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"RIVER DARLING AND THE MOUTH OF THE BAMAMERO CREEK AT SUNSET WITH THE ANTI TWILIGHT. DECEMBER 19, 1860. No. 32. DARLING DEPOT."

A water colour sketch by Ludwig Becker, artist and naturalist, who died in camp on April 28, 1861 while a member of the Burke and Wills Expedition.

THE ROYAL SOCIETY OF VICTORIA FROM THEN, 1854 TO NOW, 1959

By R. T. M. Pescott

[Read 12 November 1959]

Melbourne! 1854! Such was the setting for the foundation of something new in the scientific life of the recently formed but rapidly developing colony. The seeds that were sown then were to grow from year to year until finally a society was to develop which was to reflect throughout the world the scientific life and thought of the State of Victoria.

In order to fully appreciate the significance of events that took place at that time, it is desirable to have some appreciation of the conditions that existed in Melbourne in and immediately prior to 1854.

It was only 19 years since John Batman, a founder of Melbourne, had sailed from Tasmania to Port Phillip Bay, and in June 1835 located the Yarra R., making his famous diary entry—'This will be the place for a village'. It was only 17 years since the first Crown Land sale was held in Melbourne, and only 16 years since the first newspaper, the *Melbourne Advertiser,* had been published by John Pascoe Fawkner.

The most important single factor in the development of the Colony of Victoria up to 1854 was undoubtedly the discovery of gold in 1851. The inevitable first effect of this discovery was an exodus of the male population of both Melbourne and Geelong to the 'Diggings'. At the beginning of 1851, Melbourne had a population of approximately 20,000 people. Immediately this number became drastically reduced, and new suburban areas nearby, such as Richmond, almost became abandoned, while the city itself became more and more deserted day by day. Incentives were offered by employers to keep employees in the city—government officials, e.g., being hastily granted a 50% increase of salary to induce them to remain at their posts. This exodus was only a passing phase; in a week or so the gold seekers were drifting back, some successful, some disappointed.

Before long, the mighty flood of immigration from other parts of the world set in to seriously embarrass the whole life of Melbourne. During 1852, 1853 and 1854 the numbers of persons arriving in Victoria by sea averaged 90,000 a year, or nearly 250 a day, so that by 1854 the population of Melbourne and suburbs was close on 80,000. This immediately created an accommodation problem. It was obvious that the buildings already constructed in the town proper, less than 10,000 in number, could not house this tremendous influx. The solution lay in the rapid growth of 'Canvas Town', as it became known, an extensive area of tents of all descriptions on the S. side of the river, on what is now known as the King's Domain. The city itself on the other side of the river contrasted sharply with this mass of canvas but was equally unreal. No two houses adjoining were of the same height or of the same material, while large numbers of iron buildings had been imported over the years for use as stores. This had caused the City Council to tighten its building regulations.

By 1854, when the Town Hall was completed, neither water from the Yan Yean supply, nor gas from the newly formed Gas Company, had been reticulated through the city area, and the streets, though formed, were still of gravel, and not particularly well drained. The business houses of Melbourne were largely concentrated in the heart of the city proper, with little or no expansion to the nearer suburbs.

The scientific life of Melbourne was centred largely on government departments, with meetings being held at the offices or at the homes of individual scientists. The recently formed University of Melbourne, situated in 'the bush at Carlton', was in the process of organization, with the foundation stone laid, and the first 4 professors appointed but not yet arrived. With regard to the natural sciences, the need for university supervision was considered of the utmost importance, 'as questions of the most ordinary character are being daily referred to England'. It was to Professor Frederick McCoy that the University was looking for this guidance—McCoy, a scientist with an overseas reputation who was also to make a name in Australia, and cause considerable embarrassment at times, particularly in the affairs of the National Museum, to the Philosophical Institute and later to the Royal Society of Victoria.

The National Museum of Natural History had commenced in a small way in the Crown Lands Offices under the guidance of the Surveyor-General, while the Public Library was at a very similar stage to the University—the foundation stone being laid, but the building not completed.

It was into this type of environment that, in 1854, two separate scientific bodies, with very similar aims and ideals, came into being within a month or so of one another. These were the Victorian Institute for the Advancement of Science and the Philosophical Society of Victoria. It was their amalgamation in the following year, to form the Philosophical Institute of Victoria, that paved the way for the granting, in 1859, of the title 'Royal Society of Victoria' to this latter organization.

It may seem strange to us in 1959, viewing the position that existed in 1854, that two such societies should spring into being at about the same time. But after all, was it strange? The late Sir Russell Grimwade, in 1954, wrote a short statement that admirably sums up the position.

> The making of the bridge-head of British people on the coast of Australia towards the end of the eighteenth century is now a well-known matter of history. The difficulties of the first settlement in an empty and comparatively harsh land were tremendous and of such magnitude that it was doubtful at times whether the planned occupation could be carried on. Carefree Australians today are apt to forget that at the time of first entry their land produced no orthodox food and its soils had never been cultivated and that the abundance of foods produced within its boundaries today all have their origin overseas. The germ of all edible plants and animals was imported from foreign lands, mostly those of the northern hemisphere. The provision of food, storage of water, and the development of means of communication constituted the first duties of the pioneers. When these very first needs were fulfilled, even in a rudimentary manner, the obligation to posterity became revealed. We are fortunate that from our very beginnings there have been far-seeing and intellectual giants amongst us who, almost fanatically, have sought to gain a full knowledge of their surroundings.

It was those 'far-seeing and intellectual giants' who had the initiative and the ability to found the two somewhat kindred scientific societies in the same year.

Victorian Institute for the Advancement of Science

Early in 1854, William Sidney Gibbons, an analytical chemist of 5 Collins St. E., Melbourne, and a lecturer at the Mechanics Institution, conceived the idea of the foundation of a scientific society in the newly formed but rapidly developing colony where men of science, of all branches, could meet and discuss mutual problems.

After much personal thought and, at times, animated discussion with fellow-citizens of similar interests, the project so developed and became of such importance to him, that he proceeded with the organization of a public meeting to place his proposals before those interested.

This meeting was convened at the Mechanics Institution for Thursday, 15 June 1854, at 4 p.m., when His Worship the Mayor of Melbourne took the Chair. Here, Gibbons spoke at length on the aims and objects of his proposed new society, and so convinced those present that it was unanimously decided to form 'The Victorian Institute for the Advancement of Science'. The main purposes were stated at that meeting to be—

(*a*) a means of communication between persons engaged in the pursuit of science;
(*b*) the cultivating of a refined taste among the people of Victoria;
(*c*) provide a source to which the community generally may look for information on scientific subjects;
(*d*) provide a centre for the collection of observations and specimens from all sources;
(*e*) provide an agency for the development of the resources of the colony.

It was also proposed that membership consist of ordinary members and corresponding members, and should be open to anyone whose interests were similar to those of the Institute, but that they would be required to be admitted by ballot. The subscription rates, in terms of modern figures, were extraordinarily high, ordinary members being required to pay an annual subscription of £4 with an entrance fee of £2, and corresponding members £2 per annum with an entry fee of £1. It was also proposed that, if necessary, the Institute divide itself into sections for the consideration of special problems.

At this public meeting, a committee of 6 was appointed to hold office until 31 December 1854 and to prepare a constitution which would be submitted to a general meeting on Saturday, 24 June. The 6 chosen for this task were Captain C. Pasley, R.E., Colonial Engineer; J. J. Moody; W. S. Gibbons, Analytical Chemist; Dr John Maund; F. Sinnett; and A. R. C. Selwyn, Government Geologist; all respected citizens and scientists of Melbourne.

This committee presented their report and rules at a general meeting held, not on 24 June, but on 31 July, and without amendment they were unanimously approved. The laws were based on the observation of the working of similar bodies elsewhere, the main principles of the British Association for the Advancement of Science being used as a model. The first office bearers were—

Patron:
His Excellency Sir Charles Hotham, C.B.

President:
His Honour the Acting Chief Justice

Vice-President:
Captain A. Clarke, R.E., Surveyor-General

Treasurer:
John Maund, M.D.

Honorary Secretary:
William Sidney Gibbons

Council:

F. Sinnett	E. G. Mayne
Captain Pasley, R.E.	M. B. Jackson
A. R. C. Selwyn	A. K. Smith
George Higinbotham	George Holmes
F. Mueller	

The inaugural conversazione of the Institute was held in the Mechanics Institution on 22 September 1854 with the President in the Chair. In his inaugural address, the Acting Chief Justice, Mr Justice Barry, summed up the position in his opening sentence—'We assemble in the vestibule of the Temple of Science, many of us unacquainted one with the other, invited to engage in a course of mutual improvement, and to assist in the cause of general instruction'. Throughout the room were ranged contributions by members, some 33 in all, representative of the objects of the Institute. They varied from cases of gold specimens, to physical and chemical apparatus, to the prize design for Government House, to a model of a steam ferry, to statues. A series of short lectures by such men as Dr Mueller, Dr Maund and Mr W. S. Gibbons concluded the inaugural conversazione.

At the ordinary meeting held the following week, 5 sections of the Institute were formed, viz.—sanitary economy, engineering, political economy, chemistry, and microscopic investigations. The membership by this time had grown to 82.

In all, some 6 papers were delivered and 20 published during the time the Institute was in existence. These papers covered a wide field, with perhaps the greatest emphasis on the commercial development of the country, such subjects as water supply, gas and gas works, bridge construction, sanitation and food manufacture being brought prominently before the members. On the other hand, the deliberations of the Philosophical Society were largely concerned, in the first year, with botany and the natural resources of the country.

It was in November 1854 that the Institute saw the wisdom of amalgamation with the Philosophical Society, which had been founded in the meantime, as 'the existence of two separate societies caused a division of the forces which might be brought to bear upon the same subjects, and the colony was hardly able to support adequately the two separate institutions having the same objects'. By January 1855, they were ready with a definite proposal. This proposal was apparently received rather coldly at first by members of the Philosophical Society who apparently felt they had little to gain by such an amalgamation. However, after considerable negotiation between the two bodies, amalgamation finally took place with a new body, the Philosophical Institute of Victoria being formed, the last meeting of the old Institute taking place on 7 June 1855.

The amalgamation was obviously not unanimous as far as the members of both societies were concerned, although it was the obvious course to follow. For many years after amalgamation, bitter controversies raged between individuals. Perhaps the most unco-operative was the original founder of the Victorian Institute, Sidney Gibbons. The following extract from his papers found after his death clearly illustrates this—

> A little after I formed my Institute, some official formed a club at the Lands Office. Seeing my success, this club opened its doors and became a competitor with the public under the name of the Philosophical Society. After a year or more of their competition the Victorian Institute proposed and ultimately effected an amalgamation only to find the Philosophical Society was moribund and in debt.

Philosophical Society of Victoria

Within a month of the calling of the public meeting to form the Victorian Institute for the Advancement of Science, a somewhat similar organization, the Philosophical Society of Victoria had its inception.

It is clear that, although the first general meeting of the Philosophical Society took place on 12 August 1854, presumably in what was then the Museum of Natural History, considerable work had been put into the preliminaries of founding such a society, as at that meeting, an inaugural address was presented by the first President, Captain Andrew Clarke, R.E., Surveyor-General of the Colony.

The actual initiation of the foundation of the Philosophical Society was undoubtedly to the credit of Captain Clarke. In response to a proposition submitted to the Legislative Council on 23 September 1853, that the Government should set aside a sum of money to establish a museum of natural history, the Colonial Secretary, in reply, promised the necessary assistance 'if the honourable member and others who were interested in the subject, would form themselves into a committee, or initiate some society or institution which would co-operate with the Government in carrying out the objects in view'. Acting on this, Captain Clarke called the first meeting of interested persons on 17 June 1854, at his offices, where the nucleus of a museum was already extant. At that meeting, 8 men were present, and they voted Dr R. Eades, a prominent Melbourne physician, to the Chair.

Eight similar meetings took place after that date. The original intention was to found a society known as 'The Victorian Philosophical and Literary Society', but at the first meeting, largely through the agency of Dr Ferdinand Mueller, Government Botanist, the title 'The Philosophical Society of Victoria' was adopted.

At this meeting, a sub-committee, consisting of Dr R. Eades, Dr D. E. Wilkie, Dr F. Mueller, Mr S. Hanaford, Mr F. C. Christy, and Mr S. Wekey, was appointed to draw up a prospectus of the proposed society, together with rules and regulations for its conduct. This was duly carried out and approved by the provisional council, and the office bearers *pro tem.* were elected at a preliminary meeting held in the Mechanics Institution on 15 July 1854. It was most appropriate that the Surveyor-General should be elected President, and at the same time the Society was assured of the use of the Museum of Natural History at the Crown Lands building for its regular meetings.

Before discussing the composition of the initial executive committee, some details of the prospectus of this Philosophical Society, under date of 1854, are very important, as they had a very great bearing on the later developments of the Society, finally resulting in the formation of the Royal Society of Victoria as we know it today.

It is well to realize that the original full name of the Society was 'The Philosophical Society of Victoria (to be incorporated by Royal Charter)'. The prospectus stated that 'After the grant of the Charter, this Society shall assume the title of The Royal Society of Victoria', and it is clearly evident that those who were instrumental in its formation were basing their organization on that of the Royal Society of London, a society with which many of the organizers were clearly familiar.

The object of this new society, as defined in the original prospectus, was stated very simply as 'embracing the whole field of science, with a special reference to the cultivation of those departments that are calculated to develop the natural resources of the country'. This simple statement of objective, so different from that of its fellow Victorian Institute for the Advancement of Science, gave an early indication of the way in which it was proposed the new society would develop, i.e. the formation of separate departments or committees within the Society, to specialize in some particular field of work.

The objects of the Society were to be carried out by original researches conducted by the members, and by original papers to be read at the periodical meetings and published under the direction of the Society. This latter objective laid down a principle which over the years, through exchanges of publications with other societies, has produced the now world-famous library of the Royal Society of Victoria, rich in overseas periodicals and in literature relating to science generally.

Membership of this new society was to consist of 3 categories—Fellows, Ordinary and Honorary Members, and here again the likeness to the Royal Society of London was apparent. It was proposed that Fellows should be elected from ordinary members by ballot, with a 4/5 majority necessary for election, whereas ordinary members would be admitted on application to the council. Honorary membership was to be considered one of the highest marks of distinction that the Society would confer.

The office bearers who were to be elected annually were to be a president, one or more vice-presidents, treasurer, secretary, and these, with 8 other members elected from among the Fellows of the Society, formed the council. The office bearers and council of the Philosophical Society of Victoria who were placed in office *pro tem.* until the first anniversary meeting in 1855, were published as follows:

Patron:

His Excellency the Lieutenant-Governor

President:

A. Clarke, M.L.C., F.R.S.L.V.D., Surveyor-General

Vice-President:

Godfrey Howitt, M.D., F.R.B.S.E.

Council:

Rev. A. Morison, V.D.M.	R. Eades, M.B., F.R.C.S.I.
A. Selwyn	S. Iffla, M.D.
F. Mueller, F.R.Bav.S.	F. C. Christy, Assoc. I.C.E.
J. Hutchinson, M.D.	W. Blandowski

Treasurer:

D. E. Wilkie, M.D.

Honorary Secretary:

S. Wekey

Prior to the first public meeting of the Society, the interim council appointed its first two Honorary Members—Captain J. H. Kay, F.R.S., Private Secretary to the Lt-Governor; and William Howitt, the explorer.

The enthusiasm of the members of this Society was apparent when it was unanimously decided that the monthly meetings should be held on the 2nd Saturday of each month commencing at 7 p.m.

For the first year, every member was expected to pay £3.3.0 in fees without any entrance fee, but after the first 12 months an entrance fee of an additional £2.2.0 would be required of all new members.

Perhaps the most significant feature of the early activities of the Society was the very close link that existed between it and the then new-formed National

Museum of Natural History. Apart from meeting monthly in the museum, the early constitution provided that 'the effects of the Society in books, specimens, models, of what kind soever shall be considered the property of the National Museum until otherwise ordered and resolved by the annual general meeting of the Society'. It is not an exaggeration to state that the early development of the National Museum resulted almost exclusively from the activities of the Philosophical Society.

It is not surprising that with men on the council like Captain Clarke, Surveyor-General; Dr Ferdinand von Mueller, Government Botanist; Mr W. Blandowski, Curator of the Natural History Museum; Mr A. Selwyn and Mr Brough Smyth, Geologists; men who had all participated in exploring work in the new colony, and with the gold rush vividly in their minds, one of the first activities the Society proposed was 'the organization of exploring expeditions for the purpose of prospecting in different parts of the colony, with a view to the development of its natural resources'. This project, presented to the monthly meeting of the Society held on 10 September 1854, was referred to a special sub-committee for detailed report.

Their report, when presented to the following meeting, formulated a policy of exploration which placed the Society, and later the Royal Society of Victoria, in the pioneering field of this important stage of development of a new country. It is well to record, in some detail, the resolutions of this sub-committee which were unanimously adopted by the general meeting of the Society held on 18 September 1854, as they formed the basis for the organization of later exploration parties, including the ill-fated Burke and Wills expedition. The resolutions were as follows:

1. That the Society shall organize exploring expeditions, which shall be despatched from time to time, for the purpose of discovering new auriferous fields, coal, etc., and to collect additional information respecting the various mineral and vegetable resources of Victoria.
2. That each exploring party shall be furnished with special instructions by the Society.
3. That the reports of such expeditions shall form part of the *Transactions* of the Society, and be published for general information.
4. That in addition to the individual exertions of the members, the whole proceeds of the first *Transactions* of the Society shall be appropriated to this purpose, and the half of each subsequent publication.
5. That any further funds which may be required to carry out this object shall be raised by public subscription.
6. That the President be requested to communicate with His Excellency the Lieutenant-Governor, as patron of the Society, requesting him to give his assent to the enterprise.

To assist with the proposed exploration parties, a public appeal was opened by the Society in September 1854, with contributions to be forwarded to either the Museum of Natural History or the offices of the Victorian Vineyard and Fruit Garden Company. It is not clear what connection this latter organization had with either the Philosophical Society or the proposed exploration party. The immediate response to this was not encouraging.

The November 1854 monthly meeting must always stand out in the history of the Society for two decisions that were made. The council was instructed to carry out—(*a*) the preparation of petitions to His Excellency the Lt-Governor and to the Honourable the Legislative Council to assist in the carrying out of exploration, and (*b*) the preparation of the form of application for the incorporation of the Society by a Royal Charter.

The first of these decisions was apparently implemented at once as, in December 1854, a copy of the prepared memorial was despatched from the Museum of

Natural History by the secretary of the Society to the Private Secretary of the Lt-Governor. The reaction to this memorial, however, was unfavourable as not only did the Lt-Governor refuse to receive the deputation from the Society but 'he regrets that the insufficiency of the public funds to meet the public requirements renders it imperative upon him to stay every possible expenses, but that with regard to gold, the numerous prospecting parties (which are searching the length and breadth of the land), in the Lieutenant-Governor's opinion, fully encompass the end sought by the Society; whilst with regard to coal, it is reported that the fields at Western Port are sufficient to last a generation'.

With this abrupt refusal on the part of the Lt-Governor to assist in this section of the Society's plans, the matter of exploration was dropped for the time being.

The second of the discussions was not implemented at once, in fact, it was to be approximately 5 years before the desire of the council was realized, and then not in the form of a Royal Charter.

At this stage in the development of the Society, a proposal was received from the Victorian Institute that the amalgamation of the two organizations would be a desirable one. This was in January 1855, and at once the Society commenced negotiations for its accomplishment. However, this proposal was temporarily relegated to the background, following a very contentious paper delivered to the Society by Dr David E. Wilkie who spoke on the subject 'On the probable failure of the Yan Yean Reservoir', a subject which was, of course, of vital importance to the development of the rapidly expanding Melbourne. His objections were based on what he considered the inadequacy of the supply and its unsuitability from a sanitary point of view. As can well be imagined, this paper brought forth a clamour for a detailed investigation of the whole scheme, and a special commission was appointed by the Society consisting of 3 engineers and the secretary to investigate the matter further. This investigation was carried out over the following 2 months, and a report submitted to the Society; later, it was published in detail in the *Transactions* of the Society for 1855 as Article XV. This report in many ways vindicated the opinions submitted by Dr Wilkie in his earlier paper and made recommendations for what it considered to be improvements in the design of the whole water-catchment proposal.

