report of the Under-Secretary to the Treasury for the year 1867 that the Government Savings' Bank had absorbed the three institutions which had previously been established under the old system. I append to this paper a progressive statement of the operations of these Banks for the five years ending 31st December, 1869, by which it will be seen that the number of Banks have increased from 28 in 1865 to 39 in 1869; that the number of deposits have increased from 5254 to 13,965, and the amount from £82,065 to £241,774; and that the balances at the credit of 5327 depositors amounted at the close of last year to £300,522, being at the average rate of £56 8s. 3d. to each depositor.

Progressive Statement of Government Savings' Banks in Queensland, from 1st January, 1865, to 31st December, 1869.

Year.	No. of Blanks.	Deposits No	Deposits Amount.	With-drawals.	Balances.*	Average.
1865	28	5,254	£82,065†	£26,463	£56,582	£31 7 7
1866	30	9,128	136,982‡	107,646	89,451	35 19 11
1867	35	8,948	126,597	97,621	123,158	39 6 11
1868	38	12,102	210.148	120.369	220,662	51 12 1
1869	39	13,965	241,774	174,002	300,522§	56 8 3

In the last report on the working of these institutions, it is stated that 21 per cent. of the withdrawal transactions had been conducted through the telegraph wires, and that no loss of any kind had been sustained either by neglect, miscarriage or otherwise. It is moreover stated that the entire business of the department had been conducted at no cost whatever to the public revenue. The success of the system in Queensland has been very marked, and the results which I have brought forward are surely full of encouragement. They leave no reason whatever to question the expedience of combining a Savings' Bank, with every Money Order office in New South Wales. I have not the statistics of other countries before me, and therefore, am unable to fortify my argument by the example of other countries. I am satisfied, however, that we have quite enough before us to justify the immediate application of the Post Office Savings' Bank system to New South Wales. But lest we may be met by the objection that the Post Office department has already sufficient on its hands in the receipt and transmission of the mails, and in

* Including 520 deposits and £22,007 17s. 4d. transferred from the Moreton Bay (old) Savings' Bank.

† Including 100 deposits and £3527 14s. 3d. from old Ipswich Savings' Bank.

‡ With interest added to 31st December of each year.

§ To credit of 5327 depositors on 31st December, 1869.

the conduct of the "Money Order" business of the country, we will glance for a moment at the Post Office statistics of the United Kingdom; and what do they show us? Why, that the number of letters alone delivered at the several Post-offices (numbering 11,314) in one year (1867) reached the enormous amount of 774,831,538, weighing close upon 7000 tons, besides over forty-two millions and a half, or nearly 3000 tons of newspapers, and over fifty-nine millions and a half, or nearly 5000 tons of book packets, yielding, together, a revenue exceeding four millions and a half sterling (£4,548,129).

In addition to the vast amount of work involved in the receipt, sorting, and delivery of these letters, newspapers, and book-packets, there was carried on a money-order system, under which there were issued, in the same year (1867), no less than 9,348,410 money orders, amounting to £19,282,109, and there were paid 9,427,085 money orders, amounting to £19,688,704, together making up a sum very little short of thirty-nine millions sterling.

When we contemplate these figures, and when we know that the gigantic business involved in them did not deter the Post Office authorities in London from undertaking to open Savings' Banks at every money order office in the United Kingdom, through the instrumentality of which transactions were carried on to the extent of close upon thirty-three millions sterling, in the six years from their opening to the close of 1867, averaging over five millions in each year,—I say, when we contemplate these facts, we cannot help being struck with the wonderful organisation which has surmounted the difficulties and made smooth the path by which such stupendous results have been effected, and moreover with a regularity, precision, and dispatch which excites our wonder, and holds out an example for our imitation. In the face of the great success which has marked the establishment of these institutions in the mother country and in the adjoining colonies, I don't think any one will question the expediency of their being tried in New South Wales, and in the face of the facts adduced with reference to the practical working of the system I think no one will be bold enough to say that the organisation of the Post Office is not equal to the undertaking; indeed the only organisation upon which this important duty could be cast.

I have not thought it necessary in the remarks which I have offered to urge the political importance of this question. It is upon the moral, social, and economic aspect of it that I base my advocacy—not that I am insensible to the great political stability which the lodgment of the savings of the industrious classes in Government securities is calculated to ensure. Give a man something to lose, and you give him something to protect, and the aim of a wise Government should be to encourage those habits which raise the moral standard of a people which contribute to individual happiness, and which at the same time are found to be the greatest safeguards to the maintenance of law and order.

There is also the question of advantage to the Government of the country, which a wise and enlightened administration of the funds of Savings' Banks, would confer. I say wise and enlightened administration, because the experience of the mother country teaches us that an unwise administration of their funds has involved a loss of something like five millions sterling, and I will explain how this was brought about. The rate of interest allowed on all sums deposited in the National Debt Office is £3 5s. per cent., and as the Savings' Banks deposits are generally invested in Consols, and the interest paid upon Consols bought at par is only £3 per cent., it is clear that if Government buy in at par, receiving £3 per cent., and paying the Savings' Banks $3\frac{1}{4}$ per cent., they must lose at least $\frac{1}{4}$ per cent., which, on 40 millions, would be £100,000 a year in interest alone. The only condition on which they can receive interest equal to that they pay is by purchasing Consols at $92\frac{3}{8}$. The people save money, as a matter of course, when it is plentiful, and just at that very time the price of Consols is high. In times of pressure and distress money is scarce, and the price of stock low. This is the time that Savings' Banks depositors require their money most, and at such times the Government must sell out at a low price the stock they bought at a high price, and suffer the loss which it is obvious must result from such a proceeding. The effect of the Government at home dealing with the funds of Savings' Banks since the passing of the Act of 1817, has been as I have stated a loss to the country of nearly five millions, of which about three millions and a-half arose from paying higher interest than they obtained by the investment of the money, and something approaching one million and a-half by selling out stock in times of pressure to pay withdrawals at a lower price than that at which it was purchased. But the Government have not been the only losers by Savings' Banks at home. The known frauds amount to nearly a quarter of a million, while the amount of those that have been made good by trustees or subscription wlil never be known. Then there is the question of security to depositors, which the guarantee of the Government alone can render perfect. But it is beyond the purpose of this paper to enter upon the consideration of these, which I regard as the political aspects of the question; and, therefore, not wishing to trespass upon the domain of politics, I leave them for discussion elsewhere.

The remaining portion of my subject, namely, that which relates to Friendly Societies, and the establishment of Government life assurance and annuity offices, opens too wide a field of inquiry to be entered upon at large to-night. But little is known of the working of our Friendly Societies, and it may be considered perhaps an evidence in their favour that we hear of no frauds committed in connection with the administration of their funds. In the interest of Friendly Societies, I took the trouble, some years ago, to investigate the quinquennial returns furnished by them under the "Friendly Societies' Act" of 1853; and I communicated the result in a report to the Government, hoping that public attention might be thereby directed to the subject. The report appears amongst the Parliamentary papers of the session 1861-2. I therein stated that if these self-governed societies presented no more valuable contribution to the cause of social progress than the practical education of their members in habits of self-dependence and the constant exercise of the duties and functions appertaining to the management of their affairs, they would deserve the support of every true friend of the people. I think so still, and that it would be undesirable to interfere with or to discourage that feeling of independence and self-reliance which induces certain classes of people to club together for their mutual benefit, and to manage their own sick funds and annuities in their own way. But it is entirely another question whether it may not be desirable to hold out to the artisans and industrious classes inducements by means of Government Assurance Offices to provide against the wants of sickness or of old age, or for the benefit of widows and children, in a way that is not exposed to the risks which experience tells us are incident to the working of Friendly Societies in the mother country. In so far as my inquiries have extended, I do not find that the Government Life and Annuity Offices have, as yet, answered the expectation of their promoters; but they are yet in their infancy, and as they become better known, and their claims to public confidence become more clearly established, they may be found to develop proportions commensurate with the aspirations of their warmest supporters.

I append a progressive statement of these institutions in the "United Kingdom," from their commencement in the year 1865 to the close of the year 1867.

Progressive Statement of the Post Office Life Insurances and Annuities in the United Kingdom for the years 1865 to 1867 inclusive (the first year for England and Wales only).

INSURANCES.

Year.	No. of Policies	Premium.	Amount insured.
1865	560	£1,333	£41,735
1866	1150	2,698	86,593
1867	1485	3,458	111,437

IMMEDIATE ANNUITIES.

Year.		No.		Purchase money.		Amount.
1865	...	94	...	£24,349	...	£2,236
1866	...	283	...	71,568	...	6,427
1867	...	551	...	136,637	...	12,393

DEFERRED ANNUITIES.

Purchased by Single Payments.

Year.		No.		Purchase money.		Amount.
1865	...	10	...	£1,006	...	£138
1866	...	27	...	3,010	...	443
1867	...	40	..	4,376	...	620

Purchased by Annual or more frequent Payments.

Year.		No.		Purchase money.		Amount.
1865	...	44	...	£507	...	£927
1866	...	80	...	809	...	1,675
1867	...	97	...	990	...	1,954

The progress is very manifest throughout, but the returns do not exhibit that marked appreciation on the part of the public which has been noticed in the case of the Post Office Savings' Banks.

ART. II.—*Remarks on the Report of the Water Commission, especially with reference to the George's River Scheme, by Andrew Garran, Esq., M.A., L.L.D.*

[Read before the Society, July 6th, 1870.]

THE importance of an adequate supply of fresh water to great cities, alike for the purposes of health and manufacture, is now so universally admitted that no words need be wasted in urging it. In the case of a city like Sydney, situated as it is in a hot climate, and certain (if not hindered) of great future commercial and manufacturing prosperity, it is of the utmost importance that the supply of water should be both ample and reliable. At present the city enjoys neither a sufficiency nor a certainty. Twice within a comparatively recent period the citizens have been inconvenienced by being placed on short allowance. In order to economise the supply, the streets had to remain unwatered during the hot and dusty weather, and fires raged with unnecessary destructiveness because the water had been shut off at night in order to diminish the waste. In consequence of this limited supply, there has been a tendency for manufacturing industries to locate themselves at a distance from Sydney where a supply of water may be relied upon, and the citizens have been justly alarmed lest the growth of population should rapidly outstrip the capacity of the existing Water-works.

So obvious was the urgency that the Government appointed a Commission to investigate the whole subject. The members of this Commission bestowed great pains on the enquiry, and made an exhaustive list of all the possible sources of supply. After considering the merits and demerits of each separate scheme, they decided finally on recommending a plan for drawing water from the Upper Nepean, and storing it in a reservoir near Prospect. At the close of their report they speak in modest and candid language of their consciousness that there may be defects in their work, and desire in the public interest that general criticism on their labour may correct its errors, and supply its omissions. "We now," they say, "invite the closest scrutiny of our results, sensible that if our scheme be in the main the best attainable, it will be improved by passing through the ordeal of enlightened criticism, while if any better scheme still lies undiscovered, the same criticism will we trust, bring it to light."

It is in the spirit of this invitation that I now venture to criticise the scheme recommended by the Commission; as, with all due deference to the talents of the gentlemen employed, and with a hearty appreciation of their painstaking labours, I cannot but think that the conclusion they have come to is erroneous, and requires in the interest of the public to be revised. It is now nearly nine months since this report has been issued, and yet the scheme recommended has not been at all adequately discussed, though it is of the utmost importance that no grave error should be committed. Under the impression that a discussion of the merits of such projects might be of public service, I have by request undertaken to prepare a short paper on the question, and, in the absence of abler critics, I trust that it will not be thought presumptuous for an unprofessional man to take a popular survey of the scheme for which the public are invited to pay.

After a careful consideration of the report, I cannot avoid the conviction that there are many grave objections to the plan recommended by the Commissioners—that their natural enthusiasm for their own scheme has prevented those objections from being fully presented in their report, and that to this extent therefore they have left it to outside critics to put the project in its least favourable light. I also think that they have too readily discarded the proposal for closing the estuary of the George's River—a scheme which I hope to be able to show will supply a larger quantity of water with more certainty and at less cost, than can be otherwise done.

The Upper Nepean scheme involves the necessity of constructing a conduit of sixty-three miles in length. This would not only be costly to make but costly to repair, and consisting as it would sometimes of pipes, sometimes of tunnels, sometimes of open conduit, passing under roads and over roads, would be exposed to a great variety of risks of damage. It is necessary, by this scheme, to go to this distance from Sydney to get the requisite altitude, which is fully attained at Pheasant's Nest, the point where the water is first intercepted, and which is four hundred and twenty feet above the level of the sea, or two hundred and eighty above the top level of the water in the existing Crown Street reservoir. This is an elevation sufficient to deliver the water with good pressure on the top of the highest roof in Sydney, but then, unfortunately, this advantage is wasted in the course of of bringing the water down. It is impossible to find any route by which the channel can be maintained at the desirable height, and the storage reservoir at Prospect could only deliver water 31 feet above the top level of the Crown-street Reservoir, so that all the difference between 280 feet and 31 feet is forfeited on the journey between Pheasant's Nest and Prospect. This remaining elevation of 31 feet is largely lost in delivering the water into the Crown-street Reservoir, as the distance to be traversed between these points is 21 miles, of which about 11 would be in pipes. So far, therefore, as pressure is concerned, we shall gain little advantage over the existing system. We shall not have sufficient force to drive machinery, nor to supply the upper stories of houses in the more elevated parts of Sydney, and it would be necessary to have recourse to pumping to supply the higher suburbs. This loss of elevation would be avoided to the extent of 68 feet by the adoption of Mr. Grundy's proposal for a reservoir at Bull's Hill, but this would involve piping all the way thence to Sydney, and the scheme was abandoned by the Commissioners, on the ground of its heavy extra expense.

