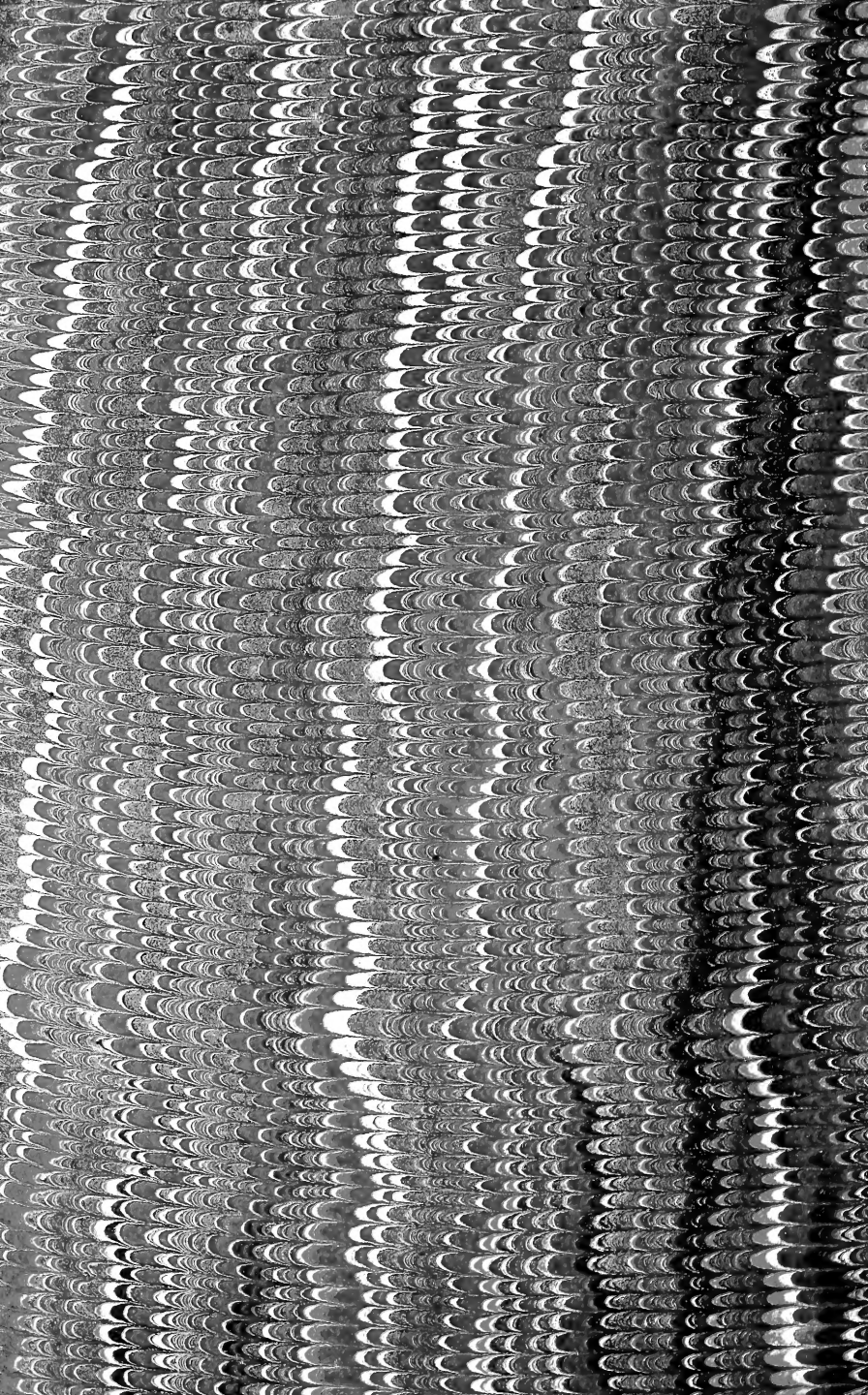
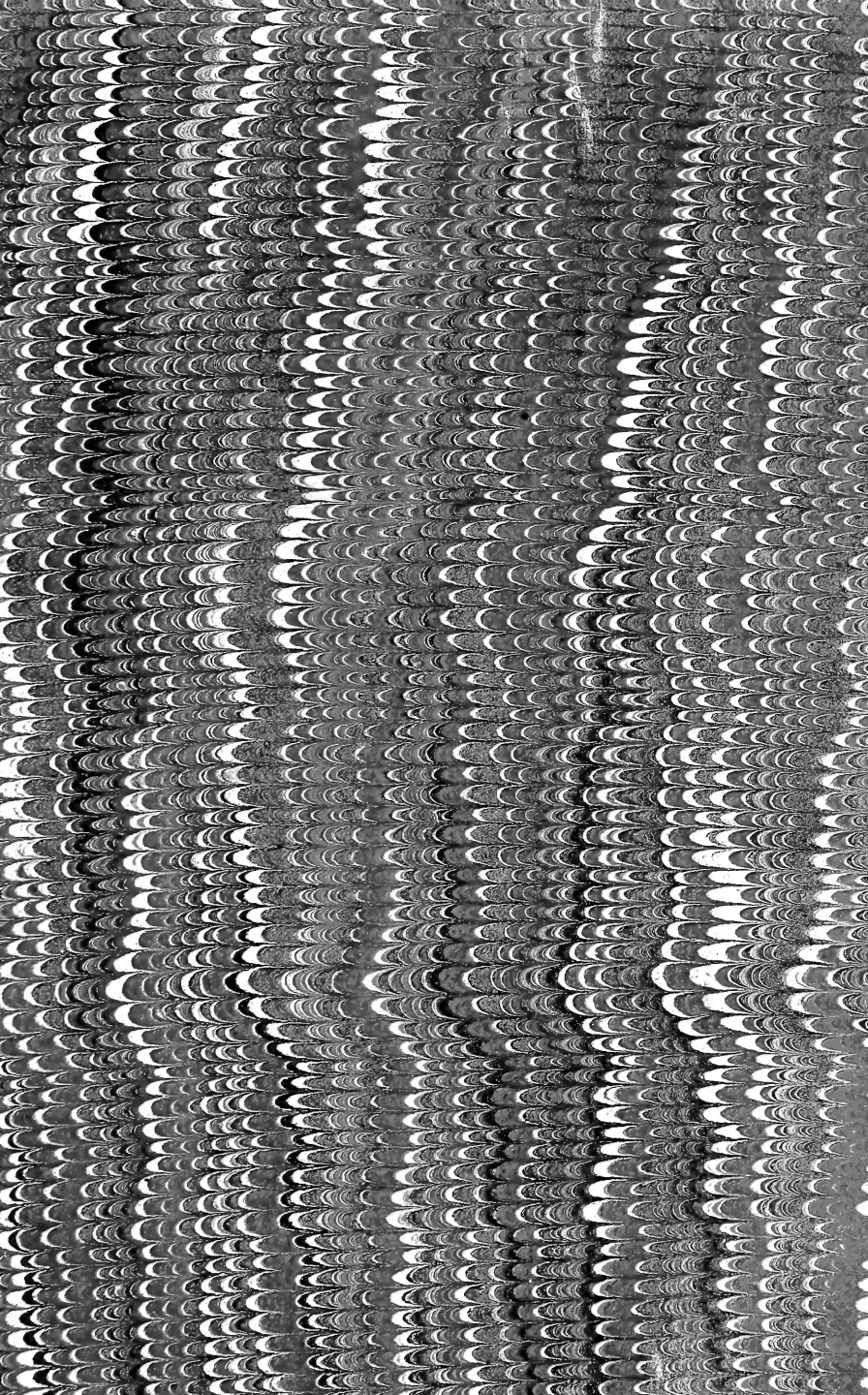


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TRANSACTIONS

OF THE



ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR THE YEAR 1872.



SYDNEY : THOMAS RICHARDS, GOVERNMENT PRINTER.

—  
1873.





506.944

# Royal Society of New South Wales.



## OFFICERS FOR 1872.



### PRESIDENT:

HIS EXCELLENCY SIR HERCULES ROBINSON.

### VICE-PRESIDENTS:

REV. W. B. CLARKE, M.A.  
PROFESSOR SMITH, M.D.

### HONORARY TREASURER:

H. C. RUSSELL, ESQ., M.A.

### HONORARY SECRETARIES:

REV. WM. SCOTT, M.A.

| CHARLES MOORE, ESQ., F.L.S.

### COUNCIL:

EDWARD BEDFORD, ESQ.  
E. C. CRACKNELL, ESQ.  
EDWARD S. HILL, ESQ.

| DR. LEIBIUS.  
CHRIS. ROLLESTON, ESQ.  
CHARLES WATT, ESQ.

## 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 to 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 By-Laws.*

8. By-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.

## BY-LAWS.

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### *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 By-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 By-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.  
Allen, George Wigram, M.P., Elizabeth-street.  
Allwood, Rev. Canon, King-street.  
Allerding, F., Hunter-street.  
Armstrong, Walter Dickinson, Macquarie-street.
- Barker, Thomas, Maryland, near Liverpool.  
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Bedford, Edward, Alberto Terrace.  
Beg, Rev. Dr., Crown-street.  
Beilby, E. T., Macquarie-street.  
Bensusan, S. L., Spring-street.  
Berry, Alexander, North Shore.  
Bennett, W. C., Department of Works.  
Bode, Rev. G. C., Domain Terrace.  
Bolding, H. E., P.M., Raymond Terrace.  
Bradridge, Thomas H., Town Hall.  
Brereton, Dr., Macquarie-street.  
Brazier, John, 360, Crown-street, Surry Hills.  
Boyd, Dr. Sprott.
- Campbell, The Hon. Charles, M.L.C., Pine Villa, Newtown.  
Cane, Alfred, Stanley-street.  
Clarke, Rev. W. B., Branthwaite, North Shore.  
Cox, Dr. James, Hunter-street.  
Comrie, James, Northfield, Kurrajong.  
Cracknell, E. C., Telegraph Office, George-street.

- Campbell, The Hon. John, Campbell's Wharf.  
 Cave, Rev. W. C. Cave Brown, St. Leonards, North Shore.  
 Cronin, J. D., Darling-street, Balmain.  
 Creed, Dr. Mildred, M.P., Scone.  
 Croudace, Thomas, Lambton.  
  
 De Lissa, Alfred, Pitt-street.  
 Deffell, G. H., Elizabeth-street.  
 Docker, The Hon. Joseph, M.L.C., Australian Club.  
  
 Elliott, F. W., Pitt-street.  
  
 Fairfax, Alfred, George-street.  
 Fairfax, John, *Herald* Office.  
 Fairfax, J. R., *Herald* Office.  
 Faithful, G. E., Australian Club.  
 Flavelle, John, George-street.  
 Forster, R. M., York-street.  
 Fortescue, Dr., Hyde Park Terrace.  
 Forlonge, William, Civil Service Club.  
 Francis, Judge.  
 Fraser, Collin, M.P., Australian Club, or Bannockburn, New  
     England.  
 Farnell, J. Squire, M.P., The Hon.  
  
 Gardiner, Martin, C.E., Gordon Terrace, Liverpool-street, East.  
 Garran, Dr. Andrew, Phillip-street.  
 Goodlet, J., 124, Erskine-street.  
 Gowlland, John, R.N., Ashfield.  
 Goodchap, Charles, Civil Service Club.  
  
 Halloran, Henry, Colonial Secretary's Office.  
 Hale, Thomas, Exchange.  
 Hill, F. W., Money Order Office.  
 Hill, Edward, Rose Bay. (Life.)  
 Hill, Roland, Joint Stock Bank, West Maitland.  
 Holden, G. K., Land Titles' Office.  
 Holt, The Hon. Thomas, M.L.C., The Warren, near Sydney.  
 Hordern, A., Darling Point.  
 Hovell, Captain, Goulburn.  
 Horton, Rev. Thomas, 23, Upper William-street, North.  
 Hood, Thomas Hood Cockburn, F.G.S.

- Jones, Dr. Sydney, College-street.  
 Josephson, Judge, King-street.  
 Krefft, Gerard, Museum, College-street,  
 Lang, Rev. Dr. J. D., Jamieson-street.  
 Liversidge, Archibald, Sydney University.  
 Leibius, Dr. Adolph, Branch Royal Mint.  
 Lord, the Hon. Francis, M.L.C., North Shore.  
 Marsden, Right Rev. Dr., Bishop of Bathurst.  
 Macarthur, the Hon. Sir William, M.L.C., Camden Park.  
 Macafee, Arthur H. C., York-street.  
 Mackenzie, John, Examiner of Coal Fields.  
 Manning, John Edye, King-street.  
 Mansfield, G. A., Pitt-street,  
 Mayes, Charles, Pitt-street.  
 McDonnell, William J., George-street.  
 McDonnell, William, George-street.  
 Metcalfe, M., Bridge-street.  
 Miles, Charles, 54, Upper William-street,  
 Mitchell, D. P., Cumberland-street.  
 Mitchell, James Sutherland, Argyle Bond.  
 Morehead, R. A. A., 30, O'Connell-street.  
 Moriarty, Edward, Department of Works.  
 Moore, Charles, Director of the Botanic Gardens.  
 Morell, G. A., Phillip-street.  
 Murnin, M. E., Exchange, Bridge-street.  
 Morgan, Dr. Wm. Crosby, Bathurst.  
 Paterson, Dr., Elizabeth-street, North.  
 Paterson, Hugh, Macquarie-street.  
 Pell, Professor, Sydney University.  
 Phillips, Captain, Pacific Insurance Company.  
 Pilcher, Charles Edward, King-street.  
 Prendergast, Robert, Hay-street.  
 Porter, H. J. Kerr, 91, Dean-street, Soho Square, London.  
 Prince, Henry, George-street.  
 Purves, William Adams.  
 Ramsay, Edward, (Life) Dobroyde.  
 Reading, E., Castlereagh-street.

- Reed, Howard, Potts' Point.  
 Renwick, Dr. Arthur, Elizabeth-street.  
 Richardson, A. H., Pitt-street.  
 Roberts, J., George-street.  
 Roberts, Alfred, Phillip-street.  
 Robertson, Thomas, M.D., Deniliquin.  
 Rolleston, Christopher, Auditor-General.  
 Ross, J. G. 193, Macquarie-street.  
 Rowe, Thomas, Pitt-street.  
 Russell, Henry C., Sydney Observatory.
- Scott, Rev. William, (Life) Warden of St. Paul's College.  
 Scott, J. H. L., Civil Service Club.  
 Senior, F., George-street.  
 Sleep, John S., 139, Pitt-street.  
 Stephen, Sir Alfred, Supreme Court, King-street.  
 Stephen, George Milner, B.A., F.G.S., Wynyard Square.  
 Smith, Professor, M.D., Sydney University.  
 Spencer, Walter W., College-street.  
 Stephens, W. J., Darlinghurst Road.
- Tebbutt, John, junr., Windsor.  
 Thomson, the Hon. E. Deas, M.L.C., C.B.  
 Thomson, James, Treasury.  
 Thompson, H. A., Pitt-street.  
 Tooth, Frederick, Parramatta-street.  
 Tucker, William, Clifton, North Shore.  
 Tunks, William, M.P., North Shore.  
 Twynam, E., Goulburn.  
 Tarleton, Rev. Waldyre W., Bourke.
- Ward, R. D., North Shore.  
 Watt, Charles, Parramatta.  
 Walker, P. B., Telegraph Office, George-street.  
 Wallis, William, Moncur Lodge, Potts' Point.  
 Weigall, A. B., Head Master, Sydney Grammar School.  
 Williams, J. P., New Pitt-street.  
 Wright, Horatio G. A., Wynyard Square.



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ERRATA.

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ANNIVERSARY ADDRESS TO ROYAL SOCIETY, 22 MAY, 1872.

- Page 19, line 9. *For "p. 17" read "p. 15"*  
,, 22, ,, 29. *After "not" read "much, if at all"*  
,, 48, ,, 18. *For "de" read "de la"*  
,, 54, ,, 15. *For "rest" read "rests"*

## ANNIVERSARY ADDRESS,

*Delivered 22nd May, 1872, by the REV. W. B. CLARKE, M.A.,  
F.G.S., &c., Vice-President.*

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A NEW year brings with it new duties, or a repetition of the old. Of this we are reminded on the present occasion, when we are assembled for the business of another session.

Nothing can be more appropriate than to turn our first thoughts to the past—to notice what we have lost or gained during the year that has gone, and to anticipate what may be our prospects in the future.

The Treasurer's report has stated so much of the first as belongs to the financial condition of our Society, and I wish it had been more satisfactory than it appears to be.

The decrease in our receipts is understood to be occasioned by the neglect of regular payments of subscriptions, as these, together with entrance fees, amount to considerably more than the Treasurer has received.

This is not altogether creditable to us, and the fault must rest either with the collector or the members.

It is to be hoped that before the next meeting this defect will be remedied.

But our retrospect and our anticipations should have a wider range than the balance of a money account.

It is in a social and scientific view that we should charge ourselves as debtors or creditors.

We have, however, sustained a loss which we may hardly expect to see balanced for a long time to come.

In the year 1870 it was my duty to ask you, Gentlemen, to record your sentiments on the death of my former colleague in the office to which by your favour I have again been elected this evening.

It is no disparagement to the memory of the late Astronomer to say that we have sustained a loss of an equally serious kind in the decease of the young and ardent philosopher whom we followed to the grave towards the close of our last session. The pupil and the teacher now lie together in the same Cemetery.

Although the regret of his personal friends and the respect of the University in which he laboured so diligently have already been testified, yet, considering his connection with ourselves, and the contributions he gave to our Transactions, I could not, in justice to my own feelings, nor to the esteem in which he was held amongst yourselves, allow this occasion to pass without expressing my hope that the name of Alexander M. Thomson will not be erased from our list of members without a recorded testimony to the value of his professional services and to the many excellences of his private example.

Death has also taken from us another of our members, who, though not a frequent participator in our gatherings, or a frequent contributor to our proceedings, is entitled to our respectful mention, for the many good social qualities of his character, the blamelessness of his life, and the length of time in which he held an office in connection with one of the great sources of our Colonial wealth, and who contributed considerable aid in the perfection of our Colonial wines,—a matter of great importance to the masses, who are exposed to intemperance from recourse to foreign drinks.

Mr. William Keene, as Keeper of Mining Records, must have died in possession of valuable facts relating to our Collieries, which it is expected will be made available to the public by the Government hereafter.

It would be unseemly, when we are commemorating the services of departed friends, to omit another name which deserves our grateful remembrance—I mean that of Sir William T. Denison, who not only presided with ability over the Philosophical Society to which we once belonged, but who, on all occasions, was foremost, during his government of this Colony, in advancing and encouraging the advancement of science and learning, and who did not disdain, amidst the cares of office, to be a fellow-worker in all the useful associations with which he was connected.

It is to be desired that, so long as our Society retains its present constitution, we may ever find our President as active and considerate as was the last Governor-General of Australia. I borrow from the obituary of the Astronomical Society of England the following record of his career:—"He was called hence, after a brief illness, on the 19th January, 1871, in his 67th year, in all the honours of deep and unfeigned attachment amongst his personal friends; and amongst those who only knew him in public life, with all the respect due to his unblemished career, as 'a soldier, an officer, and a gentleman';—such, at least, is the testimony of a few brother officers who have been privileged with his friendship during half a century." (*Annual Report of Council, R.A.S., 9th February, 1872.*)

I now turn to the more immediate purport of this Address.

In comparison with some former sessions, the work of the last was less profuse in contributed papers than usual.

It might, perhaps, be said by one in a playful mood, that the quantity of "cold water" imported into discussion the year before,\* however warmed up by party views, may have for a time damped the ardour of some of our contributors; but the absence of one, and the illness of another, and the death of a third, may have had something to do with meetings which lapsed for want of matter to discuss.

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\* Alluding to a debate, in presence of the Society, on a paper in the last volume, on the best source of Water Supply to Sydney.

But the following list will show that the topics brought forward in 1871 were of an interesting kind, and sustained the Society's character :—

- (1.) "Anniversary Address," by Professor Smith, M.D., Vice-President. "Remarks on the Nebula around Eta Argûs," by H. C. Russell, Esq. (May.)
- (2.) "Magnetic Variations at Sydney," by H. C. Russell, Esq. "On the Deviations of Compasses in Iron Ships," by Rev. William Scott. (July.)
- (3.) "On the Constitution of Matter," by Professor Pell. (September.)
- (4.) "Remarks on the Botany of Lord Howe's Island," by Charles Moore, Esq. "Remarks about the Spectrum of the Nebula round Eta Argus," by H. C. Russell, Esq. (October.)
- (5.) "New Guinea—a highly promising field for Settlement and Colonization—that such an object could be most easily and successfully accomplished," by Rev. J. D. Lang, D.D. (December.)

#### EXPEDITION TO NEW GUINEA.

For a long time the idea of working rich deposits of gold in New Guinea has occupied the minds of many of our fellow-colonists. And the last paper on the preceding list, owing to the reputation of its author, and the arguments employed, may have influenced some in undertaking what, from unforeseen causes, turned out a disastrous failure.

It would have been well had advice, given privately and publicly by those who saw danger in such an undertaking, been allowed its proper influence.

In a paper contributed by me to the publication on "Industrial Progress"—(On progress of gold discoveries from 1861 to 1870)—I ventured to raise a warning voice, in these words: "It would be folly for a band of prospectors to go out on any Quixotic expedition without the preliminary arrangements which can only be made and defended by public authority."

Five months after this was spoken, the late Sir Roderick Murchison, in his last Address to the Royal Geographical Society of London, delivered exactly this day twelve months (22nd May, 1871), speaking of the difficulties of negotiation with the natives of New Guinea, used this language:—

“ We learn from an official report of Lieutenant Chester, the Government Resident at Somerset, Cape York, that he himself visited a native settlement on the South Coast, in company with Captain Banner.

“ It appears that a display of armed force and great precaution are necessary in these undertakings; and the native interpreter brought from Warrior Island, in the Straits, was careful to recommend to Lieutenant Chester to say to the Papuan chief of the village that, although desirous of being on friendly terms with him, he was prepared to fight, if the natives preferred it.

“ No progress, in fact, has been made towards winning over these formidable people to peaceful commercial relations with the traders of the Australian Seas.” [*Proceed. R.G.S., vol. xv., No. iv., p. 302.*]

It is with no unfeeling desire to comment unnecessarily on the sad destiny of those who, in following out what they considered a laudable enterprise, not only neglected preparation for possible hostile encounter with the Papuans, but rashly intrusted lives which were sacrificed and fortunes which were destroyed, to a too ready confidence in the ignorance and incapacity which have proved as formidable to the adventurers as the poisoned arrow or the warlike ferocity of the savage.\*

Had the conduct of the maritime part of the expedition been intrusted to our fellow-member who so successfully searched out the dead and the missing of the party, it would have been well; and it is earnestly to be desired that men whose courage and zeal might have made them, under proper protection, the pioneers of civilization and moral advancement, will not be a second time

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\* See *Forster's Journal of the Voyage (Sydney, 1872.)*

allowed to become the victims of a too-ready reliance on the mere shadows of those qualifications which should alone justify sensible men in committing themselves to the navigation of a dangerous ocean.

Lieutenant Gowlland deserves great credit for the manner in which he conducted his exploration. It was his second voyage along the N.E. coast, the first having been unsuccessful and disappointing in its results to our Colonial Astronomers, from causes beyond the control of any Palinurus or Kepler of modern times.\*

Turning from the gloomy pictures represented in these references to the past, let us glance at the prospects presented to us in relation to the progress now being made in the investigation of the mineral wealth of the Colonies.

#### DIAMOND FIELD OF BAHIA.

In my last Address I offered such information as I had obtained as to the origin of, and search for, diamonds in Brazil, India, Africa, and Borneo.

As new matter on the subject relating to Brazil and Africa has been obtained, I would wish, so far as I am enabled, to supplement what I have previously stated.

After that Address had been circulated beyond the Colony, I received a letter from an eminent geological explorer in Brazil (The Rev. C. G. Nicolay,) a communication on the occurrence of diamonds in the province of Bahia, my former remarks extending chiefly to the province of Minas Geraes, to the south of Bahia.

Mr. Nicolay was ten years travelling in Brazil, and has collected a great amount of information respecting the diamond-bearing rocks in the Chapada of Bahia. An abstract of a paper on the subject, which had escaped my notice, was published by the British Association; and in the valuable account of the "Geology and Geography of Brazil," by Professor Hartt, of Cornell University published at Boston, in 1870, as part of the Scientific Results of

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\* In reference to the Expedition to watch the Eclipse of the Sun on 12th December, 1872.



a Journey in Brazil, by Louis Agassiz and his travelling companions, Mr. Nicolay's reports are often quoted, and therefore his accounts come before us with every claim to our reliance on their accuracy and value.

In resuming a discussion on the subject of the diamond, I am desirous only of throwing as much light upon it as recent discoveries and investigations afford, especially as, since 1870, the further development of the diamond fields in Africa has created fresh excitement, and made it desirable to afford explorers in Australia the fullest information.

Mr. Nicolay has ascertained certain facts which leave little doubt that, however the diamond may have been formed, whether according or not to any of the theories mentioned by me in 1870, its matrix in Bahia is certainly a *sandstone of Tertiary age*.\* This too is Mr. Hartt's inference from Mr. Nicolay's researches.

The sandstone it appears must once have overspread the whole of the regions in question. It now forms the summits of flat-topped ranges, which are designated by the word Chapada. In 1755 diamonds were discovered at Jacobina, in another portion of the same sandstone on the strike of the diamond beds north-east of St. Isabel do Paraguassu, as will be seen on the tracing which I have had prepared from a sketch kindly lent to me by Mr. Nicolay, on which has been shown the line of railway from Cachoeira to Urubu. This tracing, together with Halfeld's and Wagner's map of Minas Geraes (containing the geography of that province up to 1862, the date of Tchudi's Memoir), will show you the course of the Rio Francisco, the great river bordering the mineral districts of the two provinces named.

You will observe that the river Paraguassu rises in the central part of a series of Serras, stretching from the Rio de Contas to the neighbourhood of Pilao Arcado, on the Francisco, and runs into the Bahia of Todos os Santos, on the Reconcavo or border of which, at the sea junction, San Salvador, or the City of Bahia, is

built. Whether these ranges do or do not form any outliers of the long ridge of Soaves and Contendas, in Minas Geraes, those that are depicted in Mr. Nicolay's map of Bahia may be considered as partly forming the versed sine of an arc of which the Paraguassu is the chord of a great segment formed by the lower course of the Rio Francisco.

The general strike of the ranges varies from N.W. to N.E.; and the central portion occupied by the Districto Diamanto is that which is sometimes known as *the* Chapada Diamantina.

The diamond region, which is traceable in other parts of the territory between the great river and the sea, must have a wide area. The country has not yet been thoroughly explored, and it is partially covered by dense forests, as in the Mattas do Orobo.

Mr. Hartt confirms Mr. Nicolay's statement as to the matrix of the diamond in Bahia. He says, "From Mr. Nicolay's report, as well as from what he has stated to me in conversation, there can be no doubt that the diamonds of the interior of Bahia occur in a sandstone bed, forming part of the great sheet which once overspread the whole country, tying in with the sandstones and clays of the Jequitinhonha basin; and this sandstone, as we shall see from Mr. Allen's report, is found at Jacobina, at which place, in 1755, diamonds were first discovered in the province of Bahia.

"I saw specimens of the diamantiferous rock from the Chapada in the hands of Mr. Nicolay. It was *not* Itacolumite, but it seemed to me to bear a very close resemblance to the sandstone bed overlying the clays in the Jequitinhonha basin. It also bore a close resemblance to the tertiary sandstones on the Bahia Railroad, near Pitanga, where diamonds also occur. The diamantiferous sands I saw in the possession of Dr. de Lacerda, at Bahia, appeared to have resulted from the disintegration of the Chapada sandstones." Mr. Hartt continues: "It is much to be regretted that the diamond mines of the Chapada Diamantina have never been critically examined, but I feel convinced that, from their study, the mystery of the origin of the diamond is to be solved." (*See Scientific Results by Agassiz, p. 307.*)

I may add here that the minerals alluded to, in a note to the above quotation by Mr. Hartt, as having been determined by M. Damour, were previously referred to in my Address of 1870 (p. 17 and p. 19 of our Transactions), in connection with the Cudgegong diamonds.

As to the amount of diamonds found up to 1870 in the province of Bahia, Hartt tells us that in the Serra do Sincorá they were found over an extent of twenty leagues. "A very rich deposit," he says, "has been discovered within the last few years at Sincorá, and the city has grown to a large size. The City of Lençoes, the head quarters of a diamond district (to which the map will show there is a branch railway) is a large and important place, and in the vicinity great quantities of diamonds are washed."