Following this discussion on the Yan Yean Water Scheme, the matter of amalgamation of the two societies was again brought into prominence. The members of the Philosophical Society also felt very strongly on the matter, and pointed out that—

> whereas the Victorian Institute had only a credit balance of £68 in March 1855, the Philosophical Society had available funds to amount of £170 which, in the case of amalgamation, would, leave, in favour of the Victorian Institute, £102. Moreover at the same date, only six papers had been read at the Institute compared with seventeen at the Philosophical Society, which also in the case of an amalgamation, would leave in their favour eleven papers.

However, it was pointed out that as far as the officers of the Institute were concerned an amalgamation *de facto* had already taken place, since the president of the Institute with several members of the council had actually become members of the Philosophical Society. At this time, the Philosophical Society had 132 members.

Following the appointment of a committee of 6 from the Society, who later met a similar committee of 6 from the Victorian Institute, and held 4 meetings discussing the amalgamation of the two societies, a detailed statement was presented to the members of both organizations, recommending amalgamation under certain terms:

1. That the two societies be amalgamated, under the title, pending the grant of a Royal Charter, of 'The Philosophical Institute of Victoria'.
2. That the first office bearers of the proposed Institute be—

President:	Captain A. Clarke, R.E.
Vice Presidents:	His Honour Mr. Justice Barry
	Godfrey Howitt
Council:	The existing members of the Council of the Philosophical Society and the Victorian Institute.
Treasurer:	D. E. Wilkie.
Hon. Secretaries:	S. Wekey
	R. B. Smyth
	W. S. Gibbons

3. That the objects of the Philosophical Institute shall be the same as that of the Philosophical Society, and that the mode of operation of the new Institute shall be the same as that of the old Society.

Thus was effected an amalgamation of two kindred societies who in their own particular sphere of activity had contributed largely to a detailed knowledge of the natural resources of the colony. It also effected a co-ordination of the activities of the scientific life of the community, producing an active and virile society which in the years ahead became the Royal Society of Victoria, a society that played an honoured part in the scientific development of the State of Victoria.

Philosophical Institute of Victoria

The first meeting of the new-formed Philosophical Institute was held at the Museum of Natural History on 10 July 1855, with a representative of the Victorian Institute, Dr J. Maund, in the Chair. At this meeting the following papers were read:

On the physical character of the County of Heytesbury. By Robert Scott.
On the favourable geological and chemical nature of the principal rocks and soils of Victoria, in reference to the production of ordinary cereals and wine. By Clement Hodgkinson.

In addition, a meteorological table of the climatology of June was presented, and a large number of natural history specimens, some new to science, were exhibited.

It was obvious that the amalgamation of the two societies had not been received too well in certain quarters, as shown by an incident that occurred at this first meeting. The date and time of meeting for the new Institute being under discussion it was pointed out that the plan pursued by the late Victorian Institute was to hold meetings on the first Thursday in each month, which generally occurred when the moon was full. This immediately brought a retort from the secretary of the late society that such trivial subjects were never brought before a general meeting of the Philosophical Society, and he hoped would not be discussed at a meeting of the new-formed Philosophical Institute.

The Colony of Victoria at this time was faced with serious financial difficulties, with a result that scientific work came under very careful scrutiny, with expenditure being drastically curtailed. This had its effect on the work of the Institute also, with the botanical work of Dr Mueller suffering most. Economies were so severe that Mueller was forced, because no money was available, to give up his official post of paid Government Botanist, but was allowed to retain the title of the position without pay. He took advantage of this to join the Gregory exploring expedition to the NW. of Australia, an experience which was to prove most valuable to the Institute later when the Burke and Wills expedition was being organized. As there was a distinct possibility of Mueller's services being lost to science in Victoria, and particularly to the new-formed Institute, he was elected in July 1855 the first honorary member of the Philosophical Institute, an honour he greatly prized.

The relationship between the Philosophical Institute and the Natural History Museum was very much in the fore at this particular time. It should be remembered that the Philosophical Society was instituted with relation to the Museum of Natural History, and that the monthly meetings of the Society were held at the museum. Moreover, an important feature of the constitution of the Society was that the advancement and extension of the museum should be one of its main objects. Thus it was logical that the new-formed Philosophical Institute should also concern itself with the future well-being of the museum, and make representations thereon to the government. The rumour that it was contemplated that the museum would be moved, at least temporarily, to the University of Melbourne caused great concern to the Society.

The reason for this contemplated move arose from the inability of Captain Clarke to house the collections any longer in his room at the Assay Offices. Apparently with the advice of Professor McCoy, an offer was made by the Governor, Sir Charles Hotham, to the council of the University to take charge of the specimens collected, and house them until other arrangements could be made.

In October 1855, the council of the Institute presented to the Governor a memorial asking that the National Museum be not removed to the University. Sir Charles listened courteously to this request, but at the same time was not able to give the council a definite answer, obviously because of his previous commitment to the University.

Not hearing anything further on the matter from the administration following the death of Sir Charles Hotham, and having learned that it was the immediate intention of the government to go ahead with the proposed transfer, the council of the Philosophical Institute, by a decision made on 20 May 1856, decided to make further representations against the proposals. Accordingly, a committee of 5 members of the council were appointed as a 'Museum Committee' to memorialize the government on the matter. On 17 June 1856, they presented their memorial to His Excellency Major-General Edward Macarthur 'directing your Excellency's attention to the serious disadvantages that would result to the public and to the cause of science from such an arrangement'. The same committee, on 1 July 1856, made direct representations to the trustees of the Public Library asking that, if any move were necessary, it should be to a portion of the Public Library building.

Professor McCoy, always the opportunist and seeing that this was the strategic time to strike, delivered an address to the Philosophical Institute on 15 July 1856 on the subject 'Museums in Victoria'. In this he paved the way for the next step he was to take, by stating that it was recognized in other countries that a museum and a university were inseparable, and that in Melbourne facilities existed at the University for the housing of the specimens already collected.

This address so nettled the council of the Institute that a further petition was drawn up and directed to the Right Worshipful the Mayor of Melbourne calling for a public meeting of protest. This meeting, held on 26 July 1856 at the Mechanics Institution, decided to again interview the 'officer administering the government' to lodge a further protest against the proposal.

Again, McCoy was a step ahead of his antagonists, as, on the night that the special committee was organizing a further public meeting, he hastily removed the whole of the collections of the museum from the Assay Building and delivered them to the University.

Obviously this latter bombshell from McCoy so disheartened the council that no further reference to the transfer was made, except that from time to time they took steps to ensure that the museum did not become completely absorbed into the University.

The suggestion at the April 1856 monthly meeting that a commission be appointed to consider the utility and practicability of introducing the camel and other useful animals into Victoria was to have an important bearing at a later stage on another project the Royal Society sponsored—the Burke and Wills expedition.

A special general meeting on 19 June of the same year, called to discuss a number of contentious subjects, brought heated argument on the subject of life membership. The principle of life membership was never in question, but the amount that should be paid was the subject of repeated motions and amendments. Finally a figure of £20 was decided upon, whereon a number became life members at once. However, the matter was not finalized at that point, as, at the next meeting, the following motion by the treasurer was approved—'That in order to liquidate the existing debt of the Institute the fee for Life Membership be reduced to £10, until the sum of one hundred and twenty pounds shall have been raised'. What happened to those who had paid their life membership fees the previous month is not recorded.

Another project with which the Philosophical Institute became interested at this stage of its life owed its beginning to a paper delivered by Professor Wilson at the November 1856 monthly meeting 'On the steps taken in England to provide a telescope for observing the nebulæ of the Southern Hemisphere'. Considerable discussion followed this paper as to the necessity for astronomical work in Victoria with the result that a committee of 5 was empowered 'to take such steps as may seem expedient, to induce the government to place upon the estimates a sufficient sum to establish an Astronomical Observatory in Victoria'. The steps taken by this committee were apparently effective as the government immediately expressed itself most favourably respecting the establishment of such an observatory, and asked for detailed estimates of cost. This was provided to the extent of an initial sum of £7,000 for equipment and buildings, with an annual sum of £1,300 for staffing. The original suggestion called for a site of land on the W. portion of Royal Park, clear of trees, on the brow of the hill overlooking Flemington.

The latter part of 1857 saw the commencement of what was to be one of the greatest undertakings of the Society and one of the epic stories of Australian exploration. This was a proposal put forward at the October meeting that consideration be given to 'The practicability of fitting out in Victoria a Geographical Expedition, for the purpose of carrying out the great idea of the lamented Leichhardt, of exploring the vast interior of Australia from east to west, and for the purpose, if possible, of gathering some tidings of the fate of Leichhardt and his party'. It was estimated that a sum of £6,000 would be necessary to organize and maintain a suitable exploring party for a period of two years. A large committee of 32 members, including a number of members of both the Legislative Assembly and Council, was appointed to draw up proposals to accomplish this project.

This committee, after four meetings and after taking evidence from explorers in other States, presented their detailed report at a special meeting late in December, with a recommendation that, as soon as financial support was available, the project get under way.

It had been obvious for some time that, to meet the growing needs of the Institute, now with over 230 members, a special building for the Institute was necessary. The facilities provided at the Museum of Natural History, while satisfactory and most desirable in the early life of the Institute, had become hopelessly inadequate for the fast-growing and energetic organization. Consequently, on 27 October 1857, an approach was made to the President of the Board of Land and Works for a grant of land on which to erect a building for the Institute to hold its meetings and to preserve its property. With this request was submitted a list of 4 allotments in order of priority as being suitable for the purpose. After an interval of nearly 3 months, the Institute was informed that the Governor in Council had been pleased to approve of a reserve of 1 rood 6 perches being made available for the purpose at the junction of Victoria St. with LaTrobe St. It is interesting to note that this site had the lowest priority of the 4 sites suggested by the Institute. However, after consultation with the architects it was found that this area was too small on which to erect an adequate building, and further representations were made to the government for this area to be increased. Eventually, in August 1858, the whole triangular piece of land consisting of 2 roods 6 perches lying between Victoria St., LaTrobe St. and Rathdown St. was reserved for the Institute. The land was immediately fenced, and a competition held for the most suitable plan embracing a large hall capable of seating 300 persons, museum, library, laboratory, and caretaker's quarters.

A number of detailed plans and drawings was received from architects and builders throughout Melbourne and some of the nearer suburbs, and one, an architect's plan, was finally chosen after months of discussion. Estimates called for the construction of such buildings resulted in prices ranging between £4,300 and £5,800 for the bare minimum of a building, with at least an additional £1,500 for plastering and finishing the inside and outside of the building and finishing the joinery work.

These tenders having proved most unsatisfactory, the council rapidly lost faith in the architect in question, and sought a new architect with new ideas. The choice, by ballot, happily fell on Joseph Reed, a partner in the firm of Reed and Barnes, Architects and Surveyors, of 9 Elizabeth St., Melbourne. The word 'happily' rather underestimates the position as Reed became famous in Melbourne as the designer of such buildings as the Town Hall, Wilson Hall at the University, the Public Library, the Exhibition, the Scots and Independent churches in Collins St., and many banks and business houses.

Reed was given the task of providing 'a building restricted to a meeting room with temporary accommodation for a keeper, and that the meeting room should contain 1,800 square feet on the floor and its contents to amount to 40,000 cubical feet'. Again tenders were called and, on this occasion, that of Matthew Taylor for £2,750 was accepted, with the provision that, if external plastering or cementing was required, an additional £350 would be necessary. However, it was decided to do without this latter 'luxury'. Work commenced on this project almost as soon as tenders were accepted in May 1859.

The annual report of the Institute for 1857 drew attention to the fact that no definite steps had been taken as yet towards obtaining a Royal Charter, and recommended that an immediate application be made to Her Most Gracious Majesty the Queen to accomplish this.

The period 1857/58 saw one of those happenings that fortunately occur very infrequently in the life of such a society. The occasion in question arose on the presentation of a paper by a council member, William Blandowski, Curator of the National Museum, describing several new species of freshwater fishes collected by him on an expedition he had made into N. Victoria. Whether this council member had any bad feelings towards other council members before the presentation of this paper, we shall never know; but one thing is clear, he had many enemies after—and perhaps with good cause. In naming these fishes, he proposed to 'honour' certain members of the council by using their names for the specific names of the new species. This is a common and accepted practice in taxonomy and, provided good taste is observed in its use, is not objectionable. However, for 2 of these species, named after 2 very prominent members of council, the following descriptions were used:

> Sample N. Slimy, slippery fish. Lives in the mud. Is of a violent bluish colour on the belly. The whole upper surface is of a dirty olivish-green colour, with numerous irregular dark patches.
>
> Sample B. A fish easily recognized by its low forehead, big belly and sharp spine.

When it is realized that one of the two members of council concerned was the leader of an important religious organization in Melbourne, and the other a highly respected physician in the city, it is understandable that a near-riot resulted. The author, refusing to withdraw his paper and description, was immediately censured, and his expulsion from the Institute sought. However, the necessary two-thirds majority not being obtained, the 2 Council members concerned immediately resigned from all active participation in the Institute. The paper in some way having been printed prematurely, then presented a problem, and the council ordered all copies of the offending pages to be destroyed. All but one were apparently surrendered and destroyed, the sole survivor being now in the possession of the Public Library of Victoria. In the appropriate number of the *Transactions* will be found the following reference to this incident:

> Pages 131, 132, 133 and 134 are expunged from this volume as containing matter injurious to the Institute.

Will the one surviving copy cause any difficulties to the taxonomists of the future? Time alone will tell.

The rapid expansion of the membership of the Institute at this stage was causing considerable concern to the council in that there were insufficient interests within the Institute to obtain the maximum benefits from this increased membership. Consequently, a proposal was put forward that, within the Institute, there should be a series of sections developed, in which members with similar interests could concentrate upon and specialize in their particular branch of science. In all, 7 sections were nominated as follows:

Section A.	Physical, astronomical, and mechanical science, including engineering.
Section B.	Chemistry, mineralogy and metallurgy.
Section C.	Natural history and geology.
Section D.	Medical and microscopical science including physiology and pathology.
Section E.	Geography and ethnology.
Section F.	Social science and statistics.
Section G.	Literature and fine arts, including architecture.

The adoption of this new principle at the annual general meeting held on 8 December 1858 ushered in a new era of scientific endeavour within the Institute, which was to set the pattern of activities for many years to come, and was largely responsible for much of the detailed scientific work that emanated from the Institute.

In 1859 occurred a number of developments in the working of the Institute. Firstly, the proposals for Australian exploration were advanced a step further; secondly, towards the end of the year approval was granted for the change of title to 'The Royal Society of Victoria'; thirdly, the main hall of the new building was completed. The development of the exploration proposals followed a decision by the council that the project was now sufficiently large that it should not be confined to members of the Institute but should be one in which all participated. Following an earlier public meeting, at which the sum of £1,000 was promised by an anonymous donor towards the expenses of the expedition on the condition that the Institute found a further £2,000 within 12 months, the Institute took up the challenge and, by the end of the stipulated period, had not only exceeded this amount but also had the promise of £500 for transport of goods along the Murray and Darling R. In addition, the government having voted the sum of £6,000 for exploration, the general exploration committee applied for and was successful in having this sum added to the moneys already raised by their own efforts. With the financial arrangements secure, the Institute felt it was in a position to embark on the project and offered the leadership of the party to Mr A. C. Gregory of New South Wales who had only recently returned from a similar journey of exploration to the NW. of Australia.

During August of the same year, the application of the Philosophical Institute to assume the title of 'The Royal Society of Victoria' was forwarded to London for the consideration of Her Majesty the Queen. At a special meeting called for 23 January 1860, the President, Dr Mueller, read a copy of a despatch from His Grace the Duke of Newcastle to His Excellency Sir Henry Barkly as follows:

Downing Street.
8th November, 1859

Sir,

I have received your despatch No. 70 of the 5th of August last, requesting, on behalf of the members of the Philosophical Institute of Victoria, of which you are the Patron, that Her Majesty will be pleased to permit that Society to assume the title of 'The Royal Society of Victoria'.

Having laid this application before the Queen, I have much pleasure in informing you that Her Majesty has been graciously pleased to signify her assent to it, and to sanction and approve of the Philosophical Institute in future assuming the title of 'The Royal Society of Victoria'.

I have etc.
(Signed) Newcastle

Governor Sir Henry Barkly, K.C.B.

This approval arrived at a most opportune time as it coincided with the completion of the hall of the new buildings in the master plan for the new site. This hall also afforded temporary accommodation for the museum of the Institute, and supplied necessary accommodation for sectional meetings. The opinion was expressed at the time that it was hoped to complete another section of the master plan at an early date so as to afford facilities to those members desirous of prosecuting experimental studies, and enable the sections of the Institute to carry out their researches successfully. As an expression of the valuable services rendered to the Institute in the completion of this hall by their honorary architect, Mr Joseph Reed, the council presented him with a life membership.

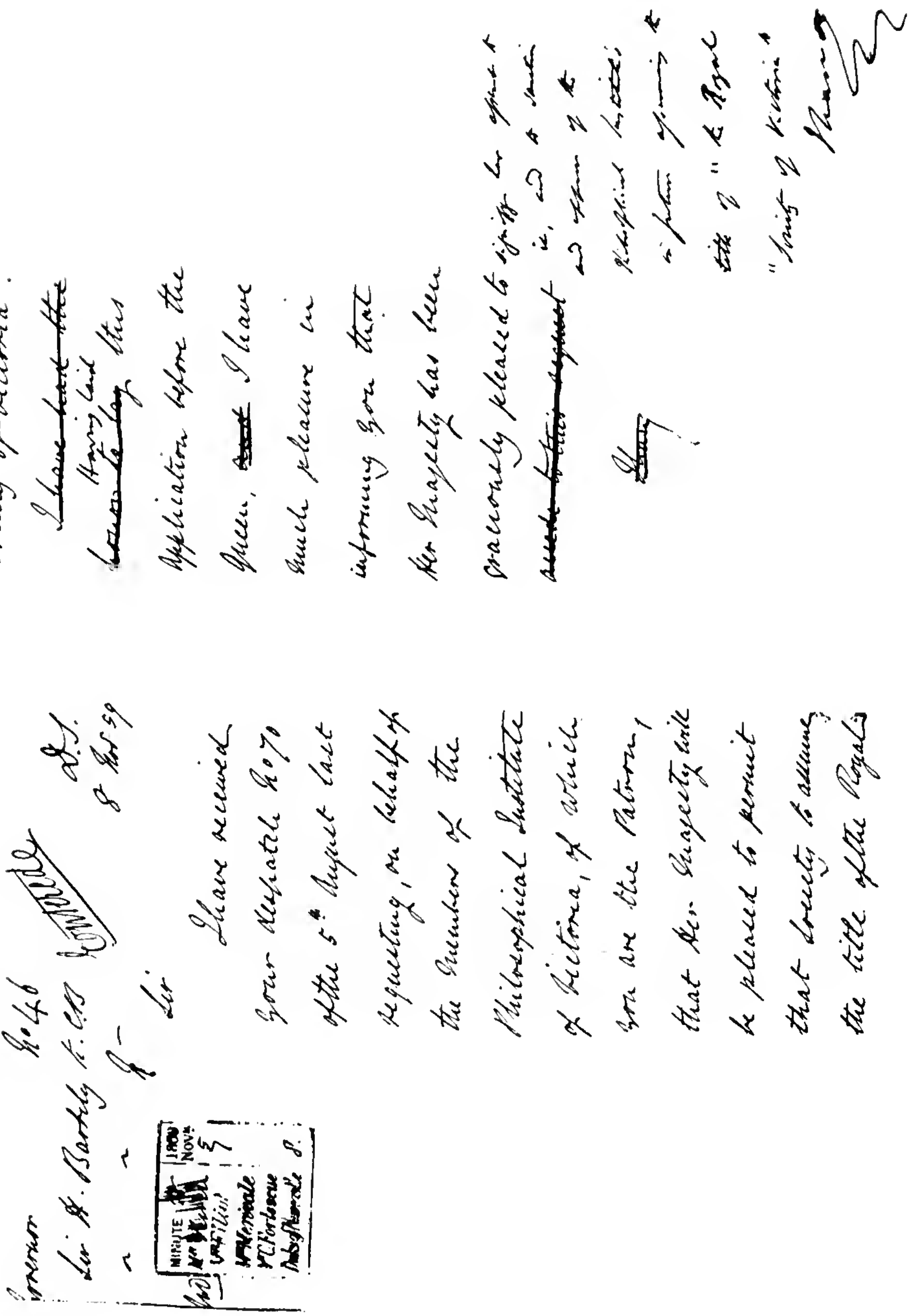

Victoria
No 70 – 1859.
No 46
Governor Sir H. Barkly K.C.B.
Sir
I have received your despatch No 70 of the 5th August last requesting, on behalf of the Members of the Philosophical Institute of Victoria, of which you are the Patron, that Her Majesty will be pleased to permit that Society to assume the title of the Royal Society of Victoria.
Having laid this Application before the Queen, I have much pleasure in informing you that Her Majesty has been graciously pleased to

FIG. 1.—Draft of notification of permission to use title 'Royal Society of Victoria', from Duke of Newcastle to Sir Henry Barkly, 8 November 1859.