The construction of the storage reservoir itself is not free from objection. It is to be formed by means of a dam which at its deepest point would be 80 feet. This is a great height, and would justify considerable anxiety about its security. Should it burst, the damage would be very serious; it would take some months to repair it, and the reservoir could not be refilled under a twelve-month. Moreover, a large amount of the labour and expense involved in the construction of this dam would be wasted, seeing that only the upper 25 feet of the water could be drawn off. Fifty-five feet, therefore, of height of the dam would serve no useful purpose so far as the storage of water is concerned. The reservoir would hold 10,000 millions of gallons, but 3000 millions would remain unutilised, unless pumped out, as they would lie below the level of the outlet.

Another and very serious objection to the scheme is that it provides no storage on the line of supply. The consequence of this would be that flood waters could only be very partially impounded. In this country where heavy floods alternate with prolonged droughts, our aim should be to detain in the wet weather as much water as we may want in the dry, and only to allow that to escape which we wish to get rid of. But under the proposed scheme the capacity for impounding water is limited. The Commissioners propose to draw off no water at all unless the river is running at the rate of 10,000,000 gallons per diem, as that amount is required for the settlers lower down the river and the conduit is only to be constructed to carry 80,000,000 gallons. I leave out of sight the question as to whether the settlers will be contented with the million gallons, especially in dry weather or whether they will claim more, or claim compensation. Some of the water, therefore, they must give away—some they must allow to go to waste. It is only what is intermediate between these two limits—between what they must give and what they must lose—that they can secure. In a dry period, therefore, when the reservoir might urgently require replenishing, if there were only occasional showers that did not set the river running at a greater rate that 10,000,000 gallons per day, none could be impounded for the use of the city; and we often have a succession of light rains at short intervals. On the other hand if heavy rain should happen to fall continuously for several days, the surplus water could not be sent into the reservoir, even though it were half empty, because the conduit could not deliver more than 80,000,000 gallons a day. It would require the conduit to to be running at its full capacity for 125 days to fill the reservoir in the first instance, and if we suppose only the upper 25 feet of water to be drawn off after a long drought, it would require the conduit to be running at its full capacity for 87 days to refill the reservoir. But our heavy rainfalls are generally of short duration, and after a prolonged drought it would probably require a considerable lapse of time before we could average 87 days of maximum delivery. The Commissioners' tables show that, in the year of their observations, the conduit would only have been running full for 90 days.

The total quantity that could have been run into the reservoir in the year would be 12,000 million gallons. But the total estimated rainfall on the watershed of the Cataract and the Nepean was 227,280 millions of gallons, and the quantity actually measured as passing down the river was 87,688 millions of gallons.

The cost of the proposed works I do not enter into but the Commissioners themselves estimated it at little less than a million sterling for their high level scheme, and £750,000 for their low level scheme. In a new undertaking of this kind it will be necessary to leave a large margin.

These objections are undoubtedly grave. If it were impossible to do any better we should even be obliged to submit to them, and must then content ourselves with making the best of disadvantageous circumstances. But, fortunately for the citizens of Sydney, I think it may be shown that we are not shut up to so unsatisfactory an alternative, and that the George's River scheme, when more closely considered, will be found to help us out of the the difficulty. The catchment area of the George's River basin is 375 square miles, while that of the Upper Nepean is only 354 square miles. The difference is not material. Both watersheds are ample, but that of the George's River is at least at no disadvantage in the comparison. But there is this enormous difference between the two schemes,—that while the benefit of the Upper Nepean area would be largely wasted, that of the George's River would be utilised to the full extent required. In a dry season when light showers fall, all that is not absorbed in the soil, or evaporated, would find its way into the reservoir, while, if we could suppose such a case as that of the reservoir being dry, the whole value of a rain-storm would be secured until the reservoir was full and the water ran over the weir. There would be no waste, therefore, except of water that was absolutely surplus.

A second advantage would be that no artificial conduit would be necessary to bring the water to within a moderate distance of Sydney. Kind nature would do that work for us. The channels of the watercourses are conduits ready made to our hand, and would gather all the disposable water, and bring it down to a point from which we could easily draw it. The artificial works for delivery would be simply confined to what would be necessary for forwarding water from George's River to Sydney.

The quality of the water in George's River would be equally good with that from the Upper Nepean, most of the formation being sandstone, and the whole area being only slightly inhabited. The only contaminating causes at present in operation of any importance are at Liverpool, a distance of 28 miles from the site of the proposed dam. But even if these causes continue to exist in full force they would not perceptibly affect the quality of the water at the point at which it would be drawn off for city use. But the probability is that when a superabundance of water is supplied to the city of Sydney the manufacturing industries will aggregate round the metropolis.

An objection has been made that part of the water running into George's River drains off the Wianamatta shales. This is true, but the area of shale is small compared with the area of sandstone and the quality of the water could not be materially depreciated on that account. Recent investigations in England seem to intimate that extreme purity is not desirable. Moreover it should be remembered that the drainage into the river would be mainly surface drainage. The water will run rapidly off grass lands without having had much time to become contaminated It should be remembered also, that the conduit proposed by the Commissioners runs for a considerable distance through the Wianamatta tract, and that the great storage reservoir is to be constructed in it. The water their scheme will supply to the city will be stored in this shale prior to its delivery, which will afford the maximum chance of impregnation, and they admit that for some years the water will be so clay-coloured as to be very objectionable in appearance, and the clay will be so fine that the water cannot be effectually refined by filtration.

The next advantage I wish to mention is, that to construct the reservoir at the mouth of the George's River would require but a comparatively small outlay. To make the reservoir at Prospect would require a dam; to make the reservoir at George's River would also require a dam. But the former would be eighty-one feet in height at its deepest part, and a mile and a quarter, or 6600 feet in length. A dam at Sans Souci would be only 1850 feet long, and the river is only 35 feet at its maximum depth. The former work would have to resist a pressure from water 80 feet in depth on its upper side, with nothing to support it on its lower side. The latter would be supported on both sides by water, the relative levels of which would not ordinarily vary more than about six feet. The former work is said to be possible —the latter to be impossible—except at an outlay of £650,000. On this point more hereafter.

Supposing the dam to be made (and for the present I may be allowed to make the supposition), a reservoir would be constructed of certainly not less than 3000 acres. This is the rough estimate of the area made by the Commissioners, supposing the dam to be at Tom Ugly's Point, but which I am inclined to think is considerably under the mark. An exact estimate of the area is not possible as there are no accurate surveys on which to base it. But the river is considered to be 27 miles long by its course from Liverpool to Tom Ugly's Point, and the tributary creeks show a large expanse of water at high tide. The Woronora and Salt Pan Creeks are both navigable by boats for several miles. Even supposing this to be not under estimated 1000 acres additional would be secured by making the dam at Sans Souci. According to the evidence of Mr. A. K. Smith, C.E., this amount of storage with a depth of only four feet would be equal to 3267 millions of gallons, and one inch of rain on the watershed would give this four feet of water. But four feet is a great under-estimate of the average depth. The difference between low neap tides and high springs is about six feet, and the weir would have to be kept some distance (say a foot) above the highest tide, to prevent the sea water from coming over. There would, therefore, be a depth of seven feet over the whole of the reservoir, except the margin between low and high water mark, *i.e.*, the foreshore ; and this quantity would be exclusive of all that the reservoir would hold at the level of low neap tide. We might very safely calculate this at considerably over a foot, as, though the river has some shallows, it has also some deep holes. Only three sections were taken across the river at points about a mile apart, and these give a depth, in the channel, of 33 feet, 41 feet, and 51 feet. Instead, therefore, of 3000 acres at four feet, we shall be within the mark if we reckon 4000 acres at eight feet, which would give us a storage of 8700 millions of gallons. According to the statement of the Commissioners, if only one inch of rain per annum were impounded from the George's River watershed, it would be capable of affording more than 15,000,000 gallons per diem. As far as regards quantity, therefore, the scheme is unexceptionable ; and though the evaporation from a large surface would be greater than that from a small one, this loss is more than made good by the constant and extensive replenishments the reservoir would receive.

Of course, as the water is collected at the sea level, it will be necessary, as at present, to pump up all that is wanted for the use of the city. Whatever the advantages of gravitation, they have in this scheme to be surrendered, but we have to set the cost of pumping against the cost of a conduit. From George's River to Sydney will be at the very most ten miles—the Commissioners' conduit would be 63 miles. The difference is 53 miles. The cost of the conduit for 53 miles would be about £240,000 ; the cost of pumping would be about £4 per million gallons. The Commissioners' pipes will only deliver 12,000,000 gallons per diem—a quantity that can be easily supplied by pumping. The present engines at Botany supply from 3,000,000 to 4,000,000 gallons per diem. It would be only necessary, therefore, to duplicate the capacity of these engines, and have a second pipe to duplicate that rate of supply.

I have now endeavoured to show that by draining George's River, we shall drain a watershed slightly larger, than that which the Commissioners propose to drain—that the reservoir will hold a superabundant supply—that the water will be of excellent quality—that the smallest rainfalls will be made available *pro quanto*—that the largest rainfalls will all pass through the reservoir and only what is not wanted will go to waste—that nature will bring the whole supply within 10 miles of Sydney and within a much less distance of some of the suburbs, without cost, and that the expense of pumping it up will be much less than that of making and maintaining 53 miles of artificial conduit. The whole of this argument rests upon the supposition that the river can be effectively dammed near its mouth and at a moderate cost. If that cannot be done, the whole scheme must be admitted to be a failure; if it can, it can hardily be denied that it is superior to the "Upper Nepean." Upon this little "if" the whole question turns, as on a pivot. To the possibility therefore, of constructing an efficient dam, let us now turn our attention.

The cost of a dam across the George's River is estimated by Mr. Moriarty at not less than £650,000. Even if this were a correct estimate, I am not sure that the greater recommendations of this scheme would not justify such an outlay in comparison with the amount required for the Upper Nepean scheme. But then Mr. Moriarty has estimated for a masonry dam, built on the rock bottom, and for a banking up of the river to a height of fourteen feet six inches above high water at spring tides. But would not this be a wholly unnecessary expenditure? There would be no necessity, for *storage* purposes, at any rate for a long time to come, to raise the dam or the weir beyond the limits necessary to keep fresh water from going over the former, or salt water over the latter; and would it be necessary, in order to construct a dam of sufficient retentiveness and solidity, to have artificial masonry, or even to go down to the rock bottom? The method I suggest is, in the first instance, to construct a breakwater of rubble stone, well intermixed and covered with tenacious soil; and then, on both flanks of this breakwater, to put a thick padding of sand. There is an unlimited supply both of stone, and mud, and sand in the immediate neighbourhood, and the cost of tipping it into position would be comparatively small.

With respect to a dam so constructed, two questions present themselves for consideration: First, would it stand? Secondly, would it keep the salt water away from the fresh? It must be understood that the water is not intended to go over this dam; on the contrary, the most ample precautions would be taken to prevent such an occurrence. South of Cummins' Point are two dips in the rocky ridge, either of which would furnish an available site far a waste weir. The ground is rock, and would only require to be cut down to a level just sufficient not to allow the highest spring tide to send salt water into the river. The weir could be made of any length required, and ample to allow a free discharge for the water of the river in the heaviest floods. It should be observed that so extensive are the bays in the lower reaches of the George's River that they act as flood-moderators. The consequence is that the heaviest flood makes scarcely any appreciable change in the river level at Sans Souci. A dam across the mouth would alter the present conditions for free discharge, but there is no impossibility in making the weir capable of discharging with equal freedom all the flood waters. And in this connection it must be borne in mind that water passing over the weir would have a fall varying from 1 foot to 7, and would get away with a proportional velocity.

Premising, therefore, that after the dam is completed the water will never go over it, we repeat the question—will a dam of the proposed construction stand? The breakwater at Plymouth, the dyke at Cherbourg, and the stone embankments that have been constructed at Portland, Holyhead, and other places, furnish familiar examples of the durability of such works. In all these places they have been found to stand the concussion of heavy waves. A rubble bank at George's River would be exposed to no such trial. The site I have pointed out is well within the estuary, and sheltered from the direct action of the sea. During its construction it would have to withstand the inflow and outflow of the water caused by the rise and fall of the tide and the river current, and, after its completion, would have to withstand the pressure of the water against it. It can scarcely be denied that a stone embankment may be constructed capable of resisting this pressure. There is an unlimited quantity of material available, and the breadth of the dam, both at the base and at the surface, may be adjusted so as to furnish the required resistance.