Castlenau says these diamonds occur amidst the vast detritus of conglomerates cemented by black paste, and are regular in shape, with exception of octahedrons. Burton, whose exhaustive work on the Highlands of Brazil I have only recently perused, states that at Chique Chique they occur in Itacolumite, but Hartt marks this as doubtful. He considers the rock to be of the same character as that of the diggings at the Chapada.

It appears that from 1862 to 1865, notwithstanding an enormous amount of smuggling, there passed through the Custom-house at Bahia diamonds to the value of 4,505,850 dollars; and, according to Burton, one weighing  $76\frac{1}{2}$  carats from the Chapada, brought 30 contos, or nearly £30,000 sterling. The annual production is set down by Hartt as worth 3,000,000 dollars.

I may mention here that the railway crosses the diamond district near Lençoes, and that a branch goes up from Bahia to Alagoinhas, about 40 miles to the north; so that any persons from these Colonies who may happen to touch at Bahia may find easy conveyance in a land that is otherwise very difficult and inconvenient to traverse.

Mr. Nicolay shows that the principal bottom rocks are Palæozoic, chiefly gneiss; passing, on the one hand, into porphyry and granite, and, on the other, into hornblende rock and quartzite. They are surmounted near the coast by conglomerates and schists, and in other parts by sandstones, a tertiary conglomerate, or sandstone, forming the Chapada and other horizontal surfaces to which that name is given. The general strike is N.N.E. to S.S.W.

The area includes not only that of his map, but also some portion of the province of Piahy, to which his explorations extended.

The beds described all cross the province of Bahia.

The Chapada is 200 miles from the western edge of the Lagos or bay, attaining an elevation of 3,000 feet, and carrying the diamond workings to the summit.

The sandstones are more transmuted there than near the coast. In the latter district they are rich in diamonds, but the works have been abandoned.

In ascending order we have the following geological series:—

1. Primary rocks.
2. Schist.
3. Limestone.
4. Sandstone.
5. Quartzite (an altered rock).
6. Conglomerate.

These are traversed by dykes of trap and chert, with veins filled in with earth, sand, and clay.

In the Cascalho or diamond beds are found the following minerals:—

1. Crystals of iron pyrites, derived from quartzites—the latter without diamonds.
2. Magnetic iron.
3. Oxide of iron (*Pedra de ferro*).

4. Black silica (*Pedra de fogo*).
5. Hyaline quartz (*Pingua d'agoa*).
6. Hydrophosphate of alumina (*Fabras* and *Cabocles*).
7. Schorl (*Fejoes* or *Feijao*).
8. Yttria.

The colours of the diamonds are various, changing with the distinctive localities, but the characteristic colour is green.

According to the published lists and the testimony of Mr. Hartt and others, the gneissic rocks and older clay slates in Brazil are of about the same age as the Laurentian formation of North America, with a probability that some of the mica schists are of Lower Silurian age. In Bahia province there are also some dioritic gneiss and syenite.

Itacolumite, of which we have heard on a former occasion, is a sort of bugbear to geologists; it seems to be, after all, only a lower Palæozoic rock.

In Bahia no Devonian rocks have been ascertained, nor is it certain that carboniferous rocks exist in that province, if, indeed, at all north of the tropic. But rocks referable to Cretaceous are common a little south of Bahia (the bay), and are found at intervals in the provinces to the north. The group at Bahia is considered to be Neocomian. Of tertiary rocks there is a great abundance in Bahia, and we have already seen that the diamonds of that province belong to sandstones of that age.

There is also a vast amount of conglomerated drift, of which the Cascalho often rests on gneiss, which when bare is found to be pot-holed. Diamonds are often found in the holes. Mr. Nicolay considers the Cascalho near the coast to be more silicious than at the Chapada.

Combining his opinions with Mr. Hartt's, we must conclude that the diamond in Bahia does not belong to the Itacolumite, but to the sandstones of the Chapada, which have lent their detritus to the Cascalho.

Certainly, then, if there are no carboniferous rocks in Bahia, the suggestion of Mr. Norman Taylor, referred to by me in 1870, as to the possibility of the diamonds at Cudjegong resulting from the carbon derived from such rocks, must go for little. Another suggestion has been offered, viz., that carbonic acid gas of recent times has been in requisition. But since Mr. Hartt rejects an Itacolumite origin *all through Brazil*, we are driven nearer and nearer to a tertiary source.

"I do not believe," he says, "that the diamond ever occurs in true Itacolumite in Brazil, but that it is derived from tertiary sandstones." Capt. Burton, on the other hand, maintains the opinion that Itacolumite is a matrix of diamond; and mentions one sent by him to England imbedded in that rock.

It is probable, therefore, that in Australia, river-drifts, formed from various deposits, may be the present derivative sources of supply.

Since the question was first mooted, I have been on the look-out for fresh localities in addition to those already known. I can now add to our former scanty list of diamond sites, one near the Horton River, having examined specimens collected there; and another from a portion of the Macquarie River, a long way above Suttor's Bar, and only a few miles below Bathurst, from which spot diamonds were shown to me in that city in April last. A third locality is near the head of the Fish River, which is, in fact, the Macquarie; so, *that* river is at intervals diamond-bearing for many miles, as from the neighbourhood of Oberon to Burrendong it cannot be less (in crow-fly distance) than 90 miles. These new sites raise the number of localities in Australia to *twelve*, of which two belong to South Australia, and five each to New South Wales and Victoria.

There may, doubtless, be many more; but of a tertiary sandstone, resembling that of Bahia, I have seen nothing in Australia, where also Itacolumite is not known to exist. Such negative testimony may not be worth very much, but it has its value notwithstanding; it may point to other sources than those yet known.

It may be asked, perchance, what is the use of diamonds if found in such abundance as in Brazil and Africa? Would they not lose their commercial value if they were to become so common that every person we met should possess a diamond ring?

Such a condition of things is not likely, though in Brazil and in the Union of North America many persons of inferior rank make great displays of them. Looking at a valuable diamond as always retaining its value, it is a far more convenient means of transporting property than any other.\*

Captain Burton has collected, in his "Notes on the Diamond," some interesting commercial facts as to the fluctuations in the price of diamonds.

"Castelnau" (II, 345), he says, predicts "that at the end of the present century the diamond will be worth only twenty per cent. of its value in 1800"; but he adds:—"I venture to say that, unless stone can be manufactured, the reverse will approach nearer the truth."

We must not, however, regard the diamond as a mere article of luxury. It is destined to come into active use when its multiplication by means of increased searchers for it shall have become a hundredfold. It is even now employed in difficult engineering operations. The tunnel through the hard rocks of Mont Cenis—one of the marvels of the present age—was greatly advanced by the use of diamonds used as boring points on properly adjusted tools, when set in motion by a very simple contrivance. The originator of this diamond-drill was Monsieur R. Leschot, a civil engineer of Geneva, resident in Paris. His contrivance was first employed by French engineers at Pistoia, in Italy, on the Bologna Railway. After the first expense, the renewal of the diamonds constitutes the whole charge. It is clear, therefore, that not only is a new method obtained of cutting hard rocks, but means are found for the utilizing and disposal of a vast amount of small

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\* See Burton, "*Highlands of Brazil*," vol. II, p. 149, and generally his chapter X, from which I borrow a few notes in the Appendix (B).

and otherwise useless diamonds, such as constitute the by far greater product of all diggings.

#### AFRICAN DIAMOND FIELDS.

Turning now to South Africa, we find that the diamond field has become wonderfully prolific since 1870. The facts ascertained up to November, 1871, have been collected by Professor Rupert Jones, F.G.S., of the Royal Military and Staff Colleges, at Sandhurst, in a reprint of his own paper in the *Geological Magazine* for February, 1871, supplemented by fresh details of other writers, and printed for private circulation only. These details consist of "*Letters by Mr. Cooper, Government Surveyor, written on the Diamond Fields, Vaal River,*" with foot-notes by Prof. Jones,—of a paper read before the Society of Arts, "*On South African Diamonds, by Professor Tennant, of King's College, London,*"—of some observations by the latter before the Royal Geographical Society "*On the Discovery of Diamonds in the Cape Colony,*"—and of an abstract from the *Times* of the shipments of diamonds during 1869 and 1870, together with a note from the Proceedings of the Geological Society on the large size of diamonds from the Cape, many out of 10,000 examples being from 30 to 90 carats each.

Since that, he has communicated to the Geological Society, with additional notes by himself, a paper "*On the Diamond Gravels of the Vaal River, South Africa, by George W. Stow, Esq.,*" and also "*Notes on the Fossils of the Devonian Rocks of Witzenberg, Cape Colony.*"

Dr. Hooker also communicated a paper, in 1871, to the same Society, by Dr. John Shaw, "*On the Geology of the Diamond Fields of South Africa.*" [See Q. J., Feb., 1872.]

In 1871 also, a pamphlet, with sections, was published at Cape Town, entitled "*Notes on the Diamond Fields, by E. J. Dunn,*" formerly on the Geological Survey of Victoria.

A little book called the "*Digger's Practical Guide,*" went into a second edition at Cape Town, in 1870.



The literature of the subject is, therefore, already considerable.

On this occasion remarks on the subject must be of a very general character, but the titles given will enable inquirers to seek information in the works themselves.

It is however satisfactory to myself to be enabled to introduce here a copy of a note appended to Professor Jones's paper. "I must add, that a great store of useful information about the diamond and the geology of the diamond fields in Australia, India, Brazil, and elsewhere, has been brought together by the Rev. W. B. Clarke, &c., in his Anniversary Address, on May 25, 1870."

The brief account which was given by me in that Address of 1870 was prepared at a time when the first opening of the diamond field had been just reported. In the copy published since, a note is added, making the paper exhaustive up to 18th November, 1870. In that note is given a statement of the amount of diamonds then shipped for England. Mr. Jones differs a little in his abstract returns from the quotation I copied from the only available source of information in my power. What appears tolerably certain is this,—that in 1869 the value of exported diamonds was £7,405, and up to 29th December, 1870, the value of such exported diamonds was £124,910; making the produce upon which wharfage was paid, £132,315. Up to February, 1871, it amounted to £146,765, all from Port Elizabeth alone, whilst from all ports of South Africa the amount in 1870 was £220,000.

At present the area is limited, but diamonds have been found on the Vaal River over an extent of 370 miles.

Mr. Dunn says, the first diamond on the Vaal River was found, after three months preliminary search, on the 7th of January, 1870, and the first diamonds found at Du Toit's Pan and Bultfontein were picked out of the mud plaster covering the walls of an outbuilding in the latter place in 1869.

It seems that the diamonds are now found either on the surface or at a depth of from 3 to 7 feet, from which depth all the large ones have been obtained.

At Du Toit's Pan the most common depth is from 5 to 9 feet ; but diamonds occasionally, and rarely, occur at 30 feet. Sometimes they are broken from concussion,—sometimes with chipped edges,—and in the river beds are water-worn and unabraded.

The average yield per cubic yard is difficult to assign ; but in one place 35 loads of surface sand yielded fifteen diamonds, of average weight each 8 carats. Underneath this, a hole 1,280 cubic feet in extent produced nine diamonds, weighing in all  $6\frac{1}{2}$  carats.

As affording some distinct idea of the geological character of the country from Cape Town to Pniel, Mr. Dunn gives the following order of succession:—

First, 70 miles Lower Silurian rocks ; 35 miles of sandstone—*Devonian* or *Upper Silurian*—*newer* than Table Mountain. (I am glad, in this statement, he confirms my view of the age of the rocks about Table Mountain, as they appeared to me in my exploration of them in 1839). Next, 5 miles of *trap conglomerate* or *breccia*, filled with boulders of granite, gneiss, mica schist, porphyry, sandstone, jasper, slate, &c. Then 65 miles of slaty sandstone, with fresh-water and land plants, &c. Next, 115 miles of lower dicynodon beds, with huge fossil saurians ; 210 miles upper dicynodon beds, full of igneous dykes and beds. These also are full of fossil saurian and vegetable remains. “*On these are situated our present diamond fields of South Africa.*”

It is nevertheless remarkable that, as in Bahia, a gneissic rock appears to be the base of the diamond region, but it is by no means clear that it is of the same class as the Brazilian rock.

Professor Jones demonstrates some agreement with what is known of Bahia, and also some peculiarities of a different kind, such as sandstone *not* tertiary, as I believe, underlying the trap and resting on schists.

Agate gravel is very common, and forms a striking feature in the upper sources of the Vaal. This has been held by some to be indicative of diamonds.

My friend Mr. Daintree, who, I am happy to say, is now Agent-General in London for Queensland, was unfortunately wrecked in the "Queen of the Thames," on the southern coast of Africa; but he obtained, on his overland passage to Cape Town, some local information respecting the structure of the country, and had an opportunity, on arriving thereat, of inspecting a good collection of rocks and minerals from the diamond region. In it he noticed the prevalence of an agate conglomerate from the drift of the Vaal, which reminded him of a similar conglomerate at Agate Creek, on the Gilbert River, which he had been exploring. This being considered by him as an indication of diamond, he reported his opinion to the Government, and since then a public reward has been offered for discovery of a diamond field in Queensland; and, strange enough, applications have been made to me by persons anxious to claim that reward, asking me to point out to them likely places in which to find the gems. That agates may occur in a diamond field wherein are evidences of the existence of vesicular traps is far from unlikely; and at Louee, not far from Cudgegong, such conglomerate also exists. But agates are common enough in various places where no suspicion of diamonds is acknowledged; for instance, at the back of Mount Wingen, in this Colony, is a mass of trap in which agates abound; so they exist at Kinnoul, near Perth, in Scotland; at Oberstein, in Germany; and in the rock of the Giant's Causeway, in Ireland, as well as in many other parts of Europe, and in America.

But, as it appears to me, it is an inference not very probable to deduce from agates, which are a silicious deposit, a connection with diamond, which is pure carbon, except so far as both may be found in a district where trap eruptions have occurred. And Weiss tells us that in Southern Brazil a chain of amygdaloidal trap is the source of the great quantities of chalcedonies, agates,

carnelians, rock crystals, and amethyst that cover the banks of Uruguay downwards below the Rio Negro. This amygdaloid has on its slopes a sandstone, considered tertiary, as young as the brown coal formation of Europe; but there is no mention by any one of diamonds in that neighbourhood.

All that can be said with certainty is, that agates, which have been dispersed by the destruction of amygdaloids in which they were segregated, are found in Africa, where diamonds occur; but as yet no diamonds are found amidst the multitudes of agates in the drift of Uruguay. The drift is evidently due to causes of posterior date to the age of the rocks to which the diamond has been referred for its parentage; and, therefore, in the present state of the evidence no conclusion can be drawn as to the positive indication of diamonds, because agates are present.

I may add that, from Dr. Comrie, of H.M.S. "Dido," and one of his brother officers, I have received a small collection of agates, carnelians, and chalcedonies, from Du Toit's Pan; these are mingled with beautifully clear crystals of quartz, opaque quartz, rounded bits of jasper, spinelle-ruby, &c., all highly polished, and in no respect differing from drifted mineral of the same kinds in our New South Wales rivers, where no diamonds have been found.

I will conclude this subject by reference to what I consider an interesting fact bearing on a question of human history, which cannot be further alluded to. In a limestone cave at Capè Point, Dr. Comrie found, with bones and rude pottery, several flat stones of hard rocks, and amongst them some rounded perforated stones, such as are represented in Sir John Lubbock's edition of Sven Nilsson's *Primitive Inhabitants of Scandinavia*. These latter appeared to me to have been used as *sinkers* for fishing; others consider them as hammers. (*Plate I, figs. 12, 34.*)

Now, in Mr. Dunn's report I find the following:— "There is a tradition among the Booshmen that in former times their forefathers made journeys to the banks of the Vaal River to procure a small white stone, with which they bored holes in those perforated

stones used by them to add weight to their digging sticks, one end of which was inserted in the hole. Possibly the white stones referred to were diamonds, as the material out of which these stones were formed is often intensely hard, and holes are drilled through with great nicety. They (the perforated stones) were handed down from father to son as heir-looms." Supposing these conjectures to be true, then the use of the diamond in mechanical work dates in Africa long before the time of the Bologna Railway (*see p. 17*), and we have a satisfactory reason assigned for the preservation of worked stones in caverns. But it is hardly to be supposed that diamonds were used by the Scandinavians of the "Stone Age," in working up their hammers and other implements.

#### GOLD FIELDS.

As gold is found generally in the drifts where diamonds occur, we are naturally led to connect them in our minds.

It will, I hope, be considered not uncalled for if I pass from one to the other, especially at a time when the subject is so generally exciting public attention.

It would be needless to repeat here remarks that found their appropriate place in the paper "On the Progress of Gold Discovery in Australasia, from 1860 to 1871," which forms a part of the work entitled "Industrial Progress of New South Wales."

Since then, the attack of illness which kept me away from your meetings during the year 1871 led to a visit to the Western Mountains, and to an opportunity of inspecting some of the gold fields previously examined by me, and of others that have come of late into activity.

Here it may be right to explain that my attention has been principally directed to gold mining and not so much to gold digging; and that from the first I confined my studies chiefly to the occurrence of gold in the matrix, and was the first person in these Colonies to call attention to the value of quartz (*S.M.H.*, 8 July, 1851). It is upon that occurrence that I founded my constant expectation of the great harvest of which we are now

reaping the first-fruits. This also has placed my endeavours to work out the wide field of inquiry on independent examination; although my deeply lamented friend Sir Roderick Murchison was opposed to its value, expressing his hope that our population "would not be so foolish as to mine in the rock for gold," alleging that gold was not found in depth, an opinion which, when adopted by some leading Professor in a neighbouring Colony, led to much hindrance in the progress of gold production.

As a rich reef has been recently struck at a depth of 800 feet, in Victoria, the views of the shallow-reefing theorists will have to give way.

It was very strange that so talented and practical an authority, and who so thoroughly understood the value of indications offered by certain rocks, should have undervalued the working in rock formations in comparison with alluvial deposits, of which he foresaw and foretold the evanescent character.

Now and then we hear of fresh alluvial diggings, such, for instance, as those at Gulgong, which are in an extension of a field proclaimed many years since; but experience has shown that an increased and increasing resort to the crushing-mill is influencing the minds of the mining community.

That gold production is on the increase no one can doubt; and if prospectors will but go out into districts that abound not far from the vicinity even of gold fields, where no pick or spade has been employed, new ground will assuredly be found where "reefs," as they are called, meet the eye of the traveller at almost every turn, and where there is every legitimate reason to infer that some will be productive.

It is not too much to say that, no sooner are we off the Carboniferous areas rich in coal and its associated minerals, than we are in a region in which are tracts where gold and copper and lead abound. And passing from the sedimentary to the plutonic rocks, we can discover granites which, however barren externally, are within frequently charged with the valuable ore of tin. So

that the three great geological divisions of our Colony are replete with mineral treasures that are practically inexhaustible.

It is, perhaps, difficult to assign any strict measurement in superficial area to the actual amount of land capable of furnishing present proofs of this, because, as we well know, metals are local, and not universal; and if they were not, what would become of our pastoral interests, which, by the blessing of Providence, are just now in as prosperous a condition as our minerals are?

During my last visits to different parts of the Western District, I not only saw the operations that are going on, but passed over many miles of country in which the rocks that belong to a golden area yet remain in their original condition, and will so remain till some fortunate adventurer stumbles by accident on a tangible encouragement.

It is not necessary to make special mention of the rich shaft from which was derived that crown of gold which was the surprise of so many during the late Exhibition of the Agricultural Society.\* But when the excitement that is now rife shall have subsided, and we shall have less dread than some exhibit of spelling speculation without the initial letter, there will be found inducements to study the structure of the country more than the market price of its products.

Already miners have begun to realize one of the lessons which I have endeavoured to inculcate,—that many of the theoretical views relating to the nature of gold-bearing rocks are only partially reliable.

During my visit to what is oddly enough known as Ophir, I was very much pleased with an illustration of the way in which two respectable young men were acting on a principle that proved they had turned their former observations to account. On the Uralla River the miners made shafts through the basaltic

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\* The production of nearly 8,000 ounces (in addition to the previous great result) in the space of a few months is a wonderful fact, confirmatory of the value of mining and crushing.

covering, at least 100 feet thick, which concealed the auriferous deposits overlying granite. At Ophir, where quartziferous soft slates are overlain by basalt, of about the same thickness, these enterprising men had driven into the soft slate, and had then mined *upwards* from the drive to the bottom of the basalt, between which and the top of the slate they had found drift and sand and pebbly cement with gold, proving that in their case, at least, mining was not an unintelligible guess-work.

Such persons deserve encouragement, and it would gratify me much if the mention of their undertaking could induce assistance towards its completion. This is clearly a case in which alluvial gold is itself procured by ingenuity in mining.

The notion that available gold is *only* to be found in quartz-veins running through the lower Silurian rocks must be abandoned.

It was pretended, at one time, that the Californian rocks were the clue to those rocks in New South Wales that led to the opening up of the first worked gold field at this very Ophir. That field is, at any rate, in a Palæozoic area. And yet we have the published official statement of the State Geologist of California, Mr. Whitney, that not a single fossil of Middle or Lower Palæozoic age has ever been discovered in California, or anywhere west of the 116th meridian; proving that any *true geological comparison* of the two regions must have resulted, at the time, in disappointment. Again it is doubted by those who have the best right to doubt, whether any Silurian deposits exist in Queensland. The gold of Ravenswood, for instance, and Charter's Towers also, is all from granite, or deposits of brown ironstone—not only from quartz in the former, but also from *solid granite*. The rich gold field of Gympie appears to be not older than the Carboniferous formation. In New Zealand the wonderfully rich finds on the Thames occurred in rocks not older than the Trias; whilst in California a large portion of the auriferous rocks are as recent as Trias and Jurassic, and no inconsiderable portion is as recent as transmuted Cretaceous rocks. The great secret is there, as at Gympie, in transmutation.



Such was the effect that produced much of the gold at Hill End and Tambaroora, as well as elsewhere in the Western districts of this Colony.

The transmuted rocks at Hawkins's Hill, in which the lodes occur, are so much like those that have made Gympie so celebrated that I can see on actual comparison no essential difference, except that the latter contain fossils which are yet wanting in the former.

Then, if we look to the lodes themselves, many of them contain quartz only as an adventitious substance, or as mixed up with mica, calc spar, and mundic, amongst which the gold is indiscriminately sprinkled. I pointed out, some time since, to a gentleman engaged in mineral surveys at Hill End, that some of these lodes, so far from being true quartz-veins are clearly derivative from the action of a transmuting agency, and have their nearest resemblance to that variety of mica-trap which the Germans call Fraidronite. The casing, which has sometimes been mistaken for chlorite slate, appears to me to be often the result of the influence of lime on the materials of the transmuting rock, and is of similar character to what may be observed on the faces of columns in quarries of basalt. The slates and shale, which are the main rocks of the region in question, are, I presume, very much younger than any true chlorite slates, and are, so far as my experience goes, not older than Silurian. But no fossils have yet been detected in them nearer than Louisa Creek and the Meroo. The Hill End country is occasionally to the westward traversed by porphyritic and syenitic intrusions. A rock resembling Phonolite may be traced all through the Tambaroora series exposed in the old workings of the diggers, and ranging side by side with the quartz reefs towards the Turon. The trappean schists are, like those of Gympie, charged with carbonate of lime, and effervesce with acids. An overflow of vesicular basalt crests Bald Hill and some of its slopes; and at Frederick's Valley Creek (Ophir) is strongly developed, covering auriferous deposits over slates of the same age as those of the country from Hill End to Sofala and

Meroo, whilst on the south of the Turon, granite occupies a tract some miles in extent. Eventually the whole of this large tract will be found productive.

At Canoona and Mount Wheeler, in Queensland, the mother rock is serpentine. At Wentworth, near Orange, the gold was found in abundance between serpentine and basalt. I can only express astonishment that no wider area has been taken up in that district, for there is every reason to suppose that the whole of Frederick's Valley is auriferous, and the operations have not been extended to the hills on the east of the valley.\*

The first gold I ever saw in Australia I procured from granite in 1841, and within the last four months, I have had the opportunity of ascertaining that fine gold is procurable from granite for several miles in that region.

Bathurst Plains are a wide area of granite, and yet, after rain, gold may be, and has been, collected from the surface within the bounds of the city itself.

At the Junction Mine, on the Belubula, the gold is found in *beds* of ferruginous reticulated quartz and in the midst of altered slates, sometimes prismaticized, and in decomposed diorite, which is traversed by hard dykes and diorite bands.

At Brown's Creek, not far from the granites of Cowriga Creek, a still more remarkable case occurs, where, I think, there is little doubt the chief agent has been a hot mineral spring, in conjunction with diorite eruptions. Such springs have also operated at the Forest Reefs,—a gold field about midway between the Canobolas and Mount Lachlan, at the back of Carcoar, in the very heart of a country occupied by igneous formations. There, and in other fields along the same auriferous band, following for many miles

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\* As appears by a letter in the *Sydney Herald* of June 7, 1872, this expression of my convictions led to a search for reefs at the head of the valley, as stated by the writer, Mr. Newman, who thus, in four days time, discovered auriferous indications of some promise, realizing on the first trials, gold at the rate of from 112 to 672 ounces per ton.

At Sally's Flat also, between Sofala and Tambaroora, a reef was opened in a similar way, and another at Wiagdon Hill, between Sofala and Bathurst.

the direction of the 149th meridian (which in the year 1851 I pointed out to the Government as deserving of search), interferences with what has been held by some distinguished geologists as the normal condition of gold veins may be detected, in which some of the ordinary trappean rocks exhibit a wonderful decomposition, and in the detritus of which halloysite, chert, resinite, and chalcedony, and other minerals which probably point to springs, occur as veins, though not to the exclusion in the neighbourhood of more ordinary quartz reefs. In all the instances named, mispickel, marcasite, or common pyrites, sometimes galena and indications of copper ore, are present, and in many cases the gold is held in the sulphides of iron. This is especially the case with the granites, one variety of which on Cox's River is often sprinkled with galena.

Persons are often confused when they see auriferous stone suddenly, as it were, losing the gold and becoming charged with the sulphides of iron. But it is a fact, established by close observation, that where these sulphides abound, the gold generally becomes invisible. That, however, is no sign of its actual disappearance. Nevertheless, the experience of miners in other countries shows plainly that an excess of pyrites is as unfavourable to the presence of gold as the absence of it; and "*when either is too much in excess, the auriferous property of the lode is impoverished.*" [Treloar. Reports of St. John d'el Rey Company.]

When twenty-one years ago I announced the fact that invisible gold was oftentimes held in quartz, the late Mr. Stutchbury appended a note to one of his reports, calling the fact in question as incomprehensible to him. But it is now almost universally acknowledged as a fact.

Similarly, persons may doubt the truth of the above statement relating to the sulphides; yet, on looking through the work on Brazil, to which I have made so many previous references, I find Mr. Hartt stating the same fact in relation to auriferous quartz in Minas Geraes, Brazil. Where the vein rock is rich in sulphides, the gold is, as a rule, not visible, but intimately mixed with the

rock. This is the case at Morro Velho. The sulphides consist of magnetic iron pyrites, which is most abundant, and yields a little gold; common pyrites, which is less abundant, and gives more gold; and mispickel, or arsenical iron pyrites, which is the principal gold-bearer.

A similar change from gold to the sulphides (holding gold) was reported to me by the late energetic Gold Commissioner at Ravenswood, in Queensland, Mr. Hacket, and in fact it is a universal law from which there is no exemption, even at Hawkins's Hill.

Mr. Arthur Phillips also points out the same fact in Brazil. Mr. Hockin, the director of the Morro Velho mine, stated to Mr. Phillips that the composition of the pure ore may be taken at about 43 per cent. of silica and 57 per cent. of pyritous matter. Such ore yields by assay from 4 to 6 ozs. of gold per ton; and where crystals of this mineral make their appearance the yield of the precious metal is large. Cubical pyrites is of more frequent occurrence, but is far less rich in gold. Solid specimens of this substance, but slightly mixed with quartz, yield about an ounce and a half of gold per ton. Magnetic pyrites yields rather less than 4 dwts. per ton. Bunches of clay slate are often found in the principal veins, and this rock, by assay, affords from 5 to  $7\frac{1}{2}$  dwts. per ton.

“Quartz without any admixture of sulphides,” he says, “has never been found to be auriferous, and it is a remarkable fact that the smallest speck of gold is rarely seen previous to the concentration of any of the ore in the mine.”