Royal Society of Victoria

The first meeting of the Institute to be held in the new hall was the annual general meeting of 21 December 1859 when the President, Dr Ferdinand von Mueller, congratulated the members on the circumstances of their meeting together in their new building, and later delivered a special address to mark the occasion. His concluding words are worthy of repeating and becoming the motto of the Royal Society:

> May the tempest of discord never re-echo from these walls! May every word resounding here be one expressive of friendly feelings, of philosophic thoughts, of elevated inspiration for all that is noble; and in aiming to fulfil the destiny for which we here are called, may our symbols be 'Concord and Progress'.

The pride with which the council looked upon their new building was soon evident when it was decided that it would be advantageous to have the hall open at evening. However, enthusiasm caused a little chaos, as, in the first month, it was agreed the building should remain open 4 p.m.—9 p.m. This was rapidly changed to 4 p.m.—6 p.m., and then almost immediately to 4 p.m.—10 p.m. Such apparent inconsistency was understandable in the pride of something new and of great importance in the scientific life of the State.

As an illustration of their faith in the new Institute, in 1859 the government set aside a considerable sum of money to be awarded as prizes for 'Prize Essays', open to the public of Victoria, with the Institute being requested to nominate 7 suitable subjects for such essays. After considerable discussion, the following 7 subjects were selected early in 1860, with the recommendation that a prize of £150 be given for the best entry in each section:

1. On artesian wells in reference to their practicability in certain localities in Victoria.
2. On the origin of gold in quartz veins and its association with other minerals.
3. On the most improved means of extracting gold from its matrices.
4. On the diseases of cultivated plants in Australia; their causes, treatment and prevention.
5. On agriculture in Victoria especially in reference to the geological condition of soils, to the rotation of crops, and to the application of manures.
6. On the prevailing diseases of domestic animals in Australia; their causes, treatment and prevention.
7. On the collection and preservation of water in Victoria for motive power, irrigation and general water supply.

While these exact titles were not approved by the government, 4 titles were selected to cover similar interests, and judges were appointed by the council of the Royal Society in October 1860. Twenty-six entries were received and the awards were made early in 1861, a prize of £125 stg. and a gold medal to the value of £25 stg. being made in each of the 4 sections. The recommendation of the judges that the winners' essays be printed was approved by the government, the 4 essays appearing in one volume from the Government Printer in 1861. The originals of these essays are still in the possession of the Society.

Thus, 1859 was one of great significance for the Institute in that, for the first time, it had a meeting place of its own, and also received the title 'The Royal Society of Victoria'. An important era in the history of the organization was completed.

The exhibition, at the meeting held on 4 June 1860, of specimens of 'malleable iron' from Cranbourne in the Western Port district of Victoria brought forth considerable discussion as to the nature and origin of such material. The original samples came from a Mr Cameron, a resident of Cranbourne, who believed the deposits in question to be portion of a series of strata extending through the locality for a distance of 5 miles in sufficient quantity to constitute a commercial inducement to the formation of a railway to the area. However, further enquiries revealed that there were only 3 masses of such material present in the district, and that they were of meteoric origin. These masses became known later as the Cranbourne meteorites which attracted much attention, not only locally, but also in scientific circles overseas.

The final arrangements for the exploration party envisaged earlier and the despatch of that party on their journey northward were completed in 1860. As this project constituted one of the major activities the Society had considered up to that time and proved of such interest at a later date, it is well to consider in detail the arrangements for such exploration. It will be remembered that the exploration committee had raised a sum of more than £2,000 privately in order to secure the donation of £1,000 that had been promised anonymously, and that the legislature had voted the sum of £6,000 for the same purpose. The importance of taking advantage of the winter season to commence the expedition was nullified to some extent by the decision to obtain camels from India for the transport of the party. To this end the sum of £3,000 was forwarded to India. The camels, 25 in number, arrived in Hobson's Bay on 25 June 1860 in good order and condition on board the *Chinsurah,* and were immediately landed and properly housed.

The important duty of selecting a leader for the expedition was met by publicly calling for applicants. From a large number of applicants, the choice of Robert O'Hara Burke was made by the committee. Burke was the superintendent of police in the Castlemaine district and a former cavalry officer in the Austrian service. His appointment was unanimously endorsed by the government. The selection of the remaining numbers of the party was not such an easy task, as over 700 candidates applied for the various positions. These were invited to meet Mr Burke at the hall of the Society and, after careful inquiries and personal interviews, the following were selected:

George James Landells, Second in Command
William John Wills, Surveyor and Astronomer
Herman Beckler, Medical Officer and Botanist
Ludwig Becker, Artist and Naturalist
Charles Ferguson, Assistant and Foreman
William Patten, Assistant
Patrick Langan, Assistant
Owen Cowen, Assistant
Robert Fletcher, Assistant
Henry Creber, Assistant
William Brahe, Assistant
John Drakeford, Assistant
John King, Assistant
Thomas McDonough, Assistant

The final organization of the expedition was quickly accomplished, and after a careful and thorough briefing, the party departed from Royal Park, Melbourne, on 20 August 1860 in the presence of a large number of people, including the Mayor of Melbourne, Dr Richard Eades, who was also vice-president of the Royal Society.

Two nights previously, on 18 August, a special meeting of the Society had been called, the main business being to take leave of the exploring party and to read and sign the Memorandum of Agreement between the exploration committee of the Royal Society of Victoria and the several persons forming the exploration party. This set out fully the right of succession as leader of the party and the rates of pay of individual members of the party.

The story of the progress and ultimate fate of this exploration party need not be considered here, except to say that the Society received regular reports on its progress and, in spite of adverse public criticism, did all in its power, as was shown later, to provide assistance when disaster overcame it. The untimely death early in the expedition of Dr Ludwig Becker, the artist and naturalist, was greatly lamented by the Royal Society, as Becker not only had been a very early member of the Society but had contributed greatly, by papers and discussions, to its progress. The safe return of John King, the sole survivor, was made the occasion for a special commemorative meeting of the Society, when a gold watch, a gift from the Royal Geographical Society of England, was presented to him.

The government now agreed to provide a National Observatory amalgamating under one roof the Magnetic Observatory from Flagstaff Hill and the Astronomical Observatory at Williamstown; a new site to the NW. of the Botanic Gardens was chosen, which, because of its commanding situation and the absence of buildings, lent itself admirably for such a purpose. Thus came into active being, in 1863, through the initiative and drive of the Royal Society, a major scientific institution which, for nearly 100 years, was to serve in a very distinguished manner the scientific life of Australia.

The lack of sufficient funds within the Society at about this period, due largely to the sudden withdrawal of State aid, brought about a serious delay in the publication of the *Transactions*, so much so that the whole of the proceedings for 1861-1864 were brought out in one volume (Vol. VI). This event caused the Society much concern as, apart from any other consideration, the failure to publish was affecting the reputation of the Society as well as the exchange of periodicals from abroad. A number of papers which should have been published in full were lost, and abstracts only were published, and the whole situation was far from satisfactory. It was obvious that, at this period in its existence, the Society was losing something of the earlier enthusiasm. This is particularly shown by the fact that, in 1864, only 39 members paid their subscriptions, and the Society was facing a financial crisis of such a magnitude that it was forced to appeal to the government for help. To assist with subscriptions, the council appointed a paid collector of outstanding subscriptions working on a 10% commission basis and by this arrangement, which carried on for many years, a great deal of arrears was collected. The printing position was somewhat relieved by an offer of the proprietors of one of Melbourne's daily newspapers to publish the *Transactions* for the mere cost of printing and paper.

In 1864, a change was made with regard to the dues necessary for life membership, in order to overcome arrears of publishing. The existing rule was amended as follows:

> Members may compound for all Annual Subscriptions of the current and future years by paying ten guineas. But for the purpose of establishing a Permanent Publishing Fund of the Society, all Life Subscriptions shall be devoted exclusively to a Publishing Fund, such subscriptions to be invested solely in State debentures, and the annual interest arising therefrom to be devoted to the issue of publications alone.

However, the decision of the government at this time to defray the cost of publishing the Society's arrears of *Transactions* relieved the immediate burden of the position, and enabled the Society to catch up with this important phase of its activities.

Honorary membership of the Society was also recognized at this time by the granting of illuminated diplomas, based on designs of overseas diplomas.

The outstanding event of 1865 was the exhibition of gems, both Victorian and foreign, and of works in the jeweller's art, held in the hall of the Society for a week in May. The organization of this exhibition was carried out by the President, Rev. J. J. Bleasdale, in an endeavour to bring before the public the gem and gold potential of Victoria, and to encourage the prospecting for such valuable minerals. In this, the president succeeded above all expectations, some 385 separate specimens being shown, with a distinct impetus being given to the interests in these materials.

It is obvious that in the early years of the period 1860/1870, the Royal Society held a very honoured place among the departmental scientific institutions and, in fact, became their spokesman on many occasions. It became the accepted principle for the President of the Royal Society in his anniversary or presidential address in March of each year to review in some considerable detail the progress made by such bodies as the National Museum, Geological Department, Botanical Department and Astronomical Observatory. This is perhaps not so surprising when it is realized that the directors and senior officers of these institutions were all at one time executive officers of the Royal Society and had no other means, in most cases, for the dissemination of the results of their research.

The widespread nature of the subjects of lectures and papers delivered during 1867, e.g., bears this out. In that year, there were 2 contributions relating to physical sciences, 3 to the natural history of Australia, 3 to the development of natural resources, 2 to pathological science, 4 to the geology, mineralogy and palæontology of Australia and New Zealand, 1 to social sciences, and 2 to applied chemistry—a very good cross section of the scientific life of the State.

The visit of His Royal Highness the Duke of Edinburgh to Victoria in 1867 was made the occasion for the presentation to him of a specially illuminated address and a copy of the *Transactions* of the Society. In addition, the hall was 'on the night of the general illumination of the city' illuminated for the first time.

1867 also saw the completion of negotiations with the government for obtaining the Crown grant of the land on which the new Royal Society hall had been built. This entailed the appointment of trustees, thus commencing a system which has been maintained through the life of the Society. The first trustees were Sir William Stawell, the Chief Justice of Victoria; Rev. Dr J. J. Bleasdale, St. Patrick's College; R. L. J. Ellery, Government Astronomer and President of the Royal Society; and C. W. Ligar, Surveyor-General of Victoria.

The state of the Royal Society buildings was causing serious concern at this period, and a detailed proposal estimated to cost £800 was submitted to the council by a special sub-committee to overcome these disabilities. The proposal called for the altering of the building to provide a meeting room 33 ft. square with the full height of the existing hall, fitted with rising slats like a lecture theatre, 2 rooms on the ground floor each 22 ft. by 16 ft. which would be used as a council room and secretary's room, and also a 'handsome' room on the first floor 33 ft. by 22 ft. for a library and reading room which would be open daily. It was estimated by the architect that these proposed alterations would cost approximately £450, together with £350 for a caretaker's cottage. This immediately brought an outcry from some members for the removal of the Society to another locality, the existing site being described as 'a desolate one'. The new site most favoured by them was the Public Library reserve, where it was hoped all the scientific societies and collections would collect, but it was later pointed out to them that it was much better to remain on a site that was their own than to build on a place in which they would only be on sufferance.

This proposal being rejected by the members, the council was given authority to call for tenders. At the same time, it was recommended that a lodge should be erected in the grounds where an attendant could reside and safeguard the property of the Society.

Tenders for the above alterations to the hall were called early in 1869, and the tender of John Woods, a building contractor, for £415 was accepted—those for the lodge being deferred. During alterations to the building, meetings of the council took place in the Town Hall Chambers, while meetings of the Society as a whole were suspended. On the completion of alterations to the hall, it was decided to proceed with the construction of a brick lodge at an estimated cost of £330, the combined works being completed during August 1869, when regular meetings again were held in the building. The financing of these alterations presented some problems, and it was decided to approach the government with a request that the sum of £800 be placed on the estimates to enable this work to be carried out. However, a flat refusal was forthcoming from this source, and the whole project was then brought back to the Society for private financing.

Negotiations for this were finally successful on the following terms:

1. That the offer of the Melbourne Bank to lend the Royal Society money on promissory notes at six months eaeh, renewable for two years, and bearing interest at nine per eent be aeeepted.
2. That subseription lists be opened and circulated, one for donations to the building fund, and one for debentures of £5 each, bearing interest at £8.8.0 per eent per annum. That the proeeeds of these subscription lists be applied to paying the money borrowed from the bank.
3. That any member of the Soeiety, holding debentures to the value of £15, shall be entitled at any time to surrender his debentures, and beeome a life member of the Society.

The success of these proposals was assured when debentures for over £200 were subscribed at the first meeting, the first one being taken out by James Bonwick, the historian and writer.

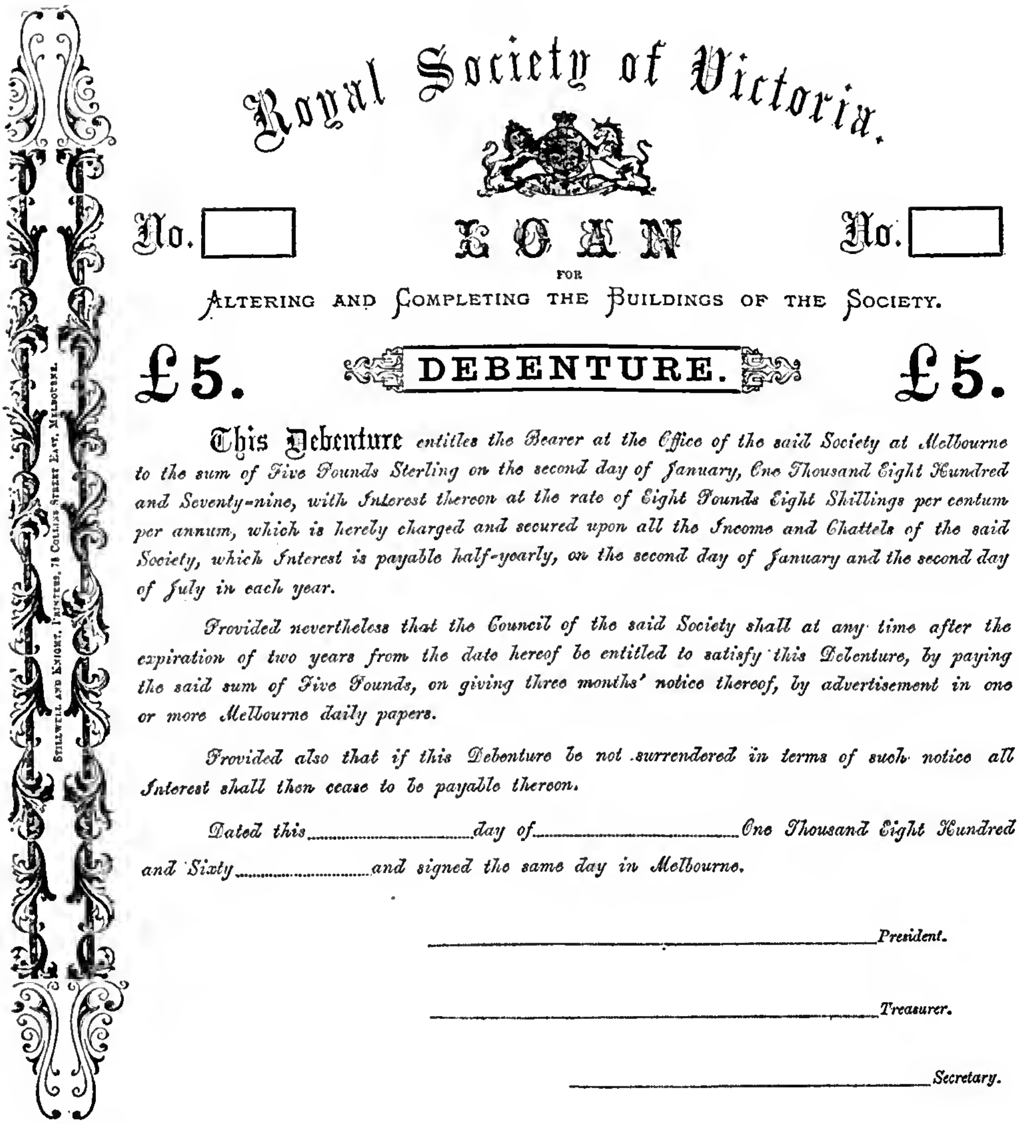
The first occupier of the newly completed lodge was Sergeant O'Flaherty of the police force, and it is illuminating to record his duties and his remuneration for same.

> The lodge keeper has to be married with a small family, be a praetical gardener, active and healthy, write legibly so as to be able to render clerical assistanee, have no oeeupation whieh would keep him away from the meetings of the Society; shall perform the neeessary cleaning of the hall, light fires when required, act as offiee keeper and messenger generally, keep the grounds in good order, and be of a thoroughly respectable charaeter.

For these qualifications, he was to he paid the princely salary of 10 shillings per month, in addition to free occupancy of the lodge.

The printing of the *Transactions* received a further set-back in 1868 when the government subsidy to the Society was withdrawn. This position was not corrected until 1872 when sufficient funds became available through members' subscriptions to allow printing to be resumed, and liberal treatment by the government in 1873 assured continuity of such printing.

Additional financial worries followed in 1870 as, at that time, it was found that the treasurer had not been paying to the credit of the Society moneys which he had been receiving for subscriptions, and that cheques had been drawn and not



Royal Society of Victoria.

No. [ ] LOAN No. [ ]

FOR

ALTERING AND COMPLETING THE BUILDINGS OF THE SOCIETY.

£5. DEBENTURE. £5.

This Debenture entitles the Bearer at the Office of the said Society at Melbourne to the sum of Five Pounds Sterling on the second day of January, One Thousand Eight Hundred and Seventy-nine, with Interest thereon at the rate of Eight Pounds Eight Shillings per centum per annum, which is hereby charged and secured upon all the Income and Chattels of the said Society, which Interest is payable half-yearly, on the second day of January and the second day of July in each year.

Provided nevertheless that the Council of the said Society shall at any time after the expiration of two years from the date hereof be entitled to satisfy this Debenture, by paying the said sum of Five Pounds, on giving three months' notice thereof, by advertisement in one or more Melbourne daily papers.

Provided also that if this Debenture be not surrendered in terms of such notice all Interest shall then cease to be payable thereon.

Dated this..........................day of..............................One Thousand Eight Hundred and Sixty..........................and signed the same day in Melbourne.

______________________President.

______________________Treasurer.

______________________Secretary.

Stillwell and Knight, Printers, 78 Collins Street East, Melbourne.

Fig. 2.—Debenture form issued in 1869 to finance alterations to Royal Society's buildings.

accounted for. Following exhaustive enquiries among members, a considerable deficiency in funds was found, and the treasurer, in the absence of any explanation whatever, expelled from the Society.

The most noteworthy event in the life of the Society during 1871 was the organization of an expedition to Cape York for observing the total eclipse of the sun on 12 December 1871. With liberal aid from the governments of Victoria, New South Wales, Queensland and South Australia, a well-equipped party of 8 observers and 13 passengers sailed from Melbourne, and was joined by a similar party of

6 observers and 3 passengers at Sydney. Arriving at their destination on 6 December, the scientific equipment was set up on a sandbank, and completed in time to allow for a day and a half of rehearsals. The weather, which had been perfect for observations for days, broke the night before the eclipse with thunderstorms and rain. With the exception of one moment when a break appeared in the heavy cloud to show the last thin crescent just before totality, nothing else was seen. This momentary break was all the Australian eclipse expedition saw of the total eclipse of 12 December 1871. Although disappointed by the lack of the hoped-for results, the expedition did not return empty-handed—botanical and natural history collections generally being made, together with a series of meteorological observations.

A major change of policy became evident in 1873 when an attempt was made to popularize the affairs of the Society. It had been evident for some years that the interest of the public in the Society had been waning and that, apart from the annual conversazione, very few members of the general public knew anything of the Society. It was realized that 'the real hard business of the Society, many of the questions to which the members should devote their energies, are of a kind productive of papers which, however valuable in a purely scientific sense, are the opposite of what is called popular. We gain something by popularizing our meetings.' It was therefore decided that, in the following year, a limit would be put on ordinary meetings, and a series of meetings of a more social character inaugurated. Which category the paper presented by James E. Neild, M.D., at the meeting immediately after this decision was made, entitled 'On the advantage of burning the dead', and strongly supporting the principle of cremation, came under was never disclosed.