Colonel R. Baird Smith, in his work on Italian irrigation refers to several dams in the Italian rivers made of immense blocks of stone of irregular forms, supported by piles and woodwork frames, and some of these dams have been in existence for centuries. The rivers being fed by Alpine torrents, the impact of the water is at times very severe, and many early works were carried away. The timber has been added to bind the structure together, but a dam at George's River would not have to stand the same sort of blow, and timber, therefore, would be better away, as tending to increase the porosity of the dam rather than otherwise. In some localities banks of sea shingle have been found to make a good barrier against the rise of the tide, and in many works carried out in England for reclaiming low lands from the sea, banks of rubble stone have been found to possess the requisite strength. A stone breakwater, however, is only a part of the proposed dam. It is, if I may so express myself, only the core of it. In tipping in the stone it would be accompanied by a sufficiency of tenacious soil. There is close by in Wooloware Bay, an extensive deposit of very sticky mud, which could be easily dug or dredged up and dropped on the line of the stones, and a good coating of the same material could be thrown down on the sides of the dam after it had reached high water mark. Some of this might be washed away, but much would be driven in to any remaining crevices. To protect the outer slope of the dam against tidal action sand should be tipped in, leaving the water to wash it down to the ordinary sea-beach slope. That slope once attained would never be disturbed by the action of waves. Even if exposed to a heavy surf it would not be more destroyed than the ordinary sea-beach is, but at the site indicated only comparatively small waves would ever beat upon it. On the inner side it is proposed to make a similar slope of sand. It might not be necessary in the first instance to make it at the same angle, because the river would always be bringing down silt, and because the pressure on the dam would be more outwards than inwards, except in the case of such a drought as would reduce the height of the fresh water below the level of the salt. A dam thus constructed, with its core of stone flanked on either side with a broad padding of sand, would be immovable either by the pressure of the river on the one side or the pressure of the highest tide on the other. As the dam will be used as a high road for crossing the river, and perhaps ultimately for a railway, it would be desirable to have it not less than a chain wide at the top; and this roadway should be sufficiently high to secure it from ever being under water. A project somewhat similar in its main features is referred to in the last edition of the "Encyclopedia Britannica." "The noblest attempt of the sort ever made in Britain was that of Mr. W. A. Maddocks, in order to unite the counties of Merioneth and Caernarvon by a mound across an estuary and embouchure of the Glasslyn, two miles wide. After consulting various engineers the first operation was begun in 1807, and consisted in forming an immense bridge of flood gates in the solid rock of the shore, as such a bridge and gates could not be formed in any part of the mound. The use of this was to admit the exit of the river. This done, the mound was commenced from both shores, and rocky, sandy, and clayey materials thrown down in the direction of the mound and left to take their own slope. The greater part of these materials consisted of argillaceous rock, broken into small pieces, which being mixed with clay the mound would have been of the strongest texture. As the works proceeded, an iron-railroad was laid along the top of it, and extended to the quarries and excavations, by which means much labour was saved. In the course of three years the work was brought within fifty yards of meeting in the middle, but it was found extremely difficult to close it, from the rapidity of the influx and reflux of the tide. This difficulty however, would have been overcome and the proposed improvement effected at little more than the estimated cost, £20,000, had not the various and extensive projects in which the proprietor was at that time engaged led him into pecuniary difficulties which put an end to the undertaking." Though this work was not completed, the eminent authority that refers to it not only does not ridicule it as impossible but speaks of it as quite practicable.

Assuming, then, that the dam once made as proposed would be stable, the second question has to be considered: Would it prevent the intermixture of the salt and fresh water, and would the river once sweetened be kept sweet? I think it would. It will be remembered that the normal condition of affairs will be this—that the sweet water would stand at the higher level. As long as water was running over the weir it would stand one foot higher than high water springs, and seven feet higher than low water neaps. If there were any percolation at all, therefore, the feesh water would run into the salt, and not the salt into the fresh. The stronger pressure would overpower the weaker. All along the sea coast we have frequent illustrations of the fresh water being close to the salt without their intermixing. Wells sunk in the beach above high-water mark almost always are found to contain fresh water. Where creeks run out into the sea it is to be noticed that a sand-bar is thrown up at the mouth when the creeks are not flowing. The inland water is quite fresh, although the salt is only a few yards off, and there is nothing but a sandbank between them. The water pumped into the city from Botany is within a few yards of the salt water, and separated from it only by a rocky ridge and a sandbar. In the case of the proposed dam there would not only be sand, but stone between the two waters, and this stone would, in course of time, tend to become very firmly consolidated. Sir John Rennie, describing the Plymouth breakwater, says, "That so solid had the work become, that it appears to be but one huge stone," and "whenever excavations are required they can only be made by quarrying in the usual way." These excavations could only have been wanted near the surface, and we may infer from this how solid the work had become lower down. A rubble breakwater is of course in the first instance porous, but as it settles down and the interstices get filled up it tends to become more and more like a solid mass.

In works of this description, we need not be above taking hints from the engineering of Eastern nations, who had learned a great deal by practical experience before Western science was born. In a paper on Irrigation in India, read by Mr. Allan Wilson before the Institution of Civil Engineers, the writer gives some interesting statements as to the construction of river dams in India. A few of these remarks I will quote, as they are singularly *apropos* to our present subject.

"A tank is simply a reservoir, formed by throwing an embankment, or *bund*, as it is called in India, across a valley to dam up the drainage. The most simple description of *bund* is constructed entirely of earth, which is generally dug from the bed of the intended reservoir. Tanks of large dimensions have on their inner slope a pitching of loose stone, to prevent the embankment being injured by the action of the waves, and when stone is abundant this revetment is from 18 inches to 2 feet in thickness, the native workmen considering these dimensions the most economical as regards facility of building. The earth *bund* is constructed by a class of labourers known as 'tank-diggers,' or 'earthwork-wudders,' similar to the English navvy, the earth being carried in baskets to the site and there deposited. Puddle is seldom or never used, indeed it is not required, as, owing to the lodgment of silt, a tank will puddle itself after it has been once filled."

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"It should be remarked that whilst the native engineers have generally shown great skill in combining simplicity with efficiency and economy in the selection of the site and the construction of the work, they seem to have under-estimated the quantity of water to be carried off by the bye-wash, for it is found that many of the tanks that are now useless have been breached from no other apparent cause than the want of sufficient outlet to allow of the escape of the surplus water during floods."

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"The sites for many of the *anicuts*, or masonry dams (also called weirs), thrown across rivers, have been so judiciously chosen by the native engineers that very little expense has been incurred in building them. The *anicuts* across the river Toombuddra, which forms the boundary between the Madras Presidency and the dominions of his Highness the Nizam, at a point where it is divided into two streams by an island in the centre, and where the north stream has a dip of about five feet, may be mentioned as an instance in point. Between this island and the river bank there are a number of small islands composed of large blocks of granite and pieces of rock. All these have been utilised in constructing the *anicut*, which consists simply of boulders and blocks of granite 'thrown promiscuously together to filll up the spaces between these natural aids.' Whilst very little artificial work was required in constructing it, sufficient water has nevertheless been dammed up to cultivate a large area."

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"Besides these weirs of rough stones, the natives construct others of a temporary description. These consist of banks of sand either run up the river for a considerable distance parallel to the bank, or obliquely across it to the opposite side, until a level has been reached where the lowest part of the bed of the river is higher than the mouth of the channel. As, however, these weirs require annual re-construction, they become in course of time more expensive than the permanent construction of rough stone, and are not now so generally used as they were formerly."

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"The natives have, as a rule, selected rock for the foundation for dams, and it is no doubt preferable to any other, both as regards economy and stability. A rock foundation is not however absolutely necessary, as has been fully proved under British rule in India;—many works having been constructed on rivers, the beds of which consist entirely of sand. No better example of such masonry work could be found than the *anicut* across the Kistnah river; the length of this *anicut* is nearly 3800 feet, the breadth 300 feet, and the height in front is 21 feet above the deep bed, and 14 feet above the summer level of the water. It consists of a mass of rough stones thrown into the river and allowed to assume its own slope."

These illustrations of Indian engineering are sufficient to show that rivers may be dammed by rubble breakwaters resting on a sandy bottom and that they are not only firm enough to resist the pressure of the current, but sufficiently impermeable to bank up the water We may add to these extracts a bit of Australian experience extracted from evidence taken before the Commission. Mr. A. K. Smith, referring to a saw-mill constructed for himself in Victoria, says, "the mill was built by some Canadians, and they formed a dam across a creek in the Dandenong ranges. They made simply a timber frame in the bottom, and when I looked at it I had an idea that it would not be tight, because there was nothing at the back, and the fall was considerable. But the creek brought down something which made a deposit, and the dam became perfectly tight."

It may be said that though percolation in the dam I propose at Sans Souci might be practically innocuous so long as the fresh water is kept above the level of the salt, that yet I am bound to forecast the possibility of a case in which a long drought will have emptied the reservoir, and the salt water will be pressing against the outer side of the dam. What will then be the state of the case? Will not the salt water then ooze through? To this I reply first: it is extremely improbable that such a contingency could arise. The tributaries to the George's River have never yet been known to cease running even in the driest season. The Commissioners measured the delivery from the Woronora, and found it, in a moderately dry period, delivering half a million gallons per day. They also examined the upper part of the George's River, and found it delivering nearly two million gallons per day, "the period being rather dry." We may conclude from this, that even in dry seasons there would always be some contributions going on to the George's River reservoir, as the streams examined were only two out of several.

Secondly, if even the George's River should become dry, we may be quite sure, that in the same season the reservoir at Prospect would have been dry much sooner, and therefore, on a comparison of the two schemes, the Prospect reservoir would not show to advantage. Thirdly, the present delivery at Sydney does not exceed four million gallons per day, and though it was quite proper in the Commissioners to make provision for a future delivery of 12,000,000 gallons, still it would only be gradually that such a demand would arise. At 4,000,000 gallons per day, the George's River reservoir would hold out for 2000 days (assuming of course my calculation that it would hold 8,000 million gallons is not excessive, and leaving out of count loss by evaporation) without any addition being made to its supply. This is provision for a contingency such as the history of the colony has never yet known, and such as the Upper Nepean scheme would not be better able to weather. It must be remembered too, that even in what is called a drought there are occasional showers, especially on the sea coast. The Commissioners' figures show that the flow down the Nepean at the Cataract was equal to more than one-third of the estimated rainfall, and if the George's River reservoir would catch one-third of all that fell on its watershed it would be replenished at every rainfall, even though some extra allowance should be made in a dry season for absorption.

And lastly, before any such contingency could arise, or even before the reservoir could be reduced materially below the level of neap low tides, I think we may safely assume that the dam would become so thoroughly consolidated as to be impermeable.

Even if the George's River reservoir should become empty and the last drop be pumped out, its bed would only be in the same relative position as Lake Haarlem and a large part of Holland, which is below the sea level, and protected only by embankments. It may be urged however, that in such a state of things, even if the dam should be impermeable, the boundary rocks might not be so, and that through the fissures of the sandstone salt water might ooze. It is said that at Botany, when the engine-pond has been very low, sea-water has thus percolated through the barrier of sand and rock that separates the pond from the sea, although Mr. Bell, the City Engineer, denies that this has been the case.

But suppose this objection to be valid, there is still a resource. Although I do not consider it absolutely necessary to take any special precaution against what I regard as an improbable contingency, still such a precaution is perfectly feasible. If one dam will not be a perfect protection against the percolation of salt water, it does not require any great stretch of the inventive faculty to suggest the construction of two. A second and outer dam might be made either from Doll's Point to Towrah, or from Stripper's Point to Pelican Point. Though not absolutely essential this is the plan I should most recommend, as the additional expense would be more than compensated by the additional assurance; and in a matter of such importance to the community it is proper to eliminate risk as far as it can be done without incurring disproportionate outlay. With two dams we should have the following state of matters. There would be two lakes —an outer and an inner. In ordinary seasons the outer would receive the first water discharged over the weir, and the water in it would in course of time become fresh. But none of this water would be pumped out for the use of the city, nor would it rise and fall with the tide. It would stand at a constaut level. In the case of the supposed drought, therefore, which completely dried up the bed of George's River, this outer reservoir would be full, less only the loss by evaporation, and the water in it would be substantially, if not perfectly, fresh. If any salt water should ooze through the outer dam, it could only be in small quantities, and it would only very slightly affect the large body of water in this outer reservoir, and it would only be this very slightly brackish water that could find its way through the inner dam. The dilution, therefore, in the inner reservoir would be infinitesimal.

If it should be determined to adopt, from the very first, the system of a double dam, then, if the outer one were constructed first, some modification might be made in the suggested structure of the inner one, as it would not be exposed to any tidal action; and its cost and difficulty of construction would be diminished.

On the double dam system, too, it might be thought expedient to make the outer dam from Doll's Point to Towrah, and the inner dam from Stripper's Point to Pelican Point. This would involve some deviations from the plan I have suggested, which, however, it is not worth while to discuss in detail, I mention it just to show that any engineer who may be called upon to design works for sweetening George's River is not shut up to one plan, but has several alternatives befose him. Of course, the lower the inner dam is placed down the river, the larger is the area of the inner reservoir, and though Wooloware Bay is shallow and mostly dry at low water, its inclusion would add fully a thousand acres to the storage capacity of the river.

As illustrative also of the possibility of extention in future years, I may add that altogether apart from the possibility of dredging the shallower parts of the river and so increasing the capacity of the reservoir for storage, the George's River scheme has this further advantage, that Port Hacking might also be dammed in a similar way, leaving its embouchure, as at present, available as a harbour of refuge for coasting vessels. This would store the water of a pretty considerable area, all the country being sandstone. The water thus stored could be easily conveyed to supplement the resources of George's River, though I apprehend that it would be a distant generation that would require such a work.

Supposing the dam or dams to be constructed as described, and to be efficient, it would of course depend upon the character of the ensuing seasons how soon the water became fresh. But I have ascertained that during the late rainy season the water was quite drinkable at the ebb tide between Doll's Point and Towrah. and that it was tested at Sans Souci, at a depth of twelve feet, and found to be perfectly fresh. In such a season as this it would not take long to sweeten the water. The quantity of fresh water passing through the reservoir in an average every year would be over 90,000 millions gallons.

I shall not detain you by discussing how the water might be best conveyed from George's River to Sydney, as that is a matter of detail, which may be left till the general question of the feasibility of the dam is decided. Whether it should be conveyed to the present Waterworks and thence pumped into Sydney—whether it should be conveyed in an open canal to Marrickville *via* the line of fresh-water swamps that lie parallel with the western beach of Botany bay, or whether it should be pumped to a reservoir at Petersham, which would be ten feet higher than the present reservoir at Crown-street—are questions which may be allowed to stand over. There are several other matters of detail to be attended to when the scheme comes to be closely studied. But I have not wished to encumber this paper by referring to them. The main quetion to be first considered is—can the river be dammed—can it be done at a moderate cost—would the supply be ample, and would the scheme, if admitted to be feasible, be preferable to that suggested by the Commissioners? It will be time enough to discuss minor matters when these questions are answered in the affirmative.