Mr. Weddell says that the old miners at Gongo Soco once took out £100 in three hours—(Hartt, p. 541)—a feat which certainly beats most of our Australian gold-doings; though, perhaps, it did not take even so long to knock to pieces the famous hundred-weight of 1851. From that mine the annual income for three years was £1,388,416, of which £375,163 was profit. I would repeat here, that where certain igneous rocks are present, such

as diorite or greenstone, or felspathic elvans, or felstones *in company with pyritous minerals*, the conclusion is almost irresistible that gold will be present also.

Mr. Hartt refutes the generally received idea that the gold mines of Brazil are exhausted. This is a great mistake. He says: "There are still surface deposits of great extent which, with modern appliances, could be successfully worked. The underground wealth of the country is almost untouched, and if the mining public of America knew Brazil better, I am persuaded that the gold fields of that country would not be neglected by American capitalists."

We may re-echo these encouraging words, substituting New South Wales for Brazil, and British for American capitalists.

In concluding this division of my subject, I recommend to all who wish to become acquainted with Brazil to read Mr. Hartt's work, in which will be found quotations from Mr. Nicolay, to whom he confesses his obligations.

I may add that Mr. Nicolay is at present in Western Australia, from which Colony I have lately received, collected by himself, a useful contribution to my cabinet, settling at the same time the position of a fossiliferous locality of which I was in doubt.

But I must not omit to state that, in addition to Mr. Hartt's work, Captain Burton's volumes on the Highlands of Brazil should be consulted. The greatest amount of statistical knowledge of all kinds in connection with Minas Geraes is, however, to be found in the most valuable contribution "On the Gold Mines" of that province, contributed by that accurate observer and expounder, W. J. Henwood, F.R.S., F.G.S., to the eighth volume of the Transactions of the Geological Society of Cornwall, published in 1871,—a volume filled by that author's most clear and wonderfully elaborate papers on mineral districts in South America, North America, India, Spain, France, England, Ireland, and Scotland.

## TIN AND COPPER.

There are two other sources of mineral wealth now being drawn upon, to which it is needful to refer.

In the course of my explorations in 1851-2-3 tin ore was discovered by me in various places, and mentioned in my reports to the Government.

It had been already named by me as a product of this Colony so early as 1849; and on various occasions since, to the present time, I have kept up the mention of my discovery of tin in 1851-2-3, with a view of inducing operations for its development, and I have every reason to believe this has assisted in the present search for and working of the ore.

I have introduced some extracts from my Reports and other public documents in the Appendix (C), which will justify the assertion that, notwithstanding the claims of any other person, *the first mention and first discovery of tin, as a product of New South Wales, were made by myself.*

Many of the facts were also specially mentioned in my Researches in the Southern Gold Fields (p. 128) in 1860. Moreover, I exhibited stream-tin at Paris in 1855.

Tin ore was discovered in Victoria, in March, 1853, the date of my explorations in the MacIntyre tin districts, but not till 1866 was it wrought as an article of commerce.

The journals of that Colony, between those periods, contain correspondence and other contributions on the subject; amongst others, Mr. Milner Stephen wrote about it in 1853, and Mr. Storer, of the U.S. Navy, in 1854.

At the preliminary display in Sydney of the articles forwarded to the International Exhibition at Paris, in 1867, four samples of stream tin, averaging by Mint assay 49.625 per cent., and four bars produced from the same quantities of the ore, were exhibited by Messrs. Lamb, Morris, E. Hill, and Milson. Stanniferous sand was also exhibited by Mr. Hill, from the Rocky River.

The present yields of stream and tin ore and matrix tin have thus grown out of these various introductions of the new industry ; but in neither Colony is the “*discovery*” so “*very recent*” as has been represented.

In the course of a discussion on the letter in which the words *italicized* occur, Mr. David Forbes said, at the Geological Society’s meeting in December, 1871, that he had received specimens of the granite from the New South Wales tin region, in the year 1859, and that he found them to be perfectly identical with the stanniferous granites of Cornwall, Spain, Portugal, Bolivia, Peru, and Malacca.

I may add that in the gigantic elements of the granite in various parts of New England, and the association with the tin found in the granite, of certain minerals, such as molybdenite, wolfram antimony, and iron of various kinds, and with schist, the identity is much closer than would appear from the species of the granite composition themselves.

Some of the largest and longest crystals of quartz and felspar that were ever seen occur at Oban and Bolivia and in some other localities.

Mr. F. Gregory has reported to the Queensland Government, and the account has been forwarded to England, that having measured 170 miles of creeks and river-beds in that part of Queensland which touches the northern boundary of New South Wales, he found, on calculating the value on a fair assumption of the average amount of stream tin (irrespective of vein or matrix tin) that it amounted to *thirteen million pounds sterling*.

I would remark here, that tin seems subject to a similar law to that which affects gold. The metal, whether gold or tin, is *generally* found in alluvial deposits, richer in quality than in the matrix, at small depths. As affects gold, this has been proved in Bolivia, New Granada, Chili, and Russia, as well as in parts of Australia ; and as relates to tin, the statement rests on the testimony of Mr. Henwood. (*G. T. Cornwall, IV, p. 65.*)

Geologists at Home have settled it that the stanniferous granite are Palæozoic, pre-Permian, and post-Silurian.

The stream tin must, of course, be quaternary or recent in its present position. Tin stone has been found loose in the bed of the Shoalhaven, but the actual lode has never been discovered. In several other localities tin is known to me as having been found, either as stream tin, or wood tin, in the ordinary gold drifts with other loose minerals,—indications, as I consider such instances, of future discoveries in parts of the Colony not yet searched.

In more than one case the tin reduced from the peroxide, either by accidental fires, or by miners who did not know what they were doing, has been found by me. In one instance *silver* was stated to me to have been found; but on inquiring on the spot I was led to the conclusion and reported my conviction that it was *tin* which had occasioned the mistake.\* Tin ore is, therefore, far more common in our granite country than has been suspected.

The great granite masses in this Colony are not, probably, all so richly endowed as some particular spots which are now found so prolific; but having seen the greater part of them, I am impressed with the opinion that for centuries to come the industry now commenced will continue to occupy a prominent position among the producers of Colonial wealth, just as the mines of Tenasserim, Merghui, and Malacca have not decreased in value since the commencement of their working. In Malacca many of the lodes are horizontal. The average produce of the above-named mines is from 60 to 80 per cent., and its value is reckoned at nearly  $4\frac{1}{2}$  millions per annum.

The Island of Banca has mines, first discovered in 1799, which some years since supplied an annual amount of 3 millions sterling. The tin there is associated with iron in veins at the junction of granite and sandstone.

In all these countries to the north of us the tin is always in the state of peroxide.

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\* See my Report of 14th February, 1853.



Tin in Cornwall has been wrought from the time of Augustus, the Roman Emperor, nor are its supplies yet exhausted. It may, however, be doubtful whether the produce of Australia will not have hereafter some effect upon the English market.

Several very curious facts relating to the influence of tin on the world are mentioned by Mr. Hawkins in the third volume of the Transactions of the Geological Society of Cornwall, and in other works referred to by Sir H. de la Beche, in his Report on Cornwall, Devon, and Somerset (1839). Amongst other anecdotes respecting the use of tin, it is mentioned that the London merchants in the beginning of the seventeenth century advanced money on tin to the Cornish gentry who came to the metropolis, and by which the tanners were losers. It is not improbable that the word "*tin*," sometimes used for money, may have thus obtained currency. There is little novelty in the affairs of commerce; and Sydney merchants are now obtaining profits by tin, as their predecessors in London did in the days of Queen Elizabeth. The Survey Office leases will, in many cases, have the same effect as the advances to the Cornish tin men had two centuries and a half ago. Those will grow rich by tin who profit by the labours of the working miners,—speculating on probabilities in lieu of labour.

In the time of Diodorus Siculus the trade in Cornish tin was with Gaul and the Phœnician Colonies in Spain, being carried overland through France to Marseilles.

In the 6th and 7th centuries Western Europe had the trade, church bells, and instruments of warfare requiring bronze, of which tin is an ingredient. Bruges in Flanders was the emporium in the 13th century. In the 14th, the Levant countries became consumers.

In the time of King John the mines were farmed from the Crown by Jews, and after that people were banished in the reign of Edward I the mines were neglected. Other curious records of the history of Cornish tin may be found in the writings of Carew and Borlase.

## COPPER.

There are certain cases in which tin becomes an indication of copper. In Cornwall it is found that copper is seldom abundant in a lode, unless *gossan* forms the back of the lode; and oxide of tin very frequently occurs in the *gossan*. Formerly many copper lodes have been worked for tin. Mr. Carne, an author well known among Cornishmen, states that *gossan* was worked for tin as recently as 1827. Tin occurs as well as copper in bunches; and as much of the copper in New South Wales occurs in bunches or "blows," it would be well if some experiments were made to ascertain whether tin may not occur in our copper mines.

Copper and tin appear to be as abundant metals here as in Cornwall; and if any reliance is to be placed on indications, persons looking for the former in a granite country should search at the junction of granite and the slates that often adjoin it. Formerly granite was *not* considered a likely rock for copper; but it has been found that, in one of the richest copper lodes in Cornwall, where the lode left the granite the copper ceased.

A contrary fact relating to granite and gold is shown in Victoria, as I have seen myself. The rich gold reefs of Castlemaine and Bendigo stop at the junction of the slates and the granite.

Another fact which I have observed is, that copper often occurs in a wash of inconsiderable value, though deceiving to the eye, on what is really a gold lode. Such is the case at Kilkivan, in Queensland, and in other places.

It is a pity we have no public record kept of the peculiarities observable in the occurrence of our Colonial ores. It would be very useful hereafter.

I would invite particular attention to the condition of hardness or of decomposition of our granites and traps; inasmuch as (especially of late) I have noticed the occurrence of elvans in soft granite, and gold in decomposed trap, under circumstances of great interest and importance.

It is remarkable how at this juncture the eastern Colonies of Australia exhibit, contemporaneously, a great development both of tin and copper. Surely this, and the revival of our auriferous wealth (mostly, be it noticed, by mining in the rock) is not without a very significant design on the part of Providence.

Errors in the practical management of these deep-seated treasures, whether by the Government or by the community, may lead to difficulties of immense importance, bringing with them corresponding inconveniences to all.

Respecting the development of copper, its appearance has been made known in great abundance within the last year in the far western interior, which was generally considered to be a flat uninteresting desert between the Lachlan, Bogan, and Darling.

Coba, about 90 miles S.E. of Fort Bourke, is now a mining district; and having examined them, I can speak favourably of the value of its ores. Some gold has been detected in another quarter nearer the Darling, and iron, which also occurs at Coba, is found on the New Year's Range, S.E. of the junction of the Bogan. Copper is expected also from that Range. The character of that then waste country given by Sir T. L. Mitchell—"low, bare ridges, scanty vegetation, water very scarce, and vast level plains"—will shortly deserve to be exchanged for one of a more valuable kind.

Beyond the Darling, too, in the very region where Captain Sturt found "an inhospitable desert," and met with great privations, copper has since been found and indicated to me by the excellent and enterprising Commissioner of Crown Lands for the far distant Albert District, one locality of which is not far from the vast hill of magnetic iron ore mentioned by Sturt, at Peisse's Knob, of which he gives a figure in *Central Australia* (II., 127), and another is close to Mount Lyell.

The ranges and veins of metallic ores running N. and S., parallel with other ranges east and west of them, are either parallel with, or on the strike of, the great copper and iron mines of the Cloncurry in Queensland.

The Courtundie and Malia, and the Coonbaralba Ranges of the Barrier will, it is to be presumed, some day furnish their quota to the general fund of mineral wealth.

Some years since, in compliance with a suggestion of my own, a search for gold was instituted in the Barrier, but the season was unfavourable, and it was not successful. I am, nevertheless, of opinion that there are indications of metallic wealth in that rocky region which will be hereafter turned to good account.

Recently, copper lodes have been taken up near the head of the Bogan,—at Buckenba, at Burrawang, and not many miles from the dividing ridge between the Little River and Lachlan Waters. Nine years since I examined those lodes, and found them exhibiting the usual indications of copper as observed in New South Wales, and I have since been impressed with the great value of the whole area between Molong, Croker's Range, and the head of the Bogan River. On Buckenba Creek gold also exists in various localities.

Similarly we may notice the development of copper to the south of Bathurst, in the Great Cow Flat Mine, which I visited two months ago, and which is not far from another mine visited by me in 1863—and the extension of copper-mining in Queensland as at Peak Downs, Mount Perry, Rawbelle, and Gladstone—which are realizing some of the expectations before expressed by me to this Society in relation to Queensland.

Some excitement has been occasioned by discoveries of a conglomerate ore of gold, silver, and copper, near Gympie. It is ascertained to be very rich. This is not however a solitary case. In Maneero too there has been found copper alloyed with antimony; and I have a specimen from near Bathurst, in which no less than eighteen ores and other minerals are combined together. Silver and gold, silver and lead, silver and copper, are common. But in general such combinations as three or more are not considered encouraging.

It is time to conclude. But before I do so I must not omit a further allusion to that great Colony.

## EXPLORATIONS IN QUEENSLAND.

Having been honoured by the confidence of the Government in relation to their endeavours to provide for the mineral exploration of that Colony, I may mention, as I do with satisfaction, that my friend Mr. Daintree, whose name has often been by me introduced to this Society, and whose wreck in the "Queen of the Thames" I have mentioned in a former part of this Address, has been occupied in bringing before the British public the claims to the notice of capitalists of that Colony of which he is now the accredited representative.

On his voyage home with a very large and well-assorted collection of the rocks, fossils, and minerals of Queensland, these, of course, went to the bottom. But he lost no time in writing to me and our friend, the late Professor Thomson, requesting us to send him for the Exhibition such fossils as we possessed that would serve his purpose. Such were despatched by each of us.

He had made a sketch map of the Colony, which was supposed to be lost also; and as this was a desideratum in Queensland, an application was made to me by one of the Ministers for a copy of it. But as no copy was left with me, I promised, if time were allowed, that so far as our personal knowledge went, a substitute should be produced; and by the aid of Mr. Norman Taylor, in Melbourne, who saw more of it than Professor Thomson or myself had seen, a blank map was coloured here, and one of the only three copies in existence I have exhibited to-night, in order to point out not only what is going on to the north of us, and what unpaid geologists have been doing in this Colony, but for the higher object of showing how very probable it is that, as copper and tin are now bringing us into parallelism with Cornwall and Devon, so Queensland offers in a large portion of her eastern area similar *geological* resemblances.

It is now considered that there is very little, if any, of the Silurian formations in Queensland, and therefore all the slaty country represented on the map is held to be of Devonian age. The patches marked metamorphic may, however, be transmuted

Silurian. But I confess to have seen no fossils from Queensland older than Devonian or Upper Silurian.

Mr. Daintree has published in England a corrected map, but when it reaches us I do not believe that there will be detected many alterations on the whole between it and the substitute which is now exhibited.

In looking at this map it will be seen that the York Peninsula is not coloured. But the western part along the Gulf is partially known from Mr. Jardine's journeys; the northern portion from Dr. Rattray's researches about Cape York (a paper by him respecting which I formerly read to you), and part of the eastern coast border is known from Kennedy's fatal wanderings.

Immediately to the north of the Lynd River of Leichhardt, there is a tract of country which, at the end of last year, was traversed by Mr. Hackett, of Lolworth Station, and a party of explorers, whose private journals have been kindly submitted to me. And the remaining portion, in which I have long anticipated an extension of the gold region, is now entrusted by the Government to Mr. Norman Taylor, who has, ere this, I believe, set out on his arduous adventure. We shall, therefore, be shortly able to complete the filling in of the whole map. On the west part of the southern part of the Gulf of Carpentaria, some geological facts of interest are known to me; and I have sent home specimens of a Trilobite (also of a Devonian genus), from a district not included in the present sketch.

I will now, with your leave, quote a passage from Mr. Daintree's last letter to me from England. It may be of more use than any other argument I could devise on its subject:—

“ Queensland Government Offices,  
“ 32, Charing Cross, London,  
“ 16 March, 1872.

“ I HAVE received instructions from the Queensland Government to build an Annexe for the forthcoming Exhibition, so am busy preparing for the adornment and getting a catalogue ready for the opening day, the 1st May.

“ I have tried to rouse the Australian Colonies, through their Agents here, to combine and build a permanent Annexe, worthy of our place in the scale of Nations, but ‘*no instructions*’ is the universal reply.

“ Oh, for a ‘forty-parson power’ to revive the inert mass of slumbering politicians in Australia. However, plucky little Queensland, in the meantime, goes in for an Annexe of her own. \* \* \* \* Where there’s a will there’s a way, and it shall go hard with me if I do not make it a success.\*

“ As soon as those specimens of yours, which are being figured, are completed, I will send them back.

“ This applies to the Don River series especially.”

#### OPALS.

My final reference to Queensland will be a mere mention of the discovery in 1870 of the Precious Opal, of which some specimens were shown in the Exhibition just closed. They have been collected from a hill in Secondary rock, near the head of Bulla Creek—a water running to and losing itself in the flat country south of the Barcoo, and on the dividing ridge separating the Langlo and Paroo Rivers from the heads of the Hope, Woroolah, and Gowen Creeks, which flow towards the Barcoo.

The opal is distributed in thin veins and plates through a brownish and partly calcareous shale (much hardened), and under conditions that lead me to suppose it was originated in silicious waters, probably warm; and not far from that district there now occur numerous water cones, or springs, forming a deposit at the lips of the openings from which they rise. As opal only differs from ordinary quartz by the presence of water of composition, it is not strange that the opal should simulate in this instance the mode of quartz-veins of a certain class. Whether this mineral will become a profitable affair is at present doubtful; but it deserves notice on the present occasion. Two specimens of

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\* This pledge has been, according to late English journals, well redeemed. It will, it is hoped, have a good effect on this and the other Colonies. (*August, 1872.*)

Precious Opals, found by me at Jutaba, in Maneero, in 1852, were reported by me at the time, and were shown at Paris in my collection at the Exhibition in 1855.

I have entered thus fully into the matters discussed, not knowing whether another, or so good an opportunity will be ever again afforded me of addressing you on these few of the many topics I could easily have discovered worthy of your notice.

#### CONCLUSION.

The result is this :—

We have now evidence that Eastern Australia is what I have often stated, one vast field of mineral wealth. From north to south, and from the coast to the 141st meridian, the western boundary of New South Wales, we know that coal, gold, copper, tin, and, in many places, lead, and other minerals of less local importance, are found in abundance.

It is to us, as emigrants from Britain, who are destined to see a British population and British institutions established in these Southern regions which have even now less than a century of history or tradition, that all this wealth has been allotted for a wise and providential purpose.

May it be the aim and study of ourselves, our fellow-colonists, and our descendants, to use it aright, as responsible to Him who has given us this “good land,” this “large land,”—“a land that the Lord our God careth for.”



## APPENDIX.

## A.

[Extracts from the Author's Anniversary Address, 25 May, 1870.]

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 Cudgong 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

\* A paper subsequently read before the Royal Society will be found in the Transactions for 1870.

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, 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 crystallizations 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,

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\* "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).

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 realized 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 *furor*) 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.

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\* Professor Thomson and myself were often puzzled by finding bits of a *blue* glass in collections of drift, till we traced them to the blue bottles in which castor oil is sold.

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 drift, and of necessity of the gold drifts, *fluvial* 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 inquiries, but there are many who (as Mr. Taylor does) think the diamond is a product of

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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 recognize 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 oxidized 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.

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 organization 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 various origin; that there are at Berlin one which contains bodies resembling *Protococcus pluvialis*, and another green corpuscles linked together, closely

resembling *Palmoglæa 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 gem-stones; 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 inquiry, 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 esiste 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 rotondati. 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 segnalalarla, 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 Géognostique, 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 pyrophyllite lime; others consider it an iron schist.

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 thirty-two 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 water-parting of the basins of the Amazon and Parana Rivers, a little south of 14° S. latitude, and at an elevation of some 1,200 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 Itacolomite has also affected the diamond crystallisation. For a long period the red Psammite and the secondary Itacolomite 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 Itacolomite, 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 *Gurgalho* 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 Itacolomite is known as *Pizarro*; but all belong to the decomposed rocks.

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

The *Cascalho* of the old watercourses goes by the name of *Gui-para*; 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 Itacolomite and Metamorphic schist, yet it is not so necessarily; for the Itacolomite mountains do not always contain diamond, and in that of Itacolomi 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 *Cascalho* 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 Cascalho 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 carats; but as they were different in size, the average is assumed at one carat each, the largest being  $1\frac{3}{8}$  carat. 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 find 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. Od.), 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 substance of the previous and following quotation 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 indusie 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 Cascalho 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 Cascalho 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 Cascalho 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 Gerães 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. Hockeder'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. Géol. 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 silicious 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 psammities, 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 Science"—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, siliceous 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. Malcomson, which was read in November

and December, 1837. In it he alludes to the Cuddapah 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 galena 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 Jurassic 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, rest on gneiss, hornblende 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 hornblende rocks by a fault on the Takiria River and 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 Bridjapur it consists of 2 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 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 sub-angular 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-silicious 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, 20 feet of regular beds of cherty and compact limestone rest on 50 feet of alternating sandstone and shale, based on rich syenite; 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 12 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, syenite, 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 1,050 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 some of those at Ballarat, but which seems to have derived its pebbles and boulders from Palæozoic and Metamorphic and ordinary igneous rocks ; *laterite* itself covers 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 8,000 feet above the sea, the idea of diamond belonging to it as its actual source is not sustainable.

In a subsequent 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 of 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 and basaltic formations of India are not all of one age.

If we compare the Indian 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 honor 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 Chrestovodsvingsk, 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, was shortly after deputed to carry on the search, and four were discovered, which are described as colourless, diaphanous, smooth, and very bright, with forty-two 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 rhomboidal 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 Adolphskoi 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 considered 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 Cudgong, 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 Cudgong 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 *Solfataræ* 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 syenite 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, stating 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. Radeloff, 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.\*

\* 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 are 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 £8,000. 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.”

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

NUMBER AND VALUE OF DIAMONDS SENT FROM THIS PORT.

	Diamonds.	Value.
1870.		
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” .....	1,240	22,255
Per post.....	26	1,300
	2,326	£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 2,000 diamonds, valued at a large amount.



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-eighth 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 have been anxious to collect from every available source, in the course of my own reading and observation, all that bears upon our new 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. .

## B.

*Extracts from "Explorations of the Highlands of the Brazil," by Captain Richard F. Burton, F.R.G.S., &c. Vol. II, p. 147-8.*

"The diamond merchant in the Brazil still cleaves to the old system of money-weights introduced by the Portuguese in the days of colonial ignorance.

"The Brazil has, like ourselves, an especial diamond-weight; but practically, and amongst miners, one hears of nothing but 'grain' and 'oitava'—'quilate' or 'carat' is not popular.

"The old French lapidaries said, for instance, 'eighty grains,' not twenty carats.

"The following is a complete list of weights:—

"The Brazilian measures (found in books) are—

4 grains = 1 quilate (carat) = 0.203 grammes.

6 quilates = 1 escrupulo (scruple) = 1.218 grammes.

"Our diamond rule is—

16 parts = 1 grain = 0.8 grains troy.

4 grains = 1 carat = 3.2 grains troy.

151.50 carats = 1 ounce troy (oitavas or 256 vintems).

16 ounces = 1 pound.

[The Brazilian measure above allows 233.81 grammes to the Lisbon pound. The Brazilian Custom House makes the pound = 458.92 grammes, which reduces the carat to 0.199 and the scruple to 1.195.]

Dezreis	=	1 grain (0·892 grains troy).
Vintem	=	2 grains.
Oitava	=	64 grains (72 grains Portuguese).
„	=	17·44 carats.
„	=	32 vintems.
„	=	16 carats.

“The Hindu equivalent of the carat is the rati (ruttee), which Tavernier makes =  $\frac{7}{8}$  carat =  $3\frac{1}{2}$  grains.

I may add to the above that Dr. Kelly, in “The Universal Cambist” (vol. 1, p. 220) gives the carat =  $3\frac{1}{8}$  grains troy, or  $205\frac{1}{4}$  French decigrammes. This is less than Burton’s value by 0·034.

“Pearls are weighed by the troy standard, but the pennyweight is divided into 30 grains instead of 24, and therefore an ounce contains 600 pearl grains; hence 4 troy grains = 5 pearl grains.

“Gold and silver are weighed by the troy standard.

In valuing quartz by the ton avoirdupois, and gold by the ounce troy, mistakes may occur. It should be remembered that a pound of the former is equal to 7,000 grains troy, and an ounce of the latter to 480.

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### C.

EXTRACTS from Reports and Evidence by Rev. W. B. Clarke, in reference to the discovery of Tin in New South Wales.

1. *Extract from an article on Mining, in Sydney Morning Herald of 16th August, 1849:—*

“Here, for the sake of usefulness, we suggest that, though tin has not yet been found in this Colony, it may hereafter be discovered. It is not improbable that it will be found along parts of the Murrumbidgee, where granite occurs with abundance of *schorl*; since, in granitic districts of Cornwall, oxide of tin bears a marked connection with *schorl*, which latter mineral is a principal ingredient in tin lodes. The writer of this suspects, however, that he has found crystals of tin in granite from the locality mentioned, though he did not pay particular attention to the fact. The abundance of copper in this Colony would naturally suggest the probable occurrence of tin, though it is equally probable that the abundance of our copper is mainly due not to the existence of true granites, but to the occurrence of the trap rocks of the more usual varieties.”

2. *Extract from Report to the Colonial Secretary, dated Jindebine, County of Wallace, 24th December, 1851 :—*

“ I found the summits of the Muniong to be composed of coarse syenitic granite, partly concretionary, much jointed, and rising in denticulated masses and rounded bosses, so as to present, in connection with the slopes of snow, the outline of a true Sierra Nevada.

“ The tourmaline places the granite not far from that of Dartmoor, and one might expect tin in the vicinity. I obtained one small specimen from the granite. None was, however, found amidst the detritus.”

3. *Extract from Report to the Colonial Secretary, dated Ranger's Valley, Severn River, 7th May, 1853 :—*

“ Of metals, besides gold, I have met with sulphuret of antimony ; molybdenite, in radiating masses, occurs in the granite east of Dundee, and in more plentiful quantity near New Valley ; wolfram and oxide of tin, with tourmaline, occur near Dundee and in Paradise Creek, and it is probable that this ore of tin is plentifully distributed in the alluvia of other tracts, as I have found it amidst the spinelle rubies, Oriental emeralds, sapphires, and other gems of the detritus from granite.”

“ Mr. Fox obtained oxide of tin in the form of crystals of felspar (De la Beche, Report p. 390) ; it is in similar form that I have seen oxide of tin in New England.”

4. *Extract from Evidence before the Select Committee on the Gold Fields Management Bill, 19th August, 1853 :—*

“ In sixteen of these counties (Northern Gold Fields) gold has been found to exist. Besides gold, there are lead, copper, antimony, molybdenite, iron, and tin, and various gems.”

5. *Extract from Report to the Colonial Secretary, dated 14th October, 1853, on the Geology of the Basin of the Condamine River :—*

“ I may, however, remark that there are gems and tin ore in many localities, of which little account was taken, but which may one day prove as valuable as gold. Respecting the tin ore, I may state that I found it in almost every mass of drift in every portion of the country I have explored for gold, and that it is frequently abundant where gold is wanting. It exists in all the western streams from the Peel to the Condamine, and it was equally common in the southern districts.”

6. *Extract from a letter to the Editor of the Herald, dated 13th January, 1854 :—*

“ Sir,—Observing in your impression this morning a notice of tin ore like the ‘ stream tin ’ of Cornwall, by Mr. Storer, of the U. S. Ex. Ex., in the alluvia of the Ovens, I take occasion to state that

this valuable ore is not confined to the Ovens, but exists, as I have found during my late exploration of *this* Colony, as well as of Victoria, in a vast number of localities, always with gold derived from granite, and frequently where no gold has been discovered I found it abundantly in the southern country, and all through New England and its flanks. I was first led to anticipate tin from observing the presence of tourmaline granite, and the indication has not deceived me. It is from precisely such granite that it has been derived in Cornwall; and coupling this fact with another, viz., that tin exists in great abundance at Banca, and gold also in others of the islands of the Indian Archipelago, we have every reason to conclude that both these metals (since the geological formations are persistent) will be found in certain localities all through the range of the Australian Cordillera up to Torres Strait."

7. *Extract from Evidence before the Select Committee on Claims, 12th April, 1861:—*

"147. With regard to tin, I consider I was the first to find tin in the Colony."

"148. I did not find it on the Ovens—it was on the Murrumbidgee, on the Alps, and in New England."