It was also in 1873 that the Society recognized the necessity for making some provision for country members when compounding subscriptions for life membership. Consequently, on 12 August of that year, the following law was approved:

> Members resident in Melbourne, or within 10 miles thereof, may compound for all annual subscriptions of the current and future years by paying £21, and members residing beyond this distance may compound in like manner by paying £10.10.0.

The falling off in membership of the Society, which was most apparent earlier, was still serious in 1874 when the total number was only 110. The Society suffered a serious loss also in that year with the death of Professor W. P. Wilson, who had been one of the earliest members of the Society and a vice-president for many years. His influence at council meetings had been of the highest, and his ability in discussion at general meetings considerably raised their standard.

Two further developments occurred in 1878 which were to have an important bearing on the future of the Society. Firstly, in order to attract young members it was decided that, as the entrance fee of 2 guineas together with 2 guineas subscription was prohibitive for this type of person, the constitution be amended to admit associate members at half price and without any entry fee, with privileges which would, with a few exceptions, be equal to those of members. It was hoped by this means to attract 'young men of the community whose tastes and education lead them towards our ranks, and whose enrolment is much to be desired'. Secondly, applications were received from one or two kindred societies of Melbourne for permanent accommodation within the building. Consideration was immediately given to continuing the floor of the library over the theatre, throwing the whole upper floor into one chamber, with the space beneath giving two more commodious rooms. The honorary architect of the Society was called upon to prepare estimates of the cost of this work.

We fail to realize in these so-called modern days of science, the tremendous impact that some of the essential parts of our normal lives nowadays had on the scientific life of the community when they were first introduced. It almost reads as part of a fairy story to find in the presidential report for 1878 the following statements:

> In my last address, I referred at some length to the then recent invention of the telephone. Since then this wonderful little instrument has been greatly improved, and is now in actual use in Melbourne, not only as a scientific toy, but as a means of communication. We had no sooner become familiar with the telephone, than we were astounded by accounts of a still more wonderful apparatus, the phonograph. While a wonderful future is predicted for the phonograph, at present, if we except its power of giving a peculiar graphic representation of multiple and complex sounds, it cannot be said to be out of the category of scientific toys. I believe there are actually specimens of these instruments in the building tonight.

I wonder if our reactions to modern inventions in the fields of nuclear physics, rocket space ships, radio and television, to mention but a few, have been any different.

The decision in 1858 to form a number of sections within the Society did not produce the results that were anticipated. Certainly a number of meetings were held in the first year or so, but after that the sections functioned either not at all or, at the best, only spasmodically. However, through the keenness of the President, Mr R. L. J. Ellery, who was also Government Astronomer, Section A (Physical, astronomical and mechanical science) was re-constituted in 1879, with a membership of 40. In the first 6 months, 5 meetings of the new section were held, all well attended, at which papers and demonstrations were given.

Alterations and renovations to the buildings that had been approved some time earlier were completed in 1880. Apart from the additional space provided within the building, the renovation 'in a plain but substantial style' of the outside of the building, which for a long time had presented a somewhat shabby and dilapidated appearance, produced a building of some dignity that was the subject of much admiration. In the same year, the sectional activity of the Society further advanced with the formation of another section, combining sections B, C and D in the original classification, which immediately commenced active work. However, its activity was short-lived as, after about 12 months of activity, meetings lapsed.

The year 1880 was also important in that the Field Naturalists Club of Victoria was formed on the lines of the old and well-known English one of the same name. As the objects of this new club were very similar to those of the Royal Society, although a greater emphasis was placed on field excursions for club members, it was only to be expected that a close relationship would exist between the two organizations over the years.

The death of Sir Redmond Barry on 23 November 1880 at the age of 67 years brought to an end the active association of this eminent legal authority with the Society. He was the first president of the Victorian Institute for the Advancement of Science, and later assisted in the formation of the Philosophical Institute which, after a short period, became the Royal Society of Victoria. He was at all times an active council member, and exhibited a sincere regard for the welfare of the Society.

A further step forward, and one which ensured a site for all time for the Royal Society, was the application made to the government in 1882 for the grant of the land on which the building stood. Previously the land had been only permanently reserved for Royal Society purposes, and vested in a number of trustees. This application received the approval of the government, and enabled the Society to go ahead with permanent improvements to the property. The Crown grant of the site registered in Volume 1471 Folio 294133 was notified in the Government Gazette for 6 April 1883, and came into the possession of the Society shortly after, being then lodged for safe keeping with the Bank of Australasia.

In 1882, for the first time for many years, membership rose beyond 200, there being 163 members, 41 associate members, 6 corresponding members and 8 honorary members, a total of 218. This rapidly increasing membership was causing some embarrassment to the Society, so much so that, for the first time in its history, the Society was compelled to move away from its own hall for its annual conversazione which was held in the Melbourne Athenæum on 14 September 1883. This was a really promising sign, as it attracted a number of members of the general public who, in the past, had been very loud in their criticism of the Society and its objects.

The resignation of Mr R. L. J. Ellery, Government Astronomer, as president in 1886 brought to a conclusion a term of nearly 20 years as president of the Society. To Mr Ellery must be given the credit of holding the Society together during a very difficult period when membership declined, financial assistance from the government was abolished, and the attitude of the public to the man of science was not at all tolerant. Through this troublous period, Ellery maintained his faith in the Society, gave encouragement and assistance to those younger members requiring guidance, and perhaps greatest of all showed to scientists in other parts of the world that, amidst all the excitement and turmoil of the foundation and growing up of a new colony, scientific investigation was not forgotten, but was proceeding at an increased tempo. Ellery was succeeded as president by Professor W. C. Kernot of the University of Melbourne, who, in his presidential address for 1885, detailed the essential requirements of a Royal Society, particularly with regard to fundamental matters. His address on that occasion is well worth reading as a yard-stick of scientific aims and achievements.

Although some years had elapsed since the ill-fated Burke and Wills expedition, no strong move within the Society had been made for further exploration until 1886, when a committee was set up by the Royal Society, in association with the Geographical Society of Australia, to consider the question of 'Antarctic Exploration'. For a number of years, European countries had been very active in the field of Arctic research, particularly in the establishment of meteorological and astronomical observation stations, and attempts had been made with similar ideas for the Antarctic. The committee pointed out that, as it was nearly 50 years since the last expedition was despatched to Antarctica, it was time that another scientific expedition be organized and despatched.

The Society had had some contact with polar exploration as, in 1874, during the visit of the *Challenger* to Melbourne after it had crossed the Antarctic Circle and closely approached what is now known as Princess Elizabeth Land, Professor Wyville Thompson, the scientific leader of the expedition, was made an honorary life member of the Society, and a set of the *Proceedings* donated to the library of the expedition.

It is perhaps well to consider in some details the early work of this committee, as Antarctic exploration was to play a prominent part in the life of the Society in latter years. The committee consulted a number of interested bodies both in Australia and overseas and, in addition, enlisted the sympathy of appropriate governments. It was felt that, provided a suitable steam vessel was available, no great difficulties were likely to be encountered, while the harvest of scientific results that could be reaped by such an expedition would most probably be high, and substantial advantage of a commercial nature might well be secured.

The representatives of the Royal Society, which included, among others, the president, Professor Kernot, and the Government Astronomer, Mr Ellery, met with the members of the Geographical Society on 8 separate occasions during 1886 and 1887 and, after exhaustive enquiries throughout the world, produced a series of 23 recommendations which were forwarded to the Honourable the Premier of Victoria for his consideration. From these recommendations, the following warrant special consideration:

1. The Antarctic Committee begs respectfully to recommend to the Honourable the Premier the propriety of stimulating Antarctic research by the offer of bonuses.
2. That a sum of £10,000 be placed upon the estimates to provide for the amount of the bonuses, and for the expenses of the equipment and the staff.
3. That the Government invite tenders from shipowners willing to perform the duties involved.
4. That tenderers must provide two fortified steam ships, each of not less than 175 tons register, 60 horse power, and A1 at Lloyds, or of equivalent class.
5. That the master and chief mate of both ships shall have held similar positions in Arctic steamships.
6. That the tenderer shall provide, free of charge, cabin accommodation in each ship for two gentlemen, who will sail as the scientific staff, also a separate cabin as an instrument room and office.
7. The chartered ships will earn a special bonus upon their entering at the Customs House a cargo of 100 tons of oil, being the produce of fish caught south of 60°S.
8. The services desired are—a flying survey of any coastlines lying within the Antarctic Circle, the discovery of new waterways towards the South Pole, and the discovery of commercial products.
9. The Government should pay for only one observing camp established for each 120 miles of latitude or longitude etc.
10. Both ships must be in Port Phillip Bay and ready to sail on the 15 October 1887.
11. That in case of any difficulty arising in England between the Agent-General and the contractor, it shall be referred to the British Antarctic Committee for decision.

Broadly summing up the purposes of the expedition, the committee considered it was desirable that more precise knowledge respecting the physical conditions of the Antarctic regions should be obtained, especially with reference to terrestrial magnetism and volcanic and seismic agencies, and still more particularly to the meteorological conditions of the several zones to the south of the 50th parallel.

This 'Memorandum of Recommendations' was forwarded by the Premier of Victoria to all Australian governments, and to the Agent-General in London who circulated likely sources throughout Europe. However, while immediate offers of assistance were received from shipping and exploring interests overseas, no immediate action resulted.

The preliminary meeting held in Sydney on 10 November 1886 for the founding of an Australasian Association for the Advancement of Science in 1888 was attended by Mr Hunt of the Royal Mint, Sydney, a country member, on behalf of the Society. The April 1888 meeting of the Royal Society announced the establishment of this Association, and pointed out the desirability of co-operation between the States in successfully launching in August 1888 the Australasian equivalent of the famous British Association for the Advancement of Science. The delegates from the Society to this first meeting were Professor Kernot (president), Professor Baldwin Spencer and Mr R. L. J. Ellery.

In June 1887, one of the smaller societies which had formed in Victoria some years earlier, the Microscopical Society of Victoria, offered to amalgamate with the Royal Society, and to form Section D, for the study of the microscope and its applications. This offer was accepted by the council and the opinion was expressed that it would be advantageous for other societies to follow suit. At the July meeting of that year, 41 members of the Microscopical Society were admitted as members of the Royal Society and 5 as honorary members.

In 1888 it was decided that the *Transactions* of the Royal Society of Victoria should be published in the same form, with the same shape and size of plates, as the *Transactions* of the Royal Society of London, and be kept separate from the *Proceedings*. In these, original work of members of the Society would be published. To Professor Baldwin Spencer was given the honour of filling the first volume with his monumental work on *Megascolides australis*, the giant earthworm of Gippsland.

Two other matters of considerable scientific importance also were formulated in this year—firstly, the necessity for a detailed biological survey of the waters of Port Phillip Bay, and secondly, the desirability of the preservation of Wilson's Promontory as a national park. In both of these projects there was active co-operation with the Field Naturalists Club, both in committee and field work.

The Port Phillip Biological Survey Committee is worthy of some attention, as it was one of the most important of the research projects with which the Society had an active interest. Formed towards the middle of 1887, it consisted of 7 members (Messrs W. M. Bale, A. W. Cresswell, A. H. S. Lucas, P. N. McGillivray, Baldwin Spencer, C. A. Topp, and J. Bracebridge Wilson), all authorities in some field of the proposed survey. The aims of the committee were many, the chief being:

(*a*) To make a catalogue of the existing literature relating to the fauna and flora of Port Phillip.
(*b*) To set up a number (32) of littoral and marine stations of which the life forms of each will be explored.
(*c*) To prepare an extended catalogue of the plants and animals of each area, recording such details as life history, associations and commercial value.
(*d*) To have the specimens collected identified by competent scientists, so that published records will be accurate.
(*e*) To investigate biological problems as may arise from time to time.

It was intended *pro tem.* that the specimens obtained should be kept at the University under the care of Professor Baldwin Spencer. The council approved an annual grant of £50 to this committee to help defray expenses, and arranged for a display of specimens obtained from the first year's operations at the annual conversazione.

Dredging operations commenced at once, and continued over many years with prominent members of the Field Naturalists Club assisting with the work. Reports were regularly submitted to the council, and papers read to the Society setting out details of what had been accomplished. It is to the credit of this committee that so much information on the biology of Port Phillip was obtained in such a short period. When the committee was finally disbanded many years later, the specimens obtained were distributed to various museums and individuals throughout Australia, the valuable Bracebridge Wilson collection of sponges being offered to the National Museum in Melbourne.

The annual meeting of the Society held on 14 March 1890 took on a new form after the council had decided that at the annual meeting of each year, a popular and brief outline should be given by recognized speakers on the progress made in various branches of science during the previous year. At this meeting, short addresses were given on astronomy, chemistry, biology, public hygiene, geology, literature and fine arts.

In 1889 the death occurred of another of the original founders of the Society, Sir William Stawell, who for some time filled the position of Chancellor of the University of Melbourne and was interested in all scientific matters. Another section (Section G, literature and art) was formed during this year. Although its formation was somewhat of a new departure in the history of the Society, it was provided for in the laws.

The nomination of a lady as a member in July 1889 marked a new era in the life of the Society. She was Miss Helen H. Neild, daughter of Dr Neild, honorary librarian of the Society. The president, in giving a ruling on this matter, stated:

> After careful search through the laws, the council can find nothing to prevent a lady becoming a member of the Society. I believe the Society was formed on the supposition that ladies as well as gentlemen would become members of it. The ladies had not hitherto come forward to claim their right, but it was improbable that many others would follow the example set by Miss Helen H. Neild.

Miss Neild was duly elected an associate member. This apparently had a marked effect on the membership of the Society as, at the following meeting, it is recorded that the president submitted a long list of names of ladies nominated for membership.

By the end of the year, the membership of the Society had risen to 18 life members, 125 ordinary members, 38 country members, 6 corresponding members, 12 honorary members, and 93 associate members, a total of 292.

Professor Baldwin Spencer, Professor of Biology at the University of Melbourne, was actively associated with the Society at this juncture. Only recently arrived in Melbourne from England, Spencer brought with him all the enthusiasm for scientific research for which he was noted overseas and which played an important part in his appointment as the first Professor of Biology at Melbourne. Through his direct representations to the government, the annual grant to the Society was raised to £500, which proved indispensable to the continuation of its publications. At the same time, his skilled organizing as the first Victorian Secretary of the Melbourne Meeting of the Australasian Association for the Advancement of Science in January 1890 ensured its success. Spencer, in later years, was to exert a profound effect on the affairs of the Royal Society as honorary secretary, president and trustee.

An ethnological section of the Society (Section E) was formed, with the consent of council, in April 1890. The reason given for its formation was that, as traces of the aboriginal race were growing fainter and fainter, the section might be able to save from oblivion many interesting facts and relics. This section was entrusted to the capable hands of Mr A. W. Howitt, secretary of the Mines Department, and Rev. Lorimer Fison, of Essendon, who were shortly to be joined by Professor Baldwin Spencer.

As a further example of the varied interests of the Society at this time, it is worth recording that, in 1890, a committee of experts was appointed to enquire into the subject of cremation. The prime mover behind this action was Mr H. K. Rusden, a life member, who for many years had been interested in the subject, and who at the Melbourne Meeting of the Australasian Association had read a paper, 'Cremation, a sanitary necessity'. The committee so formed consisted of Professors Masson and Kernot, of the Melbourne University, and Mr H. K. Rusden.

Another project which the Society was considering was the necessity for a gravity survey of Australia. A strong committee recommended that such a survey was not only highly desirable, but readily possible, as the Royal Society of London had offered on loan the pendulum apparatus employed for a similar purpose in the great trigonometrical survey of India. Co-operation for this project was immediately forthcoming from a number of States, and approval was forthcoming, finance permitting, for this work to commence.

The subject of Antarctic exploration entered a new phase in this year when a definite offer was received from Baron Nordenskjold and Baron Oscar Dickson of Sweden to send a Swedish ship to the Antarctic, provided that Australia contributed £5,000 to the cost. The expedition was not to be a whaling and scientific one, which all experts condemned seeing that the two objects would be in conflict, but would be a purely scientific expedition. This magnificent offer to defray half the cost of such an expedition was immediately accepted by the Antarctic committee, and public subscriptions were called to raise sufficient funds to allow the expedition to be despatched during the summer of 1891. The Royal Society headed the subscription list by voting £100 towards the funds.

Early in July, at a public meeting held in the Athenæum to appeal for funds, it was stated that the original estimate of £10,000 had grown to £15,000, but that it was hoped to raise £22,000 to place the success of the venture beyond doubt. An individual donation of £1,000 at that meeting gave the organizers great encouragement. It was also reported that the Swedish explorer, Baron Nordenskjold, had commenced active preparations to lead the expedition in some 14 or 15 months' time. Considerable discussion ensued as to which Australian scientists would accompany the expedition, but no final decision was made pending further information.

The committee formed to report on the controversial subject of cremation finally produced its report towards the end of 1892. After carefully surveying the field of human burial the world over, the committee 'confidently recommends cremation as incomparably the best solution of every difficulty, particularly on hygiene, sentimental and economical grounds. It seems clear that both the public advantages of cremation, and the public dangers of burial, are infinitely more important and practical than any private predilections either way'. A model of a suitable crematorium was displayed and its action explained. The report was adopted by the Society and printed in the *Proceedings*.

The division of the members into sections, as was envisaged in the original constitution and as was carried out by certain sciences, came very much under criticism early in 1892, largely because of the so-called un-society attitude of Section G (literature and fine arts). Professor Baldwin Spencer was the leader in this reform move and, after stating that the Society was not large enough to be broken up in sections and that any such breaking up must weaken the Society as a whole, was successful in having the appropriate rules of the constitution rescinded. Thus ended a period in the developmental life of the Society which, in some ways, had served particular branches of science satisfactorily, but which, in others, had caused dissension and disunity among members.

The financial depression that occurred throughout Australia in the early '90s was felt in the Royal Society as elsewhere. The reduction of the government grant from £500 to £250 in 1892 brought about the discontinuance of the *Transactions* of the Society, publication being limited to the *Proceedings*. This was greatly regretted by the council as by its members.

It is interesting to record that in 1892 the Society valued its assets for insurance purposes at £4,000, made up of building £2,650, furniture £350 and books £1,000.

1893 saw further marine work carried out by a member of the Society in co-operation with a government department. The necessary permission having been given to the secretary of the Customs department for a scientific representative to be present during the trawling operations of the *Swansea* off Lakes Entrance, Mr T. S. Hart was appointed representative of the Society, and financial assistance was given to the project. On his return, Mr Hart submitted details of his results in a paper to the Society.

As one of the means for economy within the Society, the taking of shorthand notes of council meetings, which had been the custom for many years and which had involved a considerable sum of money, was discontinued after the June 1893 meeting. In this year, also as an economy measure, it was decided to call tenders for the publication of the *Proceedings*, the tender of Messrs Ford & Sons, printers, of Carlton, being accepted. Thus commenced an association with this firm for the printing of the Society's publications which was to last with only short breaks for over 60 years.

The departure of the steam whaler *Antarctic* from Tonsberg in October 1894 under the command of Capt. Christensen was an evidence of the interest created in the region by the active agitation of the Antarctic exploration committee during the previous 10 years and, although the primary objective of the vessel was whaling, some meteorological observations were made and specimens collected. The accounts of the voyage, which reached 74°S., whetted the appetite of the committee for the fulfilment of their earlier objectives.

The further reduction of the government grant to £100 in 1895 brought to the fore a financial crisis in the Society which required great pruning of everything but essentials to enable the Society to pay its way with maintenance of the building and library. The foregoing of the publication of certain papers that had been presented to meetings became a necessity, and the publication funds became exhausted with the printing of Vol. IV of the *Transactions*.

1896 brought to a close the life of another of the pioneers of the original Society, an explorer of some considerable fame, and a botanist of worldwide reputation—Baron Sir Ferdinand von Mueller. Mueller, a foundation member of the Victorian Institute for the Advancement of Science and of the Philosophical Society of Victoria, had always been actively engaged in the work of the Society either as president or as a council member, and his contributions to the Society in the field of botany and exploration brought fame not only to himself (for which he cared but little) but also to the Society. His service of over 40 years as Government Botanist brought a clear picture of the potential of the vegetation of Australia and, at the same time, his knowledge of overseas plants suggested possibilities for commercial introductions.

With the object of bringing members of the Society together at an annual gathering, the council in 1896 decided to re-inaugurate the conversazione which had once been a feature of the annual life of the Society. This was held in the Society's hall in October in place of the normal monthly meeting; two short lectures were given, followed by a musical programme from students of the Conservatorium. This annual reunion of members was later to become an important part of the year's activities, bringing together, as it did, all interests of the Society.