I hope I have shown some grounds for believing that this affirmative answer is possible—that the mouth of the George's River may be effectually dammed at a moderate cost, and by simple constructions; that the amount of water it would store would be in excess of what could be usefully stored at Prospect—that into this reservoir the water would come free of cost—that every shower of rain would contribute something to it—that during the longest drought there would be some contributions to it—that the artificial conduit to Sydney would not exceed at most 10 miles in length and would pass through several populous suburbs—and that the whole might be rendered available in a comparatively short period, and without imposing any excessive financial burden on the citizens of Sydney. If there is any force in the considerations I have urged, it will follow that before adopting the Upper Nepean scheme as recommended by the Commission, the Government should at least re-consider the whole question, and it is under the conviction that such a re-consideration is demanded in the interests of the city that I have ventured to dispute the conclusion come to by the members of the Commission, for whom both personally and professionally I entertain a cordial regard, and who I am sure will be the last to resent any fair investigation of the fruits of their laborious inquiry.

Art. III.—*On the Botany Watershed, by Edward Bell, Esq., M. Inst. C.E.*

[Read before the Society, September 14th, 1870.]

In submitting the following remarks to the Royal Society of New South Wales upon a subject of such great importance to the inhabitants of Sydney and the adjacent suburban boroughs, I would state that I have endeavoured to be as brief as possible, and to confine myself to facts (as far as practicable) which have come under my own observation while engaged in the construction of the several works which have been carried out under my direction during the last fourteen years for the Municipal Council of Sydney for improving the supply of water to this city. It is necessary, in the first place, that I should give an outline of the general features of the Lachlan, Botany, and Long Swamps, all of which are so closely connected that it is difficult to define exactly their separate boundaries. I will, therefore, for the purposes of this paper, call these gathering grounds collectively the "Botany Water Shed" or "Basin."

The Botany watershed covers a superficial area of 5473 acres. Of this surface, about 4562 are sand hills, and the remaining 913 acres are valleys of sand covered by bog—the whole overlying the solid sandstone rock which forms a large natural basin from east to west, with a declivity from north to south towards the sea at Botany. It would appear that the sand which covers this watershed has been carried by the southerly winds from the seashore near Botany Bay, and deposited in this basin. The sand is perfectly free from loam or other viscid or clammy matter, and is therefore highly absorbent. I may mention, that on more than one occasion, I have filled a measure with five parts of sand, and pressed down tightly so as to bring the sand even with the top of the measure. Then I poured into the sand which the measure contained, very nearly three parts of water. After standing some short time, the sand so wetted settled down about one-eighth of an inch below the rim of the measure, and some of the water I had poured in, which had before been covered with sand, appeared on the top of the sand about one-sixteenth of an inch in depth. Of course, after the particles of sand have been brought closely in contact by the application of water, the absorbing power is sligthly decreased, still if sand be tolerably dry it will always absorb considerably more than one-half its own bulk of water. During my operations in this watershed I have repeatedly had occasion to make borings to ascertain the depth of bog, sand, and rock below the surface, and I have found almost invariably, that the boring tools shortly before reaching the rock have to pass through a stratum of what appeared to be a very tough, tenacious clay, which, during the operation of boring, becomes mixed with sand, and which mixture sticks so hard upon the tools as to materially impede the boring, and prevent the withdrawal of the tools from the holes. The highest swamp in this basin is called the Lachlan Reserve, the northern or head waters of which are led by gravitation through Busby's Tunnel to Hyde Park in the heart of the city. The sill of this tunnel is about 105 feet above the level of the sea at Botany. The fall of the stream in the first mile below the tunnel is 36 feet; that of the second mile is 26 feet; that of the third mile is 22 feet; that of the fourth is 12 feet, and that of the last half-mile is 9 feet. The bog in the Lachlan Swamp is about 9 or 10 feet deep in the centre, and shallow at the sides. The depth gradually increases with the course of the stream to about 30 feet near Botany. The sand below the bog also increases in depth, but not in the same ratio. Thus there is a rapid fall in the surface of the sandstone formation towards Botany until we approach the northern shore of Botany Bay, at which point the sandstone rock crops out above the surface and is covered by a stratum of rich yellow clay, varying from two to three feet in thickness. The average depth of the sand hills on both sides of the swamps above the sandstone formation is about 30 or 40 feet. Thus we have a gathering ground whose surface comprises about one-sixth bog, and the remaining five-sixths pure sand, which is protected from the wind and rays of the sun by a covering of low scrub and brush-wood—and whose bottom is sandstone rock covered with a stratum of clay—which will admit of no percolation through it. This is, I believe, at once the most absorbent and the most retentive catchment that is known to exist in any habitable part of the globe.

Amongst all the sources of supply mentioned by the Water Commission there is none which can be compared in value with this. No similar locality has been found with an equal power of conserving water. It must be admitted that sand has greater absorbing powers than any other soil, and the immense body of sand I have described, extending as it does over so large an area, absorbs the rain as it falls, and thus becomes saturated with water. The absorption is so immediate and so perfect that no puddle or run of water can be discovered on the surface of the sandhills during the heaviest rains. The whole of the water which falls on the surface being embodied in the sandhills, passes down slowly by filtration, and after storm time the water may be seen oozing out of the base of the hills into the swamps; by this means some is given off to the watercourse or rivulet which passes through the swamps, whilst the remainder descends farther down and is given off to the stream or dams at lower levels. The fact of this large basin of sand having a sandstone bottom renders it quite impracticable for the water which has been absorbed by the sandhills to escape in any direction but towards Botany. Sooner or later the sand will give off the water by percolation, which it has absorbed during the wet seasons, either to the adjacent stream, or at lower levels before it reaches Botany. The watershed is so admirably formed by nature that it loses nothing by absorption and very little indeed by evaporation. Let it be borne in mind that the stream of water which passes by gravitation through the tunnel into Sydney has never yet, in the driest season, ceased to flow, nor has the stream which used to discharge itself into the sea at Botany; also that enormous quantities of water have run to waste from this watershed into the sea at Botany during the rainy seasons of the last twelve years that the pumping engines have been at work, for want of storage room. When the tunnel was gauged by order of the Government in the year 1852, the quantity of water found passing through was 320,000 gallons per diem. Since the year 1856 the number and lengths of the service mains issuing from the tunnel have been largely extended, aud consequently the draught has been greater, and the flow of water through the tunnel has been increased from that cause. The quantity which now passes through the tunnel amounts to 1,200,000 gallons per diem. The correctness of this quantity was proved lately during a stoppage in the tunnel, when connections were made between the service pipes usually supplied from the tunnel and those which are supplied by the low-level reservoir, in order that the whole district might be supplied from the latter source.

Where the supply of water is obtained from surface collection, the first point to be ascertained is the average rainfall over the entire area of the watershed. The indications of the rain gauge are found to vary so materially at different points within a very short distance of each other, and within the same gathering grounds, that the determination of an approximate average is a very intricate operation. The comparative amount of rainfall on the same watershed is affected by elevation as well as character of surface, whether it be wooded or otherwise. The aspect of the slopes of the watershed in respect to the direction of the prevailing winds affects the rainfall, more rain falling at equal heights on the windward margin of the basin than on the opposite one. Formerly the only rain-gauge in the neighbourhood of Sydney was that kept at the South Head, near the Lighthouse, some two or three miles distant from the nearest point of the Botany watershed. For the last few years this gauge has ceased to furnish any returns. They have been issued from the Observatory on the Flagstaff Hill instead, where a gauge was established by the late Astronomer at an elevation of 155 feet above the sea. About two years since I established a rain-gauge at No. 1 Dam, near Botany, at an elevation of 21 feet above the sea, which is very carefully tended by the man in charge of the dams. At the same time I established another gauge in the flat at Double Bay, at an elevation of 10 feet above the sea, to which I have attended myself. It will be seen that only one of these gauges is within the area of the Botany watershed, that at Double Bay being situate at the foot of the northern slope of the hill which forms the northern boundary of that watershed. The gauge at the Flagstaff is about one and a half ($1\frac{1}{2}$) mile west of the station at Double Bay. The following is the return from these three stations for the year 1869:—Observatory, 48·13 rainfall; Double Bay, 56·65 ditto; No. 1 Dam, Botany, 45·87 ditto. And to the 31st August, 1870:—Observatory, 45·59 inches; Double Bay, 53·57 ditto; No. 1 Dam, Botany, 43·37 ditto. The difference in these returns shows the necessity for more gauges in the

Botany watershed. In order to obtain fairly an approximate average, I have long felt the importance of a station on the windward or southern slope of the northern boundary of the watershed, because of the very heavy flow of water which occasionally passes off from the Lachlan Swamp, when the flow is very light in comparison at Botany. But the difficulty of getting these gauges properly tended, and preventing them being tampered with, where there are no habitations to protect them from mischievous persons has prevented for the present the establishment of a station at this place. In considering what proportion of the ascertained quantity of rainfall is available for storage, it is generally admitted that the proportion varies with the character of the soil, whether absorbent or otherwise, with the acclivity of the gathering ground, with the amount of evaporation, and with the character of the rainfall, whether more or less intermittent or continuous. If, in providing storage room we construct dams and form open ponds or reservoirs for the purpose, we must of course expect to submit to some loss from evaporation, as they do in all climates. The precise amount of evaporation—at least with respect to large reservoirs—has yet to be practically determined. It is an acknowledged fact that experiments on evaporation, on a small scale, carried on at different observatories, give results considerably in excess of the actual loss of large reservoirs from that cause. Many eminent engineers, who had paid great attention to the subject, and who had been practically engaged all their lives chiefly in the supply of water to towns, had arrived at that conclusion, and had most strongly expressed their opinions to that effect. The result of such small scale experiments are vitiated by the impossibility of guarding against the effect of the heat radiated by the small vessels in which they are conducted. Mr. Hawksley, C.E., eminent more especially in connection with the supply of water to towns, gave a rule for calculating the loss by evaporation in large ponds or reservoirs—by which it would appear that it amounts to from 9 to 16 inches only per annum. Mr. Bateman, C.E., also celebrated in connection with the supply of water to towns, says that at Manchester the proportion of flow to rainfall actually used by him at that place is ·617; but he is of opinion that three-fourths can be made available. Mr. Copeland, C.E., also of similar note, says that he uses at Paisley, ·548 of the rainfall, but is of opinion that 84 per cent. can be utilised when required. The report of the Water Commission states that at the Yan Yean Reservoir, in Victoria, the evaporation is believed not to exceed two feet per annum Now everything we know in practice tends to confirm these statements, and the gentlemen I have mentioned, who have been engaged all their lives in waterworks, and have become eminent in that branch of engineering, are of opinion that from 75 to 84 per cent. of the rainfall can be available in such towns as Manchester and Paisley; surely with such a highly favourable watershed as that of Botany, we may reckon upon an available quantity of at least 80 per cent. of the entire rainfall, even with reservoirs and ponds uncovered; and, if covered, we may reckon upon nearly the whole. However, regardless of all this, the Commissioner deputed by the Water Commission to inquire into the Botany supply, in making his calculations (page 108) of the proportion of flow to rainfall, reduces it to one-fourth. Then he says, "*This would be rather a small proportion.*" Why, I would ask? If his elaborate calculations and deductions are worth the paper they are written upon, why cast them aside and say, without reference to any calculation at all, "this would be rather a small proportion?" I perfectly agree with that Commissioner that one-fourth would, in fact, be too preposterously low to be believed by any one, even the most credulous. It would seem that some one had suggested this, for he says immediately afterwards, and again without reference to any calculations or deductions, "It is considered that one-third of the rainfall may reasonably be relied upon, *even in the driest season.*" Now, although this is but a mere guess, it is an advance from one-fourth to one-third; and while he was about it, he might as well have extended it to two-thirds. It would have accorded more with the results of practice, and would have been more consistent in every respect. In the next page (110) in continuiug his calculation, he puts aside two-thirds of the entire rainfall as an absolute loss, and then immediately afterwards makes another reduction for loss by evaporation from reservoirs at the rate of 6 feet per annum, when the evaportion at the Yan Yean in the report of the Water Commission, as before stated, is given at two feet only. If the evaporation at the Yan Yean is believed not to exceed 2 feet per annum, why does the Commission state that 4 or 6 feet for Sydney is "as near an approximation as our present knowledge will justify." The report further states that in India and other tropical countries the rate for evaporation generally allowed is 6 or 8 feet per annum—the report does not tell us by whom this allowance is made. They are no better informed in India on this subject than we are here. They have their Observatory instruments, from which they tell us that the rate of evaporation at Bombay is 8 feet, and at Calcutta, where there is but little sensible difference in climate or atmosphere, they tell us it is 15 feet. This shows that the results obtained at different observatories with regard to evaporation are themselves so anomalous that they cannot be depended upon as even relatively correct, and consequently the results derived from the instruments by which they profess to show the amount of evaporation not being applicable to large reservoirs, ought to have been treated as such by the Water Commission, and their results should in no way have influenced their calculations. If the Water Commission allowed its judgment to be guided by the results of these observatory experiments in India, and fixed an absolute loss at two-thirds of the rainfall on the Botany watershed accordingly, it should tell us what becomes of it, or where this large body of water goes to. That which is absorbed by the sand can afterwards lose nothing by evaporation until it comes to light again at a lower level. It will descend into the sand, at most, as far as the rock, then with an elevation in the watershed of 110 feet, and a sandstone bottom with a declivity towards the south, the water absorbed in the rainy season will percolate through the sand and appear at Botany, or before it reaches there, some time or other. It cannot be lost in such a watershed by absorption. If it were, the accumulation in the earth of two-thirds of the rainfall of past ages on the Botany watershed would be something fabulous. We have a right to conclude that it reaches Botany in the dry season of each year—that is, in the months of November, December, January, and part of February—and keeps up that continual and copious flow which surprises every beholder. The Water Commission eulogises it in its report (page 18), in the following words:—"As the Lachlan Swamp is about 110 feet above the sea, and the stream has a gradual slope (in about five miles) to Botany, we have here an immense body of sand to get saturated with water in time of rain, and to give out this water slowly by percolation at the lower level. In our investigation we have found no similar locality with an equal power of conserving water. When we visited the extensive swamps at the head of the Cataract River, in December, 1867, we found them delivering less than half the water delivered at the same time at Botany, although the drainage area was more than double the extent; and in 1868, the Warragamba, with its drainage area of more than 3000 square miles, was delivering no more water than is usually supplied to Sydney from the Botany stream." Now, if the members of the Water Commission found the extensive swamps at the head of the Cataract River delivering less than half the water delivered at the same time at Botany, although the drainage area was more than double the extent, they must readily admit that the conserving powers of the Botany catchment must be nearly, if not quite, five times greater than those of the Cataract. Then, when it is considered that at the time this observation was made, the head waters of the Botany catchment were passing from the Lachlan Swamp through the tunnel into Sydney at the rate of 1,200,000 gallons per day at the very least, and that a similar quantity must have been running from the Long Swamp into the sea near Bunnerong, we may safely conclude that the conserving powers of the Botany watershed are seven times greater than those of the Cataract, equal to those of the Warragamba, and greater than those of any other catchment visited by the Water Commission during its investigation. After writing in such high praise of the Botany watershed, strange as it may appear, the report of the Water Commission goes on to state:—"We have come, after mature consideration, to the conclusion that it (the Botany supply) can barely be made adequate to the existing wants of Sydney, and cannot keep pace with the demands of an increasing population; that it should therefore be abandoned for another scheme which we will describe in the sequel." The scheme in the sequel is that which comprises the Cataract and the Nepean at the Pheasant's Nest. This source, in consequence of the non-absorbent nature of the watershed, it being composed of sandstone rock without any sand to absorb or conserve the rainfall, has, so I am informed by a gentleman of high respectability, been so free from water in the dry season, that he could walk across dry-footed. So much for the Cataract and Nepean watershed in comparison with that of Botany. It will be seen by the returns from the Government Observatory that the average annual rainfall during the ten years from 1859 to 1868 inclusive, amount, within a small fraction, to 50 inches. It amounted to about the same in 1869. The greatest rainfall in any one of those years was 82·81 inches=21,870,730 gallons per diem on the catchment, and the lowest 23·98 inches, equal to 6,333,294 gallons per diem. I commence with the year 1859, because the returns from that date were made by the late Government Astronomer. I have great faith in those returns. In the next place, I completed the pumping machinery at Botany in the end of 1858. Since that period I have been professionally and practically engaged, more or less, in and about the Botany watershed. I have studied the rainfall closely and believe the returns to be perfectly reliable. The returns made previously to 1859 do not appear to have been kept or supervised by any responsible official, or at any particular place; for this and other reasons I ignore them. The superficial area of the Lachlan and Botany catchment, which would naturally discharge its waters into the sea at Botany, is 4249 acres. It will be found by calculation that 50 inches of rain falling upon 4249 acres during one year will amount to 4,819,959,375 gallons, and this quantity divided by 365, shows that the quanity ot water which has fallen upon this catchment alone averages for every day throughout the last eleven years, 13,205,368 gallons. Then we have, in addition, the Long Swamp catchment, which contains a superficial area of 1224 acres, and now discharges its waters into the sea near Bunnerong. These waters may easily be brought to the pumping station at Botany by a main which should be laid for the purpose. 50 inches of rain falling annually upon 1224 acres, will give on the average 3,804,041 gallons for every day during the last eleven years. Therefore the average daily quantity of water falling on the Lachlan and Botany Swamps being 13,205,368 gallons, and that on Long Swamp, 3,804,041 gallons, we have had from the rainfall on the Botany watershed a supply at the rate of 17,009,409 gallons on the average for every day during the last eleven years. A quantity, if conserved, that would supply nearly 35 gallons per head per diem to a population of 486,000. We have used as much per diem as six and a half millions of this quantity for the present population, the remainder has necessarily run into the sea to waste, because we have not had sufficient accommodation to conserve it. Having shown the average daily quantity of water with which Providence has supplied us in the Botany watershed during the last eleven years, and having had nearly the same quantity this year to the 31st August, I think we may fairly reckon on a similar quantity of rainfall in years to come.