"149. With regard to the black sand of New England, I had some correspondence respecting it. I have placed some of it under the microscope, and I find it is a mass of pure crystals."

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## SEPARATING GOLD FROM ARGENTIC CHLORIDE.

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ON an improved method of separating the Gold from the Argentic Chloride produced in Gold-refining by Chlorine Gas.

[*Read before the Royal Society of New South Wales, 20th November, 1872, by ADOLPH LEIBIUS, ESQ., Ph. D., Senior Assayer of the Sydney Branch of the Royal Mint.*]

IN refining argentiferous gold by means of chlorine gas (Miller's patent) the silver is eliminated in the form of chloride of silver, or as now termed, argentic chloride.

In the paper read by Mr. Miller before this Society, on December 1st, 1869, he described this process so fully that I need not refer to more of it than that part which speaks of the argentic chloride produced. This argentic chloride is never pure, but contains, besides chloride of copper, a considerable quantity of gold, stated by Miller, in the paper quoted above, as 2 per cent. of the gold previously refined. If this auriferous argentic chloride is reduced to metallic state without freeing it of its gold, silver bullion results, containing from 12 to 20 per cent. of gold, the average being about 18 per cent. This gold exists chiefly in combination with chlorine, and also as a double compound of chloride of gold and silver. By melting the chlorides in a boraxed clay pot, with from 8 to 10 per cent. of metallic silver, the greatest part of this gold was removed, but never the whole. Miller states that with proper care the amount of gold remaining in the silver need not exceed 3 parts in 10,000. While such was the case in many instances during the time the experiments were going on, the amount of gold left in the silver bullion produced varied from 3 to 27 parts in 10,000, the average being 13 parts in 10,000. Lengthy experience obtained since, has shown that, when working on a large scale, and therefore with less time at disposal than when engaged in experimental trials only, the results became still more variable, the gold in the silver bullion having been not seldom as much as 100 to 150 parts in 10,000, and often 10 to 40 parts in 10,000. This irregularity in the results obtained made it desirable to institute further experiments with a view of arriving at a method which would if possible take out all the gold, or at all events would only leave a minute and regular proportion of this metal in the silver bullion produced. To free the silver bullion from gold by dissolving it in acid would,

in the Colony, where acids are very expensive, not be found remunerative, especially as silver bullion containing 5 grains of gold per lb. troy, can be more advantageously sold in London. When the auriferous argentic chloride is merely fused in a boraxed clay pot without any addition of silver or anything else, about 60 per cent. of the gold therein is separated, while about 40 per cent. remains in combination with the argentic chloride.

In the use of metallic silver, which was employed in strips about  $\frac{1}{8}$ " thick, the silver thus added acts decomposing upon the gold compounds, forming chloride of silver, at the expense of the chlorine formerly in combination with the gold. The silver had to be in contact with every part of the molten chloride, which was, as much as possible, achieved by stirring the same with the silver strips employed. Was the heat of the furnace a little too great and thus allowed the silver strips to melt too rapidly, the silver sank to the bottom of the pot with only a portion of the gold, producing a silvery gold button, while more or less gold was left in the liquid chloride. This no doubt was the chief cause of irregularity in the results obtained by employing silver strips. But even had this not been so frequently the case, a considerable objection to its use would always have been the fact that a large amount of metallic silver would annually have been converted into argentic chloride, and back again into metallic silver.

To avoid this addition of metallic silver, and to substitute other reducing agents, a series of experiments was instituted; fusion, with addition of argol and of resin, as well as reduction by means of hydrogen gas, and also coal gas, were successively tried; the results have, however, not been found sufficiently practicable.

The addition of carbonate of soda promised more success. Indeed, during the experiments carried on in the Sydney Mint, in 1868-9, conjointly with Mr. Miller, by Mr. Hunt and myself, to test the applicability of the refining process on a large scale, the employment of soda for freeing the argentic chloride from gold was suggested by me; but only one trial was made, and not having been carried out with the precaution which I now found to be required, a considerable loss in the operation caused its rejection in favour of the before-mentioned metallic silver strips. When soda is added in powder to fused chloride of silver, the action ensuing is very violent, and this causes a spitting and throwing up of metallic silver, thereby causing great loss; but when the fused chloride is covered with a layer of borax one-eighth to one-quarter inch in thickness, and the soda is gradually introduced on the top of this layer of borax, the action is found to be very gentle, and can easily be regulated. The quantity of soda required may vary from 16 to 20 ounces per 230 ounces of chloride fused

in a No. 18 boraxed French clay pot. Twenty ounces of soda produce a gold button weighing about 35 ounces, assaying from 870 to 880, while the silver bullion produced will contain from two to five parts of gold in 10,000 parts.

The operation is very regular in its results, but as seen, not all the gold is removed thereby; in fact, in no case, even with an increased quantity of soda, was the whole of the gold removed in one operation. To produce silver bullion *free* from gold was, however, *always* successful when the argentic chloride was subjected to a second treatment, with about 3 ounces of soda pro 200 ounces of argentic chloride. This second operation is done similar to the first, but in a new pot, also boraxed; it requires a short time,—about one hour. The argentic chloride containing only traces of gold from the previous treatment with soda, fuses much more readily than when it contains much gold. The time occupied by the first operation varies somewhat, according to the heat of the melting furnace and the character of the chloride. To fuse 230 ozs. argentic chloride, after having been introduced into a red-hot pot, placed inside a guard, takes from 60 to 80 minutes; the addition of the soda from 20 to 30 minutes, after which the pot is covered and the heat of the furnace increased to get all in good fusion, which takes from 10 to 20 minutes. The pot is then removed from the fire, allowed to cool sufficiently for the gold to solidify, when the still liquid argentic chloride is poured off into iron pans and placed into the galvanic battery, a description of which I gave in a paper read before this Society in December, 1869.

While the soda is being added, the top layer is occasionally gently dipped with a stirrer slightly underneath the molten chloride, without stirring the same; in fact, it is preferable not to stir the fused chloride, but to let the gold collect at the bottom of the pot, and to pour the chloride carefully off.

The presence of a large proportion of copper in the chloride has been found to prolong the operation considerably; it is therefore advisable to refine gold bullion containing much copper by itself, and to free the resulting argentic chloride, which therefore contains much copper, by dissolving the same after being reduced to the metallic state.

It is remarkable how uniformly the gold is diffused in the argentic chloride. Any portion of a slab of this chloride, free from borax, may be assayed for gold and will be found alike. This offers a convenient means for ascertaining the result of the treatment with soda before the argentic chloride is placed in the battery for reduction. A small piece is broken off from one corner of the slab of chloride, and reduced to fine powder in a wedgewood mortar; the powder is kept in a corked glass tube,

and from thence weighed out for assay in an assay balance ; 10 grains are wrapped in a piece of lead-foil  $1\frac{1}{2}$  inch square, and cupelled at low heat with about 60 grains of lead ; the resulting silver button is boiled out, and the gold weighed.

This mode of assaying the chloride is so quick—six samples can be easily assayed, inclusive of powdering, in one hour—that it is well worth employing in all cases. Should the assay show more gold in the chloride than desirable, it must be subjected to another treatment with soda. Such a case need, however, only rarely, if ever, occur.

The question whether the *whole* of the gold should be removed from the chloride by a second treatment with soda, as described, or whether such additional expense for pot, fuel, &c., is better avoided, if silver bullion containing little gold were readily saleable, must naturally be left to the consideration of the circumstances attending each case.

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## ASSAYING ANTIMONY ORES.

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REMARKS on the fallacy of a certain method of assaying Antimony Ores given by some Manuals of Assaying.

[*Read before the Royal Society of New South Wales, 20th November, 1872, by ADOLPH LEIBIUS, ESQ., Ph. D., Senior Assayer of the Sydney Branch of the Royal Mint.*]

SINCE antimony ore in the shape of sulphide of antimony is frequently found in Australia, and its percentage of pure antimony may become a question affecting many commercial transactions, I deem it right to make a few remarks with regard to a method for assaying such antimony ore.

In Mitchell's Manual of Assaying, 3rd edition, page 432, it is stated, after going into several methods of assaying different antimony ores:—

“The best method of assaying sulphide of antimony seems to be one in which it is mixed with four parts of cyanide of potassium, and heated very gently in a crucible. The heat required in this case is so low, and the operation is made so quickly, that none (if any) of the antimony is lost: so that this process is decidedly preferable in the way of an assay. In particular cases, however, the wet method must be had recourse to.”

Now such a statement by such an authority, and from which it may possibly have been copied into other treatises on assaying, is very apt to mislead.

It is not a new fact that cyanide of potassium, in decomposing sulphide of antimony, reduces a part of it to metallic antimony, but it also forms a sulpho-salt of antimony and potassium, which keeps in the flux; and therefore, the percentage of metallic antimony in a sulphide of antimony ore, when obtained by direct fusion with cyanide of potassium, is very considerably below what it really is.

In order to show you plainly the result of such a treatment, I have here a very good antimony ore, sulphide of antimony, with but little gangue; 50 grains of it were reduced to metallic antimony by an indirect process, while the other assays, each with 50 grains of the same sample, were made by direct fusion with

cyanide of potassium. You see at a glance the difference in the size of the antimony buttons :—

No. 1, done by indirect fusion, weighs 32·42 grains = 64·84 per cent. of pure antimony.

No. 2, done by direct fusion, weighs 17·24 grains = 34·48 per cent. of pure antimony.

No. 3, done by direct fusion, 17·16 grains = 34·32 per cent. of pure antimony.

It is not an uncommon thing to accept two identical results of one sample as a proof of the correctness of an analysis; but you see here, that such is only true when the method employed is free from error. It is singular that this sulpho-salt should form in such regular proportions, since in several experiments with different quantities of sulphide of antimony, I always obtained 34 per cent. of antimony from an ore containing in reality 65 per cent. Pure sulphide of antimony contains 72·77 per cent. of antimony. It is not my object to do more than point out this fallacy of the direct fusion with cyanide of potassium. I may observe, however, that in cases where a sulphide of antimony ore is free from lead or other metals, the objection of direct fusion may be overcome by evaporating 30 or 50 grains in a small porcelain crucible with strong nitric acid, and heating very carefully until the sulphate of antimony is completely converted into oxide of antimony, sulphuric acid being driven off; this oxide can then readily be fused with cyanide of potassium. Of course other antimony ores, containing lead, copper, &c., or antimony alloys, require different ways of analysis, the choice of which must be decided in each case, according to the substance from which the antimony requires to be separated. But the object of the foregoing remarks being merely to point out a possible source of error, I need not here enter into a description of the best methods for assaying other antimony ores.

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## TIN ORE.

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### REMARKS on Tin Ore, and what may appear like it.

[*Read before the Royal Society of New South Wales, 20th November, 1872, by ADOLPH LEIBIUS, Esq., Ph. D., Senior Assayer of the Sydney Branch of the Royal Mint.*]

AFTER more than nine months have elapsed since the excitement respecting our Tin discoveries, both here and in Queensland, began, it may almost seem superfluous to say anything about tin ore. Many, no doubt, have already found out to their cost, that the old proverb, "it is not all gold that glitters" may be supplemented by saying, "it is not all tin that looks like it."

It is very curious that at first few (if any) samples of tin ore were to be seen which were not highly satisfactory. Gradually, as the tin fever spread, samples were more frequent containing but little tin, and lately titaniferous iron and tungstate of iron were the rule rather than the exception.

The colour of native tin ore varies from white to pink, ruby-red, grey, greyish-black to black; it therefore is certainly no very reliable criterion for distinguishing tin ore.

A safer characteristic is the weight, or specific gravity, that of tin ore being 6·8 to 7·0. Unfortunately, however, the specific gravity of tungstate of iron is nearly the same as that of oxide of tin, in fact a little higher, being 7·19 to 7·55.

Titaniferous iron has a specific gravity of from 4·5 to 5·0, and magnetic iron 4·9 to 5·2.

Basaltic hornblende and silicate of iron have also come under my notice as having been mistaken for tin ore; but the specific gravity of the former being only 3·1 to 3·4, and that of the latter 3·8 to 4·2, ought to have saved such mistakes. The colour of the powdered ore forms a much better criterion than that of the un-powdered ore. The powder of good tin ore varies only from whitish grey to dark drab, while tungstate of iron powders reddish brown, and titaniferous iron black.

Hitherto most of the samples which came under my notice appear to have been mistaken for tin ore on account of their dark granular pieces having been taken for such; but I have here a sample, which I examined lately, and which consists of blackish

pieces with about 50 per cent. of small indistinct crystals of a pink and dark ruby colour, with a few small white crystals. The whole mixture being pretty heavy, has certainly at first sight all the appearance of good tin ore. Even on closer inspection, when the darker portion just referred to might have been recognized as an iron compound, the ruby-coloured portion might readily pass muster for tin ore unless chemically examined. I confess my surprise when, on further examination, I found the whole sample to be *free* from tin. It was found to consist—1. Black portion, about 50 per cent. of the sample, having a specific gravity of 4.47, was found to be titaniferous iron. 2. Ruby-coloured and dark red pieces, about 50 per cent. of sample, with a specific gravity of 4.57, found to be zircons or hyacinths, showing the characteristic property mentioned in Professor Thompson's excellent "Guide to Mineral Explorers," of becoming completely and lastingly colourless when exposed to heat with the blowpipe. I produce here a piece so treated. 3. Besides these zircons were found a few small topazes and garnets, and also a small sapphire. The specific gravity of the mixed sample, as received, was 4.55. I produce part of the original sample, as well as the titaniferous iron and zircons picked out from a portion of it.

As already mentioned, there was positively no tin in the sample, and it forcibly illustrates the necessity of the precaution, in dealing with tin ore, to have it carefully assayed.

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## GEMS OF AUSTRALIA.

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ON the Gems of Australia, with a Dissertation on Mineralogy, as applicable to them.

[By GEO. MILNER STEPHEN, ESQ., *Fellow of the Geological Societies of London, Germany, Cornwall; Natural History Society of Dresden; F.R.S., Sydney, &c., &c.*]

IN submitting to the Royal Society a paper on the subject of the Precious Stones of Australia, it is desirable to make some preliminary observations. A bare catalogue of those gems, with the localities in which they are respectively found, would doubtless be beneficial to some extent, by putting the inquirer on the right scent, and thereby sparing him a needless expenditure of time and money in searching for gems in places, or under circumstances, where they are not to be found; yet he must carry with him some slight knowledge of the physical character or appearance of the gems he seeks, otherwise he may labour in vain, although in their midst. It is indeed a matter of deep regret, as regards the public welfare, that in a Country having so vast an area, and teeming with the most valuable minerals, there should be no School of Mines, as on the Continent of Europe, for giving instruction to all classes of all ages,—if even of an elementary character,—in the art of mining and searching for minerals. And the observation may be excused, that as it is ever an anxious inquiry with parents in Australia, in what manner their sons can be brought up profitably and respectably, it may be answered that two thousand youths might now find profitable employment, if not wealth, in mining pursuits (which in Australia do not involve the “loss of caste”!) if they could only obtain sufficient instruction of a practical nature, as afforded in those valuable mining seminaries, in the rudiments of Geology, Mineralogy, Chemistry, Metallurgy, and Mining; for what capitalist, or working miner, would not gladly associate with himself a young man, so trained up to grapple scientifically with the real difficulties of mining, instead of trusting to the “happy-go-lucky” system so universally prevalent in Australia, with the exception of a few well-organized enterprises?

To return from this digression. Without presuming to give instruction, a concise and practical dissertation, on that branch of Mineralogy forming the subject of this paper, may be permitted;

as it prepares the mind to grasp and retain certain leading principles, which it is essential for the mineralogist, or the "prospector" (as the man who searches for minerals is christened in Australia) to remember.

*Distinction between Geology and Mineralogy.*—Although the two sciences are so intimately connected, that the two terms are often used synonymously, there is in fact a wide distinction. To give definitions in the simplest form of words,—Geology treats of the structure of the earth, and the changes it has undergone from its creation out of chaos to the present time; Mineralogy describes in detail the various component parts or substances of which terrestrial matter is formed, and declares the forms, properties, and qualities of those substances. For instance, the geologist,—in passing by a deep railway-cutting, or descending the shaft of a mine,—possibly finds a stratum of rounded pebbles; and knows that they have acquired that form by friction, as they have been driven over rocks, or against each other, by moving water in some bygone age. The mineralogist examines the component parts of the stratum, and finds that the pebbles are composed of granite, quartz, greenstone, &c. Again; the geologist observes that a deposit of a blue stone or lava, many feet in depth, has overlaid thick beds of sedimentary rocks, or a drift of pebbles and gravel (the washdirt of the gold-miner), and knows that the lava was once in a molten state, and ejected from a volcano at some period of the world's history. The mineralogist observes the character of the lava; he finds it is of that specific kind called "amygdaloidal" basalt, from the almond-shaped cavities in the mass; and he possibly finds some crystals of olivine in those cavities. The mineralogist then declares the value of the basalt, for its toughness and durability as a building-stone or metal for roads, and of the olivine, as an ornamental gem, known as chrysolite. In short, it is the object of Mineralogy, as well observed by Professor Ansted, to describe the form, the internal structure, the chemical composition, the physical properties, and the uses to man, of all those natural material productions or substances, which are not organic, *i.e.*, which do not possess vitality, or the powers of reproduction, like animals and plants.

*Physical character of minerals.*—Mineralogists distinguish these various inorganic substances, one from another, by several means:—

1. By chemical analysis.—This is the most elaborate and the most accurate test, as it determines with certainty the component parts of each specimen examined; but, as the mineral must be partially, if not wholly destroyed, it is more rarely resorted to by the mineralogist as a test for gems or precious stones.

2. By submitting the mineral to heat with the blow-pipe, or, in some cases, the flame of a candle, or jet of gas ; as some minerals impart a colour to the flame, or give off fumes of sulphur, or garlic, &c., or water ; or melt more or less readily with, and without a flux : *e.g.* native bismuth, sulphuret of antimony, and sulphuret of silver, &c., are easily reduced to the fluid state in the flame of a candle, &c. The operator must carefully note the comportment, or behaviour of the mineral substance under examination ; and any work on mineralogy will point out the characteristics of each mineral before the blow-pipe.

3. By colour.—This is a most useful test in the case of gems, when once the eye has become accustomed to discriminate the various tints assumed by the several species of gems ; for instance, the almandine garnet (often called a carbuncle, when cut by the lapidary *en cabochon*, *i.e.*, with a rounded top) has a red-purple colour, like claret ; the precious garnet has a red or red-brown colour, like port wine (these varieties being valuable as gems) ; and the common garnet has the brown tint predominating ; whilst the opaque garnet is of a black-brown tint (both varieties being unfit for jewellery). Every connoisseur knows how much the value of the ruby depends on its having the true “pigeon’s-blood” colour ; the blue sapphire a deep rich blue ; and the diamond the purity of a drop of distilled water.

4. By hardness.—This is one of the most unerring tests in the hands of an experienced observer, and the requisite skill is not difficult of acquisition ; but as it is necessarily dependent on comparison,—one mineral with another,—an acknowledged scale of degrees of hardness, which could be adopted by all mineralogists, was a great desideratum. Professor Mohs, the eminent mineralogist, accordingly proposed the following Scale ; which has been since universally accepted by mineralogists, for the purpose of expressing the relative hardness of any given mineral.

It will be seen that the diamond is the hardest mineral, as it is the hardest substance, in Nature. And it may not be deemed out of place to notice a vulgar error which has caused the destruction of many a veritable diamond, owing to persons confounding the terms “hardness” with toughness. Now, the diamond, though so intensely hard, has so little toughness in its nature that with a blow of the smallest hammer you may cleave off a slice ; and the knowledge of this property enables the diamond-cutter to reduce it a good deal by “cleavage” to the desired form, without too much waste in grinding ; whilst, on the other hand, it constantly happens that a careless workman, in the act of resetting a diamond in a piece of jewellery, breaks a splinter off, by allowing the tool to bear too roughly, or smartly upon the gem. And yet there is a common belief among illiterate people, that a diamond is so tough, as well as hard, that “*it can bear the blow of a sledge-*

*hammer on an anvil;*" and they try the experiment accordingly; when the diamond, of course, is pounded into dust!

*Mohs' Scale of Hardness.*—1. Talc. 2. Gypsum or rock-salt. 3. Calc-spar. 4. Fluor-spar. 5. Apatite, or asparagus stone. 6. Felspar. 7. Quartz, transparent. 8. Topaz. 9. Sapphire. 10. Diamond.

Any elementary book on mineralogy will explain the method of using this scale. It is sufficient now to state that to the eye of a superficial observer, knowing nothing of the crystallographic forms of the respective minerals, a crystal of quartz, a white topaz, a white sapphire, and a diamond, have a tolerably close resemblance, as respects lustre and colour, and general appearance; but by applying the sharp angle of one stone to the face of any other, and endeavouring to scratch it, he will make no impression on the latter, if it be the harder of the two; yet, if of a lower scale of hardness, it will receive an indelible scratch. If two specimens are the same mineral, or of the same hardness, they are both slightly scratched or abraded.

5. Another valuable test for minerals, especially gems, is the ascertaining their relative weight to distilled water, which is called taking their "Specific gravity." Thus, a diamond is about  $3\frac{1}{2}$  times as heavy as water; a sapphire, about 4 times; a topaz, about  $3\frac{1}{2}$  times; and quartz, about  $2\frac{1}{2}$  times: being severally marked S.G. (specific gravity) = 3.52; 3.909—4.16; 3.4—3.65; 2.5—2.66.

A remarkable proof of the accuracy, of this valuable test of "specific gravity" was recently afforded the author; who had to determine, whether a fine water-worn gem-stone of large dimensions (exceeding the size of a pigeon's egg), found in Bass's Straits, was a pale-green topaz, or an aquamarine (beryl). As no experiment involving the slightest injury to the stone was permitted, that of ascertaining its specific gravity was at once the most satisfactory and harmless. Its weight in air was 317.83 grains; in water, 201.26; and, by working out the sum, the specific gravity was found to be 2.726. A cut and polished aquamarine from Europe was then weighed, for the sake of comparison. Its weight in air was 42.64 grains; in water, 27.0 grains; and by dividing the weight out of water (*i.e.*, in air) by the difference of weights obtained out of, and in water (which is the method of working the "specific gravity" sum) the specific gravity of the latter gem was also found to be—as any person can ascertain for himself—exactly the same, *viz.*, 2.726; being within 6-1000ths of the weight assigned by Haidinger, the mineralogist, to the aquamarine (beryl): whereas the specific gravity of the topaz is nearly one-fourth greater. After such a wonderful coincidence in weights, could the greatest sceptic doubt that the larger stone was also an aquamarine, or question the accuracy of the test?



6. The "fracture," when broken, is also a test of some importance. Thus, quartz has a conchoidal fracture, like the shell of an oyster; the topaz breaks across its prism or line of axis, nearly as flat as a piece of plate-glass, and with a high lustre. The fracture of other minerals is said to be splintery, &c.

7. The degree of polish, or "lustre," is another test for minerals; some being adamantine, as the diamond,—vitreous, as glass,—metallic, as gold,—resinous, as pitch,—earthy, as chalk, &c.

8. The "streak", or mark made by a fine file across a mineral capable of being scratched by it, or by a still harder mineral, is another test, though of minor importance. For instance, many iron ores (hæmatites, &c.) yield a red streak; or, as the German miners technically express it, *es blutet* (it bleeds); some, though coloured stones, give a white or colourless streak, as spinelles of all colours; others, though dull, show a metallic or shining streak, as plumbago, soap-stone, &c.

9. "Cleavage" is of importance, to ascertain the primitive form of a crystal, by splitting off parallel faces, or by removing edges or angles, and hence determining the "System" to which it belongs. In some cases also one mineral may be distinguished from another by cleavage. Thus, water-worn or rounded pebbles of white topaz and quartz present the same appearance externally; but you may cleave the topaz straight across it, in one direction; whereas the quartz pebble has no distinct cleavage-plane, and would break with a conchoidal or shell-like fracture.

10. The last and most valuable test, in the case of gems, is their external form or "crystal." No term is more generally misapplied; as most people of the present day (not being mineralogists) apply it, as did the Ancients, only to rock-crystal or quartz: the Ancients believing that the latter was water, solidified by enormous pressure; and hence they gave it the name of *krystallos*, being the Greek for "ice."

The best definition of the word "crystal" is given by Professor Ansted.

In the transition from the gaseous or fluid state to the solid, many substances assume the condition of a regular geometrical solid, bounded by plane faces. (See chart of crystals herewith.) Such are the forms most readily recognized as crystals; and they occur, whether the solidification takes place by the separation of the solid from an aqueous solution, or by cooling from igneous fusion. The beautiful crystals occasionally found in Nature, and imbedded in various rocks, have doubtless been formed under one of these conditions.

Each substance usually exhibits a peculiar crystalline form of its own, although frequently much modified or varied; yet an absolute geometrical identity of form is not expected, even in the same mineral substance.

Mineralogists have classified those substances into Six Systems, the names of which vary with each writer. The accompanying chart is prepared by the present Author from the most approved text-books, in order to elucidate by a tabular arrangement those several systems.

It will be seen that only two or three crystals of each system, including the "primitive" octahedron or dodecahedron, as the case may be, are delineated; but infinite modifications and combinations of the simple forms occur in each system, presenting the most complex and beautiful forms of crystallization.

Professor Mohs, in his valuable work on Mineralogy, has figured no less than 277 crystals belonging to the several systems; and many more might be added.

It is worthy of remark, as bearing upon Australian Gems, that the author of this paper has for upwards of twenty years been in the habit of studying the mineral productions of Australia, using the assay-balance and all other tests, except chemical, in case of any doubt or difficulty; and his experience justifies him in asserting, that he has invariably found Nature so true to herself, here in Australia, as in other parts of the World, that he has frequently brought out the specific gravity of any mineral—the gems especially—to a decimal of a thousandth, when referring to that specific gravity as given by the most esteemed writers.\* Hence, when weight, hardness, crystalline form, and colour, coincide with those "laid down in the books," he has always felt safe, in pronouncing confidently upon the mineral substance under investigation.

The small Cabinet of Gems now submitted to the Members of the Royal Society affords a fair sample of the quality, if not of the size of Australian Gems,—found, as they are, through the length and breadth of this great island continent, under precisely the same conditions, and accompanied by the same minerals, as when found *in situ* in other localities in the several gem-producing Countries. They include in their catalogue almost every precious stone known to mankind, including the Noble Opal,—splendid specimens of which, of great fire and brilliant colours, have lately been brought to Sydney from the far North-west, and which will bear comparison with the finest specimens from the famous Opal-mine of Czerwenitz in Hungary. And when it is borne in mind, that during this month an Octahedral Diamond, exceeding 12 carats in weight, has been brought to Sydney from the banks of the Macquarie River,—that sapphires of great size and beauty,—red, yellow, blue, and green,—a pearl weighing 83 grains,—large topazes of all colours,—hyacinths of great fire and clearness,—besides other gems (including forty-one diamonds from a new locality),—are now placed before the Royal Society, we have a right to predict that the day is at hand when the Gems of Australia will be sought for as articles of commerce.

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\* See instances mentioned *ante*, p. 78.

CATALOGUE of Gems exhibited to the Royal Society, in illustration of the foregoing paper, as collected and classified by Geo. Milner Stephen, Esq., F.G.S., &c.

No.	Name.	Locality where found.
48	DIAMONDS. (White, straw-colour, greenish), from 1½ carats weight downwards, in octahedrons, dodecahedrons, and icositetrahedrons (24 sides).	The rivers Cudgegong, Macquarie, Shoalhaven, and Bingara, in New England.
50	RUBIES.*	Cudgegong River, near Mudgee.
91	SAPPHIRES. (Blue, green, yellow, brown, white, bronze, blue and green, blue and white, blue and black); some exhibiting opalescence, dichroism, floating stars of six rays (asterias), fixed stars of do., black hexagonal centres. In more or less perfect hexagonal crystals,—or water-worn,—and cut and polished; from ¾ inch downwards.	New England, Abercrombie River, near Mudgee, Shoalhaven River, Rocky River, in New South Wales: Ovens District, Ballarat, Mount Franklyn District, in Victoria.
8	CORUNDUM. (Opaque Sapphires.)	} Ovens District, Victoria.
3	Violet, or Barklyite Rubies. Blue (a hexagon). Green.	
20	TOPAZES. Blue, white, yellow, pink. In hexagonal crystals, more or less modified, and water-worn, also cut and polished.	
55	ZIRCONS. Red (hyacinths), yellow, white (jargoons). In cubic-octahedral crystals, and water-worn, and cut and polished.	New England, Abercrombie River, Trunkey Creek, Shoalhaven River, in N.S.W.: Ovens District, Dunolly, in Victoria: Cape Barren Island.
34	SPINELLES. Balas Rubies, (s. g.=3.571), Oriental Amethysts, Automalites, (red, violet, black), in octahedral crystals, and water-worn.	Mount Franklyn and Ovens District, in Victoria. Cudgegong River, New South Wales.
150	GARNETS. Almandines, Pyropes, Precious, Common, (Claret-colored, port-wine-colored, red, dingy red, black, yellow, white, green), in icositetrahedral (24 sides), and dodecahedral (12 sides) crystals; and water-worn.	Ovens District, Victoria. Trunkey Creek, New South Wales. Abercrombie River, New South Wales. Hardwicke, near Yass, N.S.W.: Queensland.