The reduction of the government grant again hampered publication but, more particularly, attention to the library where, through inability to carry out book-binding, serious losses of parts of publications were resulting.

The prevailing financial difficulties of 1897 which contributed largely to a sharp reduction in the number of financial members brought about a financial crisis which was met in a threefold way. A special sub-committee reporting on 'ways and means' prepared recommendations, which were later approved by the Society, for the following:

(*a*) The letting of the present hall for a period of years, together with the securing of rooms more central in the city which would probably retain existing members and help in obtaining new ones.

(*b*) The holding of an annual dinner, at which all members would be invited. (In later years this became a feature of the annual activities of the Society.)

(*c*) The abolishing of the entrance fee for new members to the Society. This was approved for a trial period of 3 years.

Actual experience soon showed that the first of these recommendations was impracticable, but the others produced some improvement in the membership of the Society. However, the reduction of the government grant in the following year to £50 only aggravated the position, and the Society continued struggling.

The death of Sir Frederick McCoy in 1899 removed from the Society another of the foundation members of the earlier societies and a former president. McCoy, the first Professor of Natural Sciences at the University of Melbourne, Director of the National Museum and Government Palæontologist, had contributed greatly to the affairs of the Society, and although he did not always see eye to eye with the council on matters of policy, yet was respected because of his wealth of knowledge and clear thinking.

With McCoy's death, Professor Spencer became Director of the National Museum and, because of the complete re-organization that became necessary following the decision to transfer the Museum from the University to the Public Library block, he was obliged to resign as honorary secretary of the Society—a position he had held with great distinction for ten years. However, he did not entirely sever his connection with the Society as, in a year or so following this time, he was elected president, and later a trustee.

The decision in 1901 that the International Catalogue of Scientific Literature of the Royal Society of London should be extended to Australia resulted in the Royal Society being requested to form the Regional Bureau for Victoria, with headquarters at the Society's hall. Professor J. W. Gregory agreed to become head of this bureau. However, in spite of the fact that the government expressed its opinion that it was not prepared to assist in the publication of this work, and had referred the matter to the Public Library, the Society decided to continue the work of the Regional Bureau at its own expense. Professor Gregory carried out these duties until 1904 when, because of his leaving Australia, it became necessary to appoint a new cataloguer. Professor W. A. Osborne and Mr T. S. Hall (the Society's secretary) were appointed to continue this valuable work, but owing to pressure of other duties were quickly forced to relinquish it. After the Science Faculty of the University had been offered this project, but were unable to carry it out, it was referred back to the Bureau in London which, following communications with the Agent-General there, suggested to the Premier of Victoria that the Public Library should undertake the work. This being approved, in 1911 the government offered an annual grant of £50 for cataloguing purposes, which arrangement continued until 1915 when the grant was abandoned. The work, however, was carried on by the staff of the Public Library under great difficulties, particularly during the war years, under the direction of Mr E. R. Pitt, who was also a member of the Society. How well he succeeded in this task is now known to every Australian librarian. However, in 1921, the Royal Society of London, through lack of finance, was forced to abandon the project.

Following the death of Baron Sir Ferdinand von Mueller in 1896, the question of a permanent memorial to his memory was discussed. Co-operation was immediately offered to the Royal Society of Victoria by the Royal Society of Tasmania and the Royal Geographical Society of Australia. As a result, the Mueller Medal was founded, the first award being made in 1904 to A. W. Howitt, the noted explorer and anthropologist and a member of the Society. Howitt, then an old man and in failing health, received the award at a joint meeting held with the Field Naturalists Club.

The earlier interest of the Society in the reservation of Wilson's Promontory as a national park was reviewed in 1904 when it was reported that the Lands department was proposing to throw open this area in 1,000 acre blocks for grazing purposes. It was immediately decided that a joint deputation from the Field Naturalists Club and the Royal Society should wait on the Minister for Lands to protest at this proposal. This deputation brought a rapid response as, in the *Government Gazette* for 8 March 1905, the permanent reservation of 75,000 acres there as a site for a national park was gazetted. It was felt later that this area was not enough, and that portions of the narrow neck of the isthmus should also be reserved. In this the government finally agreed—a total reservation of 103,000 acres resulting in the formation of the magnificent national park we know today.

Early in 1907, a request was received from the Federal Meteorological Bureau in Melbourne that the triangular piece of land at the E. end of the Society's grounds be placed at the disposal of the Department of Home Affairs for meteorological purposes. After ascertaining from the Lands department that there was no obstacle in the way of the Society leasing portion of their area, provided it was for scientific purposes, an agreement was entered into with the Federal department that the area in question would be available to them for £50 per annum. It was a suggestion from the government at the same time that any such moneys received should be kept in a separate account, and devoted solely to the improvement of the Society's buildings and land. Thus was established a weather station which for over 50 years has kept daily recordings of the meteorology of Melbourne.

A proposal which had been under consideration for some time that there be no distinction between members and associates, that all be treated as 'members', and that the annual subscription be fixed at £1.1.0, was finally abandoned in 1907. It was hoped to attract more members in this way, but it was found that the state of the Society's finances was such that the proposal was impracticable.

From early in the life of the Royal Society, the president was *ex officio* a member of the Board of Management of the Alfred Hospital, though the exact relation between these institutions was never made clear. This arrangement continued until 1911 when the membership of the board was reconstituted.

With the rapid improvements in essential services taking place in Melbourne in the early 1900's, the Society was faced with the desirability of the use of electric lighting in the main hall. The change from gas to electric lighting took place early in 1910 when, for a total cost of £22.0.6, the necessary installations were effected. The incomplete faith in this system was evident when the council decided that it was desirable to retain the gas fittings throughout the buildings. The economical nature of this 'new method of illumination' was shown by the monthly accounts of 2/3 paid to the City of Melbourne for the following 12 months. At the same time as this change took place, it was decided that a re-arrangement of the rooms on the ground floor was also desirable. The new proposal called for the NE. room to be devoted to the council room, with the room behind it a stack room for the library. This arrangement has persisted to the present day.

In 1913, the inadequacy of the present building to meet the needs of the Society and its tenants caused council to consider either enlarging the present building or rebuilding on the same site. An appeal by the council to the members for financial assistance brought an immediate response, £1,500 being promised, largely on the principle of debentures as used in the financing of the first building project. An approach to the government to meet this on a pound-for-pound basis was not enthusiastically received.

The proposal as approved by the council envisaged a new hall placed to the E. of the existing building, thus leaving the site to the W. available for letting at some future time. As considerably more money was required for the project than was in hand, it was decided to seek finance from the State Savings Bank. However, the title deed of the Society was such that this was not permitted without an amending Act of Parliament. Approval for this being granted by the government, the necessary Bill was prepared and eventually, late in 1915, this Bill passed through both Houses of Parliament without amendment. Immediately an agent was appointed to act for the Society with respect to the leasing of its land but, possibly because of war-time conditions, no offers were forthcoming.

In 1917 the lease of the land along Exhibition St., with a frontage of 193 ft. by a depth of 60 ft., was offered to the City of Melbourne Crêche for £200 per annum for 30 years, provided that a building approved by the council to the value of £2,000 was erected thereon. This offer was not taken up and the project lapsed.

An extraordinary event occurred in June 1915 when the council expelled from its membership an honorary member—a German professor—as a protest 'against the doctrines and methods of warfare adopted by Germany and Austria'. This rather discreditable action on the part of the Society clearly illustrated the feelings of the time, but surely science must recognize that an individual should not necessarily be held responsible for the actions of his government.

The outbreak of World War I in 1914 brought many changes in the membership and activities of the Society. Two very important recommendations, one a decision affecting the members and one concerning scientists generally, were made early in 1916. These were:

(*a*) That conscripts of scientific training should be placed where their special qualifications could be used, with proper rank and emolument. This recommendation brought to the attention of the appropriate departments the potential of scientific manpower that was available among such societies. (This policy was also in active operation during World War II.)

(*b*) That subscriptions of those on active service be held over until after the war. This decision was further implemented in 1920 when the subscriptions of all servicemen were considered paid as up to and including 1920. (The same concession was later applied to those members who served during World War II.)

The periodical difficulties of finance with which the Society had been faced almost since its inception loomed up again in 1922 when it was discovered that printing was 12 months in arrears, with no available funds to bring this essential part oy the Society's activities up to date. After considering many possible methods of overcoming this situation, it was decided to ask the government to undertake the printing of the *Proceedings* and, at the same time, to request authors to condense their papers as much as possible. The government not being willing to undertake the task, it was decided to economize by using a smaller size of type.

Throughout the history of the Society, the one important feature of its activities, the printing of the *Proceedings,* has given the council more cause for concern than any other single item. This is particularly significant when it is realized that the Society has always depended on its *Proceedings* as an exchange medium of literature throughout the world to build up the extensive and comprehensive library for which it has always been known. It is no exaggeration to state that the library has always been the most important single factor in the Society's development, and that no more important collection of scientific literature is housed in the building of any society in Victoria at the present time.

The question of sections, which had been in abeyance for a considerable number of years, was raised when interest within the Society developed around the subjects of mathematics and physics. The interest became so great in 1923 that a new section was formed—the mathematical and physical section—to be concerned specially with mathematics, physics, astronomy and chemistry. The functions were to be chiefly concerned with the development of these sciences as a whole and acquainting its members with the results of latest research work both at home and abroad. The section under the control of 10 councillors, with Professor T. H. Laby as chairman, functioned immediately with special meetings being held for its members, attendances of up to 80 being obtained. After many years of successful operation, this section became absorbed into other scientific societies.

The decision in June 1923, that all papers submitted to the Society should be refereed prior to publication, was a noteworthy one in that it guaranteed the suitability of the material for the *Proceedings.* The only exception to this principle was to be in the case of no suitable referee being available in Australia, when the council would accept responsibility for publication.

A strong deputation to the government in 1923 for increased financial assistance brought immediate results. The deputation asked not only for the restoration of the annual grant but that action should be taken to repair the Society's premises and bind its library periodicals. Following an inspection of the property by the State Treasurer, Sir William McPherson, an assurance was given that the annual grant would be raised to £200, the volumes of the library would be bound by the Government Printer, and repairs to the building would be effected through the chief architect of the Public Works Department. While these negotiations were in progress, a further offer was received by the council through their agent for the leasing of the Exhibition St. frontage for the erection of a garage at an annual rental of £300. The Treasurer of the government, stating that he was opposed to Crown Lands being leased in such a manner, brought about a refusal by the council not only of this tempting offer, but a cancellation of the earlier decision to lease portion of the site. Sir William McPherson's proposals being approved by the government, 800 volumes were bound by the Government Printer free of charge, while plans and specifications of works to cost approximately £1,000 were prepared by the Chief Architect. While the latter was not immediately forthcoming, renovations to the caretaker's cottage and the fencing were carried out expeditiously.

During the period 1880 to 1925, a number of scientific societies had been coming into being in and around Melbourne, each with its own headquarters or sharing the offices of others. Several proposals were put forward that the scientific societies of Melbourne should combine in the obtaining of a common meeting place centrally situated in the city. While the Royal Society in 1924 was not satisfied with its own building or site, it was not anxious to accede to the other proposal either, and perhaps with the good hearing that the last approach to the government had received, decided to seek alternative quarters. The proposal made to the Premier on 29 September 1924 was to exchange the existing site of the Society for a suitable site of 100 ft. by 100 ft. of land in St Kilda Rd. which the government had at its disposal, and for the granting by the government of £10,000 to erect a building there. The figure of £10,000 was stated to be the difference in value of the two sites, so that the proposed exchange would be on an even financial basis. The Premier, however, did not receive this proposal sympathetically, and stated that the Society would be better if it remained on its present site. The Society as a whole, on reviewing this matter, came to the same conclusion, but decided to ask the government to improve the existing buildings by the addition of a lecture hall and suitable offices. A change in government at this time placed such proposals in the background for the time being.

The state of the grounds around the building was also causing concern at that time, not only to the Society, but also to the city authorities who, by letter, insisted that the dead trees around the hall be removed and the fences renovated. This was the first step in a series that resulted, at a later date, in the removal of the fence altogether and the taking over of the maintenance of the lawns and garden by the Parks and Gardens department of the Melbourne City Council.

In 1925, a progressive step was made by the Society with regard to its publications by issuing a memorandum for authors in which was clearly set out those rules that were expected to be followed by contributors to the *Proceedings*. This greatly facilitated the work of the editors and effected an economy in printing.

A notable addition to the council in 1925 was Mr Russell Grimwade who later, as Sir Russell Grimwade, became one of the trustees of the Society. One of Mr Grimwade's first acts as a council member was to present a projector for use in the hall, an instrument which is frequently used at the present day. The value of Mr Grimwade's business ability and experience was evident in the negotiations that immediately followed for the leasing of a certain portion of the site for the construction of buildings that would revert to the Society after a fixed period of years. Like other prospective proposals, however, this also lapsed. Mr Grimwade again showed his generosity by paying the expenses of all these negotiations.

In 1908, an attempt had been made by interested persons to commemorate the late A. W. Howitt, zoologist, geologist, botanist and ethnologist, in some tangible and permanent form. In all, over £100 was raised at that time but, as no concrete ideas were forthcoming, the money was invested. Later, in the year 1923, Sir Baldwin Spencer drew attention to this money lying idle and suggested that active steps be taken in the matter. However, no steps were taken until 1927 when it was decided that the fund should be used for the purchase of rare books on anthropology, petrology or botany for the library, such works to be inscribed 'Purchased from A. W. Howitt Memorial Fund'. It was also decided that the following order of priority be used for purchases: 1st year, anthropology; 2nd year, botany; 3rd year, geology.

The proposal by the National Museum in 1927 that a lecture theatre should be built there for the purpose of public scientific lectures attracted the interest of the council who felt that a combined approach to the government by the two organizations might prove beneficial to having a hall erected on the Society's site. This proposal was not sympathetically received by the trustees of the museum and the matter lapsed.

The earlier work of the Society in relation to the preparation of the International Catalogue of Scientific Literature was brought to the fore again in 1927 when the Council for Scientific and Industrial Research requested the assistance of the Society in the compilation of a catalogue of the scientific and technical periodicals in various libraries. This work has now become essential in all libraries holding scientific and technical journals.

The proposal of the Commonwealth Government that a Commonwealth Natural History Museum be established at Canberra was the subject of a report by a special committee of three, two of whom were members of the Society. At the request of the Commonwealth Government, their report was discussed by council late in 1929 and general approval recorded. However, like so many other worthy projects that have been considered from time to time, no action resulted.

The future of the Royal Society of Victoria and of the sister societies in other States came under review late in 1929. The Victorian Society discussed methods whereby (1) the international status of the Society and of its publications might be increased, (2) Australian papers on a given subject might be made more accessible, and (3) there should be more inducement to publish Australian papers in Australia rather than send them abroad. As a result of these discussions, representations were made to the other societies to consider the following proposals:

(1) The Royal Societies in Australia should combine to form a Federation of State Societies or a Royal Society of Australia.
(2) The Society in each State should hold its own meetings as in the past for the reading and discussion of papers.
(3) In order to conserve State interests, the publication of papers should be divided into six sections, each to be issued under the name of a particular State.
(4) The Federal Council of the proposed new body should co-operate with the National Research Council on matters of common policy.

In reply, the Royal Societies of South Australia, Queensland, Tasmania and New South Wales felt that the subject was worthy of further discussion, and suggested that this might take place in Brisbane at the time of the next A.N.Z.A.A.S. meeting. The Royal Society of Western Australia, in dissenting from the proposal, pointed out that if it were to lose its State identity, grave difficulties could arise.

At the conference in Brisbane, it was agreed that there were two insuperable difficulties in the way of carrying out the suggested amalgamation—firstly, the question of library exchanges, and secondly, the probable loss of grants at present given by State governments. With these obvious difficulties in mind, no further action resulted.

Very shortly after this decision, however, a Royal Society of Australia was formed in Canberra, but not as the result of the above deliberations. This immediately raised a storm of protests from the Royal Societies of several States who felt that such action was most unethical and likely to lead to great confusion, not only with overseas authorities but with local government bodies. The formation of the Australian Academy of Science in Canberra at a later date was welcomed by the Royal Societies as providing an institution more nearly approaching their objectives.

A statement that the Royal Australasian College of Surgeons was interested in acquiring suitable lecture hall and office accommodation in Melbourne brought fresh hopes to the council of the Royal Society that their site would be suitable for the purpose. Accordingly, negotiations were commenced between the two institutions, whereby the College of Surgeons would rebuild on the existing site a large block of buildings in which the whole of the assets of the Royal Society would be housed in return for a certain annual rental and a long-term lease of the site (999 years). Negotiations were proceeding satisfactorily until, in 1932, the State Government offered the Royal College of Surgeons, at a nominal rental, the old site previously occupied by the Melbourne High School. This offer being accepted, negotiations between the two institutions ceased.

With the *Proceedings* of the Society approaching its 50th volume, the desirability of compiling a general index to the first 50 volumes became obvious. It was agreed that this work should be carried out on similar lines to that of the Geological Magazine. Failing the obtaining of financial assistance from outside the Society, it was proposed that the work be carried out by volunteers who would each take a number of volumes. This again proving impracticable, the honorary librarian submitted an author index for the period covering 80 years of publications, which was gratefully accepted and published.

The long period of printing the *Proceedings* by Ford and Sons received a temporary set-back in 1931 when, because of further financial difficulties, the Society was compelled to seek the further assistance of the government. There being little possibility of receiving additional money, the proposal that the Government Printer print the *Proceedings* at a concession was accepted by the Society. The government finally agreed to accept the responsibility for £100 of work with the printer, the Society to pay the balance. This arrangement continued for a number of years.

The publication in 1935 of the Pitt-Mund report on the libraries of Australia brought the inadequacy of the housing of the library of the Royal Society into prominence. The suggestion that the library be transferred to the Public Library for housing and administration was vigorously combated by the council as not being in the best interests of the Society. However, the report served a very useful purpose as it drew attention to the state of the valuable library and forced the council to take steps to improve its housing by the provision of additional steel shelving.

In appreciation of the valuable services rendered to the Society by the late Dr T. S. Hall at the turn of the century, the honorary librarian, Mr F. A. Cudmore, in 1936, donated a sum of money to be known as the 'T. S. Hall Memorial Fund'. The sole object of this fund was to be the improvement of the library, except that in the case of urgent need it could be used for the preservation of the library. Its primary purpose was to complete the holdings of periodicals, and secondly to ensure the forwarding of entries to the Council for Scientific and Industrial Research Catalogue of Scientific Periodicals. This fund opened up the way for the completion, in the following years, of a number of series of periodicals in the library.

When the Society's holdings were being checked with reference to the above memorial fund, it was discovered that there were over 8,000 volumes awaiting binding. In contrast to this, only 5,400 volumes had been bound. In order to overtake some of this enormous accumulation of unbound material, a special appeal was made to members for funds for bookbinding. This brought a ready response, £60 being received immediately, allowing a commencement to be made. This was augmented at once by a credit of £100 with the Government Printer by the State Director of Finance, who repeated the grant for a number of years. The bookbinding fund as such became exhausted late in 1938.

The increasing costs of publication of the *Proceedings* caused the council, in 1938, to take firm measures to prevent persons joining the Society solely to have particular papers published. The following resolution was adopted:

> Before papers are accepted for publication wholly or partly at the charge of the Society, the length of period of membership of their authors should be examined, and that where the author has not been a financial member or associate member for a period of 5 years, he or she should be asked to give a written undertaking to retain his or her state of financial membership until it shall have extended over a period of at least 5 years.

At the same time, it was affirmed as a general principle that universities and government departments should contribute in part, or in full, to the cost of publication of papers submitted by their officers. This principle, receiving the support of the institutions concerned, assisted the Society greatly in following years in its financial commitments.

A review of the conditions of tenancy of the triangular section of the site by the Meteorological Bureau, first executed in 1907, resulted in the annual rental being raised in 1938 from £50 to £100.

The suggestion, emanating from the Field Naturalists Club, that an annual award should be made in Australia to the person who does the most for the elucidation of the Australian flora and fauna, was strongly supported by the Royal Society. This resulted in 1939 in the gift of the Natural History Medallion by Mr J. K. Moir, of Melbourne, to be awarded annually on the terms mentioned above. The president of the Royal Society became *ex officio* a member of the award committee. In the years that followed, a number of distinguished members of the Royal Society were to receive this coveted award.