The next point to be shown is by what means we are to conserve this quantity of water that now runs into the sea and make it available for the use of the city and suburbs in the event of drought, and also to meet the wants of an increasing population. I will commence with that part of the Botany watershed north of the Randwick Road, known as the Lachlan Reserve or Swamp. There is already an embankment extending across the higher part of this swamp which diverts the head waters of about 900 acres from their natural course, and leads them into Busby's tunnel, through which they pass by gravitation into the city—as before stated this quantity has lately been ascertained to amount to 1,200,000 gallons daily. There are two places near the eastern end of the tunnel, which undulates so that the crown dips below the general level of the bed of tunnel, which places are liable to become choked with the sand which drifts through the masonry of the shafts, so much so as to impede the flow of water, and on one occasion to stop it entirely for several days. These dips in the crown or soffit of the tunnel must be cut away, and the crown so straightened as to admit a free current at all times; this, together with other necessary works which should be done in the city to facilitate distribution and increase consumption, from this source, would raise the flow through the tunnel to two and half or three millions of gallons per day, or 1095 millions of gallons per annum. For the supply of the tunnel with this quantity at all seasons, it will be necessary to construct an embankment along the northern side of the Randwick Road, extending from opposite the new toll-house to the rocks opposite the Race-course gate. The chief part of the materials for forming this embankment may be taken from the sand and bog on the north side of the embankment, and thus form a canal of five chains mean width along the whole length of the embankment to retain water. In addition to this canal, a reservoir should be excavated in the valley between two hills extending from the Randwick Road to near the mouth of the tunnel. This embankment with the reservoir and canal will retain 473 millions of gallons of water. It will also serve another highly important purpose, by impounding the head waters which now run off so rapidly in consequence of the great declivity of this part of the watershed, it will prevent floods in the neighbourhood of the lower dams, which now at considerable risk have to bear the brunt of the whole rush from this and the entire watershed between the Lachlan and No. 6 Dam during extraordinary rainfall; in fact no dams below the Randwick Road, be they constructed ever so expensively, can ever be deemed safe, until an embankment capable of checking the head waters to a large extent is made in the locality of the Lachlan Swamp. It would be premature to erect machinery for pumping all the water at our disposal into Sydney, until a sufficient number of dams has been made across the course of the stream to arrest the storm waters from approaching the sea so rapidly as they do now, and by those means retain them until they can be pumped into Sydney. At the latter end of the year 1858, when I first put the Botany engines in motion we had no dam whatever, but the engine-pond dam on the sea-shore, to hold back sufficient water for supplying the engines. This answered the purpose entirely, until in the years 1862, '63 and '64 water mains were extended throughout the city and into many of the suburban boroughs. From the fact of the storage accommodation not having been increased simultaneously with the extension of the mains or means of distribution and consumption, we began, in the months of January, February, and March, of 1865, to feel the want of some of the water which had been allowed to run into the sea during the rainy season. This led to the construction of some dams across the stream to retain the water and conserve it to supplement the stream in the dry season. The number of dams proposed to be made, including that of the engine and upper mill-ponds, was fifteen in all; three of these and the upper mill dam were made in 1867 and 1868, and brought into successful operation in the latter year, when we had in all five dams capable of heading up and retaining 174 millions of gallons. This quantity was sufficient in the dry seasons of 1869 and 1870 so to supplement the stream and give such a good supply in the months of

January, February, and March, as to obviate the necessity of shutting the water off the town at night, and discontinuing street watering, as had been done from 1864 to 1868, for some weeks in each year. It is true that this qnantity of 174 millions would not have enabled us to give a full supply for more than three weeks longer, if rain had not fallen when it did; hence the necessity for more storage accommodation, which should be increased in the watershed, and provided in the neighbourhood of the city. If we had had more dams on the stream, and a large storage reservoir near the town last year, we might have been in a position to supply the city and the suburbs for a period of twelve months longer, at the least, without any rainfall during that time. Therefore, in addition to the dam which I propose to construct at the Lachlan Swamp, and which will serve to give a full supply to the tunnel, it is necessary we should have more dams across the stream than we have now, in order to retain more water and keep the engines fully supplied. That the pumping-power should be increased at Botany, in order that all the water which the dams will not hold back may be pumped in during the wet season, and that a large storage reservoir should be constructed at the Cemetery Reserve near the city, with a capacity equal to 600 millions of gallons, into which the engines may deliver all their water over and above the quantity supplied to the city and suburbs, to be held in reservoir for all cases of emergency, and for the supply of the highest levels of the town as projected by me, and published in the *Sydney Morning Herald* of March 8th, 1869. The Crown-street reservoir contains $3\frac{1}{2}$ millions gallons; the high level reservoir contains $1\frac{1}{4}$ millions gallons; the five dams now in use retain 174 millions gallons; these five dams may be increased 166 millions gallons; seven more may be made to retain 392 millions gallons; the Lachlan Dam 473 millions gallons; the Long Swamp, 400 millions gallons; the Cemetery reservoir, 600 millions gallons: total, $2209\frac{3}{4}$ millions gallons. By these means the holding capacity of the dams and reservoirs may be extended from $178\frac{3}{4}$ millions to $2209\frac{3}{4}$ millions of gallons. This quantity of storage room above the dams, south of the Lachlan dam, may at any time be very considerably increased by excavating the sand at the margins of the ponds to the same depths as their centres. The features of the watershed are exceedingly favourable for the extension of the several ponds above the dams; so much so that the removal of every yard of sand will accommodate 160 gallons of water at the least; and when it is considered that the sand may be removed for 5d. per cubic yard, the expense could not be deemed important. It will be seen that the Water Commission in making their calculations with regard to the capabilities of the Botany watershed has drawn the cord with extreme tightness, and I think with great unfairness to their detriment, in order to show that this source of supply can "barely be made adequate to the existing wants of Sydney." First, as before stated, they say that two-thirds of the rainfall must be absolutely lost. Secondly, they deduct for evaporation at the rate of six (6) feet per annum. And thirdly, they assume that 665 millions of gallons is the utmost possible amount of storage room that can be had on the Botany watershed. In order to be in a position to shew the fairness or otherwise, of these deductions, I have taken the greatest possible pains, during the present year, to keep such a registration of facts as will enable me to show with tolerable accuracy what is the actual proportion of flow to rainfall on the Botany watershed. The rainfall at Double Bay, the 31st August, this year, was 53·56 inches, the fall at No. 1 Dam was 43·37 inches, 96·93 inches, mean 48·46. The average is 48·46 inches between the two points, and this I take as the average rainfall over the Botany and Lachlan swamps, which cover an area of 4249 acres; the quantity of water which fell upon this area during those eight months was 4,671,307,230 gallons. The quantity pumped into Sydney during the same time was 1,074,508,992 gallons; quantity passed through the tunnel, 266,400,000 gallons; quantity passed over the weir into the sea, 525,432,794 gallons; quantity passed through floodgates into the sea, 1,831,820,542 gallons; quantity now in the dams, 174,000,000 gallons; quantity used and accounted for, 3,872,162,328 gallons. Now, if this quantity be deducted from the entire rainfall, 4,671,307,230 less 3,872,162,328, — 799,145,902. Thus the quantity to be accounted for to the end of August is 799,145,902 gallons, or about one-sixth of the entire rainfall. If this quantity be divided by the acreage of the catchment, viz., 4249 acres, the quantity for every acre equals 187,000 gallons, or for every superficial foot of watershed a little over 4¼ gallons. Now the average depth of the sand comprised in the watershed is not less than 35 feet. This gives 35 cubic feet to every superficial foot, then considering the absorbent nature of sand. I think 4¼ gallous is not a large quantity of water to be diffused throughout 35 cubic feet of it, nor is it. But it must be borne in mind that when the wet season commenced in February, although the dams were nearly dry, there was a copious stream running into Botany, which enabled us to pump into Sydney nearly five millions of gallons per day; this water was that which had been retained in, and was being given off by the sand, and when, on the 26th of February, the rain commenced, there was still a very large quantity of water retained in the sand, which was absorbed last year, and would have been at our service for pumping into Sydney some weeks longer at the same rate.

So the $4\frac{1}{4}$ gallons per foot of this year's rainfall, shown to be absorbed by the sand, is in addition to the quantity which remained there when the rain commenced in February last. Thus we go on from year to year, with, in fact, a reservoir so covered and protected by nature as to prevent loss by evaporation, and which yields again to us all it takes under its influence. The quantity of rainfall so retained in the sand not actually accounted for is, in fact, constantly percolating through it, and, being replenished by occasional light showers, and by the very heavy dews which fall upon this catchment. This water it is which augments our Botany stream during the dry months of December, January, and part of February. This stream, with the assistance of 174 millions of gallons which were stored in the wet season of 1869 in the five existing dams, kept Sydney and the suburbs supplied during the dry season of 1869—from 26th July to the 26th February, 1870—a term of seven months, during which time only 15·25 inches, 2 1-6 inches per month, or a shade over 1-16th of an inch daily for 215 days. From these facts I conclude that the loss from evaporation on the Botany catchment is very slight indeed, and if the whole of the water which ran into the sea to the 31st August could have been pumped into the storage reservoir I have suggested, and that reservoir had been covered, the evaporation from it would not have been felt.