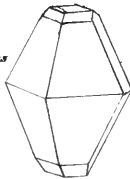
No.	Name.	Locality where found.
2	<p style="text-align: center;"><b>BERYLS.</b></p> Aquamarines, in hexagonal crystals, and water-worn (one weighing 317 grains).	Cape Barren Island. Mount Greenock, South Australia.
11	<p style="text-align: center;"><b>PEARLS.</b></p> White, pink, blue, green, grey, yellow, black, from 69 grains downwards.	Coast off Western Australia.
7	<p style="text-align: center;"><b>AMETHYSTS.</b></p> In hexagonal crystals.	Ovens District, Victoria. New England, New South Wales.
15	<p style="text-align: center;"><b>MOON STONES.</b></p>	Ovens District, Victoria.
2	<p style="text-align: center;"><b>NOBLE OPALS.</b></p>	Listowel Downs, and Springsure, Queensland.
2	<p style="text-align: center;"><b>CAIRN-GORMS.</b></p> Smoky quartz, and yellow, or false Topaz.	Ovens District, Victoria. New England, New South Wales.

\* NOTE.—For some years it was doubted whether the genuine Oriental Ruby had been detected in Australian ground. The Rev. Dr. Bleasdale and Mr. Foord, of Melbourne, both of whom are competent authorities, had assured me that the true Ruby had been brought under their notice, but I had myself not seen one; though I had discovered the Spinelle Ruby (Red Spinelle) now exhibited, in the well-known hemitrope octahedral-crystal, in the Tin Sands, at the Ovens District, in Victoria; and at the Peel River, in New South Wales. The specific gravity of this gem is 3.575, and its hardness = 8; as given by Dana. Hence I gladly secured for my Cabinet the fine Oriental Ruby (weighing over 3 carats, as cut in London), and the smaller specimens in their natural state from Mudgee District, New South Wales. The specific gravity of this cut stone I have purposely noted; being so much higher than that of the Spinelle, as it is also one degree harder in the scale, viz., = 9. This ought to set the question at rest for ever; especially as so many other Rubies from the same locality are in the possession of connoisseurs and the Trade.

A vast number of foreign precious stones are also exhibited in the Cabinet, for purposes of comparison, viz.,—Diamonds from Brazil; Emeralds from Granada; Rubies, and Sapphires, and Spinelles, in perfect crystals (hexagonal and octahedral, hemi-tropes, and twins), and Zircons from Ceylon; Topazes from India and Brazil; Amethysts from Siberia, &c., &c. Also Native Gold, in octahedral and dodecahedral crystals, from Ballaarat, Victoria; and in Antimony, Galena, Ox. of Iron, Granite, Sandstone, vesicular, and common Quartz.

4<sup>TH</sup>  
 CUBIC OR TRIMETRIC

Regular  
 combination of two of the Octahedrons  
 with equiaxial and the terminal  
 face.

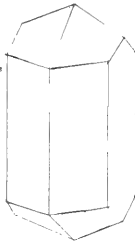


About 6

Quartz, Topaz, Heavy Spar, Sulphur, Sulphuret of Antimony, Mispickite, &c.

OBLIQUE PRISMATIC

Combination of the Oblique  
 hexahedron with the vertical Prism  
 and the terminal faces.  
 Square Octahedron  
 (not equal axes)



About 33M

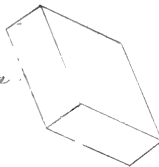
Felspar, Gypsum, Mica, Hornblende, Augite, &c

OBLIQUE PRISMATIC

Hexagonal  
 Dodecahedron

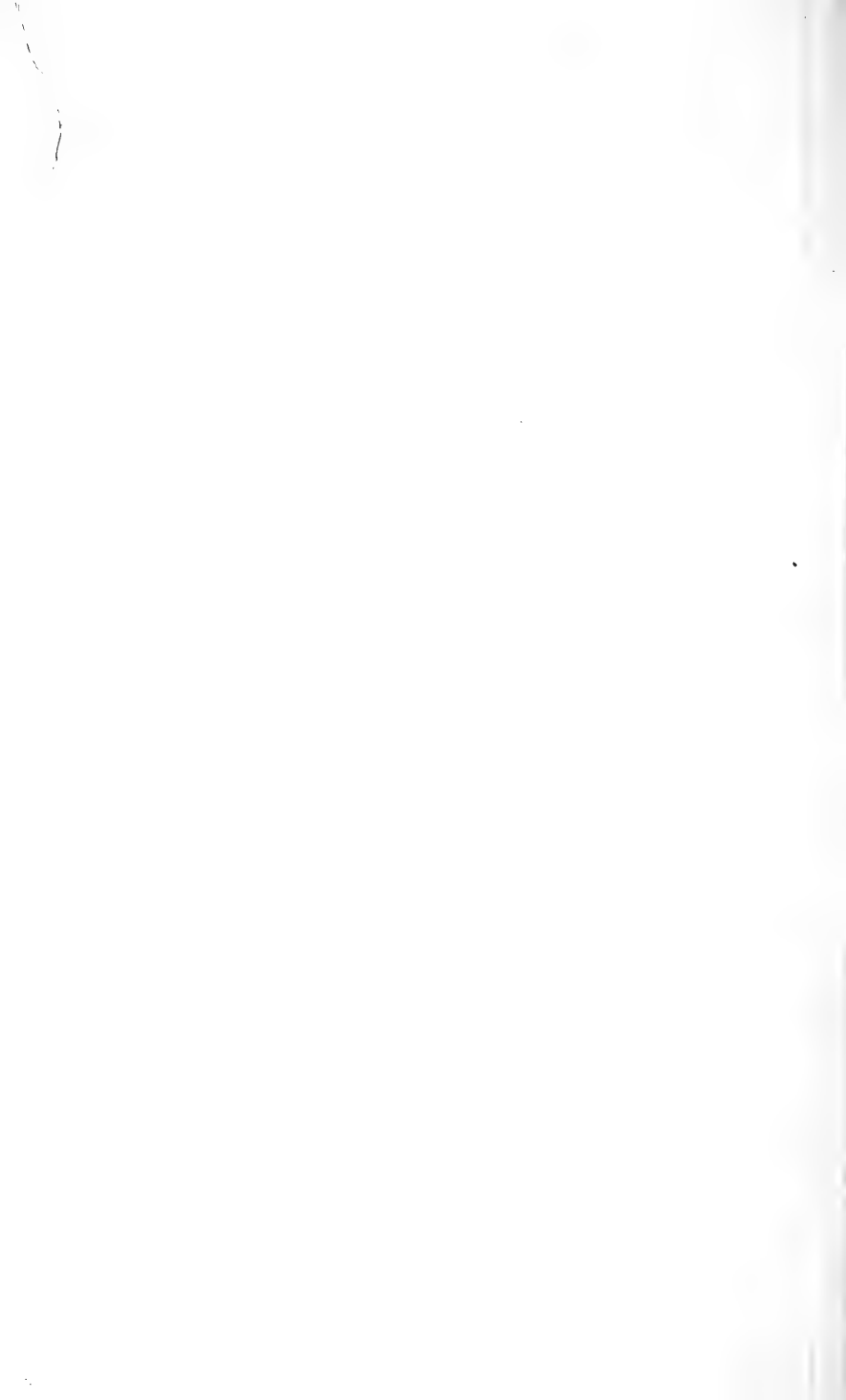


Oblique Prism



About 66

Quartz, Labrador Felspar, Albite &c.

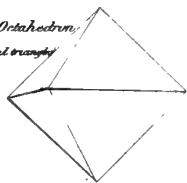


# CRYSTALLOGRAPHY

## THE FUNDAMENTAL FORMS OF THE SIX SYSTEMS OF CRYSTALS.

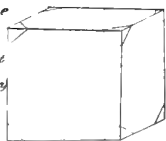
### 1<sup>ST</sup> REGULAR or MONOMETRIC

Regular Octahedron  
(All equal triangles)



Cube

(Showing the commencement of the Octahedron)



Dodecahedron



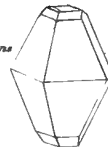
About 87 Minerals belong to this System Gold, Diamond, Garnet, Galena, Native Copper, Iron Pyrites, Chromite Iron, Spinel, Fluor Spar

### 4<sup>TH</sup> RHOMBIC or TRIMETRIC

Right Octahedron  
with a  
Rhombic base



Combination of two of the Octahedrons  
with a prism and the terminal  
face

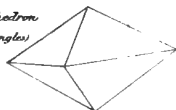


About 107 Minerals belong to this System Topaz, Turb. Heavy Spar, Sulphur, Sulphuret of Antimony, Muscovite, &c.

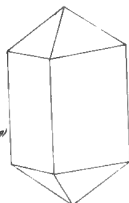
### 2<sup>ND</sup>

### SQUARE PRISMATIC

Square Octahedron  
(not equal triangles)



Square Octahedron  
with Right Prism  
(The Prism predominating)



Obtuse Octahedron  
with Right Prism  
(The Octahedron  
predominating)



About 33 Minerals belong to this System Tin Ore, Zircon, Copper Pyrites, Rutile, &c.

### 5<sup>TH</sup>

### MONOCLINIC or OBLIQUE PRISMATIC

Oblique Octahedron  
(Not equal triangles)



Combination of the Oblique  
Octahedron with the vertical Prism  
and the terminal faces

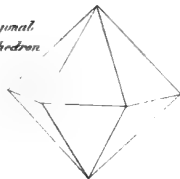


About 84 Minerals belong to this System Epidote, Feldspar, Opium, Mica, Hornblende, Augite, &c.

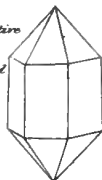
### 3<sup>RD</sup>

### HEXAGONAL

Hexagonal  
Dodecahedron



Hexagonal or Prismatic  
Dodecahedron  
(with the first derived  
Prism)



The finest known Emerald  
(About 2 inches in  
diameter)



About 68 Minerals belong to this System Emerald, Corundum or Sapphire, Quartz, Graphite, Chlorite, Tourmaline

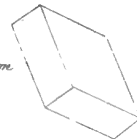
### 6<sup>TH</sup>

### TRICLINIC or DOUBLY OBLIQUE PRISMATIC

Combination of  
the Doubly-Oblique  
Octahedron with  
parts of the vertical  
prism, with several faces



Oblique Prism



About 14 Minerals belong to this System Arsenite, Labrador Feldspar, Albite, &c.





## ASTRONOMICAL NOTICE.

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[*Read September, 1872, by H. C. RUSSELL, Government Astronomer.*]

IN going over the known double stars near the south pole, I have recently found the following, which are not in Herschel's or any other catalogue in the library, and are therefore probably new double stars.

1872, July 31st.—Found a very pretty double, magnitudes 9 and  $9\frac{1}{2}$  R.A. 15h. 49m. 10s.; decln.  $65^{\circ} 37' 30''$  south; distance between them  $2'' 12$ ; angle of position  $135^{\circ} 47'$ ; mean of 6 measures power 230.

July 31st.—Found, but did not measure till August 7th, another double star, not so close as the last; magnitudes  $9\frac{1}{2}$  and 11 R.A. 17h. 2m. 16s.; dec.  $68^{\circ} 13' 30''$ ; distance between them  $3'' 42$ ; angle of position  $200^{\circ} 9$ ; mean of 4 measures power 150.

August 1st.—Found a nice double star, magnitudes 7 and 9 R.A. 14h. 50m. 6s.; dec.  $67^{\circ} 28' 30''$ ; distance between them  $5'' 66$ ; angle of position  $335^{\circ} 29$ ; mean of 4 measures power 150.

When measuring Herschel's double 4909 R.A. 16h. 55m., dec.  $50^{\circ} 57' S.$ ,—of which he says, "a very symmetrical little constellation of two large and three very minute stars forming a pentagon",—I found a sixth star, quite as large as either of the three small ones, which forms, with the two large stars, an almost equilateral triangle within the pentagon, so conspicuous that if there he could not have missed it. This must be either a variable or a new star.

P.S.—Since the above was published I have received a catalogue of stars observed at Santiago, and find that the third one on my list was observed there in 1852. Note added 26 Nov., 1872.—H.C.R.

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## THE COLOURED STARS ABOUT KAPPA CRUCIS.

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At the Monthly Meeting of the Royal Society, on the 2nd October, 1872, Mr. H. C. Russell, the Government Astronomer, read the following paper on the Coloured Cluster of Stars about Kappa Crucis :—

The beautiful cluster of stars generally known as the coloured cluster about K. Crucis is but a small one, covering, according to Sir John Herschel's estimate, only a 48th part of a square degree ; but I know no cluster in the heavens equal to it in symmetry of form and beauty of colour. There are many coloured clusters brighter and more numerous, which at first sight seem more beautiful, but not one whose beautiful features grow upon acquaintance like this ; no other to which Herschel's glowing description, "a superb piece of fancy jewellery," can be applied.

In my recent survey of this cluster, facts have come to light which would seem to give it new interest, and which probably point it out as one of the stations from which astronomers will gain knowledge of the distance of the starry systems.

Some points in the history of the cluster are remarkable, and may be here recorded for convenient reference, should some of the probabilities prove to be facts.

The first recorded observation of it is by Lacaille, in 1750. He used a telescope 26 inches long, with an aperture of only half an inch, and to him this object appeared as a nebula. This is an important point, as will appear subsequently.

No other observations were then made until Sir Thomas Brisbane established the Parramatta Observatory, when it was observed in the regular meridian work with the mural circle, the telescope of which has an aperture of nearly 2 inches, and focal length 25 inches, and was set down as "a cluster of 12 or 14 small stars, in the form of a rhomboid, very close together. Part of this cluster forms a very perfect cone of mixed stars."

It does not appear to have been examined with the transit instrument or the equatorial, both of which are larger ; but about the same time Mr. Dunlop examined it with a reflector of 9 foot focus and 9 inches diameter, which he kept at his private house, and he thus describes it (page 127, Phil. Trans., 1828):—

"Five stars of the seventh magnitude, forming a triangular figure, and a star of the ninth magnitude between the second and third [in R. A.], with a multitude of small stars on the south side." Unfortunately, he did not count them, nor give any other description than that which I have quoted, but a good (though

small) drawing is given, and from the general correctness of it, I am inclined to lay some stress on two things connected with this map. First, he puts two stars in the position now occupied by Phi No. 66, a star which has considerably altered its place since Herschel made his map. Second, the star No. 87, now a conspicuous star, is not represented at all. It is also remarkable that he says nothing about *colour*, yet it is evident from his work that he was rather fond of recording coloured stars, and it must have been very manifest in this cluster seen through his reflector, if at all like what it is now.

In 1835, when Herschel went to the Cape, Kappa Crucis was one of the objects which he rigorously examined, and deemed worthy of a monograph, in which the places of all the stars, numbering 110, in the space included in his beautiful map, representing a space  $90^{\circ}$  in R.A., and  $7' 36''$  in dec., were recorded with their magnitudes and colours. He particularly remarks that he saw no nebulous light.

In May, 1862, Mr. Abbott, of Tasmania, examined this object with two telescopes—one  $4\frac{1}{2}$  inches, 5 feet focus, the other 7 feet focus, diameter not given—and communicated the result to the Royal Society of Tasmania. The drawing which he made was not published.

He says "the smaller stars all partake of nearly the same colour, *Prussian blue*, some with a little (more or less) tint of red or green mixed with the blue." Again, "in the Cape Observations Phi is laid down to the west, *i.e.* preceding the line joining Delta and Epsilon; they are now, however, all three situated in a *straight line*, which when continued reaches the star Zeta." He laid down seventy-five stars on the map, two of which were beyond the Cape drawing, and five others which Mr. Abbott thought were in the space, but not shown by Herschel (their positions are unfortunately not given). Of the colours of the principal stars, Mr. Abbott gives them as follows. For convenience of reference I put the three estimates of colour together:—

	Herschel.	Abbott.	Russell.
Alpha	Greenish white	Greenish white	Greenish yellow
Beta	Greenish white	Greenish white	Greenish yellow
Gamma	Greenish white	Bluish purple	Greenish yellow
Delta	Green	Pale cobalt	Greenish yellow
Epsilon	Red	Indian red	Carmine red
Zeta	Green	Ultramarine	Greenish yellow*
Phi	Blue-green	Emerald green	Sky blue
a	Ruddy	Prussian blue	Carmine red
In my list.	{ Nos. 77 82, 83, 84, 89, 101, 102, 103, 105, sky blue. Two small stars near Epsilon, Nos. 80 and 81, red.		

\* One observation greenish white.

Since the above nothing seems to have been published about the object, and I determined this year to examine it and see if Mr. Abbott's statement that "certain changes are apparently taking place in the number, position, and colours of its component stars," represented the actual state of the case.

With this object in view I began the survey of which the results are here given, including a catalogue of all the stars (130) seen; and a coloured map showing all these stars, also particular notes made at the time of observation. The map takes in the same space as Sir John Herschel's, is similarly divided, but is on a scale which makes it about four times as large. The 130 stars are all that *are now* visible within the map's space with the Sydney equatorial on the most favourable evenings.

Great care was taken to render these results as accurate as possible, and the positions of all the stars (33) which are visible in full moonlight were determined with the position micrometer, used as follows:—The single spider line was carefully adjusted to a parallel of longitude, and then used as a transit wire over which the zero star and all the others were allowed to pass, and the differences of transit taken. In all cases the mean of two (or more, as in some cases necessary for the satisfaction of the observer) results is entered as one observation. While these transits were being taken, one of the parallel wires was kept on the zero star, and the other brought on the star under observation. The micrometer screw then gave the exact difference in declination, which was entered at the time. The micrometer results are given in the notes, so that if necessary they may be referred to at any future time. [See Map and Catalogue.]

As soon as these measures could be reduced, the positions of the stars were carefully marked on a map of the size of the one here given. Several of the stars were found to be different from Herschel's map—one especially (No. 11) was found to have moved upwards of  $6''$ . All these results were carefully verified, and on the 3rd April about 70 stars were entered on the map by eye-draft. Additions and corrections were made till the total number reached 130.

The blue star Phi—one of those which has moved—I have very carefully measured, and find it is not now in a straight line with Delta and Epsilon; neither will this line produced meet Zeta, but passes some 5 seconds after it. The measures of this star have been taken for the purpose of ascertaining if it has any parallax.

The night of April 12, being remarkably fine, was chosen for a careful comparison of the map and the object seen in the telescope. The magnitudes of all the stars were carefully estimated, using the large stars as guides, and the differences between my map and Herschel's carefully verified.

As soon as the map was thus completed, the positions of all the stars with their magnitudes (which, to avoid mistake, were entered on the working map) were read off and entered in a catalogue, substituting of course, in the case of measured stars, the micrometer results. The catalogue places of the stars put in by eye-draft are therefore not more correct than the map, but the catalogue is a convenient way of recording the magnitudes and comparing them with Herschel's catalogue, formed in a similar way.

The map now exhibited was then lithographed, and the proofs of it were pulled with the white lines carried across, and the positions of all the stars carefully compared with the original. As soon as all the corrections had been made, the lines were blotted out, except such parts of them as remain at the margin to indicate their places, which if required may be easily extended across for the purpose of measuring; but it was thought the object was much better represented as it is printed than with the lines on it. The telescope used was the Sydney refractor,  $7\frac{1}{2}$  in. aperture, 10 feet 4 in. focal length, powers from 80 to 400. The colours I have also examined with a silvered glass reflector, in which they appeared to me as seen in the refractor and here recorded.

## CATALOGUE of Stars in the Coloured Cluster about K. Crucis.

R.'s No.	H.'s.No. & Letter.	Mag.	Secs. before $\alpha$	Secs of Dec. + S - N of $\alpha$	Notes and Remarks.
1	1 $\pi$	10	s. 27.8	" +178.3	Mic. measures, 27.9 <sup>s</sup> 27.7 <sup>s</sup> 178.1", 178.5"
2	...	12	24.8	- 60.	Not in H.
3	...	11	24.5	+112.	"
4	...	12	24.3	+ 10.	"
5	2	11	21.3	+204.1	Mic. meas., 21.3 <sup>s</sup> 204.1"
6	...	11	19.0	+ 48.	Not in H.
7	...	15	18.0	+240.	"
8	6	15	14.5	+224.	
9	4	12	12.8	+ 94.	H. records a star, No. 5, near this, which I did not see.
10	3	13	12.2	+138.	
11	11 $\kappa$	10 $\frac{1}{2}$	12.3	+376.	Mean of 14 measures in R.A. and 5 in decln., showing since H. a change of 6.1 <sup>s</sup> and 9" in decln.—both increased.
12	8	12	12.0	+272.	
13	7	10 $\frac{1}{2}$	12.0	+163.1	Mic. meas., 12.0 <sup>s</sup> 163.1"
14	9	14	9.4	+214.	
15	12	12	8.0	+270.	
16	...	13	7.5	- 4.	Not in H.
17	14	12	4.0	+224.	
18	10	13	4.0	+184.	
19	...	13	3.0	- 30.	Not in H.
20	...	13	2.9	+ 52.	

CATALOGUE—*contd.*

R.'s. No.	H.'s. No. & Letter.	Mag.	Secs. before $\alpha$	Secs. of Dec. + S - N of $\alpha$	Notes and Remarks.
			s.	"	
21	28	12	2·8	+340·	
22	16	13	2·7	+142·	
23	17 $\mu$	10	1·7	+212·4	Mic. meas., 2·0 <sup>s</sup> 1·4 <sup>s</sup> and 212·4" 212·3"
24	15	14	2·0	+ 52·	
25	18	13	1·0	+108·	
26	21	12	0·3	- 52·	
27	20 $\alpha$	6 $\frac{1}{2}$	After $\alpha$	.....	Yellow with tinge of green. Zero star.
28	35	12	0·1	+308·	
29	19	11	0·2	+256·	H. records two stars here: I could only see one.
30	22	14	2·0	+206·	
31	...	13	2·2	+152·	Not in H.
32	24	12	2·3	- 22·	
33	25	10 $\frac{1}{2}$	2·8	+108·4	Mic. measures, 2·8 <sup>s</sup> 106·6" 110·1"
34	31	12	3·0	- 28·	
35	27 $\nu$	10 $\frac{1}{2}$	3·5	+196·6	Mic. meas., 3·7 <sup>s</sup> 3·3 <sup>s</sup> 196·8" 196·4"
36	32	10 $\frac{1}{2}$	3·7	+136·3	" 3·9 <sup>s</sup> 3·4 <sup>s</sup> 135·2" 137·4"
37	26	10	3·8	+164·7	" 3·8 <sup>s</sup> 164·7"
38	29	13	4·1	+ 44·	
39	30	12	4·3	+156·	
40	34	13	4·3	+191·	
41	33	11	4·8	+ 66·2	Mic. meas., 4·8 <sup>s</sup> 66·2"
42	37	13	5·3	+ 90·	
43	36	12	5·7	+176·	
44	38	12	7·9	+ 90·	
45	39	13	8·3	+154·	
46	41	13	9·2	+168·	
47	40	13	9·3	+155·	
48	42	13	9·8	+172·	
49	44	11	10·5	+282·	
50	43	10	11·0	+291·	
51	45	14	11·7	+ 70·	
52	46 $\omega$	11	12·1	+ 74·1	Mic. meas., 11·8 <sup>s</sup> 12·3 <sup>s</sup> 72·1" 76·1"
53	47	12	12·4	+ 88·	
54	49	12	12·5	+114·	H. records a star, No. 50, near this, but I could not see it.
55	48 $\xi$	9 $\frac{1}{2}$	12·8	+243·5	Mic. meas., 13·0 <sup>s</sup> 12·6 <sup>s</sup> 244·2" 242·7"
56	51	13	13·4	+ 44·	
57	53	13	14·1	+ 10·	
58	57	13	14·2	- 10·	
59	54	11	14·8	+190·	
60	...	11	14·8	+350·	Not in H.
61	52 $\delta$	7 $\frac{1}{2}$	15·0	+103·3	Mic. meas., 15·1 <sup>s</sup> 14·9 <sup>s</sup> 103·7" 102·9" Yellow, with tinge of green.
62	55	12	15·3	+118·	
63	58	10 $\frac{1}{2}$	15·3	+176·6	Mic. meas., 15·3 <sup>s</sup> 15·3 <sup>s</sup> 176·2" 177·0"
64	59 $\sigma$	9 $\frac{1}{2}$	16·4	+241·0	" " 16·3 <sup>s</sup> 16·4 <sup>s</sup> 240·5" 241·4"
65	61	11	16·7	+174·	

CATALOGUE—*contd.*

R.'s No.	H.'s No. & Letter.	Mag.	Secs. after $\alpha$	Secs. of Dec. + S—N of $\alpha$	Notes and Remarks.
66	56 $\phi$	8 $\frac{1}{2}$	s. 17·0	" +90·2	Mic. meas., 17·0 <sup>s</sup> 16·9 <sup>s</sup> 90·1" 90·2" Two observations make this star blue ; one, between blue and green.
67	60	11	17·4	+224·	
68	62	12	17·5	+120·	
69	...	11	19·0	+274·	Not in H.
70	65	11	19·0	+185·	
71	63 $\epsilon$	8	19·1	+75·8	Mic. meas., 19·0 <sup>s</sup> 19·2 <sup>s</sup> 76·2" 75·3" All observations make this star carmine red.
72	64 $\alpha$	12	19·2	+92·	Red.
73	...	12	19·8	+304·	Not in H.
74	67	13	20·3	+252·	
75	68	13	20·5	+258·	
76	...	12	20·5	+334·	Not in H.
77	70	9 $\frac{1}{2}$	21·2	+168·2	Mic. meas., 21·0 <sup>s</sup> 21·3 <sup>s</sup> 168·3" 168·0" Blue.
78	66	12	21·1	+70·	Red.
79	...	14	21·7	+121·	Not in H.
80	69	12	21·7	+80·	Red.
81	71	13	22·7.	+89·	
82	74	11	23·8	+2·	Blue.
83	73 $\nu^1$	9 $\frac{1}{2}$	23·8	+156·9	Mic. meas., 23·9 <sup>s</sup> 23·6 <sup>s</sup> 156·6" 157·1" Blue.
84	72 $\eta$	8 $\frac{1}{2}$	23·9	+270·8	Mic. meas., 24·2 <sup>s</sup> 23·5 <sup>s</sup> 271·0" 270·3"
85	75 $\nu^2$	9 $\frac{1}{2}$	24·2	+158·0	" " 24·5 <sup>s</sup> 23·9 <sup>s</sup> 157·5" 153·4" Blue.
86	...	12	24·7	+335·	Not in H.
87	76 $\iota$	9	24·7	—68·2	Mic. meas., 25·0 <sup>s</sup> 24·4 <sup>s</sup> 69·0" 67·3"
88	77 $\zeta$	7 $\frac{1}{2}$	24·9	+13·6	" " 24·9 <sup>s</sup> 24·9 <sup>s</sup> 14·5" 12·6" Green, yellow tinge.
89	78	9 $\frac{1}{2}$	25·6	+132·7	Mic. meas., 25·3 <sup>s</sup> 25·8 <sup>s</sup> 131·4" 134·0" Blue.
90	80 $\beta$	7	26·3	+172·7	Mic. meas., 26·3 <sup>s</sup> mean of 6 obs. 172·7" mean of 3 obs. Yellow tinge, green.
91	79	13	26·5	+183·	
92	81	13	26·6	+62·	
93	85	13	27·4	+83·	
94	82 $\theta$	8 $\frac{1}{2}$	26·8	+201·3	Mic. meas., 26·7 <sup>s</sup> 26·9 <sup>s</sup> 201·4" 200·5" From observations on April 3, 26·8 199·8" April 12, 26·9 199·6"
95	83	13	27·3	+182·	
96	86	15	27·4	—34·	
97	88	15	28·0	—26·	
98	91	14	28·7	+101·	H records a star, No. 89, near this, which I did not see.
99	84	13	28·7	+251·	
100	90	9 $\frac{1}{2}$	29·1	+215·7	Mic. meas., 29·3 <sup>s</sup> 28·8 <sup>s</sup> 215·1" 215·5" From observations on April 3, 29·2 <sup>s</sup> 216·2" April 12, 28·8 <sup>s</sup> 215·8"

CATALOGUE—*contd.*

R.'s No.	H.'s No. & Letter.	Mag.	Secs. after $\alpha$	Secs. of Dec. +S—N of $\alpha$	Notes and Remarks.
101	92	9½	s. 29·2	" +138·4	Mic. meas., 29·1 <sup>s</sup> 29·3 <sup>s</sup> 138·6" 138·1" Blue.
102	93	9½	29·2	+154·7	Mic. meas., 29·2 <sup>s</sup> 155·5" 154·3" Blue.
103	95	9½	29·6	+167·5	" " 29·4 <sup>s</sup> 29·7 <sup>s</sup> 168·3" 166·6" Blue.
104	87	13	29·8	+254·	
105	94	9½	30·4	+110·1	Mic. meas., 30·5 <sup>s</sup> 30·3 <sup>s</sup> 109·5" 110·7" Blue.
106	96	13	30·6	+208·	
107	97	12	33·1	+106·	
108	99	14	33·7	+170·	H. has another star near this, which I could not see.
109	98	12	34·1	+89·	
110	...	14	34·3	—25·	Not in H.
111	100 $\rho$	8½	34·6	+316·2	Mic. meas. 34·3 <sup>s</sup> 34·8 <sup>s</sup> 316·3" 316·1"
112	101 $\chi$	9½	35·6	+220·3	" " 35·3 <sup>s</sup> 35·8 <sup>s</sup> 219·8" 220·9"
113	102 $\gamma$	7	37·4	+26·1	" " 37·2 <sup>s</sup> 37·5 <sup>s</sup> 25·6" 26·6" Yellow tinge, green.
114	104	14	38·5	+27·7	
115	105	14	40·5	+273·	
116	...	14	40·7	—22·	Not in H.
117	...	14	41·6	+78·	"
118	106	14	42·0	+296·	
119	107 $\sigma$	9½	43·8	+233·	Secs. after $\alpha$ rest on one obs. by mic.
120	...	15	46·4	+123·	Not in H.
121	108	11	46·7	—119·	
122	109	12	48·0	+144·	
123	...	14	49·0	+20·	Not in H.
124	...	15	49·0	+108·	"
125	...	14	49·3	—34·	"
126	110 $\tau$	11	52·0	+118·	
127	...	14	52·7	+22·	Not in H.
128	...	12	53·4	+312·	"
129	...	14	55·2	—23·	"
130	...	14	58·0	+22·	"

## NOTES to accompany the Catalogue.

March 25. Began observations on K Crucis.