In 1940, the Society approved the principle of controlling the export of specimens of natural history, and presented to the Commonwealth Government a recommendation which had been agreed upon unanimously by the Royal Societies of all States and by the Linnean Society of New South Wales. Specific reference was made to the need to preserve Australia type specimens within Australia. As a result, appropriate regulations were made under Commonwealth law to prevent such trafficking without the permission of the museum of the State from which the material was being exported.

The advent of World War II led to difficulties in the forwarding of the *Proceedings* to overseas recipients. It became necessary to inform overseas societies that, in future, copies would only be forwarded on request, and then at the recipient's risk, with little or no chance of replacement.

The war also caused other problems to the Society, such as war insurance of the building and contents, A.R.P. measures, and the obtaining of permits for the supply of paper for printing the *Proceedings*. The taking over of the Society's hall by the Royal Australian Air Force for lectures in meteorology considerably inconvenienced the Society, but this was partly offset by the receipt of a rental of £100 per annum for its use, dating from 1 July 1942. A month or so later, a further sum of £52 per annum for the use of a downstairs room was received from the same source.

A proposal in 1944 by Royal Societies of several States in Australia that reciprocal benefits should be available between States to their members was agreed to in principle as being in the best interests of the scientific life of the community.

In 1945 it became evident that, with the rapidly increasing library and with the renewed interest in the Society, the buildings were not adequate for the requirements of the Society. A number of suggestions were forthcoming, one of which was that the Society should claim from the Commonwealth Government exemption from income tax of gifts to the Society. The Federal Treasurer declined to approve, and the Society was forced back to consider further the leasing of the site.

The book-binding fund, which had been closed down in 1938, was re-opened in 1946 when, in addition to a sum of money set aside by the Society, money was received from commercial organizations for this purpose. This enabled some reduction in the large number of volumes awaiting binding. An attempt in the same year to have the credit of £100 per annum with the Government Printer transferred to an outright grant to the Society was refused. This was disappointing to the council who had hoped to use the money for printing the *Proceedings* in an attempt to overcome the time lag in publishing. However, the transfer to a cash grant was not long in coming, as it was effected during 1948.

The resignation of Dr F. L. Stillwell as honorary secretary early in 1947 was received by the Society with great regret. Dr Stillwell had occupied this very important post for over 18 years, a longer period than any previous secretary. During his secretaryship he had had to contend with the effect of the economic depression on membership and publication of the *Proceedings* and later, during the war period, the irregular despatching of publications throughout the world. The fact that this work was well done and the Society made progress during these difficult times speaks well for Dr Stillwell's ability and devotion to the Society. In recognition of these services, Dr Stillwell was elected an honorary life member. The Society, however, did not lose the benefit of Dr Stillwell's experience as he retained his seat on the council.

The raising of the government grant to £200 in the 1949/50 budget was welcomed as it enabled arrears of binding and printing to be commenced. The remission of stamp duty the following year brought some further relief.

Early in 1951, preliminary discussions commenced between the Society and the Australasian Branch of the Royal College of Obstetricians and Gynæcologists concerning possible alterations to the building and the grounds which would be of mutual benefit. After considerable discussion, a plan was mutually agreed to which entailed additions to the S. side of the building to make it square in plan but, at the same time, preserving a unity of design and materials. On the ground floor, the old supper room was to be completely remodelled and available to both institutions for use, while the additions on the S. side were for the sole use of the Royal College. On the upper floor, the lecture hall was to be remodelled and refurnished, while the library was to be refurnished and available for the Royal College as a council room. The additions to the SE. corner on the first floor were for the expansion of the library of the Royal Society. The whole of the cost of the alterations and the refurnishings, amounting to over £20,000, was to be met by the Royal College in return for a long-term lease of the site. The details finally receiving the approval of both societies and the government, work commenced on the project early in 1953. While the alterations were in progress, the Royal Society used the geology department of the University of Melbourne for its monthly meetings. In order to cover the new building against damage in any way, an insurance of £30,000 was effected, this contrasting sharply with the original valuation of the property at £4,000 in 1892.

Because of the declining finances of the Society and the necessity for raising more funds for incidentals following the alterations, the council in 1953 was forced to raise annual subscriptions from £2.2.0 to £3.3.0 for members, and £1.1.0 to £2.2.0 for associates, with corresponding increases for life membership. This was actually the first increase in membership fees since the foundation of the Philosophical Institute in 1855.

The death of Professor E. W. Skeats in January 1953 brought to a close many years of service to the Society, firstly as a member, secondly as a councillor and president, and later as a trustee. Professor Skeats made a considerable bequest to the Royal Society to be used for any purposes which the council thought fit. Such bequests are commonly found among English scientific societies, but have been markedly absent in the Australian counterpart. They are extremely important and valuable to such a society, as they enable specific problems to be undertaken which would be impossible under normal circumstances.

The same year saw the resignation through ill-health of Mr F. A. Cudmore, honorary librarian from 1926. A meticulous worker and one who thoroughly appreciated the importance of this library in the scientific life of the State, Mr Cudmore was also responsible for the compilation and publication in 1934 of the author index of the *Proceedings* of the Royal Society and the earlier societies. Mr Cudmore bequeathed a considerable sum of money to the Society to be used for part payment of the salary of a trained librarian.

With the centenary of the Royal Society approaching, it was agreed to publish a special centenary volume, which would be partly historical and the remainder papers. An approach to the government for special funds for this purpose was not successful, but their annual grant was raised to £500 at this time.

The work of the new building progressed so rapidly that arrangements were made for the official opening of the new block on 25 August 1954 by His Excellency the Governor of Victoria, Sir Dallas Brooks. Prior to this opening, an agreement concerning the grounds was made which ended all the previous worries concerning this part of the property where outbreaks of fire had occurred during the summer months. The agreement was made with the Melbourne City Council whereby, in consideration of the Royal College putting the grounds in order and installing an adequate watering system, the Parks and Gardens department of the City Council would take them over and maintain them free of charge.

The visit to Melbourne of His Royal Highness the Duke of Edinburgh at the time of the Olympic Games was made the occasion, on 3 December 1956, for a symposium at the Royal Society on the subject 'Australia's part in the geophysical year in the Antarctic'. His visit to the Society in 1956 recalled the previous visit of an earlier Duke of Edinburgh to the Society in 1867. At this symposium, His Royal Highness officially opened the proceedings with an address on the importance of the Antarctic continent. Other addresses were delivered by Sir Marcus Oliphant, president of the Australian Academy of Science; Sir Douglas Mawson, 'Australian Links with Antarctica'; Mr P. G. Law, 'Australian National Antarctic Research Expedition'; and Dr D. F. Martyn, 'Australia and the International Geophysical Year'; and the whole of the proceedings published in the form of a special symposium volume. On the same occasion, His Royal Highness conducted an investiture in the Society's hall at which 23 polar medals were conferred.

It was a very happy coincidence that the date of the centenary of the Royal Society of Victoria (November 1959) coincided exactly with the centenary of the publication of Charles Darwin's immortal work *The Origin of Species*. It was therefore very fitting that any celebrations that were to be planned should combine both centenaries.

In addition to a centenary soirée that was held at the Royal Society's hall on 12 November 1959, at which historical documents and specimens were exhibited and a short historical paper read, a centenary symposium was held from 7-11 December 1959, the overall subject being 'The Evolution of Living Organisms'. For this symposium, the guest lecturer was Professor Ernst Mayr, Agassiz Professor of Zoology at Harvard University, U.S.A. On 7 December, at the University of Melbourne, Professor Mayr delivered the first 'O. W. Tiegs Oration', established in memory of a former councillor and chairman of the library committee, on the subject 'Accident or Design? The Great Paradox of Evolution'. In the discussions which were held during the following week, contributions were made by eminent evolutionists from all countries of the world, the papers being later issued in the form of a special publication by the Melbourne University Press.

This symposium was a most fitting conclusion to the first hundred years of service to science of a society founded by men of vision in a young colony seething with the excitement of a major discovery of gold.

May the second hundred years of the Royal Society of Victoria be just as rich, not only in scientific achievement but also in service generally, to a rapidly growing nation with the potential for major contributions of world importance.

Let Baron von Mueller's aim, so aptly stated in 1859, at the first meeting of the first hundred years of the Royal Society—'Concord and Progress'—be the motto for the Society from 1959 to 2059.

Acknowledgements

Grateful acknowledgement is made to the council of the Royal Society of Victoria for permission to peruse the minute books of the council and Society since their inception, and to the trustees and staff of the Public Library of Victoria for assistance with archive material and illustrations.

Explanation of Plates

FRONTISPIECE

Sketch of River Darling by Ludwig Becker, January 1861, on Burke and Wills Expedition. (Courtesy: Trustees of Public Library of Victoria)

PLATE I

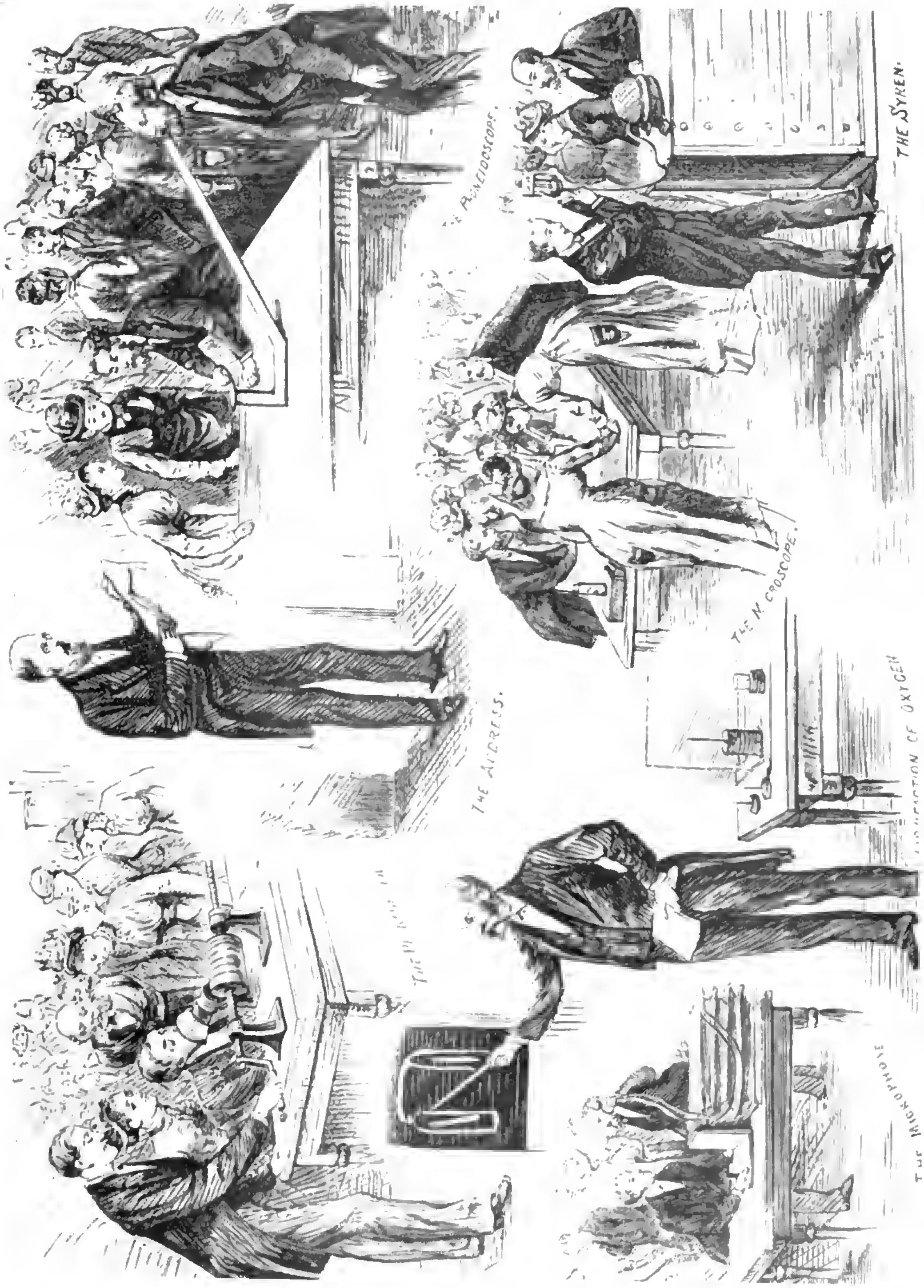
Conversazione of the Royal Society, 8 August 1878, with Professor Ellery delivering the presidential address. (From *Illustrated Australian News*)

PLATE II

Royal Society Hall, about 1900. Note dead trees which were the subject of controversy with Melbourne City Council.

PLATE III

Royal Society Hall, 1959. (Courtesy: Department of External Affairs Antarctic Division)


THE SYREN.
THE ADDRESS.
THE MICROPHONE

2

BOTANICAL SCIENCE IN VICTORIA 100 YEARS AGO

By J. H. Willis
National Herbarium of Victoria

[Read 8 October 1959]

Any attempt to discuss the state of botanical science in Victoria 100 years ago might well be introduced by some account of the attainments in this field up to, say, 1850—i.e., before the discovery of gold, and only 16 years after the first permanent settlements at Portland and Melbourne. Those pioneer settlers, needless to say, had very little time to spare for botanical pursuits, or for any other purely academic studies. What little we do know about Victorian plant life prior to 1850 comes entirely from published reports of the very few visiting British explorers and a couple of local pastoralists whose collections were all sent back to England. There was no local expert or herbarium to receive such material, and no institution in the young colony for fostering botany.

Earliest in the field was Robert Brown, friend of Sir Joseph Banks and naturalist to Captain Matthew Flinders on the *Investigator* which sailed into Port Phillip at the end of April 1802. Brown lost no opportunity to go ashore while his ship remained inside the Heads for a week; but, although he climbed Arthur's Seat, little could be found in flower so late in the autumn. He returned to Port Phillip in January 1804, and spent another week collecting in the vicinity of present-day Sorrento during the abandonment of Collins's unsuccessful attempt at settlement there. The full extent of these first botanical collections from Victorian soil is not known; but we have evidence that Brown gathered from (or noted) about 100 species, 18 of which provided him with the type material of undescribed plants.

Even more important are the gatherings of Major T. L. Mitchell, made in the W. half of Victoria, and particularly the Grampians, between June and October 1836. Professor Lindley worked up this collection in London, describing 40 out of at least 150 numbers as species new to science. Several of Mitchell's plants had already been discovered around Port Phillip Heads by Robert Brown, so that no more than 180 species accrued from the combined efforts of these investigators. Ronald C. Gunn and James Backhouse independently visited S. shores of Victoria (chiefly Port Phillip) between 1836 and 1838; a few plant specimens were taken by each, but the number has never been assessed and their effect in elucidating Victoria's flora was inconsequential.

F. M. Adamson, a settler near Melbourne from 1840 to 1855, sent plant specimens to Sir William Hooker at Kew, England. Simultaneously, J. G. Robertson built up a plant collection of 4,000 dried specimens at Casterton where he managed an early pastoral holding; they were presented to Kew Herbarium upon his return to Britain in the mid-1850's. These, apparently, were the first botanical contributions by residents within the colony, but none of their material remained here.

It is doubtful whether more than about 500 plant species had ever been collected in Victoria before 1852. During the winter of that year a youthful German migrant, Dr Ferdinand Mueller, was attracted from Adelaide to the Victorian gold-fields, his objective being to establish a pharmaceutical business among the new diggings in Castlemaine district. Also at this time Lt-Governor LaTrobe was looking for a capable man who would act as colonial botanist and undertake a thorough survey of the country's vegetation.

Dr Mueller's enthusiasm for botany equalled, if not exceeded, his interest in chemistry. He had obtained a doctorate of philosophy at Kiel University through a treatise on the familiar weed, Shepherd's Purse (*Capsella bursa-pastoris*) and, immediately upon arrival at Adelaide in December 1847, he began to investigate the South Australian flora, journeying as far afield as Rivoli Bay to the S. and Lake Torrens in the N. The strange new plants of his adopted country held endless fascination for young Mueller who published a preliminary account of their broader features in 1850—'The Murray-scrub botanically sketched'. It was to be the forerunner of some 800 papers and major works on Australian botany that flowed from his pen during the next 46 years. Although concerned with South Australia, this first small paper could apply almost equally to the Mallee areas of NW. Victoria. Queensland's greatest botanist, Frederick Manson Bailey, once paid this remarkable tribute:

> 1847 must, for all time, be looked upon as the great apoch of Australian botany . . . . it is due to his (Mueller's) zeal in the cause, and indefatigable labour, that the way of the botanist at the present time is so plain and easy.

By the time he came to Victoria, Mueller had made a favourable impression on the leading botanical men of W. Europe, both through his writings and donations of dried material. Thus, Sir William Hooker of Kew recommended his appointment as the first full-time Colonial Botanist of Victoria, and late in January 1853 he assumed office.

From then onward the story of botanical science in Victoria became identical with the personal activities of Ferdinand Mueller; he was virtually alone in the field.

So much has already been written about his exploits, his researches, his diverse interests and extraordinary powers of application, that it would be redundant to enlarge upon them now; but one may be pardoned, perhaps, for referring to one or two notable achievements of just a century ago.

The most meagre information and equipment confronted Mueller as he began work in 1853—even the few previous collections of Victorian plants were all overseas and thus inaccessible to him. Within 6 weeks of appointment he was away exploring the unknown alpine fastnesses of Mt Buffalo and Mt Buller by packhorse; thence he crossed the intervening mountainous terrain to the Latrobe R. and Wilson's Promontory, and so back to Melbourne along the coast—a 3 months' trip of about 1,500 m. Toward the end of the same year he undertook a far more ambitious journey, covering 2,500 m. and lasting 5½ months. This was W. from Melbourne to the Grampians, across to the Avoca R. sources and down that stream almost as far as the Murray, then W. again to Lake Lalbert and through Mallee scrub to Swan Hill, down the Murray to Wentworth and then back up the river to Albury, along the Mitta Mitta to Omeo, the rugged Cobboras peaks (6,000 ft.), down the Snowy and E. across the various Gippsland rivers to Melbourne. He had by now been practically all round the colony, and what a harvest these two first journeys yielded! The combined 4,000 m. trek of 1853/54 acquainted Mueller with 1,500 species of higher Victorian plants, many being hitherto unknown to science.

August 1854 witnessed the inauguration of the Philosophical Society of Victoria, precursor to the Royal Society, and Mueller was a foundation member (later president). The *Transactions* of this body began to appear in 1855, providing a local medium for him to describe the impressive array of botanical novelties gleaned from his explorations; but so pressing was the need for more and more descriptive work that Mueller seized upon any possible vehicle for publishing his researches—overseas journals of botany, pharmacy journals, natural history magazines, parliamentary reports, and even newspapers on gardening. At the time of his death this nestor of botany had published diagnoses for some 2,000 new species of Australian plants.

For 18 months during 1855/56 Mueller was away in the tropics as botanist to A. C. Gregory's North Australian Expedition—a venture that added further lustre to his name and a spate of plants to his private herbarium. In 1857 he not only became 3rd Director of the Melbourne Botanic Gardens, but secured a building therein to house his dried specimens which were simultaneously handed over to the Government; this step marked the beginning of Melbourne's modern State Herbarium, now embracing about $1\frac{1}{2}$ million sheets of specimens.

In 1858 the collection numbered 45,000 specimens, by 1861 it had risen to 160,000, and Mueller's estimate in 1868 was of 350,000—a phenomenal achievement for one man in just 15 years' endeavour. With justifiable pride he reports thus to Parliament (30/9/1865):

> It is gratifying to reflect that for independent phytographic researches now in Australia more extensive means and greater facilities exist than in many of the metropolitan institutions of an analogous tendency in Europe.

By the end of his life he had left remarkably little for succeeding field botanists to discover in Victoria; and the few mistakes he made serve only to throw his innumerable great accomplishments into sharper contrast. Two laughable 'bulls', discovered in recent years, are Mueller's description of the withered contorted flowers of an inland mallow as the fruiting structures of a new blue-bush (*Kochia* sp.), and the relatively large capsules of an ephemeral ground moss as fruits of an undescribed and unusual member of the flowering purslane family! For the sake of brevity, his earlier field labels were often written in Latin, and the habitat notes on some of these are almost lyrical, e.g. 'growing near perennial springs and irrigated by the melting snow'.

In April 1863, after just a decade in the Victorian Public Service, Mueller stated that 'the botanical investigation of the territory of our colony is now nearly completed'. But his investigations had extended far beyond Victoria, including identification of the plant collections brought back from such major expeditions as those of Leichhardt, Gregory, Stuart, Burke and Wills. Many similar assignments were to engage his attention in the succeeding three decades, as he made contacts with the remotest corners of the Continent and even the highlands of New Guinea. Apart from his critical taxonomic faculties, Mueller also looked upon vegetation through the eyes of the geographer, the forester, agriculturist and pharmacist.