It is therefore, palpable that the plan I projected in 1868, and published in the "*Sydney Morning Herald*" of the 8th March, 1869, should be carried into effect for increasing the supply of water to Sydney and the suburbs, so as to suffice for a population of 400,000. It was as follows:—*a.* To construct a large impounding reservoir near Sydney, at the Cemetery reserve. *b.* To construct an embankment, and so form another reservoir at the Lachlan Swamp. (Their contents combined would be equal to 1073 millions.) *c.* To increase the number of dams on the Lachlan stream. *d.* To send all the water pumped from Botany into the Cemetery reservoir to supply the present low level reservoir, and the greater part of the town and suburbs from it, by gravitation. *e.* To establish a pumping station near the Cemetery reservoir, and pump from it all water required for the high levels of Sydney, Paddington, and the suburbs. By this means I shall divide the present heavy column, or lift of 214 feet, and so avoid all danger to the thirty-inch main from Botany. I shall also require an increase in the number of engines at Botany, and enable the present engines to send in a larger quantity of water by reducing the lift and increasing the size of the pumps. This project of mine was adopted and brought forward by the Water Commission as its own, in its entirety, excepting with regard to the size and position of one reservoir. The Water Commission recommended an open reservoir to be made within the city, with a capacity of 29,000,000, instead of the open reservoir I projected on the Cemetery Reserve, with a capacity of 600,000,000. Open reservoirs within towns are highly objectionable, and are known to disseminate disease throughout the town in which they lie, by the impurities of the atmosphere which they absorb at night with the dew-fall, and distribute throughout the town in the water. For this reason they are forbidden at home by special enactment, and should not be tolerated here; and for this reason I cannot coincide with the Water Commission in its choice of a site for this reservoir, nor can I in its limited contents. The two storage reservoirs which I have suggested near the town will be necessary to any scheme which may be followed, either now or hereafter, so as to ensure a supply to the town and suburbs in the event of any stoppage or interruption to the works at Botany, or wherever they may be. The Water Commission, in recommending their site at Strawberry Hills *within* the town, says, "It is obvions that the most advisable expenditure would be on some work which, while supplying our own immediate wants, could be utilised in any alternative scheme that might ultimately be adopted." Then it says, "The reservoir at Strawberry Hills would answer the purpose well, and should it is considered, be at once put in hand, so as to permit of its being made available as soon as possible." Now, I think it would not be at all advisable to put this reservoir in hand, as recommended by the Water Commission, because it is not practicable to supply it with water according to the scheme of the Water Commission. Their reservoir at Strawberry Hills is actually placed at a greater elevation than the reservoir at Norwood, near Petersham, from which they propose to supply it. The Water Commission says, "It is with considerable reluctance an unfavourable opinion is expressed of the Cemetery Reservoir." 1st, On account of what is termed the difficulties of construction, and also because the upper ten feet of water only would gravitate to Crown-street. This is attributable to their neglecting to ask how I proposed to construct the reservoir, and how I meant to work it—and so it is condemned in a manner which it does not deserve.

I would here record that the water commenced running to waste over the weirs at Botany on the 10th of March last, and has continued without ceasing to the present time—with the exception of one day in the month of July, when a cry was raised that the water was running into the sea to waste, while the dams were not half full; the sluices were then shut, and the dams were all filled in the space of thirty hours, when it began again pouring into the sea. The weir at Botany is 101 inches in width, and the depth of water now passing over it is five inches. In conclusion, I would observe that I have, I think, shewn beyond a doubt that the water which falls upon the Botany catchment, if properly conserved, is capable of supplying Sydney, and the whole of the suburbs with a minimum quantity of twelve millions of gallons per diem for any number of years to come; that it will suffice until the present population (taking it at 120,000) increases to 480,000; and that the recommendation of the Water Commission to abandon it is absurd. At the same time, I would recommend that no means should be left untried of determining on the best source from which an auxiliary supply may be had, so that when required it may be brought into operation. I would therefore strongly urge that the Botany watershed should never be abandoned as the main source of the supply to these municipalities; that no trespass should be allowed on the watershed which can in any way decrease the quantity or affect the purity of its water, which stands unrivalled for its excellence.

ART. IV.—*Notes on the Auriferous Slate and Granite Veins of New South Wales, by H. A. Thomson, Esq.*

[Read before the Society, Nov. 2nd, 1870.]

IN a paper on the "Formation of mineral veins, and the deposit of metallic ores and metals in them," published in "The Transactions of the Royal Society of Victoria, for 1867," the writer discussed the different views advanced to explain these phenomena, and pointed out what appeared to be the only theory which would account for the facts observed.

It is now proposed to lay before the Royal Society of New South Wales a short description of auriferous slate and granite bands of rock occurring in this colony, and as the conditions under which the gold is found in situ in the slate and granite appear to strongly support the views previously advanced, it will be necessary to restate the conclusions then arrived at.

Mineral veins have generally been described as open fissures formed by some disruptive force, and either filled at the time they were opened with minerals in a molten or pasty state forced up from below, or else with minerals held in solution by the water circulating in the open fissures, and slowly deposited on the walls until the fissure was thus gradually closed up. Under this theory the relative age of mineral veins was calculated from the dislocations which occur at their intersections with each other, and Lyell speaks of veins being classed in series on this basis alone.

The paper referred to pointed out that mineral veins were generally formed either on the cleavage, divisional, or sedimentary planes of the rocks they traversed, and not on irregular fissures; and that when the faultings, or throws commonly seen at the intersection of veins, were carefully studied, it would be found that the conclusions as to relative age would in most instances have to be reversed, or else abandoned, on the ground that they would only fix the relative age of the joints on which the veins had formed, and not that of the veins.

As to the filling of the veins; the fact, that the quartz of our auriferous veins has the specific gravity of aqueous-formed quartz, and that numerous veins occur in such a form, and under such conditions as would render it impossible for their contents to have been forced into them from below, appears to dispose of this hypothesis.

For the vein-minerals to have been deposited from the water circulating through the fissures, it is necessary for the latter to have remained open. Now mineral veins are found at all inclinations—from a vertical to a horizontal position—and every miner is aware how difficult it is to keep even a small area of the vein open until the ore is taken out; and that for the veins to have remained as open fissures for the long period of time that would be required to deposit their present contents is an impossibility. Neither will this explanation account for the small detached leads, and bunches of quartz, so common in the schistose rocks. Nor for the veins which cut out a short distance from the surface, where the extent of ground opened is not sufficient to allow of a current of water conveying the minerals, unless the latter were derived from the adjoining strata.

The theory which appears best to accord with the phenomena observed is, that the contents of the mineral veins have been segregated from the rocks bounding the veins, and collected atom by atom on particular lines or joints of the rock, so as gradually to replace the material previously existing there. After being thus formed, many changes might occur in the large continuous veins which act as water channels in the rocks they traverse, and either through the agency of the water, or some other means, portions of the contents of veins have been removed, and replaced by some other mineral. Bischof mentions one case where the original deposit of a vein had been entirely removed—the sole trace of it left being the pseudomorphic crystallisation of the mineral by which it was replaced.

The changes occurring in the structure of rocks, known as metamorphism, is a deeply interesting subject, whose study has been too long neglected. But since the field work of the geological surveys, now carried out, has shown that the diorite, gneiss, and granite, instead of being intrusive, are only metamorphic rocks, the importance of this branch of geology has been generally recognised, and we may hope that a few years' work will add considerably to our knowledge of the subject. We can now see what powerful agents are at work, however obscure their mode of working may yet appear. In the older Silurians the rocks are laminated by the cleavage forces, and traversed by divisional planes, quite irrespective of the old planes of deposit, while the constituents of the rock have been aggregated by new lines of force, forming bands of slate and sandstone and quartz, which traverse the sedimentary planes, and in many cases have entirely obliterated them. The pseudomorphic crystals afford a good illustration on a small scale of what may be called aggregative force. On these the original mineral has been replaced by a new one, atom by atom, although it is a mystery to our finite senses, how the atoms of matter could find their way through an apparently solid body, to and from the interior of the crystal. Change in the structure of rocks is constantly at work,—consolidation and decomposition, alteration of crystalline character and of chemical forms, aggregation into bands and nodules, and the great agent to which is due the phenomena of cleavage and divisional planes, whose action can be seen in every direction, but whose real character can as yet only be guessed at.

When forces producing such great changes in the rocks are known to be in constant operation, it is surprising that they were not first looked to for an explanation of the growth of mineral veins, seeing that they readily account for most, and are not inconsistent with any of the facts observed.

Various theories have been propounded to explain the mode in which the metals and ores have been deposited in the veins —some holding that they have come from a great depth, either in a molten form or else in a state of sublimation, others that they have been brought in solution in the water circulating through the veins.

As to the former theory, it is considered that to reach the parts of the vein where the metals or ores now are, the minerals must pass through a layer of cold water some hundreds of feet in thickness, in which the molten or sublimed metal must at once have become solid, this view will have to be abandoned as impracticable.

As to the latter theory, there is not the same impossibility of its being correct, in the case of continuous veins, penetrating to an unknown depth. But it will not account for the deposition of metals in the detatched shallow veins, or for the bunches of ores in rocks, or in flat veins, or nodules of ore in the solid limestone rocks, or for the cases where the veins traverse a series of distinct beds of rock, and are invariably rich or barren in accordance with the character of the rock bounding the vein.

The theory deriving the metalliferous deposits in veins from the rocks bounding those veins appears to be the only satisfactory explanation of the phenomena recorded, for it meets all cases yet known. In support of this view we might refer to the interesting experiments of Becquerel and Fox, and to the repetition of the experiments of the latter by Mr. Hunt, of the School of Mines, London—to the peculiarities attending the deposit of lead ore in the carboniferous limestones of Derbyshire and the North of England, and to the late deposits of ore found in old mining works.

This, however, only refers to the first segregation of the metals from the bounding rocks, as opposed to their derivation from some great deposit in the interior of our globe—after aggregation the ores may in many cases have been re-arranged in the veins, and where currents of water exist in veins, they may have had some part in effecting this re-arrangement, although the cases where this is possible are not numerous. A similar operation is still going on in the watered alluvial drifts, where gold is being deposited, along with sulphuret of iron (iron pyrites), on organic matter (such as old timber) undergoing decomposition.

The two instances of gold aggregated in bands of rock now brought under the notice of the Royal Society clearly support the above views.

The first case is the slate vein of Cowabee, on the Murrumbidgee River, which can hardly be distinguished from the bounding rocks; the latter consisting of Lower Silurian sandy slates. It is a simple band of slate, nearly vertical, and striking, with the cleavage, nearly north. At the surface the band is fourteen feet wide, and at sixty feet deep it is from sixteen to eighteen feet wide. When closely examined, there is a slightly more mineral look in this band than there is in the adjoining rock; but the difference is so trifling that it would easily pass unnoted unless attention were drawn to it. The gold is deposited in fine flakes, like gilding on the faces of the cleavage planes, where it has evidently been aggregated in its present form, and not in conjunction with pyrites: neither is there any sign of the latter ore having been collected in the band in such quantities as to affect the gold deposit.

In this close schistose rock there could be no currents of water to carry the gold about in solution, neither is there any passage through which it could have been forced up from some unknown deep region. The sole explanation which could be upheld is that it was formed by aggregation on the line of the band, and derived from the adjoining rocks.

Instances have been previously met with where the quartz usually filling up the space between the walls of a vein had been replaced by auriferous slate of exactly the same character: but this is the first example of a large auriferous band of slate which has been brought under general notice.

The second case is a similar deposit of gold in granite bands at Major's Creek, near Braidwood, but differing somewhat in character. This district has a granite formation, traversed by bands of hard crystalline schist, with every intermediate shade of difference between this rock and the granite.

The alluvial gold is of the fine flaky character always marking gold derived from the granite, but is accompanied by titaniferous iron instead of by stream tin.

At Major's Creek several auriferous bands of granite have been discovered, and some are at present worked to profit.

Generally, the bands are more or less decomposed; but in one face, where the band was thirty feet wide, it had undergone little change, and was only distinguishable from the bounding rock by its colour, changed through the decomposition of pyrites. These bands are nearly vertical, with a westerly bearing; and have yielded from a trace up to one or two ounces of gold per ton. The gold is of the same fine description as that taken from the alluvial ground, and has originally been pyritous gold. The rock is studded with cavities, retaining the form of the crystals of pyrites, but now filled with brown oxide of iron, and the gold liberated by the decomposition of the iron ore.

At two points where the bands could be seen below the water level, the pyrites was unchanged, and in such quantities as to form a large percentage of the rock. Here the gold will, no doubt, be enveloped in the pyrites, and a rough assay made of the latter gave over an ounce of gold per ton.

In the above case, we have an aggregation of gold and sulphurets of iron on bands of rock,—these bands having, no doubt undergone partial decomposition at certain points; but still they are distinct bands of rock, not segregated from the granite, or injected into fissures in that rock, but *a portion of it*, something quite distinct from a mineral vein.

There is the same difficulty in accounting for this deposit of gold and iron ore that is felt in the case of the auriferous slate bands, unless it is referred to segregations from the bounding rocks. It, however, brings out in a more striking light the action of the force which, causing change and decomposition in a homogeneous mass of rock, on lines running parallel to each other over a large area, at the same time has aggregated on the lines thus formed the gold and iron ore previously scattered throughout the whole mass of rock. Auriferous granite bands are stated to exist in South America; but this is the first example of the kind known to me to occur in Australia.

The endeavours made to bring science to bear on practical mining have not hitherto been attended with much success, mainly because the views promulgated were formed in the closet by persons imperfectly acquainted with the facts. If real progress has to be made, the first step must be the careful collection and registration of the phenomena observed, and as these accumulate, the deductions drawn will be tested with greater certainty. At present we must, in a great measure, depend on empirical knowledge in mining affairs, using the hints obtained from scientific inquiry as aids, rather than as guides. The rough outline given in this paper indicates how much has yet to be investigated and explained; and it may take many years of combined labour before the subject is so thoroughly understood as to allow of its application to practical work; but that this will in the end be attained, we may rest assured.