March 26. Fine clear night, full moon (strong west wind). Made 126 measures of R.A. and 63 with micrometer. Stars steady, but not very sharply defined. The stars measured are all I can see of the cluster to-night, with moon, and lamplight in telescope.

April 3. Made measures of No. 11 for verification,—it is 10 mag.; also, No. 100, near  $\beta$ , which it follows 2<sup>s</sup>·9, and is 43·5" south of it; also, No. 94, follows  $\beta$  0·5<sup>s</sup>, and is 28·8" south. Entered seventy stars on the map.

Cannot detect any nebulous light.



April 4. Several stars entered on the map.  $\epsilon$  and three little stars near it all look red, the two little ones only in glimpses; also, No. 82, little star near  $\zeta$ , is blue.

April 12. Stars splendidly defined on a black sky; beautiful sight; colours very fine.  $\zeta$ , greenish white;  $\epsilon$ , carmine red;  $\phi$ , blue;  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$ , yellow, with tinge of green.  $\delta$ ,  $\phi$ , and  $\epsilon$  are nearly in a line when micrometer wire bisects  $\delta$  and  $\epsilon$ ;  $\phi$  is less than its own diameter from the wire. Measured No. 11 again, two obs.,  $12^{\circ}0'$  before and  $+377.4''$  (south) and 11 magnitude. No. 94 is  $0.6$  after  $\beta$ , 8 mag., and  $28.6''$  south. No. 100 is (two measures)  $2.5$  after  $\beta$  and  $43.1''$  south. I have to-night carefully verified and corrected, where necessary, the positions of all stars put in my eye-draft, especially those in which change has taken place. No. 112 is  $9\frac{1}{2}$  magnitude, and  $48.2''$  south of  $\beta$ . No nebulous light to be seen.

May 4. Measured No. 11 again before  $\alpha$   $12.5$ ,  $12.3$ ,  $12.6$ ,  $12.3$ ,  $12.5$ ,  $12.5$  mean  $12.45^s$ . Micrometer, two readings,  $376.3''$  south.  $\beta$  is south of the line, joining stars Nos. 103 and 77.

May 13. Magnitudes of  $\delta$  and  $\epsilon$  equal;  $\phi$  is slightly brighter than  $\iota$ , No. 87. Entered four new stars. Entered on map the magnitudes of all of the stars.

May 14. Entered nine stars in map, and examined all the magnitudes.

One of the first things I found was that, in Herschel's map, the north and south points are reversed, not the inversion right to left, which is usual in Herschel's drawings, owing to the use of a front view reflector, but the north and south points reversed. This has evidently been a mistake, either in the drawing or engraving, probably the latter, as both objects on the map have the same error, and that neither was an error of observation is evident, because at page 15, Cape Observations, line 3 from top, Herschel says of 8 Messier (*i.e.*, the nebulae on the same plate as Kappa Crucis), "three pretty distinct streaks arched together at their northern extremities." In the map this is on the south side. And at page 102, speaking of Epsilon in Kappa Crucis, "south of the red star is one 13th magnitude, ruddy." In the drawing this is to the north. It is strange that Mr. Abbott did not remark this, for he examined the object many times with care.

My observations extended over the period from March 25 to May 14; and advantage was taken of the best opportunities during that period for the work, and the results are at first sight so like Herschel's that there seems nothing to justify the conclusion that change has taken place; but a closer inspection shows a great many changes, of which the most conspicuous of all is in the change between the present and past positions of three stars, Nos. 11, 21, and 28, which have all moved from 4 to 6 seconds, and the star Phi has also moved half a second in an opposite direction, and come nearly, but not quite, in a straight line with Delta and Epsilon, which line, if produced, passes, not through Zeta, but about half-way between Gamma and Zeta; considerable change has also taken place in Nos. 100, 106, 120, 122, 126, and

some others; and it is very remarkable that the changes in the south preceding side are nearly all in R.A., while in those near Beta, and in the following side, are in declination, as if the cluster were made up of three sets of stars, two of which drift from the third in different directions.

It is a remarkable circumstance, which I cannot account for by any peculiarity either in Sir John Herschel's or my own method, that I have found, both in Eta Argus and this cluster, that it is the stars on the south preceding side which are drifting from the others in the most remarkable manner.

Five of Herschel's stars, all very small, I could not see; but this is not surprising, since he used a telescope  $18\frac{1}{2}$  inches in diameter, and mine is only  $7\frac{1}{4}$  inches; but I was very much surprised to find 25 which he did not see. Stars, which though all small, are yet in most cases brighter than some of his which I recognized, and if there when he examined the cluster, would not have been omitted; they are all well within the limits of his map, and several in parts of it which must have been most carefully examined. Two of them are near Alpha, one near the string of stars south following it, one between Beta and Delta, and two in the triangle  $50^\circ$  after Alpha, where Herschel shows 3 stars; of the others, 5 precede Alpha from  $18$  to  $25^\circ$ ; 5 follow it from  $15$  to  $25^\circ$ , and on the south side; 8 are on the north following side, and 1 on the south following. Their numbers in my list are 2, 3, 4, 6, 7, 16, 19, 31, 60, 69, 73, 76, 79, 86, 110, 116, 117, 120, 123, 124, 125, 127, 128, 129, and 130.

I may here mention that while preparing this paper it occurred to me that it would be interesting to examine the object with the old telescopes as far as possible, to see if any change in brilliancy could be thus detected. I therefore first examined it with an old telescope with a working aperture of  $\frac{1}{2}$  an inch, and 20 inches focus—dimensions very near those of Lacaille's telescope. With this instrument, on a bad night, and the object six hours past meridian, I saw distinctly four stars of the cluster, which are separated much more than many which Lacaille took the trouble to record separately; yet he simply called this a nebula. With the telescope of the old Parramatta mural circle, which is now in the Observatory, and which has an aperture of nearly 2 inches, and 25 inches focus, I could see fourteen stars, and glimpses of many more which, if on the meridian, would be visible without doubt.

I may also mention that in my list there are twenty-four stars above the 10th magnitude, and in Herschel's there are only seven, thus compared:—

Magnitude	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	Total.
Herschel ...	...	2	1	1	...	3	...	7
Russell ...	1	2	2	1	4	1	14	24

And the mean magnitude of Herschel's 110 is 13, while the mean of my 130, including of course the new stars, which are all small, is 12.

I have been thus particular in detailing the history and recent observations of this object, because some important consequences flow from the results, and very much has been lost or left uncertain, simply because early observers were not particular.

The wonderful accuracy of Sir John Herschel's work forbids us from regarding in any other light than as facts the startling changes which I have just recorded; facts which prove, I think, beyond all question, that from some cause there has here, as in Eta Argus nebula, been a considerable increase in brilliancy.

What may be the cause or causes of these changes it is very difficult to say, but the position of the object is remarkable. Situated between Beta Crucis and the Coal Sack, or rather right on the edge of that strange dark place, still a puzzle to astronomers, who know not whether it is a want of stars, a hole so to speak in the galactic circle, or whether it is a cosmical cloud, shutting out the light of many stars beyond it—though on careful examination it has to me the latter appearance, the few stars that are seen being not clear, definite points on a dark sky, but hazy specks, as if seen through a fog—but whether it be the one or the other, it is exceedingly probable that any change in the position from which objects on its border are seen would alter their appearance, either to bring them into a clearer or thicker place.

Now, we know that the sun, and with it of course the earth, is moving with enormous velocity in space, probably round some point not yet determined, but with a present direction towards the constellation Hercules, a direction which is nearly at right angles with the visual line to Kappa Crucis; so that, having been changing our place at the rate of one hundred and fifty millions of miles per annum for thirty-six years, we may have altered the visual line sufficiently to account for these changes, more especially as the rather large proper motion of the cluster is carrying it as it were into the dark space; but whatever theory we may adopt to arrange the few facts which have been collected bearing on the constitution of the starry firmament, it is very difficult on either to account for the apparition of these stars. If we take the view published in 1750, by Thomas Wright, in his theory of the universe, that the stars are probably of the same size, and arranged according to some general plan, and therefore their distance regulates their apparent size, it is not easy to see how minute stars such as these could become visible by any change which can in so short a time have taken place in their distance from us, more especially since, so far as we do know, that distance has increased, and would of course produce an opposite effect.

Sir William Herschel during his early labours took a somewhat similar view to Wright's, which he supported by his then unequalled instruments and observations ; but in the progress of his work he found many facts which could not be reconciled with this theory ; he felt convinced that the stars in the Milky Way must be very differently scattered from those which are about us, and that there were some objects "possessing a self-luminous milky luminosity," possibly at no great distance from us.

Sir John Herschel (*Outlines*, page 581), after a careful survey of the Milky Way, says :—"And it would appear to follow that the smallest visible stars appear as such, not by reason of excessive distance, but a real inferiority of size or brightness."

In "Other Worlds than Ours," Proctor has shown that not only is such a view probable, but that it is an ascertained fact, in some cases taken at random amongst the stars. For so far as can be ascertained, the two stars 61 Cygni are not more than one-third the size or brilliancy of our own sun, and are very much nearer to us than Sirius, which is estimated as nearly three thousand times as large ; and upon this and other considerations he finds the opinion "that in the galactic circle we see countless numbers of small stars in the same region as the large ones, and that, probably, this region has generally a circular cross section, but is made up of enormous "whorls," or sweeps of starry matter, and that stars may, and probably do exist, beyond these whorls far beyond the reach of our present or future telescopes."

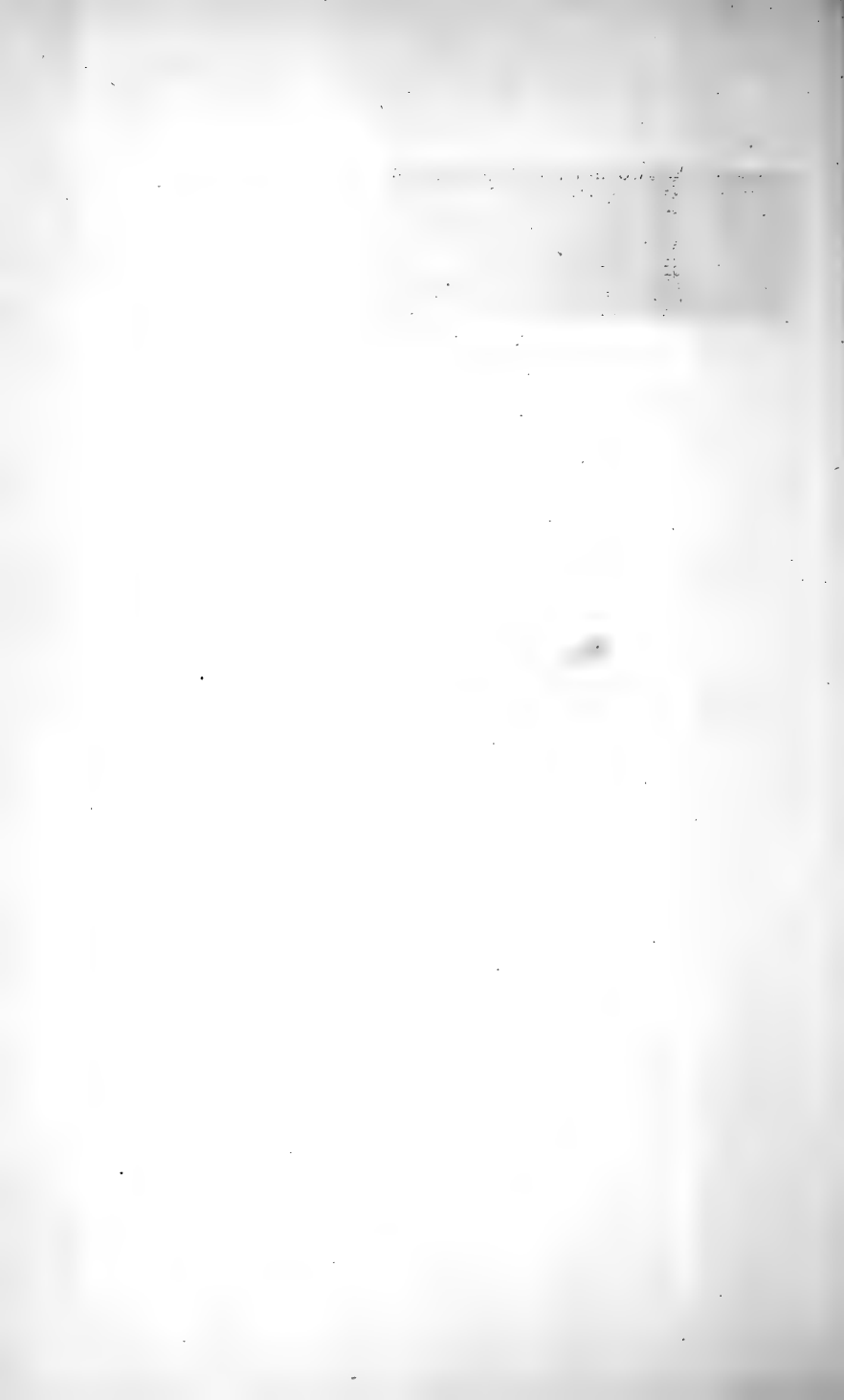
If we admit that there are great differences in the size of visible stars, it will at once afford us a probable explanation of the motion of the smaller stars composing this cluster ; for on this supposition, which is in all probability true, we can easily conceive that some of the small stars are the nearest to us, and therefore, have a larger motion. But if, on the old view, we are to remove them as far again from us at least as stars of the sixth magnitude, or twenty times as far as the nearest stars, we cannot conceive of any motion grand enough to account for such a singular change ; and it leaves us still the new stars unaccounted for.

Olbors, the celebrated German astronomer, held the opinion that light was gradually extinguished in its passage through space, and therefore, in every direction a limit of visibility must be reached ; and Struve, the illustrious astronomer of Pulkowa, considers the extinction of light proven by the circumstance that the space-penetrating power of telescopes as calculated in the ordinary way far exceeds its value as indicated by actual observation, and he found that the two might be reconciled by assuming that light in its passage from the nearest fixed star was enfeebled to the extent of one part in one hundred and seven ; and although the assumptions made by Struve are generally considered inadmis-

sible, and therefore the conclusions wrong, yet I cannot but think that we must either give up analogy, our safest guide in such reasoning, or admit the gradual extinction of light in its passage through space. For, if we consider the view which, with recent researches into the solar system, we must take of it, with its millions of meteor streams cutting the ecliptic at all angles, its thousands of comets, its meteoric dust, its zodiacal light, its solar corona, its material atmosphere so to speak, occupying not only all the interplanetary space, but more or less to the limit of the sun's attractive force, forming, may be, the nebulous light seen by both Herschels with their powerful telescopes as a "faint stippling, seen and lost again"; and if we are to take our sun as a type of other suns, and in the mind's eye see all surrounded by such an atmosphere, and people all the interspaces with myriads of myriads of comets; nay, more, if we accept the view held to be most probable by many astronomers, that it is by the deposition of this material atmosphere on the sun and planets that they are hourly growing and finding those stores of light and heat by which all things live,—it is beyond question that there must have been a time when this material atmosphere was far more dense than it is at the present moment, and that there must be in every direction other suns in all stages of the process from the great nebulousity "*without form and void*" to the finished sun, whatever that may be; or, in other words, amidst the infinitude of such systems with which we are surrounded, there are places where probably a sensible amount of clearing up has taken place within the last thirty-five years.

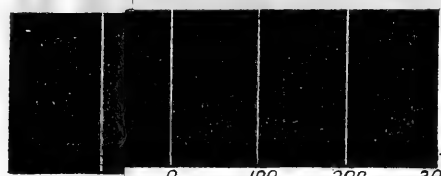
And, I think, in this view we find a rational explanation of the appearance of new stars in this cluster, more especially since it has been shown by others as well as myself, that in this region of the heavens, about the remarkable star Eta Argus, strange clearings up, so to speak, or wanings of nebulous light, have taken place, and many stars have come to view, with telescopes far inferior to Herschel's.

And whether we admit this view or not, one thing is absolutely certain: under such a material atmosphere we live and make our observations, and we are not yet prepared to say with certainty whether there may not be such changes going on in it as will suffice for a full explanation of the appearance of these small stars, if not of the great changes about Eta Argus.



1600

s



-30<sup>s</sup>

1600	1500	0	100	200	300
+384	+360		-24"	-48"	-72"

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*Sydney May 1872.*









# THE DENILIQUN OR BARRATTA METEORITE.

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By ARCHIBALD LIVERSIDGE, F.C.S., &c., *Reader in Geology and Mineralogy in the University of Sydney, late University Demonstrator of Chemistry, Cambridge.*

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## HISTORY.

We are indebted solely to the energy and perseverance displayed by our Astronomer Royal, Mr. H. C. Russell, for the discovery and preservation of this most interesting meteorite. Great praise is due to Mr. Russell for the care with which he has investigated its history. His account of it is as follows:—

“While at Deniliquin on the 9th April, 1871, on my way overland from Melbourne to Sydney, I learned from Mr. Thomas Robertson that a meteorite was to be found at a station 35 miles north-west of Deniliquin. He very kindly took me the next day to the station, which is called Barratta, and is the property of Mr. Henry Ricketson, who treated us with great hospitality, and gave me the meteorite. We found it lying in the yard close to the gate, where it had evidently been for years as a curiosity. Many small pieces, fragments of larger ones which had been broken off as specimens, were collected near the stone, and weighed altogether 2 lbs. The weight of the specimens so taken it is difficult to estimate, but probably in the aggregate it was less than 10 lbs.; the weight of the solid part is 145 lbs., so that originally its weight must have been from 150 to 157 lbs. There had also been two other pieces found with the larger piece. The smaller of these, weighing about 4 lbs., had been for years at the homestead, but was lost. The other piece, estimated to weigh between 60 and 70 lbs., had been taken to the Editor of the *Pastoral Times* newspaper at Deniliquin, and there lost. The total weight, therefore, of the three pieces originally found together must have been nearly 2 cwt.

“Barratta station is situated on a vast plain, on which no sign of rocks can be seen; under the surface there are a few small stones, but the largest I could find only weighs 2 ounces. The homestead is surrounded by a few stunted trees, from 30 to 35 feet high. The only man at the station at the time of my visit, who professed to have any personal knowledge of the fall of the meteorite, was a stockman named Jones, who had been there for many years. His account was as follows:—About dusk one evening in the month of May, ten or twelve years since, I was standing in the yard and heard a great noise as if a storm were coming over the plain; looking up I saw a large body like a bush on fire, and making a loud hissing or roaring noise, coming from south-east. It passed very obliquely just above the trees on the north side of the homestead, and I then lost sight of it behind the trees.

“The next day some fencers who were camped about four miles north-west of the homestead, came in and said they had seen a thunder and lightning stone fall into the ground near their camp. They said it frightened them considerably, because they saw it coming directly towards their camp, but after that it went into the ground, they walked down to see it, and found

it was about a quarter of a mile from their tent. A few days after this Jones went to the place, and the other men pointed out to him where the stone fell; he found the meteorite about half buried in the ground, which it had ploughed up for a considerable distance. The stone was cracked in several places, but he could not remember particularly, as it was so long since. Subsequently, in correspondence about the meteorite, I learn from Mr. F. Gwynne, of Murgah, the next station to Barratta, that he found the stone when riding over Barratta Plain, about the year 1845. As far as he can recollect, the meteorite was about 30 inches in diameter, and about 12 inches thick, and must have weighed between 2 and 3 cwt. It was lying flat on the ground; nor was there any indentation which might lead to the supposition that it had been dug up by the blacks. So far as Mr. Gwynne could judge, it might have been where he saw it for many years. The blacks could not give any account of it. It thus appears that the history of the Barratta meteorite is not satisfactory, and all my efforts to clear the matter up have so far proved useless. Mr. Robertson, who from the first has taken very great interest in the matter, has most ably assisted me in my endeavours to find the fencers who are said to have seen the stone fall into the ground, but we have not been able to find them, and the history must, for the present at least, be left as here given."

The meteorite being Mr. Russell's private property, it is still in his possession.

By way of introduction, I will now, with your permission, and in the briefest possible manner, pass in review some of the best known facts relating to meteorites generally, so that whatever I may have to say respecting the Denilquin meteorite may be made as clear as possible.

#### *Origin of Meteorites.*

With regard to the origin of meteorites very little indeed is known with any degree of certainty, but numerous hypotheses have been put forth from time to time.

One is, that they have been ejected from lunar volcanoes; another, that they are ejections from the sun; a third regards them as fragments of a former satellite or moon of the earth's which has undergone destruction; and a fourth would account for them by supposing them to be fragments of a destroyed planet now represented by the asteroids.

But against these hypotheses there are more or less weighty objections. One great objection is that some meteorites revolve in a direction opposite to that taken by other heavenly bodies round the sun; and moreover, the chemical composition of many renders it utterly impossible that they could have emanated from the sun, and passed through the fiery ordeal of its chromosphere.

#### *Composition of Meteorites.*

For convenience we classify meteorites under three heads, as determined by their chemical composition:—

*a. Metallic Meteorites*, composed mainly of metallic iron and nickel. These have been termed *siderites*.

b. *Non-metallic Meteorites* or *Meteoritic Stones*. These are mixtures of several minerals, chiefly silicates, such as olivine, felspar, augite, &c. These are also known as *aerolites*.

c. *Mixed Meteorites*. This class includes all those which are mixtures of metallic iron with various silicates. This mixed kind is far more abundant than that containing only earthy matter. They are known also as *siderolites*.

*Meteoritic iron* is always mixed with other elements; nickel is the one most commonly present, and in amounts varying from 1 to 15 or 20 per cent. Some cobalt is usually present also, and occasionally manganese, copper, chromium, tin, magnesium, &c.

Amongst the non-metallic elements we find silicon, carbon, sulphur, and phosphorus.

The presence of carbon is remarkable, and more especially as it has been proved to exist in two states; as free carbon or graphite, and also in chemical combination with the iron, just as in cast iron. Meteoric iron emits the same fœtid-smelling hydrogen gas when treated with hydrochloric acid as does common pig iron, due in both cases to the hydrogen being contaminated with traces of some evil-smelling liquid hydro-carbon.

Most specimens of metallic meteorites when polished and then etched with an acid, show remarkable more or less crystalline markings known as "Widmanstädt's" figures. Berzelius attributed the formations of these figures to the presence of an alloy of nickel and iron disseminated through the mass, and this alloy being less soluble in the acid resisted its action more than the iron itself, and thus stood out in relief on the removal of the iron by solution.

But since certain masses of meteoric iron do not exhibit these figures, although rich in nickel, it has been thought that they owe their origin to a phosphide of iron and nickel (*Schreibersite*) which forms the major part of the residue which is left on dissolving the iron in acid.

Masses of iron found on or a little below the surface of the earth are usually regarded as meteoric when containing nickel, although the actual fall of the specimen may not have been observed.

The phosphorus present usually exists combined with iron and nickel, forming the mineral *Schreibersite*, a magnetic steel-gray mineral, of H. 6.5, and with a sp. gr. of 7.2; its chemical composition is represented by the formula  $(Fe_4Ni)P$ .

The sulphur also is usually in combination with the iron, either as magnetic pyrites ( $Fe_7S_8$ ) or the monosulphide of iron ( $FeS$ ), known as *Troilite*; both may be present in the same meteorite.

Troilite is of a brownish colour, while the magnetic pyrites is more of a bronze yellow, brittle, and attracted by the magnet.

In some cases the iron sulphides are visibly disseminated throughout the mass in the form of grains; in others, they exist in such a fine state of division that they can only be detected by the evolution of sulphuretted hydrogen on treating with acids.

The *non-metallic* constituents of meteorites are usually crystalline. This can at once be proved, in such as are transparent, by the colours which they in thin sections display under the polariscope.

Amongst the minerals found in them are—

Olivine.

Bronzite or Enstatite.

Augite.

Anorthite.

Labradorite.

Calcium sulphide.

Asmanite, a form of silica crystallizing in the rhombic system.

The first two are essentially silicates of magnesium; augite is a silicate of aluminium and calcium; anorthite and labradorite are felspars, and in composition are silicates of aluminium, calcium, and sodium.

But perhaps the most surprising constituents of some few meteorites are peculiar compounds of carbon and hydrogen. Thus, the Bokkeveld meteorite, from Cape Colony, yielded a bituminous and waxy substance to alcohol; and when heated, it furnished a sublimate containing the readily volatile salt sulphate of ammonium. This meteorite contains, in round numbers, some 80 per cent. olivine, about 7 per cent. nickeliferous iron, 5.5 per cent. other silicates, and 2 per cent. carbon and bituminous matter.

About one-third of the known elements have been found in meteorites, as follows:—

Aluminium, calcium, carbon, chromium, cobalt, copper, iron, magnesium, manganese, nickel, oxygen, phosphorus, potassium, silicon, sulphur, titanium, tin, and probably in some instances antimony, arsenic, chlorine, hydrogen, and lead. All of them occur in minerals constituting the crust of the earth.

If we arrange the elements according to their importance or abundance in meteorites, they will take up the following order, thus:—magnesium, then iron, silicon, oxygen, and sulphur; next will come calcium, aluminium, nickel, phosphorus, carbon, &c., &c.

I need hardly remind you that but a few years ago, Professor Graham, of the English Mint, exhibited specimens of hydrogen gas which he had pumped out of a meteorite, and which had been occluded within its pores.

The nature and constituents of meteorites prove beyond a doubt that they have been formed under conditions which either did not furnish sufficient oxygen to combine with the iron, a

most readily oxidizable metal, or that the circumstances were unfavourable to such combination.

We are likewise justified in inferring that water was absent also.

Usually, meteorites are hot externally when picked up soon after their fall, but at times they are not. In one well authenticated case the mass was hot externally, but excessively cold internally—the interior still retaining the intense cold of space; while the surface had become heated from the friction in its passage through the earth's atmosphere.