He was deeply concerned to find out how plant life, native and exotic, could best be made to serve the needs of man. Thus he secured 24 kinds of timber from Wilson's Promontory for the Melbourne Exhibition of 1854, and in 1858 he published a paper 'On a general introduction of useful plants into Victoria'. Also, during 1857/58 he distributed 7,120 living plants and 22,438 packets of seed to gardens throughout the colony. Next year he introduced, among other plants, the now very widely grown and important Monterey Pine (*Pinus radiata*). Sometimes his enthusiasm for acclimatizing alien plants 'back-fired', as when in March 1862 he reported making available to various districts in Victoria the British Blackberry 'which proves to be remarkably prolific'—many bramble-ridden land-owners would now agree that, in the annals of the State, 1861 was not a year of unmixed blessing.

Mueller was absorbed with the commercial importance of eucalyptus oil, and was in close contact with Joseph Bosisto who established a factory for large-scale extraction at Western Port in 1862. He furnished barks and other parts of plants to Professor Wittstein in Munich for investigation as to their chemical and therapeutic properties. He advocated extensive planting of New Zealand flax which 100 years ago was realizing £20 a ton in London as raw material. He gave early lectures on rust in cereals, and wrote on a very wide range of economic subjects—e.g. plantations to mitigate drought, control of sand-drift, vine diseases, medicinal plants and the growth of cinchona in Victoria, poison plants, forest conservation, the potash status of soils, etc.

His departmental correspondence sometimes rose to 3,000 letters a year, in an age when typewriters and stenographers were unknown. Between 1858 and 1882 he published 94 fascicles of the *Fragmenta Phytographiæ Australiæ*, which has the distinction of being the only Australian scientific periodical ever to appear entirely in Latin. In 1861 began that fruitful collaboration with George Bentham in England which resulted in the great *Flora Australiensis*—7 volumes, completed in 1878 and still remaining the standard reference work on the vascular vegetation of the whole continent.

Mueller's botanical attainments of a century ago are even more astonishing when it is borne in mind that he was *ex officio* Director also of the Zoological Gardens; there he was expected to introduce and acclimatize animals that would benefit the country's primary industries—e.g. llamas and alpacas from South America, the wool clips of which were carefully measured and recorded.

His labours in the cause of science earned for him a hereditary barony from the King of Würtemberg in 1869, and a K.C.M.G. from Queen Victoria in 1879. Thereafter he was Baron Sir Ferdinand von Mueller. Governments of 18 other countries also honoured him with knightly orders and he became a doctor 5 times over. He held membership with some 150 scientific and learned bodies throughout the world. C. R. Blackett, president of the Pharmacy Board of Victoria, spoke thus of Mueller in his obituary to the *Australasian Journal of Pharmacy*, 20/10/1896:

> If Australian science is recognized in Europe, we may confidently say that it is chiefly through the labours and genius of the Baron. He was an honorary member of the Pharmaceutical Society of Australasia; he had a vast amount of knowledge in pharmacy, and nothing gave him more pleasure than the progress of pharmaceutical education.

Botanical teaching and research at the middle of last century, not only here but in Britain, was practically confined to the systematics of flowering plants and ferns—their gross morphology, taxonomic arrangement and nomenclature. Darwin's cataclysmic *Origin of Species* appeared in 1859, and his friend Sir Joseph Hooker was at once a doughty champion of evolution; but Mueller would have none of it. His sentiments are expressed in a report dated 30 September 1865:

> That through want of extensive field studies, untenable limits are assigned to a vast number of supposed specific forms admits of no doubt whatever, and it is equally evident that the vain attempt to draw lines of specific demarcation between mere varieties or races . . . has largely tended to suggest the theory of transmutation, a doctrine against which . . . I have expressed, though cursory still unequivocally, a dissenting opinion.

About 1872 the illustrious trio Huxley, Dyer and Vines are said to have 'changed the face of British botany' by lecturing at the Normal School of Sciences, South Kensington, on such neglected subjects as cryptogams, palæontology, cytology and physiology. Experimental pathology did not come into its own in Britain until the teachings of H. M. Ward from about 1880; ecology sprang into prominence under the Danish leadership of Warming from 1895; while the genetic approach in botany is even younger, stemming from about 1900 when Hugo de Vries, Correns and others introduced to the world those laws of heredity propounded by the brilliant experimenters Naudin and Mendel, who both wrote of their researches during 1865. In all these trends away from purely floristic botany, Australia has probably been slower to adopt modern disciplines and techniques than the United Kingdom.

An amusing episode from the botanical stage of early Victoria concerns one William Swainson, a visitor from New Zealand who was engaged by Lt-Governor LaTrobe in September 1852 (just prior to Dr Mueller's appointment as first colonial botanist to 'pursue investigations into the botanical character of Australian trees'; the salary was to be £350 per annum, with travelling expenses. There is no indication that Swainson and Mueller ever crossed paths (or swords), but each must have been aware of the other's activities. A year later (2/10/1853) Mr Swainson made an extraordinary report to Parliament, setting out the 'result of my botanical investigations in this province'. He claimed to have collected 1,520 species and varieties of *Eucalyptus* and 200 species of *Casuarina,* calling the latter 'Australian pines'.

With reference to the eucalypts he remarked: 'not many more than 40 species, I believe, have been published as inhabiting the whole of Australia'. As a matter of fact, 80 perfectly good species had been described up to 1852; but doubtless the works, in which some of these appeared, were not available to Swainson. He continued thus:

> Without taking too much credit to myself, I feel satisfied that these discoveries will be regarded with as much surprise, and almost incredulity, amongst the botanists of Europe as was that of gold in Australia amongst the geologists of Britain!

Sir William Hooker's 'incredulity' was expressed in a letter to Mueller, dated 9/4/1854:

> If I were pleased with your report, I cannot say that I gave to our Secretary for the Colonies an equally flattering account of Mr. Swainson on the Gum Trees!!! In my life I think I never read such a series of trash and nonsense. There is a man who left this country with the character of a first-rate *naturalist* (though with many eccentricities), and he goes to Australia and takes up the subject of Botany of which he is as ignorant as a goose. I only wait for a spare page in my journal to show that he really is so. It was stated in a Sydney paper that Swainson received £800 for writing all that nonsense.

Later in the year Hooker devoted four pages of his journal to Swainson's amazing report, and summed it up neatly in one sentence:

> This singular document concludes with a catalogue of Latin and English names, numbering 213 species of *Casuarinæ* . . . all new, and all named and described by Mr. Swainson 'without a single book to refer to'.

3

ANTHROPOLOGY IN VICTORIA 100 YEARS AGO

By D. J. Mulvaney

[Read 8 October 1959]

Victoria's aboriginal population in 1835, contemporaries estimated, numbered upwards of 5,000 (Smyth 1878, 1: 31-38). It was a closely knit tribal society in which a balance was maintained between food supply and the nomadic hunters and gatherers. European settlement destroyed this balance and with it the tribal organization. Within 15 years there were probably fewer than 3,000 detribalized aborigines, and by 1861 their number had dwindled to 2,000. By this date, most of the survivors lived in remote and unsettled areas of the colony, while only 370 aborigines were distributed over the plains of W. Victoria and Port Phillip; between the years 1838 and 1858 membership of the Yarra tribe fell from 300 to 32.

In 1858 the Victorian Government appointed a Select Committee of the Legislative Council 'to enquire into the present condition of the aborigines . . . and the best means of alleviating their absolute wants'. The committee, moved by sincere humanitarianism and a recognition of the moral obligations of colonists towards the dispossessed aborigines, questioned responsible witnesses verbally and by questionnaire. Its report, together with the evidence of witnesses and the written replies to 89 questions concerning aboriginal society and its future prospects, was published in the *Votes and Proceedings of the Legislative Council* for 1858/59. The committee expressed the hope that their findings would 'form one of the most valuable historical documents extant connected with Victoria, and be prized by the learned societies of Europe . . .' (*Report*: V). It certainly appeared at a germinal period in the development of anthropological thought, yet their report made no impact on academics overseas and, in Victoria, despite the implementation of their recommendations, the decimation of the aboriginal population continued. When, in 1877, a Royal Commission was appointed to investigate aboriginal welfare, only 774 aborigines of pure descent survived throughout the colony.

A century ago, there were basic limitations in the assumptions of European observers of all primitive societies and in their methods of studying them. In their obvious failure to gain insight into aboriginal psychology and social cohesion, the Victorian committee and its witnesses were typical of the well-meaning but ineffectual approach which characterized the pre-Darwinian era of anthropology. It is, e.g., more surprising to note that one witness advised the committee to question an aboriginal who 'possessed a great deal of valuable information', than that his comment was ignored (*Evidence*: 12).

Perhaps the greatest influence in the intellectual climate of the time, was the acceptance of *Genesis* as the basic document of prehistory. Primitive man, and all ancient civilizations, had to be assessed within a time-scale which began in 4004 B.C. The newly deciphered scripts of Egypt and Mesopotamia had confirmed Classical Greek traditions of the remote antiquity of the great oriental empires, and consequently, it was difficult to envisage any time-interval between Creation and Civilization in which to place the stone-using societies. Whereas post-Darwinians looked upon such peoples as archaic remnants of man's first strivings towards technological and cultural progress, in 1859 they were usually judged as degenerations from the supposed earlier civilized condition of mankind. In an individualistic age of self-help, slothful races, who had forsaken accepted living standards and had deliberately sought the exterior darkness of the far corners of the world, excited little sympathy.

As upholders of Christianity during a period of rather formalized and self-righteous moral conduct, mid-century Europeans judged primitive society by their own code of behaviour. It is not surprising that, when the aborigines were assessed by these criteria, they were found wanting. When the Victorian Select Committee asked—'are the [aborigines] addicted to religious observances?', 10 replies were emphatically in the negative, while another witness considered that a few 'remnants' remained (*Evidence*: 69-70). Some years earlier, a missionary had remarked of the Tasmanians, that 'all moral views and impressions . . . every idea bearing on our origin and destination as rational beings seems to have been erased from their breasts' (Dove 1842: 249). His opinion was echoed, amongst others, by an Assistant-Protector of Victorian Aborigines, who concluded that 'in the licentiousness of their lives they are as men of Sodom, sinners exceedingly' (Dredge 1845: 12).

These judgements, which condemned the aborigines as the justly punished dregs of heathen antiquity, left tribal society without function or purpose, because they denied the existence of its non-material bonds. The implications of this attitude are everywhere apparent in contemporary sources, and the 1858 Select Committee was no exception. When a witness, W. Hull, was asked his explanation of the mortality amongst the aborigines, he answered:

> I believe that it is the design of Providence that the inferior races should pass away before the superior races, and that independently of all other causes, since we have occupied the country, the aborigines must cease to occupy it. (*Evidence*: 9)

It is significant that Hull was author of a book, in which he traced the descent of the aborigines from ancient oriental civilization (Hull 1846). A comment in similar vein was made in 1853, in correspondence between a squatter and the Bishop of Melbourne (Bride 1898: 275). Providence was invoked, with some emphasis, by the contributor of an article on the aborigines in an English geographical dictionary:

> We are bold to say, that the least and worst of the settlements founded in this vast continent, has a thousand times more of all that dignifies, exalts, and adorns humanity, than ever was possessed by its entire aboriginal population. To complain of the disappearance of the latter, is . . . hardly more reasonable than it would be to complain of the drainage of marshes or of the disappearance of wild animals. (McCulloch 1854, *1*: 230)

In this mid-century atmosphere of prejudice and dogmatism it is not surprising that the pseudo-science of phrenology flourished. The advice of a Melbourne practitioner, sought by the 1858 Select Committee, was not encouraging. The combination of aboriginal temperaments, he concluded—

> renders them rather deceitful, suspicious, time-servers, or dissemblers. They are comparatively quiet and inoffensive as long as their own traditions . . . are not attacked; then they are cruel, as moral and intellectual weakness ever will be. The sides of the forehead offer the greatest possible contrast with the Grecian or artistic skill. Arts, manufactures, constructive emulation, hopeful and striving . . . hardly exist in their mind. . . . (*Evidence*: 46-8)

As exiles from Europe in the era of the National State, colonists optimistically envisaged the emergence of colonial nations; the National Museum and the Royal

Society of Victoria were building within the year of the Select Committee on aborigines. Europeans found it hard to comprehend the confined area of Victorian tribal territories and the sparseness of their population; the complexity of their social organization was seldom realized. The result was that observers continually sought larger political units or 'nations', and usually elevated some tribal elder to the dignity of the monarchy. But there was no respect, and much amused contempt, embodied in a title such as 'King Billy'.

It is not surprising that the Select Committee at first advocated a compulsory re-settlement of all Victorian aborigines in the one district. A similar policy had already completed the extermination of the Tasmanian aborigines, by transferring them to Flinders I. in 1835. Even George Grey, a sympathetic student of the aborigines, considered that enforced detribalization was the only profitable native welfare policy (Grey 1841, *11*: 217 ff). The Select Committee 'reluctantly abandoned' this convenient administrative plan in the face of opposition from William Thomas, Guardian of Aborigines, who assured members that 'the blacks would not leave their own hunting grounds, and would pine away at once if removed from them' (*Report*: V). Subsequently, however, the aborigines were encouraged to settle on government or mission stations, whose location took little account of tribal loyalties. There are few authentic records of the reactions of Victorian aborigines to their detribalization and, because of the insight it provides into the close relationship between the aboriginal and his land, the following letter is quoted extensively; it is testimony to the correctness of Thomas's assessment. On 7 January 1877, Jackey White, an aborigine on the Lake Condah Mission Station, in the Western District, wrote to Samuel P. Winter of "Murndal', near Hamilton:

> 'I want to come back to Wannon', he stated, and he continued, 'I knew you ever since I was a boy you used to keep us live I recollect about thirteen or fourteen years ago when you used to travel about five or six miles to bring us to your place, so will you be obliged to write to the government to get us off this place, so if you will write to the government for us, and get us off here, I will do work for you and will never leave you so I wish you get us off this place, I always wish to be in my country, and to be in my country where I was born, I am in a mission Station and I dongnt like to be here, they always grumble and all my friends are all dead, and now we are old, and I am now miserable, all the Wannon blackfellows are all dead and I am left, my poor uncle Yellert Perne is dead he was quiet young where he came hire when I see his grave I always feel sorry, I can't get away without leaf from the government. This country don't suit me I'm a stranger in this country I like to be in my country . . .' (Quoted by courtesy of W. L. Winter-Cooke Esq. of 'Murndal'.)

By 1859, Thomas had had 21 years' experience of living and working with the aborigines, and he understood them better than any man in the colony. He would have understood the significance of the pathetic outburst by the aborigine, Derimut, reported by W. Hull to the Select Committee (*Evidence*: 12). Derimut accosted Hull outside the Bank of Victoria and begged him for money.

> 'You see, Mr. Hull', he said, 'Bank of Victoria, all this mine, all along here Derimut's once, no matter now, me soon tumble down.' I said, 'Have you no children?' and he flew into a passion immediately. 'Why me have lubra? Why me have picanniny? You have all this place, no good have children, no good have lubra, me tumble down and die very soon now.'

Because of his limited linguistic knowledge and complete lack of anthropological training, even Thomas shared some of the assumptions of his contemporaries. For example, at the 1858 Select Committee enquiry he betrayed lack of comprehension of aboriginal religious life. In his own manuscript writings, which are preserved in the Mitchell Library in Sydney, his comments frequently indicate his ignorance of the motivation for aboriginal behaviour and typify the barrier between the European and the aboriginal cultural inheritance. A note of exasperation was recorded by Thomas in his diary on 10 August 1846. On that day his influential aboriginal friend, Billibellary, died. The men of all Port Phillip and Western Port tribes had assembled previously around his death-bed. They had come, Thomas noted:

> to determine the cause of Billibellary's approaching dissolution, the result of their deliberations was that about eighteen months back the Goulburn Blacks had found out where Billibellary deposited some hair he had cut off, they had dug it up and mixing it with kidney fat had greased their weapons and then put the remainder in the fire. Notwithstanding some very sensible blacks were present, yet these strange infatuated notions were in despite of all reasoning . . . and the dying man felt some alleviation of his short breathings in the awful threats of those who surrounded him to avenge his death, the destruction of many Goulburns.

A century later, misunderstanding and ignorance of the aboriginal mind is still widespread. However, adequate training in social anthropological methods has enabled some anthropologists, particularly Stanner (1958), to comprehend the spiritual values of aboriginal life. But social anthropology stemmed from the post-Darwinian analysis of man's place in nature. In the year of *Origin of Species,* the European ideological legacy conditioned the attitudes of even the most sympathetic observers and inhibited an understanding of aboriginal society and the formulation of suitable welfare policies. It has been shown elsewhere (Mulvaney 1958), that this resulted in a concentration upon the superficial record of material factors; the dying race took with it to the grave the secrets which had preserved its social cohesion in the centuries before European dominance.

It must be emphasized that, in 1859, Victoria had been founded a mere quarter of a century. In this frontier society, it is somewhat unreal to concentrate upon the influence of intellectual factors. The ex-convict shepherd, or immigrant urban labourer, shared the prejudices of administrators, missionaries and phrenologists, but did not justify them by any appeal to abstract principles. The callous indifference of the uneducated colonists towards the aborigines is familiar to any student of contemporary sources. Typical of many pastoral pioneers was the shepherd in the Wimmera during the early 1840's, as described by a squatter (Bride 1898: 217):

> He held a carbine in the place of a crook, and an old regulation pistol was stuck in his belt, instead of the more classic pastoral pipe. . . . After some conversation he led me to a waterhole, where the skeleton of a native . . . lay in the mud. There was a bullet-hole through the back of the skull. 'He was shot in the water,' the man told me, 'as he was a-trying to hide hisself after a scrimmage! There was a lot more t'other side.'

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MODIFICATION OF SUB-ANTARCTIC FLORA ON MACQUARIE ISLAND BY SEA BIRDS AND SEA ELEPHANTS

By Mary E. Gillham

[Communicated by A. R. McEvey 14 July 1960]

Summary

An investigation of birds and seal colonies on Macquarie I. has shown a significant uniformity among the plants which colonize disturbed areas after the original vegetation has been depressed or destroyed.

Unlike most temperate Australian rookeries, it is probable that mechanical damage by trampling is of greater importance than the toxicity of heavy deposits of manure in the modification of the flora. This is largely due to the higher rainfall washing nutrients from the soil, the lower evaporation rates preventing excessive concentration of the soil solution and the fact that the Macquarie peat would retain water and act as a 'buffer' to chemical changes in a way that the Australian sands would not. It is no doubt contributed to, however, by the greater number and larger size of individuals in the Macquarie fauna.

This and the dominant life forms of mesophytic grasses and cushion plants (a latitudinal effect) brings the vegetation more into line with that of British bird islands than of temperate Australian ones, where the dominant life forms are succulent herbs with xeromorphic grasses in the S. and salt bushes further N.

Similarities between Macquarie and N. temperate rookeries are at specific level in some instances, plants common to both being the cosmopolitan *Montia fontana* and *Luzula campestris,* and the European *Stellaria media, Cerastium vulgatum* and *Poa annua* which are introduced on Macquarie I.

Poa foliosa, which is dominant on the Macquarie peats at low altitudes, is also dominant of the ground flora on peaty mutton bird islands off S. New Zealand where it has not been destroyed by grazing animals. In both areas it is characteristically associated with a species of *Stilbocarpa.*

Introduction

Since 1948 the Australian National Antarctic Research Expedition has maintained a research station at Macquarie I. (lat. 54½°S., long. 159°E.). The author accompanied the 1959-60 relief expedition to the island in December 1959 to investigate some of the interrelationships of the flora and fauna.

Macquarie I. provides a breeding and resting ground for the birds and seals inhabiting an area of sea as large as the continent of Australia. When ashore these animals are concentrated mainly in the *Poa foliosa* grassland around the coast—a strip about 50 m. long. They bring about quantitative and qualitative changes in the flora, but these are nullified to some extent by the humid sub-antarctic conditions.

The climate is more rigorous than in Australasian rookeries or those of similar latitudes influenced by the Gulf Stream in the N. Hemisphere. The specialized conditions brought about by large concentrations of animals, however, lead to comparable effects in widely differing climates and certain species are common throughout. These include plants both native and alien to Macquarie I.

Taylor (1955) has given a detailed account of the Macquarie vegetation and soils. The present work summarizes some of the modifications observed in rookeries visited during the 1959 relief expedition and relates these to the flora of rookeries in other latitudes. No account of rabbit effects is included, these having been dealt with in detail by Taylor.