NOTE.—The Rev. W. B. Clarke, in his "Reports on the Southern Gold-fields," calls attention (at page 58) to the existence of gold in granite, and explains how it has been held enclosed in sulphuret of iron, and liberated by the decomposition of the iron ore. The bands of auriferous granite now opened entirely confirm these views, with the exception that instead of the deposit being confined to the outer surface of the granite it is in vertical bands of rock, on which the auriferous pyrites has been aggregated. In the same district, however, there are large masses of granite rock impregnated with pyrites (far more sparingly than in the bands,) in which the oxidation of the sulphurets, and the consequent liberation of the contained gold, is continually going on near the surface of the rock.

Even allowing no greater per centages of pyrites than I saw in large masses of granite at Major's Creek,—the rich deposits of alluvial gold found in the Araluen valley are not more than might be expected to accumulate, from the denudation of the rock, in the wearing out of this large basin. In the Araluen alluvial claims, small patches of granite traversed by detached leads of gold-bearing quartz occur, and this accounts for the few particles of coarser gold found mixed with the fine granite gold obtained from the alluvial claims. At Major's Creek, small quartz veins, generally yielding pyritous gold, are also found traversing the granite rocks, having the same general bearing as the granite bands above described.

Art. V.—*On the Occurrence of the Diamond near Mudgee. By Mr. Norman Taylor (of the late Victorian Geological Survey), and Professor Alexander M. Thomson, D. Sc.*

(Read before the Society 7th December, 1870.)

Last summer the writers of this paper spent a few weeks in company at the diamond washings on the Cudgegong, near Mudgee, and were occupied in collecting the leading facts relative to the occurrence of the diamond in that locality. Having agreed to publish their results jointly, they now beg to lay before the Society the following brief remarks.

Though the subject is one which has engaged their attention, both in the field and out of it, it is upon Mr. Norman Taylor that the main part of the geological work out of doors has devolved. Such might be gathered from the previous references which have appeared, comprising four articles by Mr. Taylor, in the *Sydney Morning Herald*, also the remarks of our Vice-President in his inaugural address of this year.

The chief circumstance that led to the discovery was the gold rush of Two-mile Flat, on the Cudgegong River (nineteen miles N.W. of Mudgee), in June, 1867. The diamonds were at first overlooked, but gems of such unusual brilliancy did not altogether escape the notice of the diggers. Still, little attention was paid to the matter until the Australian Diamond Mines Company of Melbourne commenced active operations in July, 1869. The search was then taken up briskly by several independent parties of diggers.

As far as at present known, the localities on the Cudgegong which produce diamonds lie along the river, extending from its junction with Wialdra Creek (eighteen miles N. 30° W. of Mudgee), to a point further down seven miles S. W., known as Hassall's Hill. Along this line the distribution of the diamond is by no means general, but is confined principally to a few small outliers of an ancient river-drift, which occur at various distances from the present channel, and at elevations of 40 feet or so above it. These outliers of drift are capped by hard, compact, and in many instances, columnar basalt; they have all the characters of the wide-spread deposits in Victoria, which the Geological survey there has been accustomed to assign to Older Pliocene. They also agree with it in occurring underneath a basaltic rock, which presents, in Mr. Taylor's opinion, the characters of the Older Pliocene basaltic flows, such as are extremely common in Victoria. At present there is no direct fossil evidence from the diamond drift itself to assist in the determination of its exact age. Portions of a humerus and a molar tooth, the latter rather too much shattered to identify with certainty, but sufficiently distinct to show that it belonged to some huge herbivorous marsupial larger than anything living now, have been found in younger drift higher up the river, at Magpie Gully, near the Gulgong Diggings.

The patches of diamond-bearing drift (Older Pliocene) with their protective coverings of basalt, though once forming parts of a continuous deposit, have been isolated by extensive denudation. The point of eruption from which the basaltic flow emanated appears to lie to the eastward, but it has not hitherto been detected; its remnants can be followed up for at least seventeen miles along the river, in some spots still showing a thickness of seventy feet, which proves the igneous outburst to have been of considerable magnitude, sufficient to materially alter the physical aspects of the river valley; we may also infer, conversely, the enormous extent of the subsequent denudation. There is the clearest local evidence that the course of the river has been much altered since the older drift formed a portion of the channel.

Enumerating in descending order the outliers of this Older Pliocene drift which affords the diamond, the first area occurs at the starting point, the junction of Reedy or Wialdra Creek with the Cudgegong. The dimensions of this area cannot be fairly estimated, as much of the basalt has been covered up by various surface accumulations; it lies partly on private ground, and has been insufficiently explored. 100 acres might be taken as an estimate of the extent of the workings as far as yet developed.

2. Jordan's Hill.—Three miles below, on the left bank, a triangular basaltic area of about 40 acres.

3. Two-mile Flat.—Three miles below the last, at some distance on the left bank, comprising five basaltic knolls and ridges at various intervals along a large elliptical curve that the old channel followed but which the present river has cut off. Computed altogether at about 70 acres.

4. Rocky Ridge.—On the right bank, one mile below Two-mile Flat, a scarped basalt hill, extending a short way up a tributary creek. About 40 acres.

5. Horseshoe Bend.—On the left bank, opposite the Rocky Ridge, a crescent-shaped area of basalt, with its concavity facing the river. About 20 acres.

6. Hassall's Hill.—A similar crescent area, with its convexity towards the river, situated half-a-mile south-west of the Horseshoe, and covering about 340 acres.

Further down the river, on the east side, about 2½ miles west of Hassall's Hill, there is another small outlier of basalt resting on drift, as well as several uncapped drift or 'made' hills; these are as yet untried for diamonds, though formerly worked for gold. Below this there is no trace of basalt for 7 or 8 miles further down the river, when we reach a very small outlier on the right bank, but whether the older drift underlies it we cannot say. 'Made' hills of drift, apparently the Newer Pliocene, skirt the banks of river on both sides to its junction with the Macquarie; but there is no further trace of basalt.

River-drifts at high levels are traceable in many parts of the upper course of the Cudgegong, above Mudgee; but no diamonds have been discovered in them. In one patch a singular deposit of crystalline cinnabar has been found.

In all the above six localities the basalt has been sunk through and tunnelled under, and the drift containing diamonds is invariably found beneath.

The basalt, besides resting upon the drift, frequently comes into direct contact with the metamorphic shales, slates, and sandstone or greenstone rocks, which form the basis of the country.

In spots where the basalt has been denuded away, the drift has either disappeared entirely, or become scattered over the immediate neighbourhood.

The drift rests on vertical indurated strata, or on massive greenstone; it varies extremely in thickness from a few inches to 30 feet, according to the irregularities, in some cases, of its own upper surface, which is not uniformly level, and in other cases, due to the old river bed. Its composition is various, but it generally includes coarse and heavy material, some of the boulders weighing several hundred-weight; thus testifying a strength of current at least as powerful as, if not in excess of the force of the present stream.

Though the six localities of Older Pliocene drift, just enumerated, are the principal sources of the diamond, they are not the only ones. At Two-mile Flat it has been found in a younger drift, which we shall provisionally term Newer Pliocene, as it occurs at a lower level, and also contains decomposed pebbles of basalt, which appear to have been derived from the protective covering of the Older Pliocene drift. It is probable too that the diamonds in this drift have been washed out of the older deposit. We shall allude to this further on.

Many diamonds have also been extracted from the water-holes in the river, but wherever this occurs the Older Pliocene drift has been previously discharged there by the diggers when gold was the only object sought for. Except in such spots the river bed of the Cudgegong has not afforded a single diamond.

Before describing the general nature and contents of the Older and Newer Pliocene drifts, it will be as well to give a brief sketch of the geology of the Cudgegong basin, and of the neighbourhood more immediately surrounding the diamond district; this will assist in any inferences regarding the original sources of the various materials which compose the ancient river gravels.

The Cudgegong rises in the acute angle, open to the west, which the Dividing range forms in latitude 33° S., and the first part of its course is N.W. sixty miles. In this part it is bounded on the N.E. by the Dividing range, which presents a summit of horizontal sandstone with various coal seams; the range in its continuation southwards completely encircles the head of the Cudgegong, and presents a similar formation of Carboniferous rocks. Accordingly we find outliers of Hawkesbury sandstone and underlying Carboniferous deposits, which include Glossopteris shales and coal seams, occurring in great force about the upper sources of the river. Several outcrops and cappings of basalt also occur on summits and spurs of the Dividing range. The main area of the basin and the ridges which confine it on the S.E., are of tilted slate and quartzite, with a few fossiliferous limestone bands, which are considered to belong to Upper Silurian or Devonian age; these are interspersed with small areas of granite, greenstone, quartz-porphyry, and felstone. The presence of *Calceola* in the limestone of Mount Frome, 6 miles above Mudgee, may assist in determining the age of a portion of the beds, but it is not improbable that both formations are represented. At Wialdra Creek, where the diamond-drift sets in, the Cudgegong makes a remarkable alteration in its course; it suddenly bends to the S.W., and reaches the Macquarie at a point 28 miles distant. This part of its course presents a structure like that of the older portions of its upper basin, except that limestone bands are wanting. No members of the Carboniferous series occur in this portion. The whole course of the river lies through a rugged and mountainous country.

In the neighbourhood of the junction of Wialdra Creek outliers of Carboniferous rocks are frequent. They consist of sandstones, conglomerates, with shales containing Glossopteris and other plants. These outliers form links at trifling intervals, connecting the Carboniferous formation of the Dividing Range with the coal of the Talbragar. A few miles to the north of the junction the Carboniferous beds form horizontal cappings on hills of slate or granite, whilst at Guntawang they are met with in the river valley, and near the junction they occur at a similar low level, and have been covered up by the Older Pliocene basalt without the intervention of drift. The great differences in level which the Carboniferous beds occupy deserve consideration. For our present purpose, however, it is enough to show that vast masses of Carboniferous strata have suffered denudation, and along the main stream we find relics of these rocks not only in the present bed but also in the older drifts.

The rocks immediately surrounding the diamond localities are nearly vertical beds, with a general strike N.N.W., consisting of red and yellow, coarse and fine-grained, indurated sandstones; thin white laminated argillaceous shales; pink and brown fine-grained sandstone, beautifully banded by purple stripes, in concretionary layers; slates and hard metamorphic schists; flinty shales; hard brecciated conglomerate, containing nodules of limestone, flint, and red felspar, in a greenish siliceous base. The last is not unlike the trappean ash-beds of Ireland, described by Jukes. With these there also occur dykes and outbursts of intrusive greenstone, which follow the strike of the beds irregularly, and indurate the rocks with which they are in contact. The rocks in general are devoid of mica.

Having thus sketched the geology of the Cudgegong drainage area, and seeing that the diamonds occur in an ancient river-drift, we are led to enquire whether the diamond is of drift origin, like the materials with which it occurs. If so, which of the formations afford the diamond? The Carboniferous, Devonian, or Upper Silurian? Or have the diamonds grown in the drifts in which they are now found? Before dealing with such theoretical questions we will enumerate the materials which compose the drift, and give a more minute description of its structure.

The Older Pliocene diamond-bearing drift is a coarse and heavy deposit, for the most part loose, but portions of it are united into compact conglomerate by a white siliceous cement sometimes coloured light-green by silicate of iron; in other cases the consolidation is the result of infiltration of manganese and iron oxides, in which case the colour is black or brown.

Diamonds have been picked out of the loose material, and, by a special experiment, which Mr. Taylor conducted, they have been proved to exist in the consolidated portions. Five bags of the conglomerate, weighing seven or eight hundredweight, were burned, crushed, and subsequently washed, and yielded two diamonds and three-quarters of a pennyweight of gold. The diamonds do not appear to be confined to any particular level in the drift deposit, though the lower parts are in preference taken by the miners, probably in consequence of the certainty of finding gold in this portion. The mere fact of the not unfrequent discovery of diamonds on the waste heaps round the old shafts that were sunk for gold, is enough to suggest that the diamond may occur in the higher portions of the deposit, since the bottom layer has been invariably carted to the river for gold washing. One diamond which was observed *in situ* occurred three feet from the bottom, imbedded in a mass of loose quartz pebbles, about the size of peas. Huge blocks of hard slate, sandstone, quartz, greenstone, and felspathic rock, the two latter often wasted into masses of clay retaining the original shape of the boulders, lie at the base of the drift in many parts. The drift varies much in character, but is chiefly made up of boulders and pebbles of quartz, jasper, inferior agates, quartzite, hard flinty slate, shale, and sandstone, with abundance of coarse sand, and more or less clay. The quartz pebbles are milk-white like vein quartz, but are generally encrusted with a thin film of iron oxide, either brown or pinkish. Manganese is abundant, both cementing the drift in irregular patches, and coating pebbles with a black crust or dendritic markings, or, as if smoked, soiling the fingers when rubbed. Some of the boulders and pebbles are coated all over with a remarkable brilliant siliceous polish, which cannot be the result of friction, as the concave surfaces and irregularities are just as highly polished as the more exposed parts; it is most probably the result of infiltration of silica, and is analogous to the coatings of iron and manganese.

Water-worn boulders of silicified wood frequently occur in the drift; they precisely resemble the fossil wood which is so abundant in the coal formation of New South Wales, and have probably come from the waste of similar Carboniferous rocks to those which now occur in the neighbourhood of Wialdra Creek, or form the escarpments which follow the N.E. side of the river basin, and completely surround its head waters. Silicified wood from these sources is found in the present river-bed. Coal has been seen in the older drift, higher up the river.