Meteorites are always coated with a more or less enamel-like crust. When there is an absence of iron silicates this crust is sometimes glassy and colourless; at times it is coloured, but usually it is black.

There is no doubt that the crust has been formed during the passage of the meteorite through the air, since the fragments which have become detached by an explosion are also thus coated. And when we recollect that the meteorite enters our atmosphere with a velocity of from seven hundred to two thousand five hundred miles per minute, or from twelve to forty miles per second, we need not be at all surprised at its surface being thus fused; for on entering our atmosphere its velocity is at once retarded—in fact, its motion is virtually arrested by the resistance of the atmosphere, and, as a natural consequence of this, an intense degree of heat is immediately generated quite sufficient to fuse the surface, from which fluid matter flies off. The brilliant light emitted by a falling meteor is due to this, and the luminous streak left behind in its path is caused by the streaming of incandescent matter from it.

Explosions are frequently heard during the fall of a meteorite. These are doubtless due to the high state of tension in which the different portions must necessarily be; for the intense heat generated must greatly expand the outer portion, while the inner still remains as contracted as in the cold of space; when, therefore, a portion of the shell has become so expanded that it can overcome the resistance of cohesion, it will violently detach itself from the cold inner kernel, and fly off with explosive violence.

The pitted surface so common on meteorites is probably due to the same action on a smaller scale.

I will now pass on to the more immediate subject of this note.

### THE DENILQUIN METEORITE.

It is one belonging to the third class, *i.e.*, it is a mixture of earthy silicates with metallic substances.

Externally it is coated with a blackish fused skin; this has changed to a rusty brown in parts, from the formation of oxide of iron.

From the fractured surfaces it is at once noticed that the outer layers have a strongly marked laminated structure to the depth

of about three-quarters of an inch to one inch. Deeper in than this, the structure is much more compact, and shows no traces of lamination at all, but is granular, and contains numerous spheroidal bodies.

The freshly broken surface of the outer and laminated portion is somewhat granular between the laminae, and presents numerous bright yellowish-white metallic looking particles of irregular outline, some as distinct grains, and the rest forming a fine network enclosing non-metallic matter within the meshes. Brittle. Fragments readily scratch glass.

Under a one-inch objective, this part of the meteorite presents the appearance of an iron-black material of sub-metallic lustre, with disseminated grains, and enclosing fibres of the previously mentioned metallic-looking substance. Small grains of green mineral resembling olivine are to be seen, also microscopic crystalline particles of a yellow mineral which also passes into brown. In addition, there are some minute grey grains.

The metallic-looking portions are attracted by the magnet.

This outer part of the meteorite is magnetic, but not polar.

Its powder is grey.

The specific gravity of a portion of this portion was 3.382.

As before remarked, the inner portion is not so fine-grained as the crust; it has a distinctly chondritic structure; some of the grains are comparatively large, being ordinarily about from one-sixteenth to one-eighth of an inch across; a few are a little larger. Many are grey and earthy-looking; other are brownish, and present a somewhat crystalline appearance.

The enclosing matrix has a slate-blue colour. The white metallic-looking particles are present here also.

The specific gravity of a fragment of this inner part of the meteorite was 3.503, hence its specific gravity was .221 higher than that of the outer portion. This difference is not surprising when we consider that the exterior has been subject to rather different conditions, and has probably, amongst other changes, undergone a greater degree of oxidation. Mr. Russell took the specific gravity of the main mass, weighing 145 pounds, and found it to be 3.387. We therefore see that there must be considerable differences in the specific gravity of different portions, since the mean specific gravity of the crust and interior from the above would be 3.442, instead of 3.387.

#### GREY GRANULES.

A portion was freshly broken off from this central part, as far as possible from the fused crust; was very tough and difficult to break; struck fire with the hammer, and emitted the usual empyreumatic odour of rocks when struck. Out of this some of the small gray granules were then carefully and laboriously picked and cut out by means of a hard steel penknife; a small



quantity of a light grey powder was thus obtained, which, on analysis, proved to be a silicate of magnesia, containing some iron, and is probably a bronzite. The amount obtained, after much trouble, was very small indeed.

#### NICKELIFEROUS IRON.

To ascertain roughly the proportion of this, a mass was broken off and powdered in a steel diamond mortar, and the powder passed through a fine muslin sieve, to retain the flattened scales of malleable metal.

In the first experiment 12·0618 grm. of powder was obtained, and only ·0768 grm. of metal, or about ·063 per cent.

In the second experiment 16·3170 grm. of powder was furnished, and ·1408 grm. of metal, or about ·086 per cent.

Thus the proportion of nickeliferous iron is seen to be very small indeed.

Cobalt is absent from this alloy of iron and nickel.

#### MAGNETIC PORTION.

In order to ascertain the proportion of the non-magnetic to the magnetic portions of the meteorite, 25 grammes were powdered; this gave 2 grm. of magnetic powder, or about 8 per cent. This included the total magnetic mineral. It was found that the magnet did not afford a completely satisfactory means of separation.

In the main, this part was found to consist of sulphide of iron, with the nickeliferous iron.

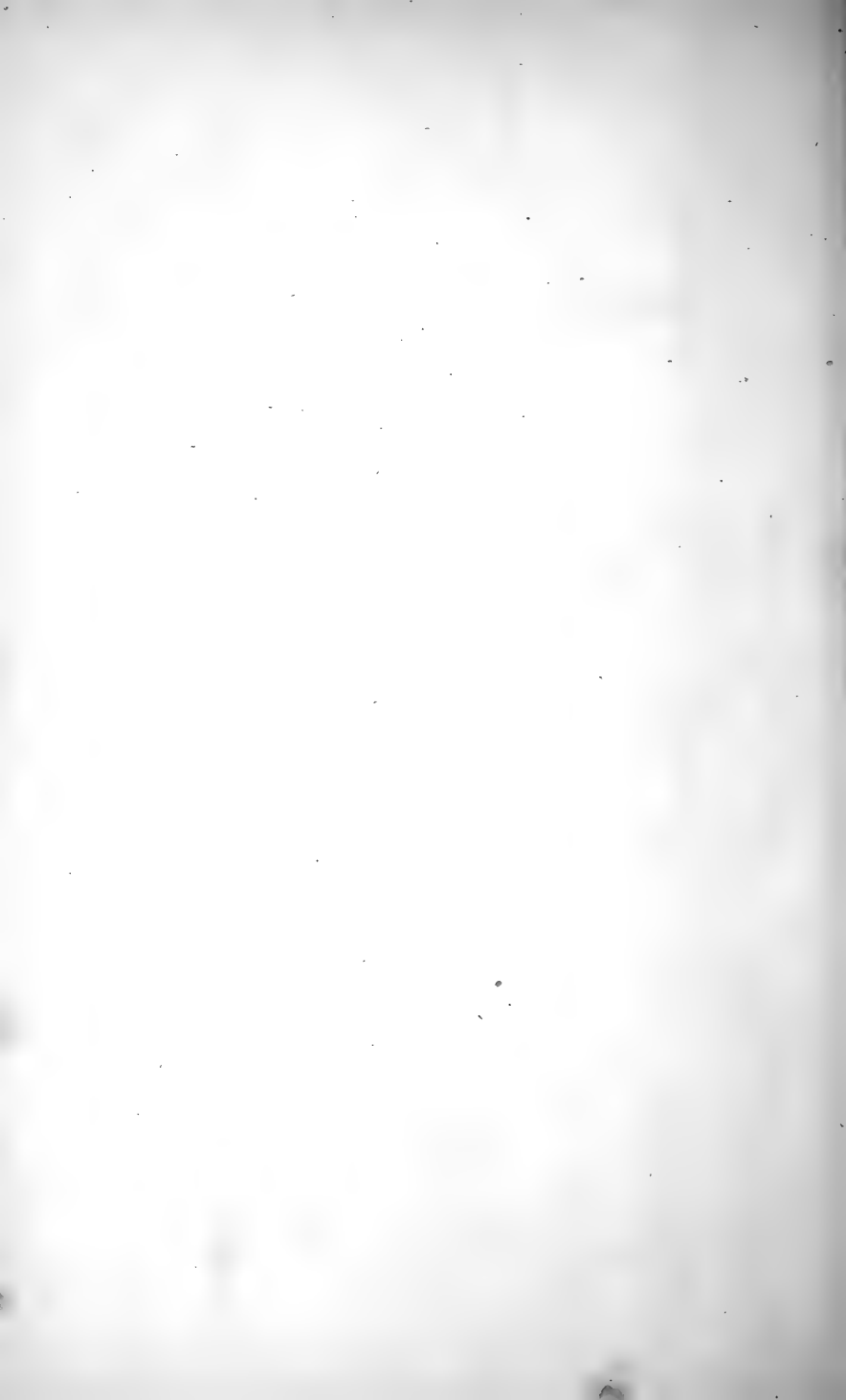
#### NON-MAGNETIC PORTION.

Gave off a copious evolution of sulphuretted hydrogen on the addition of hydrochloric acid. Mainly consisted of silicates of magnesium, aluminium, and iron and sulphide of iron. Calcium absent. Not entirely soluble in hydrochloric acid. The residue contained silicates of iron, a little aluminium, and a large quantity of silicate of magnesium.

From the foregoing it will be seen that this particular meteorite consists of about 92 per cent. of silicates of magnesium, iron, and aluminium, and about 8 per cent. of magnetic minerals. The proportion of nickeliferous iron is small in the extreme.

It is my intention to further investigate this meteorite, both with regard to its chemical composition and physical constitution, and I hope to have the pleasure of shortly laying before you the results of a complete quantitative analysis of it, my only regret being that I cannot do so on this present occasion; but the examination of such bodies presents so many difficulties, and takes up so much time, that I have not yet been able to do so, and the above must be regarded merely as a preliminary note upon the subject.

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## PROGRESS OF NEW SOUTH WALES.

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[*Statistical Review of the Progress of New South Wales in the last Ten Years—1862–1871.* By CHRISTOPHER ROLLESTON, ESQ.]

THE publication of the Statistics of New South Wales for the year 1871—lately laid before Parliament—offers an interesting subject of inquiry with regard to the progress and resources of the Colony. The Report of the Registrar General, which accompanies the volume, conveys a very clear and well-arranged analysis of the tables as they relate to the year under review, but, very naturally, extends no further. I propose, therefore, to embrace in this review a wider range of observation, and to take stock of the resources and progress of the Country during the last ten years—comparing the five years from 1862 to 1866 with the five years from 1867 to 1871. It is by comparison that we arrive at an accurate knowledge of the rate of progress we have attained, and are able to discover where we have receded—if at all, and where we have stood still, and where we have advanced. The period is free from the embarrassment which met the statistician in the earlier period of the Colony's history. I mean with regard to the loss of territory through dismemberment. In 1851, Port Phillip was separated from us: and at the end of 1859 the Moreton Bay districts were taken from us. In 1862 we had well-nigh recovered, and, in some respects, more than recovered, the losses inflicted by the deprivation of so large a slice of our territory as that which now forms the thriving Colony of Queensland. Indeed, it may at this time be said that the loss has, by the enterprise of the people, and by the fillip given to the development of the Country, through its establishment under a separate Government, been converted into a clear gain, through the growth of a vigorous, enterprising community, carrying on friendly and profitable commercial relations with us.

Statistical results are valuable for the right comprehension of the principles which should guide the proceedings of Government; and I am sure I need not at this time, and before this Society,

attempt to indicate the important bearing which statistical investigation has upon legislation. Empirical treatment of subjects without knowledge derived from facts must be as dangerous in its effect upon the body politic as upon the human frame; for it has no guide but opinions, the truth or fallacy of which—be they rational or be they visionary—is equally unsusceptible of proof from scientific data. Hypothesis and conjecture may be necessary in the pursuit of any investigation, but it is by the results of observations carefully recorded that Governments should be guided in their endeavours to promote the welfare of the people whose interests are confided to their care.

I will then, under the belief that the premises will be freely admitted, proceed to point attention to the facts recorded in the volume before me; and I am happy to bear testimony to the care and industry manifested by the compiler, in the collection, as well as in the preparation of the figures set forth for our information.

I am not going to weary you with long columns of figures in pursuing the investigation of the facts as I find them recorded; I purpose, for perspicuity and simplicity's sake, to take the averages of the quinquennial periods, and to exhibit the results with as much conciseness as is compatible with a clear elucidation of the facts to which I am about to invite your attention. The subjects will be treated under five principal heads, viz. :—

1. Population.
2. Production.
3. Manufactures.
4. Trade and commerce.
5. Accumulation.

#### 1.—POPULATION.

The number and increase of the people must always be regarded as the most important element in the progress of a Country. Let us see then what information we can gather on this head.

The Census taken on the 7th of April, 1861, resulted in a total population of 350,860 souls, of which 55 per cent. were males, and 45 per cent. were females.

The Census taken on the 2nd of April, 1871, resulted in a total population of 503,981 souls, comprising males and females in very nearly the same proportion as ten years ago.

The aggregate gain to the Country was 153,121 souls, equal to 43 per cent. in the decennary. Of this number, 108,972, or 31 per cent., was the result of natural increase by the excess of births over deaths; whilst the balance, equal to 12 per cent., is due to the excess of immigration over emigration.

Teeming with mineral wealth beyond calculation, abounding in the richest pasturage, and possessing a soil which, properly cultivated, yields to the occupier no stinted return for the toil and

labour he has bestowed upon it, we have much to do in the way of wooing a population to assist in the development of the boundless resources of this young Country.

When we consider the area comprised within its limits, and know that for each man, woman and child in it—were it parcelled out amongst them—over 400 acres of land would fall to the lot of each,—and when we reflect on this further fact, that without exceeding the density of the population as it exists in the county of Cumberland—exclusive of Sydney—we have room for a population exceeding twenty millions of souls, or forty times the number of its present inhabitants,—we cannot but hail with pleasure the prospect which is opening to us of a considerable accession to the population, not only by reason of the attraction of our mineral wealth, but by means of an assisted immigration, the funds for which have made their appearance on the Estimates for 1873, for the first time for many years. The statistics of this Colony, as well as those of Victoria, amply prove the fact that wages have declined with the stoppage of immigration, and have never ruled so high as they have reached in those years when immigration was at its full swing.

Of all causes which create national wealth the power of population is the most influential; hence the interest which attaches to comprehensive and systematic returns designed to illustrate the social progress of a nation, amongst which a Census of the people must ever be regarded as the truest index to its wealth; and instead of the repulsive dryness which thoughtless custom has ascribed to statistics of this nature, they ought to have all the attractiveness of pictures of a people's condition. For this reason, the tables that are now in process of compilation from the facts elicited at the late Census will, when published, be replete with interest, and form the basis for administrative and economical measures of the highest consequence to the well-being of the community.

A good deal of impatience has manifested itself at what appears to unreflecting persons the dilatoriness of the compilers; but any one who has had experience of the labour involved in reducing into shape and order the mass of information contained in the returns, will readily acknowledge the truth of the old proverb—“more haste, worse speed,” and that it applies with peculiar force to the elaborate details of a Census.

## 2.—PRODUCTION.

We must still under this head give precedence to our Pastoral industry, for the time has not yet arrived, although it may not be far off, when our Mineral resources may take the first rank amongst the producing interests of the Country.

The statistics show that we commenced the decennial period with the following live stock, namely :—

Horses	...	...	...	...	273,389
Cattle	...	...	...	...	2,620,383
Sheep	...	...	...	...	6,145,651

and that we close the decennary with

Horses	...	...	...	...	304,100
Cattle	...	...	...	...	2,014,888
Sheep	...	...	...	...	16,278,697

that is to say, we have increased our horse stock by over thirty-thousand; we are poorer in horned cattle by over six hundred thousand, and we have increased our sheep by over ten millions.

This is a striking result, and one which can hardly have been anticipated, viz. : that whilst we have increased our flocks in the ten years 165 per cent., we have lost 23 per cent. of our herds. Whether we owe this deficiency in our horned cattle to the ravages of pleuro-pneumonia, or to the increased demand for beef by the meat-preserving establishments, I know not—partly perhaps to both. The result, from whatever cause it arises, ought to stimulate our cattle-breeders and farmers to greater care and greater exertion, so as to keep pace with the increasing requirements of the Country. For every 100 of the population, we have 400 head of cattle, and 3,200 sheep; or, in other words, 4 head of cattle and 32 sheep for every man, woman, and child in the Country. We need be under no apprehension of starving from lack of 'butchers' meat; whilst, at the same time, it is not very clear, from the returns of the last ten years (unless we can greatly extend our power of increase) where the great surplus of cattle is to come from that is expected to feed the growing demand for our beef—whether salted, tinned, or frozen—in the Mother Country.

The decrease in cattle occurred most noticeably in the years 1863 and 1864, and it would seem that the ill effects of the pleuro-pneumonia epidemic were felt up to the year 1869, for it is not till that year the number of cattle in the Colony shows an upward tendency.

Between 1862 and 1871—omitting the two years 1867 and 1868, in which no statistics of the "overland" traffic were taken—the exports and imports of cattle and sheep across the border to Victoria stood thus, viz. :—

			Cattle.		Sheep.
Exports	...	...	551,464	...	3,440,790
Imports	...	...	33,834	...	195,213
Net exports in the 8 years			<u>517,630</u>	...	<u>3,245,577</u>

WOOL.

The tables which exhibit the export of wool—the produce of the Colony—furnish the following information:—They show us that in the year 1862 our flocks produced 20,988,393 lbs. of wool, of the estimated value of £1,801,186, which gives an average of over three pounds six ounces per sheep, and an estimated value of nearly one shilling and ninepence per pound. In 1866 the production had increased to 36,980,685 pounds of wool, with an estimated value of £2 830,348, or a little over one shilling and sixpence per pound; thus exhibiting an increase in the production to the extent of 76 per cent. Whilst in the last five years of the series—that is, in the year 1871—the exports reached the highest figures ever sent away, namely, 65,611,953 pounds of wool, of the estimated value of £4,748,160, or a little over one shilling and five-pence per pound. Not far short of five millions sterling, and equal to an increase of production of 212 per cent. in the ten years, and nearly 80 per cent. in the last five years. The clip of 1871 gave an average yield of 4 lbs. per sheep, that is, ten ounces over the clip of 1862, owing probably in great measure to the larger proportion of wool going Home in grease. We have no means of ascertaining the actual return proceeds of the clip of last year, indeed it cannot yet have been all realized. I shall not be accused of overstating the case, however, if I put down the surplus return to the Colony, over and above the value before stated, at a million and a half sterling, thus bringing up the value of the clip to six millions and a quarter sterling.

It is a noticeable feature in the returns of the exports of wool, the produce of our own flocks, that over 41 per cent. goes to Melbourne or Adelaide for shipment—a fact which suggests considerations beyond the scope of this paper to discuss.

TALLOW, &c.

As appertaining to the Pastoral interests, the sketch would be incomplete without a notice of the value of live stock, tallow, hides, sheepskins, and tinned meats, but I will treat them in the aggregate for fear of wearying you, having much ground yet to go over.

Of course we have no means of ascertaining the value of the home consumption; we must therefore be content to estimate the production by the value of the exports as expressed in the returns before us.

I find, then, that we exported seaward last year, the produce of our own flocks and herds, to the value of—

Live stock	...	...	...	...	£41,330
Salt and preserved meats	...	...	...	...	133,266
Hides and skins	...	...	...	...	48,283
Tallow	...	...	...	...	245,727
Total	...	...	...	...	<u>£468,606</u>

Thus bringing up the value of our pastoral produce to a sum approaching seven millions sterling.

Comparing this result with a similar investigation presented by me to the Philosophical Society just six years ago, it would appear that altogether, irrespective of the late rise in the value of wool, the income from our pastoral industry has very nearly doubled itself in the last six years—the pastoral exports in 1865 being then estimated at not more than £3,298,402.

But these figures, I see, include the value of the live stock, wool and tallow, exported “overland.” I must, therefore, to make the comparison complete, look up the value of the pastoral produce so exported last year. I find it is as follows, viz. :—

Live stock	...	...	...	£914,893
Tallow, skins, &c.	...	...	...	23,594
Wool	...	...	...	2,443,380
				<hr/>
Total	...	...	...	£3,381,867

If we add this to the amount previously estimated, we shall arrive at an aggregate sum exceeding eight millions and a half sterling as the total estimated value of our pastoral exports for the year 1871, viz. :—

Wool, seaward	...	...	...	£4,748,160
Tallow, &c., ditto	...	...	...	468,606
Wool, live stock, tallow, &c., overland	...	...	...	3,381,867
				<hr/>
Grand Total	...	...	...	£8,598,633

#### AGRICULTURE.

In order to illustrate more clearly the progress we have made in this important branch of industry, it will be advisable to divide the decenary into two equal periods, and average the results of each. We shall thus arrive at a more accurate knowledge of the progress we have made, than if we were to take the results of single years. The comparison then comes out as follows, viz. :—

Average five years, 1863 to 1866 : Wheat, 124,666 acres ; maize, 101,225 acres ; other crops, 125,614 acres ; total, 351,505 acres. Average five years, 1868 to 1872 : Wheat, 160,965 acres ; maize, 118,301 acres ; other crops, 155,738 acres ; total, 435,004 acres.\* We find then from these figures—

1. That the average acreage under wheat has increased by 36,299 acres, or nearly 30 per cent.

2. That the average acreage under maize has increased by 17,076 acres, or nearly 17 per cent.

\* Agricultural Statistics are made up to 31st March.



3. That the average acreage under “all other crops”\* has increased by 30,124 acres, or 24 per cent.

4. And that the total acreage under cultivation has increased in the last five years by 83,499 acres, equal to 24 per cent. I am not quite sure whether this rate of progress will satisfy the ardent aspirations of those who looked by means of a liberal Land policy to attract industry to the soil; but I cannot think they ought to be discouraged in the face of the results elicited by the late Census, and just brought under your notice, namely, that the total increase of the population in the ten years has only been 43 per cent. But I will follow up this inquiry a little further with the view of showing that, exclusive of the Pastoral tenants, the number of occupiers of land has increased from 19,361 in 1864 (the first year in which the statistics were collected) to 29,174 in 1872—rather over 50 per cent. Comparing this with the rate of increase of the population, it must be admitted that the occupation of the land has commanded a fair share of attention. But before I leave the subject of agriculture for other industries waiting our attention, I must proceed to notice shortly the results of the wheat tillage. Pursuing the comparison in the same way that I have treated the extent of land under crop, I find that the average yield of the quinquennial period was 1,270,044 bushels, or barely 10 bushels to the acre; at 8s. per bushel in Sydney (which the statistics tell us was the average price during that period) we obtain a result of £508,017, or at the rate of £4 per acre.

The average of the second quinquennial period produced 1,930,217 bushels, or 12 bushels per acre, which at 6s. per bushel—a little over the average price as given in the tables—will yield a gross return of £579,065, or at the rate of £3 12s. per acre.

I am not prepared to say whether this rate of remuneration compensates the farmer for his outlay, toil, and trouble in New South Wales, but we know that the farmers of South Australia are perfectly content to sell their wheat on the ground at 3s. 6d. per bushel, and that the average yield per acre does not exceed our own; and moreover, that wheat and flour constitute one of their principal articles of export, whilst with us the average produce is barely sufficient for the supply of one-half the population—the average of the first five years being about  $3\frac{1}{4}$  bushels per head, and the average of the last five years being about four bushels per head. The average allowance per head of the population, including wheat for seed, is estimated at  $7\frac{1}{2}$  bushels.

The value of the imports of wheat and flour, deducting exports, has averaged no less than £472,560; whilst of grain of all kinds used for food—wheat and flour inclusive, the balance of imports over exports has exceeded half a million sterling per annum, (£538,005) during the ten years under review.

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\* Barley, oats, potatoes, sown grasses, &c.

Amongst the exports of grain last year it is satisfactory to notice 741,567 bushels of maize, valued at £109,412, being at the rate of a trifle under 3s. per bushel. This is one of the most certain and prolific crops we have—maintaining a steady average yield of 30 bushels per acre, and its value will be the more appreciated when I tell you that irrespective of home consumption, we have exported on the average, annually, 783,617 bushels, of the aggregate value of £1,175,426, or at the rate of £117,542 per annum.\*

#### SUGAR.

On the 31st March, 1864, the statistics for the first time afford evidence of the aptitude of parts of this Colony for the growth of the sugar-cane. We find in that year the modest attempt of two acres, with a produce alongside it of 280 pounds of sugar. From this small beginning we trace a rapid increase, which at the beginning of this year had attained dimensions of considerable importance; for we find that no less than 4,393 acres were under cultivation, of which 1,994 acres were productive, and yielded 1,241 tons of sugar, exclusive of the produce of 748 acres in the Clarence district, which at the time of taking the returns could not be ascertained, but which, if we estimate it at the average of the remainder, will bring up the yield to as near as possible a ton to the acre. The establishment of this industry is perhaps one of the most important features in the history of the period we are recording, and I am afraid that the returns of last year do not do it justice, for I find on looking up the figures again that the yield of sugar in 1869 and 1870, with a much smaller extent of land under crop, was 3,048 tons, against 2,667 † tons in the two succeeding years. In the four years 1869 to 1872 the value of the sugar produced has exceeded £150,000.

#### WINE.

The notice of our agricultural produce would not be complete if I omitted to draw attention to the increase of the vine culture. There is no industry in which we have made greater advance, whether we regard it in quantity or quality. From 1,459 acres under crop in 1863, we have advanced to 4,152 acres in 1872, or 185 per cent. in the ten years. And in the production of wine the returns show an increase from 144,888 gallons in 1863, to 413,321 gallons in 1872, exhibiting an equal rate of production with the acreage in crop.

What value this produce may represent I know not. The restrictive fiscal policy of our neighbours has hitherto prevented

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\* Is it not strange that a cereal so wholesome, and which forms so large a portion of the food of the people in the United States and Canada, should be viewed with repugnance as an article of food by our own people.

† Allowing a ton to the acre for the 748 acres before mentioned.

its attaining any commercial value, for I can find no notice of it in the Decennial Tables of Exports, and in the Customs returns for 1871, only a few samples, amounting to 1,679 gallons in all, were exported, to which no specific value is attached. That the time however, will come when the Mother Country will as readily avail herself of our Wines as she is anxious to take our meat, no one will, I think, be prepared to dispute. But I must pass on to the next subject, only stopping to make the remark that it is impossible to reduce the produce of our husbandry, as we can our wool and gold, to any arithmetical nicety of calculation as to value. It may make no great show in the list of our exports, but it gives occupation and support to nearly 50,000 of our people; and, although I have given Agriculture the second place in this paper, I would not be so rash as to place the husbandman in the second rank amongst the wealth-makers of the Colony. Heavy losses and sore discouragements are his lot. Alternations of drought, of frost, of rust, and blight, of grub and caterpillar, are amongst the difficulties he has to contend with, and in a degree that is felt by no other producing class amongst us.

#### GOLD.

The statistics of our gold mines for the ten years ending 31st December, 1871, exhibit for the first nine years of the series a gradual diminution in production. Commencing with a value of £2,212,534 in 1862, the production declined, till it reached in 1870 the lowest point recorded since the first discovery of gold in 1851, namely:—£763,655. In the year 1871, however, there are indications of a recovery, which, during the present year have more than realized the most sanguine expectations of the mining population. The production last year mounted again to £1,143,781, making up the total value produced in the decennary to £11,591,742—the first five years averaging £1,411,786, the second five years averaging only £906,561. The industry during the first five years gave employment to about 20,000 of our people, and during the second five years to about 15,000 on the average. The value of the gold produced in the Colony and exported from 1851 to 1861, inclusive, was £13,596,686. To what proportions the energy and the enterprise that are now being directed to the development of this branch of industry may cause the production to attain, is a question beyond the power of human foresight to conjecture. I must leave it to others to discuss this problem, and pass on to the consideration of a branch of industry more certain in its results, viz.:—

#### COAL.

We are here without a rival, and may calculate with certainty on a production, limited only by the demand, for ages to come.

Whilst gold confounds all the theories of geologists and defies their conclusions, the existence and extent of our Coal formations is a matter of as much certainty to the experienced eye of the geologist as if it lay on the surface. And now that the miners and their masters seem to have arrived at a better understanding, and to perceive that it is to the interest of both to work in harmony, we may confidently hope that the production may attain proportions which will place this industry in the first rank amongst the products of the Country. In spite of the many drawbacks which have attended the pursuit, it is satisfactory to notice that whilst the average produce of the five years, 1862 to 1866, was 563,835 tons of coal annually, and an average value of £281,998, or equal to not far short of a million and a half, on the whole, the produce of the five years, 1867 to 1871, reached a yearly average of 882,272 tons, of the value of £347,957, or nearly a million and three-quarters on the whole. The value of the coal in the first period is estimated at 10s. per ton, and in the second period at barely 8s. per ton. Had the value remained the same, the produce of the latter quinquennial period would have realized £2,205,681, or nearly three-quarters of a million in excess of the earlier period. The great development of our coal mining industry will be seen in the comparison of the last with the preceding ten years:—

	Tons.	Value.
1852 to 1861 .....	2,053,864	£1,401,321
1862 to 1871 .....	7,230,553	3,149,776

#### COPPER AND KEROSENE SHALE.

These industries, although promising great results in the future, have not yet attained a development that swells up to any material extent the resources of the Colony. I find that the extent of the production in 1871 was—

Of Copper ... ..	£47,275
And of Kerosene ... ..	34,050
Total ... ..	£81,325

#### 3.—MANUFACTURES.

Under this branch of industry, we have no great progress to boast of. The most noticeable feature in the returns is the establishment within the last two years of fifty-seven mills for the manufacture of sugar from the cane, grown on the northern rivers.

In the manufacture of woollen cloth, there has been an increase of five to seven establishments only in the ten years, turning out on the average for the last five years, 218,276 yards of cloth per annum, against 120,719 yards the previous five years.

In tobacco, soap and candles, tallow and lard, refined sugar, and distilled spirits—which constitute the only remaining specimens of manufacturing industry exhibited in the tables, there is nothing to notice that would justify my detaining you; I shall therefore pass on to the consideration of the statistics of our

4.—TRADE AND COMMERCE.

In attempting to illustrate the growth of our commerce, it will be well to examine the returns of imports and exports “seaward” in the first place, leaving what is called the “overland” trade for after consideration.

Following this plan, I find that in the ten years, 1862 to 1871, inclusive, we imported seaward goods to the value of £84,832,363, and we exported goods to the value of £74,148,876; that is equal to a yearly average of imports to the value of nearly eight millions and a half sterling, and of exports nearly seven millions and a half; or, putting it in another shape, at the rate of—for imports, £19 17s., and for exports, £17 7s. per head of the average population. The value of the imports into Great Britain during the same period was at the rate of £9 5s., and of exports at the rate of £5 16s. per head of the population.

I have looked through the statistics of the Board of Trade for the last ten years, and I cannot find amongst all the dependencies of the British Crown—British India excepted—any trade that approaches in value to that of “Australia.”

The Colonies are not separately specified in the returns; but as it may be interesting to show what rank the Australian Colonies take amongst “the British Possessions” in their trade with the Mother Country, I will take leave to quote the following figures from the Statistical Abstract for 1871\*

Imports into Great Britain in the year 1870 from

British India	... ..	£25,090,163
Australia	... ..	14,075,264
North American Colonies	... ..	8,515,365
West India Islands and Guiana	... ..	5,949,199
Ceylon	... ..	3,450,974
Cape of Good Hope	... ..	2,873,910
The Straits Settlements	... ..	2,547,320
All other Possessions	... ..	2,330,219
		Total... ..
		£64,832,413

\* The total value of “imports” from British Possessions in the year 1871 is set down at £73,267,156, but the value of the exports had not been ascertained.

## Exports from Great Britain in the year 1870 to

British India	...	...	...	£20,093,749
Australia	...	...	...	10,735,481
North American Colonies	...	...	...	7,584,427
West India Islands and Guinea	...	...	...	3,639,011
Hongkong	...	...	...	3,570,733
The Straits Settlements	...	...	...	2,407,577
Cape of Good Hope	...	...	...	1,962,377
Malta	...	...	...	1,156,982
All other Possessions	...	...	...	4,240,995
Total...	...	...	...	<u>£55,391,332</u>

The imports from Australia were 22 per cent. of the whole, and the exports to Australia were 19 per cent. of the whole.

You will, perhaps, excuse this digression. It occurred to me that the information might be interesting to many who have never realized the important commercial position Her Majesty's Australian possessions occupy—second only to British India, with its teeming millions of inhabitants—and far in advance of the North American Colonies, with a population three times that of the Australias.

But to return to our own statistics, it should be notified that our trade with Great Britain constitutes no preponderating share of the whole, for I find that in the ten years we imported from Great Britain to the value of £32,575,549; Australian and other Colonies, £37,926,609; Foreign Countries, £14,330,145; that is to say, from Great Britain 40 per cent.; other Colonies, 42 per cent.; Foreign Countries, 17 per cent.; as also in exports during the same period, we exported to Great Britain to the value of £30,203,485; Australian and other Colonies, £41,467,718; and Foreign Countries, £2,472,673; that is to say, at the rate of 41 per cent., 56 per cent., and 3 per cent. respectively.

The importance of our intercolonial trade is here very remarkably exemplified, for we see by these figures that as regards "Imports" it constitutes nearly one half, and as regards "Exports" more than one half of the entire commerce of the Country.

It may be interesting here to notice the extent to which the export trade is indebted to the produce and manufactures of the Country, because the prosperity of the Colony may be judged by the productions over and above its own wants of articles, the result of its own people's industry. Well, in this point of view, we may derive satisfaction from the returns; for I find that of the exports, valued at £74,148,876 for the ten years, no less than £52,043,742 represent the produce and manufactures of New South Wales, exhibiting an annual average of over five millions sterling, and at the rate of £12 3s. 6d. per head of the population.

It has already been shown that the exports of Great Britain for the same period were at the rate of £5 16s. per head of the population; relatively, therefore, the wealth of this community has been increasing in a ratio more than double that of the Mother Country. There may, perhaps, be two reasons assigned for this. The one refers to the great national resources of the Country, which yield their riches with comparatively small assistance from man; the other refers to what I conceive to be the more effective condition of our population. If the productive class bears a larger proportion to the unproductive in one Country than in another, the power of creating wealth will be by so much increased. I have reason to believe that when the "Census" of Great Britain in 1871 is compared with that of New South Wales, it will be found that the population ineffective by reason of age bears a higher ratio to the aggregate numbers in Great Britain than it does in New South Wales. I have not the statistics before me to enable me to verify this opinion at the present time, but I remember making a comparison (in preparing my Report on the Census of 1856), and I there found that, by the Census of 1851, the population of Great Britain between the ages of 10 and 70—extreme limits—showed no less than 57 per cent. outside those limits; that is to say, that 57 per cent. were dependent for food, education and support, upon the remaining 43 per cent.; whilst, in New South Wales, between the ages of 10 and 60, \* there were 69 per cent. effective to 31 per cent. ineffective.

By the Census of 1856, I find that, taking the boys and girls under fourteen years, and the people above sixty years, the proportions were:—Between fourteen and sixty, 59·67 per cent., leaving 40·33 per cent. unproductive = 100.

The late Census, I believe, exhibits a proportion of 58 per cent. between the ages of fourteen and sixty-five, which perhaps fairly represents the present working population, leaving 42 per cent. unproductive.

I merely, in passing, throw out these suggestions for your consideration as they occur to me, in some measure to account for the larger producing power of the Australian Colonies as compared with England.

We will now proceed to analyze a little more closely the Customs returns, and compare the two quinquennial periods embraced in the decennary under review. And first as to "Imports." It appears that between 1862 and 1866, we imported articles to the value of £46,285,929, yielding an annual average of £9,257,185; whilst between 1867 and 1871 we imported to the value of only £38,546,434, yielding an annual average of £7,709,286, showing a decrease of over a *million and a half* yearly, and it appears that this decrease was not in the intercolonial

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\* The classification did not distinguish the ages over 60.

trade, but in the trade with the Mother Country; for whilst the colonial trade sustains a slightly increased average—that is, from £3,777,341 to £3,806,792, the average imports from Great Britain fell from £4,182,809 to £2,972,300, or a decrease of 29 per cent. We may I think trace here the effect of the low value at Home of our staple product, Wool, and perhaps to some extent the languishing state of the Gold-mining interest during the latter period. And may we not also attribute the decrease to a forced economy in the use of luxuries, which our comparatively straightened circumstances taught us to observe.

Let us now see how the matter stands as to “Exports.” The total value for the first five years was £38,860,002, equal to an annual average of £7,772,000; and for the second five years £35,288,874, or an average of £7,057,775, an annual decrease of not much short of three-quarters of a million. Now here the picture is reversed; the decrease is not in the exports to Great Britain, but in the Colonial trade; for whilst the annual average to Great Britain increased from £2,694,495 in the first period, to £3,347,201, or 24 per cent., in the second period, the value of the intercolonial exports decreased from an average of £4,860,199 to £3,433,344, or 30 per cent. This falling off is apparent in the figures which represent the value of the exports to each of the Australian Colonies, but appears more particularly manifest in the trade with Queensland, which dropped from the annual average of £1,173,558 during the first five years, to £798,668, or 32 per cent. during the last. And this is a very natural result, not only of the increased facilities for direct trade with the Mother Country, but also perhaps of her people having freed themselves from the galling yoke of their former pecuniary dependence upon the mercantile and banking institutions of the parent Colony.

There is still the overland traffic with the adjoining Colonies to be noticed. I do not intend to enter into an elaborate analysis of the figures presented under this head. The time at my disposal will not admit of it, and I do not wish to trespass on your attention at greater length than I can help. I will take the statistics of two years only, namely, 1861 and 1871, and compare them, that you may see the vast increase of the overland trade in the ten years.

I find that the value of the imports across the Border and up the Darling, in 1861, was under £200,000, and the exports under £900,000, whilst in 1871 we imported from

Victoria to the value of	...	...	£491,632
South Australia to the value of	...	...	135,098
Total...	...	...	<u>£626,730</u>
And we exported to			
Victoria to the value of	...	...	£3,027,714
South Australia to the value of	...	...	424,732
Total...	...	...	<u>£3,452,446</u>



that is, an import and export trade exceeding £4,000,000 sterling in value! Now, if this trade is added to the imports and exports seaward in 1871, we arrive at the following results, namely:—

Imports :

Seaward ... ..	£8,981,219
Overland from Victoria and South Australia	626,730
Ditto Queensland ... ..	1,559
Total... ..	£9,609,508

Exports :

Seaward ... ..	£7,784,766
Overland to Victoria and South Australia...	3,452,446
Ditto Queensland ... ..	7,820
Total... ..	£11,245,032

These figures exhibit an import trade at the rate of £19 1s. 3d., and an export trade at the rate of £22 6s. 2d. per head of the population—that is, more than double the import trade, and nearer treble the export trade of Great Britain per head of the population, according to the values respectively given in the Customs returns of the two Countries.

Before passing on to the last subject of our inquiry, I should like to draw a comparison between the decade we have been reviewing and that which preceded it, for they must present to the minds of colonists of a quarter of a century's standing features differing very widely in their outlines. In the earlier decade we embrace that period of intense excitement, great speculation, and remarkable development which followed the discovery of gold. In the second decade we trace in the first half of it symptoms of depression naturally following a period of over-trading and general extravagance in which confidence in the permanent stability and elasticity of our resources was well nigh destroyed. In the second half of the latter decade we may discover clear evidence of recovery, through the exercise of vigilant economy, as exemplified in reduced imports, and through the vigorous efforts made by the producing interests to lessen the cost, to improve the quality and to increase the quantity of our marketable productions, as in the face of almost overwhelming discouragements is exemplified in the increased exports to the Mother Country. Depression follows excitement as naturally in the body social as in the body physical, and it is somewhat remarkable that they seem to occupy pretty equal periods in the history of this Country.

Let us inquire then how the matter stands between the decade of "excitement" and the decade of "depression."

The decade of "excitement" shows an aggregate import trade to the value of	...	...	...	...	...	£57,650,053
And the aggregate export trade of	...	...	...	...	...	43,125,653
						<hr/>
Together	...	...	...	...	...	£100,775,706
						<hr/>

The decade of "depression" shows an aggregate import trade of the value of	...	...	...	...	...	£84,832,363
And an aggregate export trade of	...	...	...	...	...	74,148,876
						<hr/>
Together	...	...	...	...	...	£158,981,239
						<hr/>

And this is without taking into account the "overland" traffic, which we have seen exceeded last year four millions sterling.

I was hardly prepared to expect that the investigation would bring out such a result as an excess of over fifty-eight millions sterling, as compared with the great gold-producing era. The increase in the producing power of population is here remarkably brought out; for whilst the actual increase of population was only 43 per cent., the increase of trade and production was nearly 58 per cent.

Surely, then, such facts as these ought for ever to dispel the silly fears which have led to such disastrous results in the cases of many of our most valuable colonists, whose interests have been sacrificed to ignorance or timidity; and they ought to establish a well-founded and enduring confidence both here and at Home in the strength and elasticity of our resources, and in the power of production of our people.

#### 5.—ACCUMULATION.

The coin and bullion in the Sydney branch of the Royal Mint, in the Colonial Treasury, and in the Banks of the Colony, on the 31st December, 1871, amounted to £2,522,387, being an increase of 74 per cent. on the amount on the same day of the previous year. A comparison between the first and second five years of the decade shows an average of £1,278,151 for the first period, and £1,904,855 for the second, *i.e.*, an increase of nearly 50 per cent.

But it is to the amount on deposit in the several banking institutions that we must look for evidence of the accumulated wealth of the people. I find then, that at the end of 1871, the sworn returns of the Banks showed that they had on deposit no less than

... ..	£7,043,885
New South Wales Savings Banks ... ..	931,688
Post Office ditto ... ..	14,226
Together ... ..	<u>£7,989,799</u>

This was at the rate of £15 17s. 1d. per head of the population; and it seems to have been in excess of the deposits at the end of the previous year by nearly a million sterling. Dividing the decennary into two equal parts, it will be found that the average annual deposits in the Banks during the earlier five years were £5,713,974, and in the later five years, £6,490,091, showing an increase of between 13 and 14 per cent.

The discounts at the several Banks on the 31st December last represented an aggregate value of £7,668,022; and if we add to this the mortgages on land and on live stock and liens on crops, we shall arrive approximately at the indebtedness of the producing interests at the end of last year. We will tabulate them as follows, viz. :—

Banks and discounts... ..	£7,668,022
Mortgages on land ... ..	697,440
Ditto on live stock ... ..	703,333
Liens on wool ... ..	451,926
Ditto on crops ... ..	13,170
Total ... ..	<u>£9,533,891</u>

From this sum I suppose it is fair to deduct the “discharges” during the year; they were as follows, viz. :—

Mortgages on land ... ..	£318,168
Conveyances under ditto ... ..	148,340
Mortgages on live stock ... ..	333,536
Total ... ..	<u>£800,044</u>

This leaves a net liability, secured on the lands, houses, live stock, and crops of the Country to the extent of £8,733,847.

The net liability under the same heads ten years before was £6,906,066.

The increase of liabilities, therefore, is only £1,827,781, or at the rate of 26 per cent. which compared with the vast increase in the material wealth of the Country, as evidenced by the results of this investigation, ought to inspire us with confidence in the permanent stability and elasticity of our resources, and, should I not add, with shame and confusion, for our late shortcomings in this behalf.

Gentlemen, I shall carry this inquiry no further at this time. I have taken you over a large field of observation, but we have only been able to dig up the surface, and must leave a large field of investigation unexplored.

My remarks have been confined to the illustration of the material advancement of the Colony. There is the question as to the social, moral, and educational progress left untouched. The Registrar-General will have the opportunity of enlightening us upon this question, through his shortly expected Report on the Census of 1871.

The figures which I have been endeavouring to explain to you this evening represent the workings of a Society that cannot yet boast of a century's existence. On the 26th of January, 1788, Governor Phillip first moored his boat and hoisted the British flag almost on the spot where we are now assembled. The first thirty years of the Colony's history is wrapped in a good deal of traditionary darkness, and few people care to lift the veil. It is well, perhaps, that it should so be left. In 1821 the light of statistics began to dawn upon her history. New South Wales then numbered 29,783 souls, and enjoyed a revenue of £36,231. In ten years from that date she had increased her population to 51,155 souls, her revenue to £121,066, and her import and export trade reached £814,320.

In 1841 she had increased her population to 149,669 souls, her revenue to £493,980, and her trade to £3,551,385.

In 1851, after the dismemberment of the Southern Districts, she had increased her population to 198,168; but her revenue and her trade suffered by the loss. Her revenue was £406,056, and her trade £3,360,843.

In the next decade after the dismemberment of her Northern territory she increased her population to 358,278 souls, her revenue to £1,448,610, and her trade to £11,986,394; whilst in 1871 she had increased her population to 519,182 souls, her revenue to £2,727,404, and her trade to £20,854,540.

The wealth-producing power of population is, I think, fully exemplified in these figures; for we shall see that, excepting the one period marked by the dismemberment of Port Phillip, as the population increased so did the power of production, and in an increased ratio.

The import and export trade per head of the population was as follows, viz. :—

In 1831	...	...	... £15	18	4	per head
1841	...	...	... 25	4	2	„
1851	...	...	... 17	0	10	„
1861	...	...	... 33	9	1	„
And in 1871	...	...	... 40	3	4	„

We appear now to be on the threshold of another epoch of excitement and prosperity; and, whoever may live to see the decade out, may have a marvellous story to tell of the Country's progress far outstripping that which I have been able to show you to-night; and if, deriving wisdom from the experience of the past, we direct our energies aright, and endeavour to educate our youthful population up to the high standard to which they should aspire, we may hope that, with the increase of the wealth, we may at the same time be promoting the happiness of the people, so that in the course of time we may raise the national character to the standard we should try to attain—that of a wise and an understanding people.

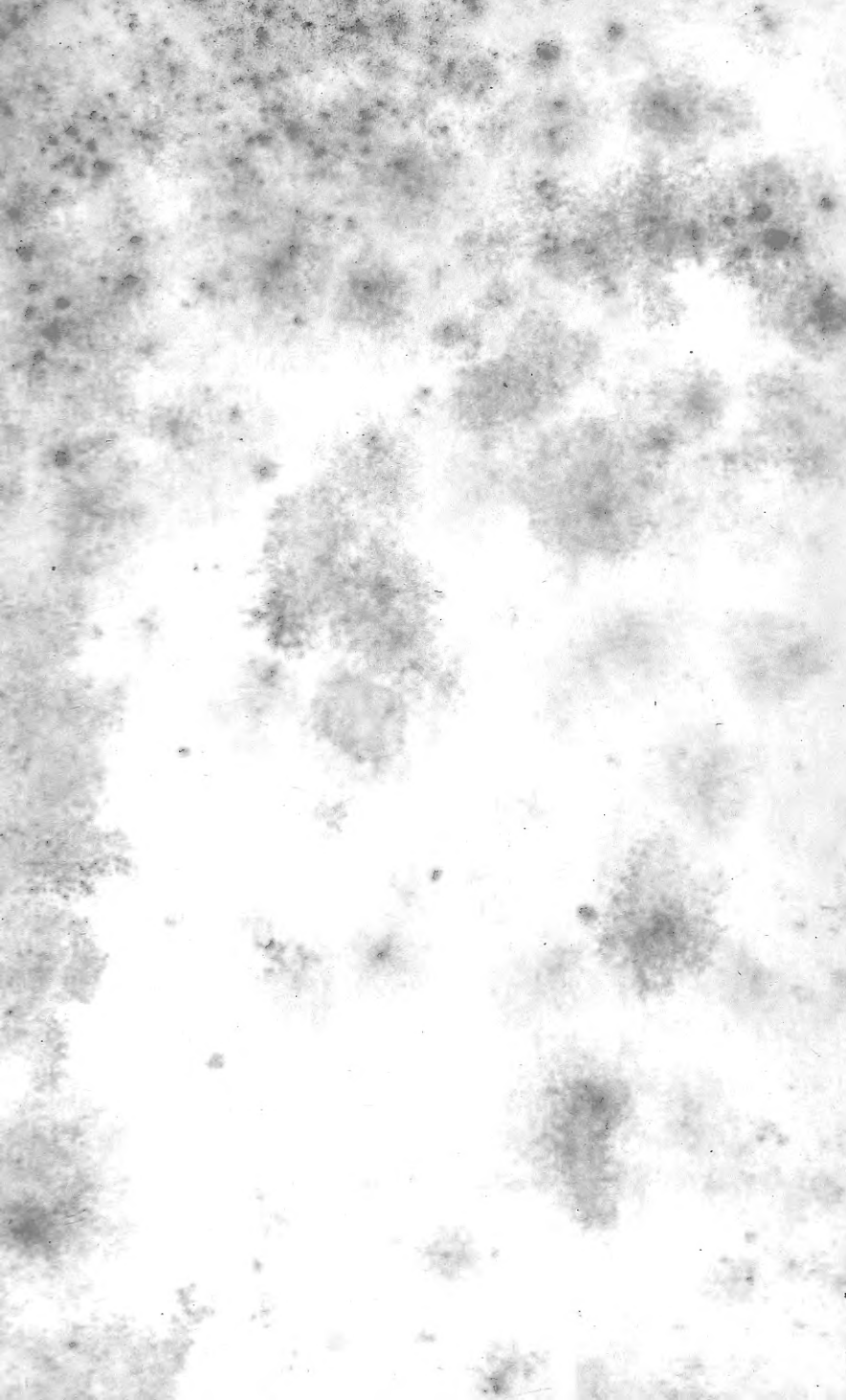
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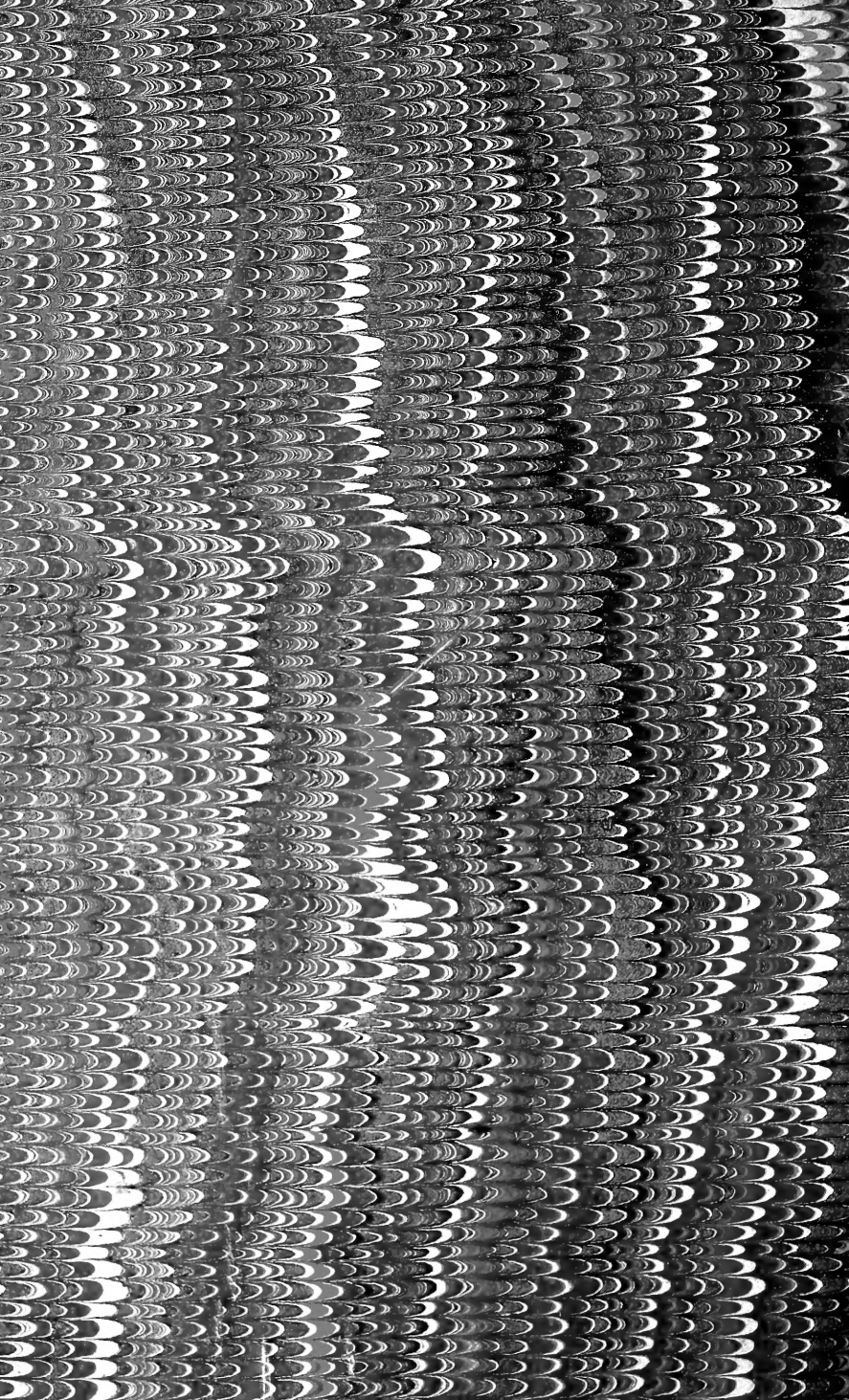


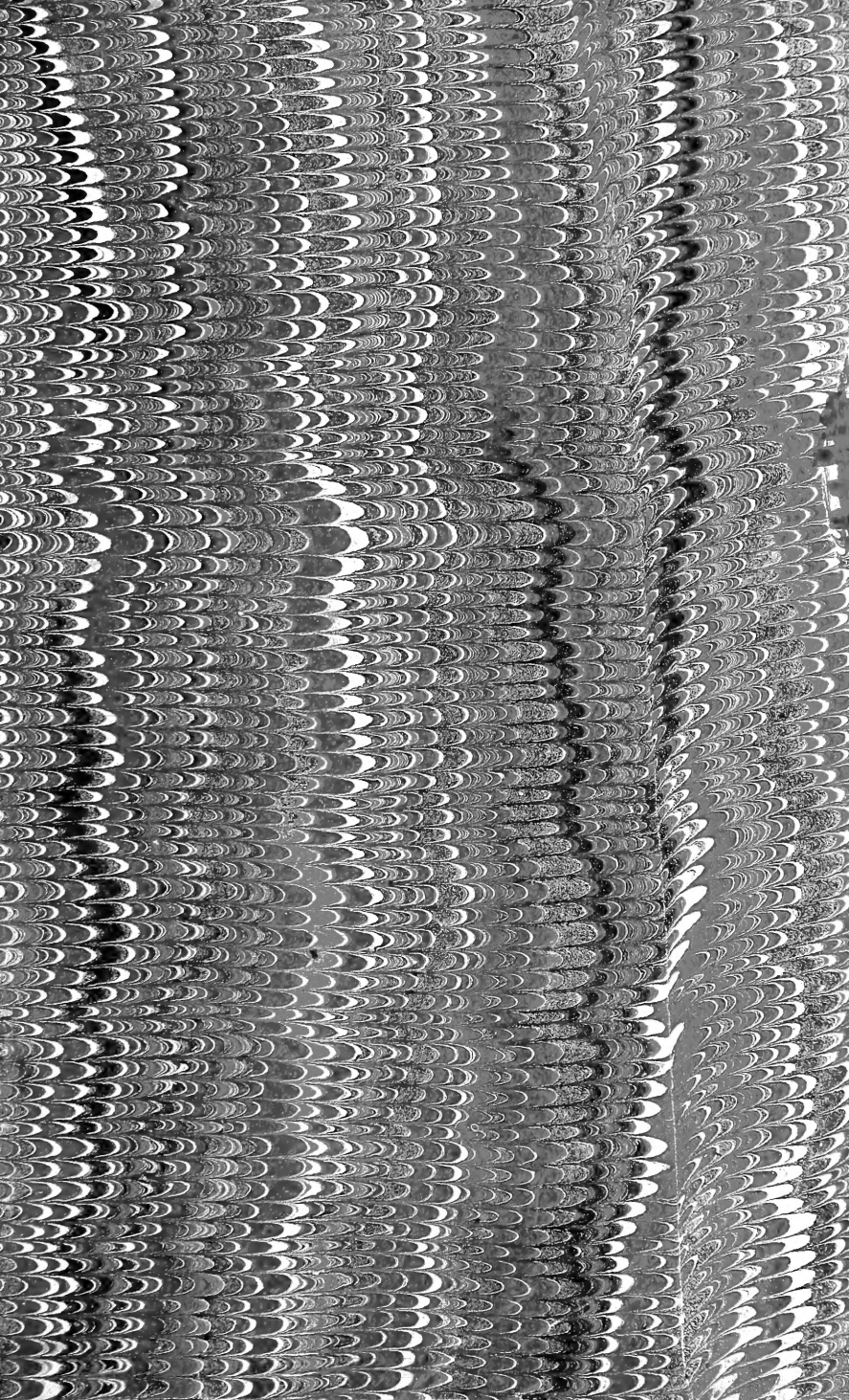












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