Other relics of fossiliferous deposits have been found more sparingly. These comprise several large rolled pebbles of the

Silurian coral *Favosites Gothlandica*, beautifully preserved in silica; also, one slate boulder full of a small *Orthis*. Fragments of brown ferruginous wood have also been detected in the cement.

It is worthy of remark that the Older Pliocene drift is remarkably free from any detritus of the rocks of the immediate neighbourhood.

In the waste heaps round the mouths of the shafts in the neighbourhood of basalt and greenstone some curious natural changes can be observed going on; botryoidal masses of hydrated mixed carbonate of lime and magnesia gradually form and bind the loose material together. A hard mineral, not unlike opal in appearance, is also produced in a similar manner, encrusting gravel, timber, old tools, or any material with which it comes in contact. It is a pure hydrated carbonate of magnesia, containing:

Magnesia	46·99
Carbonic acid	49·78
Water	4·08
	100·85

Specific gravity, 2·94

We have now to add a list of the gem-stones and heavy minerals which exist in the drift, and accumulate in the processes of washing for the diamond:—

1. *Black vesicular Pleonast.*—This mineral occurs in small grains from 1-20th to $\frac{1}{4}$ inch, and is by far the most abundant. It has a dull black surface, but shows a brilliant fracture. Some pieces are coated bluish-grey, or ferruginous brown; but the interior is the same in all, and the differences would seem to be the result of surface decomposition. It never occurs in crystals, nor shows any trace of faces; it has no cleavage; its fracture is conchoidal and jet black, with a strong vitreous lustre. Hardness, 8; streak, grey; composition, found by analysis—

Silica (and undecomposed)	2·75
Alumina	64·29
Chromic oxide	4·62
Magnesia	21·95
Ferreous oxide	4·49
	98·10

Oxygen ratio, 3·2 : 1
Specific gravity, 3·77

The mineral is amorphous and vesicular. The latter character is remarkable; the grains do not all show it in the same degree; one variety with a lustrous surface shows it best, the grains resembling a perfect cinder when seen through a lens. Several pounds weight of this mineral are obtained from each cart-load of gravel washed.

2. *Topaz* occurs in water-worn fragments, and sometimes in crystals; transparent, and commonly white; rarely yellow or very light blue. The Topaz is the largest of the accompanying minerals, varying in size up to half-an-inch diameter.

3. *Quartz.*—Opaque double hexagonal pyramids, one-eighth to one-fifth inch diameter, are very common. Quartz pebbles occur of all sizes. The varieties comprise agate of poor quality, cornelian, jasper, rock crystal, smoky quartz, and a kind which appears bluish opaline when wet. Pebbles of grey quartz, imbedding felspar, derived from a granite very similar to that which occurs at Aaron's Pass, fifty miles higher up the river.

4. *Corundum.*—

(*a.*) Sapphire, transparent, blue, green, yellowish, or parti-coloured.

(*b.*) Adamantine spar, hair brown and black.

(*c.*) The opaque magenta-coloured variety of alumina, which has received the name of Barklyite in Victoria.

All these occur in small fragments in great abundance.

(*d.*) Another variety, which is characteristic of this locality, has to be mentioned. It is in six-sided prisms, slightly barrel-shaped or tapering, with flat end faces; $\frac{1}{4}$ inch long, not exceeding 1-20th inch diameter; bluish-white, with a few dark-blue spots; opaque; hardness, 9; specific gravity, 3·59; composition found by analysis—

Alumina	98·57
Ferric oxide	2·25
Lime	·45
	101·27

(*e.*) *Ruby.*—A transparent pink variety of corundum; is found sparingly in flat grains up to 1-10th inch; its shade often passes into violet and blue; hardness, 9; specific gravity, 3·96; composition found by analysis—

Alumina	97·90
Ferric oxide	1·39
Magnesia	·63
Lime	·52
	100·44

(*f.*) A few large rolled pebbles of corundum have also been observed, exceeding $\frac{1}{2}$ inch, of a mottled dirty white and pink colour, perfectly opaque. From their low and variable specific gravity, 3·21, 3·44, and upwards, they appear to be impure massive forms of the mineral; they possess the requisite hardness.

5. *Zircon.*—This occurs in small rolled pieces and as fine heavy sparkling sand in abundance. It is transparent; brown, very pale red, or colourless.

The sapphires and zircons very rarely exceed $\frac{1}{4}$ inch diameter, and are mostly very much smaller; it is worthy of remark that these gems are found higher up the stream in pieces of considerably larger average size.

6. *Tourmaline.*—Rolled black prisms, $\frac{1}{2}$-inch long, are common; small nests of schorl in quartz pebbles rare.

7. *Black titaniferous ironsand.*—Common.

8. *Black magnetic ironsand.*—Common.

9. *Titanic acid.*—Probably *Brookite,* in flat red transparent or reddish-white translucent plates, with striated surfaces, but too much worn to distinguish the exact crystalline shape. The plates vary in thickness up to 1-12 inch, and often measure $\frac{1}{4}$ inch across; hardness, 6; specific gravity, 4·13; composition found by analysis to be pure titanic acid except a minute trace of iron.

10. *Wood-tin.*—Small, rare.

11. *Garnet,* in minute icositetrahedrons.—Rare.

12. *Iron.*—Hackly fragments of the slightly rusted metal, averaging $\frac{1}{3}$ grain, which are evidently derived from the iron tools and apparatus. Analysis failed to detect in them the least trace of nickel.

13. *Gold.*—Fine, scaly, and occasional fragments enclosed by quartz. The quantity is variable, but the average is about 3 dwts. per load of drift washed.

14.—The *Diamond* itself is distributed through the Older Pliocene river-drift sparingly and irregularly. At Hassall's Hill thirty-three loads from one claim yielded 306; at the same claim they have washed from one to fifteen to the load, but the average has been about five, with 3 dwts. of gold. At another claim, on Hassall's Hill, a washing of from twelve to fifteen loads yielded at the rate of eight diamonds to the load, and 3 dwts. of gold; the average, however, was about three diamonds to the load. This yield afterwards fell off, and the ground is now worked out. Some of the drift at the junction of Wialdra Creek gave regularly four diamonds per load, but ultimately fell off to one per two loads. In other places the yield has been only one diamond to the load.

As regards the weight of the diamonds the following parcels will afford a fair average:—

306	diamonds weighed	$74\frac{1}{2}$	carats;	largest, $\frac{3}{5}$ carat.
81	„	19	„	largest, $1\frac{1}{2}$ carat.
110	„	$26\frac{1}{2}$	„	
16	„	6	„	
700	„	$151\frac{1}{3}$	„	

Giving an average weight of ·23 carat each, or close upon a carat grain. The largest diamond hitherto discovered in this locality was a colourless octahedron, weighing 5⅝ carats; it was found in the river, between Two-mile Flat and the Rocky Ridge, at a spot where the Older Pliocene drift had been discharged in gold-washing.

During the first five months of systematic washing over 2500 diamonds were obtained, and several thousand more have been since collected. They are mostly pellucid and colourless; many have a straw-yellow tint, and tints of brown, light or dark green, and black are more rarely met with. An opaque black one has been found, and another of a dark green colour, with the external appearance of having been rubbed with black lead. Black specks within the crystal are not uncommon. The specific gravity taken from a number of crystals is 3·44. They all show a well-defined crystalline form, though irregularities of development are frequent. It is very rare to meet with worn or fractured specimens. They are easily recognised by their characteristic lustre, which is never impaired by a superficial coating of foreign matter. Sometimes they are dull, but this is not due to water-wearing or incrustation, but to multitudes of minute angles and edges of structural planes, which give a frosted appearance to the crystal. The forms met with are the octahedron, twin octahedron, dodecahedron, tris-octahedron, and hexakis-octahedron; the two latter are frequently hemihedral, with curved faces, and are sometimes developed into flat triangular twins. One specimen of the deltoid dodecahedron has also been found. The curious flat triangular twin-crystals are derivable from the tris-octahedron. If we regard the latter as an octahedron, with a low triangular pyramid on each of its faces, and out of the eight pyramids we imagine that only two, corresponding to opposite and parallel octahedral faces, are developed, on applying these two pyramids together, they would not form a closed figure, but by twisting one 180° round, we form the triangular twin crystal. Or simpler, if we inspect a twin octahedron, there are but two of the original triangular faces entire; these are opposite and parallel, and by replacing these two faces by the corresponding planes of the tris-octahedron, the rest of the faces of the twin octahedron may be obliterated, and thus the triangular crystal will result. The structural laminæ are very distinct on some crystals, and many of the octahedrons show these successive layers of growth in a very beautiful manner.

The fluctuating yield, small average size of the gems, great expense in extracting the drift from beneath the basalt, cartage to water, and washing effectually, are the drawbacks which have hitherto stood in the way of the successful investment of capital in this direction.

The Newer Pliocene drift has afforded a few diamonds. Its materials appear to have been partly derived from the older drift. In one spot, where it rests on greenstone, it consists of a pure white clay, in which gemstones are concentrated in the most remarkable abundance. It is studded throughout with black grains of pleonast, and more sparingly with sapphire, ruby, &c. The accumulations looks like the result of some natural washing process upon the materials of the Older Pliocene, so that it is not surprising that a few diamonds have been discovered in it. In the Newer Pliocene we find Carboniferous conglomerates, pebbles of quartzite containing Spirifer, others of shale retaining impressions of Glossopteris, rolled silicified fragments of Favosites and other corals, pebbles of sandstone with crinoidal stems and Orthis, silicified wood, abundance of pebbles of flesh-coloured quartz, boulders of basalt and greenstone—all occurring in addition to the ordinary contents of the older deposit. It also affords the same gems and minerals, and, besides these, a few grains of *osmiridium* have been found.

The recent deposits in the present river channel are of local origin, being derived from the neighbouring rocks, including slates, sandstones, quartz of all kinds, greenstones, characteristic conglomerates from the carboniferous rocks, and silicified fossil wood. The minerals comprise gold, black titaniferous and magnetic iron sand, sapphire, topaz, zircon, stream tin, and brown garnets crystallised in minute rhombic dodecahedrons with edges either entire or truncated. Similar garnets are found in the bed of Lawson's Creek, a tributary which joins the Cudgegong at Mudgee.

The plan which is adopted in washing for diamonds is—first to screen the drift to separate the larger stones, then to rid it of clay as much as possible in a "tom;" the coarser portions are raked aside, whilst the gold and finer matter is carried by a stream of water through the grating of the "tom," on to the blanket boxes below, where the gold, and occasionally a diamond, is deposited. From the material which passes over the blankets, the heavier fragments are separated from the lighter by various contrivances, among which Hunt's ore-separating machine is the most in use. The heavier stones accumulate in the machine, whilst the specifically lighter materials are washed away. In the heavier portion, thus reduced to a small bulk, the diamonds can be readily distinguished.

In speculating as to the original source of the diamonds in this locality, many difficulties arise. Considering that we have not yet discovered the matrix of the pleonast, corundum, zircon, and topaz, which exist in such profusion, it is hopeless to advance any hypothesis on the origin of the diamond, which is so rare in comparison. But there are one or two facts about the diamond which do not equally apply to the other associated minerals. First, the diamonds are never waterworn, and very seldom fractured, while the sapphire and all the other gems are rolled excessively. The superior hardness of the diamond may account for this peculiarity. A few shapeless ones have been found, but if their want of crystalline form is due to abrasion, the lustre has not been in the least impaired by the process. Secondly, they are not so uniformly distributed as the other gems, but generally occur in rich patches, and wherever most abundant they are also largest and purest. The diamonds found at the Two-mile Flat are larger than those found at Wialdra Creek, which is higher up the river. These and other facts have led some to believe that the diamonds actually grew in the drift. The structural planes in many of the crystals also suggest this belief; but, if such is the case, those who hold this view cannot explain why diamonds do not occur in similar drifts which are common throughout Victoria, and in other parts of this colony.

Until chemistry throws some light upon the possible modes of formation of the diamond in nature, and demonstrates the necessity of its occurrence in metamorphic rocks, it is perhaps as easy to suppose that the gem may originate in a late tertiary drift deposit as in the most ancient strata of a somewhat similar origin. Quartzites and quartzose conglomerates occur in Australian tertiary deposits, having as highly metamorphosed an aspect as those in the Silurian rocks. If the diamonds have been formed in the drift, it will account for their absence in the present river bed. On the other hand, if the diamond has been drifted from its original matrix, either it might be expected to occur in the river, where it has never yet been detected, or its matrix has been entirely denuded away in Older Pliocene times. Large areas of Carboniferous and older strata, as well as extensive tracts of tertiary basalt, have disappeared from the river basin; others have therefore proposed to assign the original position of the diamond to local and limited deposits in the demolished palæozoic rocks.

The fact of the association of the diamond with other gems, which are mostly derived from igneous or metamorphic rocks, does not prove that they came from the same rocks. Innumerable creeks and rivers in the colony contain abundance of fine sapphires, topazes, zircons, &c., but do not yield the diamond. Beechworth in Victoria, the Macquarie, the Turon (Stutchbury), Calula Creek and the Cudgegong River in New South Wales, and, we believe, Hahndorf in South Australia, are almost the only Australian localities where the diamond is at present known.

The minerals characteristic of the Cudgegong diamond area are the lustrous black *vesicular* pleonast, brookite, and the variety (*d*) of corundum already mentioned. We are not aware that these minerals have been recognised in any other part of Australia with the exception of brookite, which has been found in Victoria. The source of these has not been traced, and it will be interesting to notice whether they accompany the diamond in any new localities which may be discovered.

In suggesting that future discoveries of the Diamond are very probable, we may state that at Trunkey Creek gold-field there is a drift in most respects similar to that of the Two-mile Flat; it is found similarly situated beneath basalt, and we have seen one diamond which has been obtained from it.