A. Principal Effects of the Fauna

1 Manurial Factors

The vast populations of animals present on Macquarie I. deposit vast amounts of dung, particularly during the summer growing season, but this affects the vegetation less vitally than do smaller deposits in lower latitudes. This is largely due to climate.

The mean annual rainfall is high by Australian standards (40½ in.) and this, combined with the steep gradients and narrowness of the coastal plain, would facilitate leaching. The constancy of fall throughout the year [rain occurs on 330 days of the 365 (Law & Burstall 1956)] ensures that much of the dung is washed away as soon as deposited and before hardening into more weather-resistant form. Some of the most heavily affected areas, the larger colonies of royal penguins (*Eudyptes chrysolophus schlegeli*), are situated on permanently flowing streams, so that much of the guano gets washed directly to the sea.

Perhaps even more important than leaching are the high humidity and constantly low temperatures which cut down evaporation and prevent undue concentration of the soil solution. This concentration is of great importance to rookery vegetation further N., particularly in those parts of Australia suffering the dry summers of the Mediterranean climate. Drought effects there are intensified by the concentration of guano in the soil to toxic levels.

The average relative humidity on Macquarie I. is high [92% (Taylor 1955)] and only 10% of the readings fall below 70% (Law and Burstall 1956). The mean monthly temperature is only 40·2°F. and that for the warmest month (January) only 43·8°F. Winds are strong and persistent but are moist after travelling over many hundred miles of ocean, and mist and cloud are very prevalent.

In drier climates rookery plants have always to contend with residual guano from past breeding seasons, as well as current defaecation during the growing season which so often coincides with at least part of the period when the birds or seals are in residence. On Macquarie I. it is doubtful if manurial constituents remaining in the soil from one growing season to the next are sufficiently concentrated to inhibit normal plant growth.

At the end of the unusually dry month of December 1959 there was little evidence to suggest extensive killing of plants by fouling, although small areas of the coastal lithosere which lacked soil depth were seen to be suffering locally.

A third factor minimizing damage by guano is the steady accumulation of plant remains which disintegrate but slowly in the cool moist climate. An important property of the peat in this regard is its high power of water retention. Penetration of manurial constituents to the level of most absorptive is hindered in peats (Gillham 1956).

Where the effects of manuring can be divorced from those of detrimental factors such as trampling, there is evidence that they are beneficial rather than otherwise —as in cool moist climates of the N. Hemisphere. Members of coprophilous genera and families, principally *Poa* and *Caryophyllaceae*, are locally stimulated in such areas.

The endemic *Poa hamiltoni* is one of the most characteristically ornithocoprophilous species and is confined to the vicinity of penguin rookeries (Taylor 1955). It is particularly abundant among the otherwise dominant *Poa foliosa* at the margins of royal penguin colonies where nutrient-rich drainage waters seep out between the tussocks. It is also typical of colonies of rockhopper penguins (*Eudyptes chrysocome*) where its morphological habit and ecological niche are strongly reminiscent of those of the closely related *Poa anceps* var. *condensata* of New Zealand. The latter grows in central and northern New Zealand at the margins of gannet colonies and around the entrances of penguin, petrel and shearwater burrows.

No *poa hamiltoni* was recorded in colonies of gentoo penguins (*Pygoscelis papua*) which are of a more temporary nature, birds evidently moving to a new site before the plant can become established. The more ephemeral and more easily established *Poa annua* is an important constituent of the vegetation in these colonies and was absent from few of the guano-affected areas or seal wallows visited in the N. of the island.

The most characteristic caryophyllaceous coprophile is *Stellaria media*, associated in places with *Stellaria decipiens* and *Cerastium vulgatum* (= *C. triviale*). *Colobanthus muscoides*, common on coastal rocks, is resistant to both guano and trampling and is abundant in the nesting sites of Dominican gulls (*Larus dominicanus*), Antarctic terns (*Sterna vittata*) and coastal gentoo colonies. Few species live on these coastal rocks and they succumb to bird disturbance in the following order: *Stilbocarpa polaris, Poa foliosa, Puccinellia macquariensis, Colobanthus muscoides, Cotula plumosa*.

The last is not strictly a part of the rupestral climax flora but a pioneer phase which colonizes denuded areas when this flora is damaged. In bird-disturbed zones it often remains dominant as regeneration of less guano-resistant phases of the lithosere are prevented.

Pioneer *Cotula* on a stack denuded of *Poa foliosa* and *Colobanthus* 9 months previously in a salt storm was of very different form from that which colonizes the guano-fouled stacks. The former had small leaves, silvery with hairs, and formed a mat only a few cm. high. The latter has large leaves, less silvery because of the wider spacing of hairs due to cell enlargement, and forms dense mats up to 15 cm. high.

The foliage of *Cotula, Colobanthus* and the 3 *Poa* species is deeper green where affected by the nitrogen from guano.

Gentoo penguins nesting on the floating bog or 'feather bed' community of Handspike Point had little effect on the flora because of the high water table at the ground surface which diluted the guano as it was deposited. The rosettes of *Pleurophyllum hookeri* which stood up above the mat of bog plants were coated with guano but damage seemed to be superficial, affecting only the leaves which were replaced annually. The wet turf was dominated by bryophytes, lichens and dwarf monocotyledons and no qualitative differences could be discerned in the rookeries, no diminution of indigenous plants nor influx of coprophilous ones.

Gentoos on a drier part of this *Pleurophyllum* alliance had had a more potent effect, killing much of the locally dominant but rabbit-grazed *Agrostis magellanica*. The community was slightly more open than the wetter one and allowed entry of *Poa annua* and *Stellaria media*.

The flora of these 2 rookeries was more diverse and less specialized than that of any other rookery investigated and contained the following angiosperms:

Acaena adscendens		D	*Montia fontana*	W	D
A. anserinifolia		D	*Pleurophyllum hookeri*	W	D
Agrostis magellanica	W	D	*Poa annua*		D
Callitriche antarctica	W		*P. foliosa*		D
Cardamine corymbosa	W	D	*Ranunculus biternatus*		D
Colobanthus crassifolius	W	D	*Scirpus aucklandicus*	W	
C. muscoides		D	*Stellaria media*		D
Epilobium linnaeoides	W	D	*Stilbocarpa polaris*		D
Juncus scheuchzerioides	W		*Uncinia riparia*	W	D
Luzula campestris	W				

(W = wetter rookery, D = drier rookery)

The ornithocoprophilous green alga (*Prasiola crispa* ssp. *antarctica*, det. Womersley), members of which genus are widely distributed in seabird colonies in Australia, New Zealand and Great Britain, formed robust thalloid growths in every rookery investigated and was also found on guano-affected soil around isolated albatross nests inland.

2 Trampling of Vegetation

Mechanical damage to vegetation by trampling is probably the factor of greatest significance in the modification of the Macquarie I. rookery flora. This is largely due no doubt to the influence of climate in reducing the effects of guano, but is also related to the large number and size of individual animals inhabiting the rookeries. A bull sea elephant (*Mirounga leonina*) may be as much as 20 ft long with an estimated weight of about 4 tons (Csordas, personal communication).

The soft-foliaged plants of sub-antarctic latitudes are particularly vulnerable to trampling. Erect species suffer most, the brittle petioles and peduncles of *Stilbocarpa polaris* being most susceptible to breakage (Pl. III, fig. 2). The small-leaved, low-growing type of *Stilbocarpa* which can survive in the presence of rabbits is slightly more resistant to mechanical damage but is always in danger of extermination by increased rabbit attack.

Trampling is of greater significance as a destructive factor on Macquarie I. than it is in most Australian rookeries. The xeromorphic rookery plants of drier latitudes are often dwarf, with horizontal stems better fitted to withstand trampling than are erect ones, or are shrubby plants of the salt bush type which are sufficiently large for birds and seals to walk round or beneath them rather than over them.

Destruction of the indigenous Macquarie plants leads to an influx of mat plants, some perennial and some annual. These too are soft-leaved and may suffer damage, but their hemicryptophytic nature enables them to persist in many areas.

The mat and cushion plants of the plateau (which is dominated by *Azorella selago* and mosses) are of resistant life form but are exposed to less trampling than are the taller *Poa foliosa* stands of lower altitudes. Scattered nests of burrowing and surface-nesting birds occur on the plateau, but the chief tramplers are the sea elephants and penguins of the coast.

Destruction of herbage by penguins occurs up to 600 ft above sea level and rookeries may be large, up to 16½ acres and containing over half a million birds in one instance (Mawson 1943).

The most complete plant annihilation occurs in the large rookeries of royal penguins, but there is evidence to suggest that even these originated on soil bared by other means and spread subsequently as marginal plants were destroyed.

On the SE. coast birds are centred on the lower courses of steep creeks and the alluvial fans where the fall of these is checked at their junction with the narrow coastal plain. The colonies broaden at the lower levels where the divided drainage channels are a factor contributing to the opening up of the vegetation. The resultant penguin colonies have a series of V-shaped extensions leading uphill, 71% of which have broad creeks flowing into their upper extremities. Because of the steepness of slope these are dry for much of the time. (No detailed investigation was possible at this end of the island, but it is likely that the remaining 29% had smaller drainage channels not visible from the sea leading into them.)

Some of the rockhopper and gentoo colonies of this Hurd Point area are similarly situated, but these birds nest more sparsely than the royals, spreading through the tussock grass and creating less concentrated devastation.

All 3 species perch on *Poa foliosa* tussocks which eventually disintegrate to leave mounds of peat, but royals were seen to be doing this only at the margins of well-established rookeries or penguin highways and gentoos only in areas previously damaged by sea elephants.

It seems likely that the rock-hopping and tussock-hopping rockhopper penguins may be more suited to opening out tall undisturbed tussock vegetation than are the other 2 species. When not among rocks, rockhoppers prefer to nest beneath the tussocks and the traffic of birds between the *Poa* 'stools' forms drainage runnels and leads to a drop in soil level, so that the sheltering tussocks become elevated on columns of peaty soil.

Gentoos, on the other hand, prefer to nest on top of tussocks which have already been partially flattened by sea elephants. Both species may use considerable quantities of grass in the construction of their nests, but the rockhopper's nest is often no more than a collection of pebbles in a peaty hollow.

It is difficult to assess the amount of damage brought about by gentoos in tussock grassland because of the degenerate state of the community as a whole in the areas which they frequent. Apart from total or partial destruction of the tussocks on which the nests are built, however, it is likely that their effects are soon obliterated because of the temporary nature of the rookeries. Rockhoppers, like royals, return habitually to the same rookery which is usually too precipitate to be frequented by sea elephants, so their effects are cumulative and specific.

Sea elephants drag themselves indiscriminately both over and between tussocks but in most wallow areas a high proportion of the tussocks survive (Pl. I, II). (Living tussocks are used as back scratchers by moulting seals during December-March.) Areas which are in fairly constant use become denuded of all vegetation and no colonization by adventive mat plants is allowed to proceed very far.

Taylor (1955, p. 88) states—

> The seals do not arrive until the end of the summer, after the plants' growing period, and thus the vegetation is able to recover. Any damage done during the year is not in evidence at the beginning of the next summer, apart from permanent 'bog holes'.

This would appear to be an over-simplification, however, as many hundreds of seals, mostly young bulls moulting, were present on the tussock grassland during the author's visit (22-27 December 1959). According to Csordas, who has made a weekly census of seals in certain areas, animals are numerous among the tussocks throughout the spring and summer and a certain number are present during the remainder of the year. The more densely populated period (August–April) covers the plants' growing season and allows of little floristic regeneration except in areas temporarily abandoned by the seals.

All stages of degeneration and regeneration of the plant community were discernible in December 1959, and it is unlikely that the scars left by the animals could be obliterated by a single year's growth, even if a respite from seal damage was to occur during the growing season.

Plants other than *Poa foliosa* which survive in the wallow areas are almost exclusively hemicryptophytes or therophytes.

The endemic Macquarie I. cormorants (*Phalacrocorax albiventer purpurascens*) on North Head nest mainly beneath the lower limit of angiospermous vegetation but there is an outlier of the colony on a rock outcrop further inland. The original *Poa foliosa, Stilbocarpa polaris, Colobanthus muscoides* alliance which persists on unoccupied parts of the rock has been destroyed by trampling and defaecation in the cormorant colony. It has been replaced by *Cotula plumosa* and *Prasiola crispa* ssp. *antarctica*, together with the depauperate but still living remains of the *Poa* tussock.

The feeding grounds of Dominican gulls, which were identifiable by the accumulations of pink shells of *Cantharidus coruscans* (det. Macpherson), show the results of trampling. The dominant *Poa foliosa* becomes dwarfed and partially or wholly replaced by mat plants characteristic of earlier seral phases. In the more seaward areas *Cotula plumosa* becomes dominant with *Prasiola* and *Colobanthus*. Further from the sea *Agrostis magellanica* is likely to show the most marked increase, *Cotula* rather less.

Any effects of Antarctic skuas (*Catharacta skua lonnbergi*), which nest on small peaty mounds protruding from the 'feather bed' community or on cliffsides, are masked by the effects of rabbits. On the 'feather bed' itself trampling by gentoos and wandering albatrosses (*Diomedea exulans*) has negligible effects because of the resilient nature of the 'floating' turf.

Sooty shearwaters (*Puffinus griseus*) burrowing on North Head have worn tracks between the bases of the *Poa foliosa* tussocks and facilitated the entry of small ephemeral plants without materially altering the community structure. The steepness of slope minimizes the difficulty of becoming airborne so tracks are short, birds having only to reach a small clearing in the tussock before being able to take off.

3 Soil Disturbance

Destruction of vegetation exposes soil to erosion and the steep gradients on the coast increase the erosive power of drainage waters so that the slopes become scored with anastimosing channels. The fibrous structure of the peat and its almost perpetual moistness, however, minimize the amount of wind erosion as compared with that of sandier rookeries in less windy areas.

Differential rates of soil loss on coastal flats frequented by sea elephants leads to the formation of hollows from one to many metres across. These act as natural drainage basins and become filled with liquid mud and water (Pl. II, fig. 2). Such sites are favoured by moulting sea elephants but not all are in use simultaneously and undisturbed wallows become gradually recolonized. Their flora has been described by Taylor (1955).

At the end of a dry December there was insufficient liquid in many of the hollows for wallowing and seals were moving down to the edge of the sea more frequently (Csordas, personal communication). This entailed greater wear on the tracks but expedited the plant colonization of the drying wallows.

Tracks providing access to various parts of the Nuggets rookery of royal penguins may be cut down to a depth of 5 ft below the surface (Mawson 1914). The main penguin highways here follow the creek beds and the combined action of flowing water and continuous streams of penguins passing in both directions has removed all soil, although silt is able to accumulate in the shelter of marginal tussocks. The nesting sites which abut on to the tracks in places are also subject to a certain amount of flowing water and are worn down to the bedrock. Even during a dry spell the down of the chicks may become very fouled with peat stains from persistent puddles in the nursery areas.

Black-browed albatrosses (*Diomedea melanophris*) and light-mantled sooty albatrosses (*Phoebetria palpebrata*) construct their nests by scraping soil and vegetable matter towards them with their beaks as they sit. The nests investigated were on very steep slopes so that the resulting bare soil usually extended around only 3 sides, the outer side being sometimes occupied by a tussock which formed the basis of the nest.

Erosion from sooty shearwater burrows is prevented to some extent by the protective canopy of *Poa foliosa* but a few earth cliffs have been cut back into the hillside at the mouths of occupied burrows.

Taylor (1955, p. 91), in referring to burrows, states—'Undoubtedly they must cause some improvement in aeration and drainage'. It would be interesting to obtain further data on this point. Preliminary work in shearwater and petrel colonies off the coast of Wales has indicated that this is probably the case in the more permeable mineral soils but not necessarily in peats (Gillham 1956a).

The steep nature of the North Head rookery would ensure a rapid run-off of rainwater and absorption by only the surface layers of peat. Burrows leading in among the bases of the *Poa* tussocks would form natural points of entry for the water so that more absorptive peat surfaces could become saturated. Even in the less retentive peaty sands of the Bass Strait mutton bird (*Puffinus tenuirostris*) islands, burrows have been found to remain waterlogged long after the surface soil has dried out.

4 Plant Regeneration on Cessation of Biotic Disturbance

Although relatively few birds and seals are ashore during the winter season, temperatures are too low then for a big influx of winter annuals during the period of least disturbance. Such plant colonists as appear in the rookeries must compete with the animals during the brief summer growing season, so plant regeneration is patchy and determined by local movements of the fauna from one area to another.

Annuals are the obvious first colonists and the periods of respite are often not long enough for the regenerative succession to proceed beyond these to the perennials of the undisturbed climatic climax flora.

With light but fairly persistent animal disturbance, as at the margins of royal and rockhopper penguin colonies, the guano has a selective rather than a wholly repressive effect and annuals such as *Poa annua* become partially replaced by coprophilous perennials such as *Poa hamiltoni.* This is a plagiosere or deflected succession with the end point of *Poa hamiltoni* differing from the normal end point of *Poa foliosa.*

Return from *Poa annua* to *Poa foliosa* is most likely to occur when the deflective factor has been entirely removed as in vacated gentoo colonies and the large isthmus colony of king penguins (*Aptenodytes patagonica*). The latter colony was exterminated by sealers about 1850, but all traces of the rookery had disappeared by 1911, as had traces of a royal penguin rookery in Caroline Creek in less than 40 years (Taylor 1955).

The first stage of the hydrosere in the abandoned sea elephant wallows consists of a felt of green algae forming a crust on the surface of the drying mud. The earliest angiospermous colonist is a lax aquatic form of *Callitriche antarctica*. As the mud dries the *Callitriche* produces the more compact shoots of the terrestrial form and part of the mat becames replaced by *Poa annua*. *Cotula plumosa* follows in the moister areas or may be the primary colonist in drier areas. *Poa annua* and *Cotula* are the most characteristic species of the seal wallows apart from the dominant *Poa foliosa*. *Prasiola* is also abundant.

In later successional phases *Cotula* and *Montia fontana* may be co-dominant with little *Callitriche* or *Poa annua* remaining. Other less important species in this regeneration complex are *Stellaria media*, *S. decipiens*, *Cerastium vulgatum* and *Cardamine corymbosa*. If disturbance continues to be withheld, a low growth of *Stilbocarpa polaris* appears and the community finally returns to *Poa foliosa* (Pl. III, fig. 1).

Lush growths of *Callitriche*, *Montia*, *Cotula*, *Poa annua* and *Vaucheria* sp. colonize the margins of peaty channels which drain the nutrient-rich mud and water from the bog holes.

The drier phases of the wallow succession are characteristic of those occurring throughout the tussock areas when biotic pressure is alleviated. Annuals are predominant in the earlier successional phases, 3 of them aliens introduced originally by the sealers but now occupying the Macquarie counterpart of the ecological niche which they occupy in bird and seal colonies of the N. Hemisphere.

On coastal rocks *Colobanthus muscoides* may appear between the *Cotula* and *Poa foliosa* phases of the succession or may form 'caps' on the denuded summits of *Poa* tussocks worn bare by seals or gentoos.

Further from the coast but still in tussock areas *Acaena adscendens* increases in the vicinity of nests. Taylor (1955, p. 118) attributes this to the wetter situation by nests and adaptation of the fruits to bird carriage. *A. anserinifolia* is present on the island, occuping rabbit-grazed areas as in lower latitudes, but the ecological niche which it occupies in rookeries of lower latitudes is occupied on Macquarie I. by the apparently equally coprophilous but more water-resistant *A. adscendens*.

Nests of black-browed albatrosses had been occupied for only about 9 weeks when investigated and the chicks were still small, but already colonization of the denuded soil around the nest base by mats of *Prasiola* and seedlings of *Cotula* had commenced.

Nests abandoned the previous season showed a 25% cover of seedlings. *Stellaria decipiens* was dominant, *Poa annua* and *Cardamine corymbosa* abundant and *Festuca erecta* and *Agrostis magellanica* occasional. From the sides of the nests depauperate shoots of *Poa foliosa* and *Stilbocarpa polaris* were sprouting from underground organs which had survived the breeding season. Among them were seedlings of the 3 species mentioned above, *Acaena adscendens* and *Ranunculus biternatus*.

A flat-topped non-flowering *Poa foliosa* 'stool' used as a resting place by a light-mantled sooty albatross was much damaged and its sides colonized by *A. adscendens*. No material had been scraped up onto the *Poa* 'stool' but the surrounding ground was fouled and showed incipient colonization by *Cardamine*, *Colobanthus*, *Cotula* and *Metzgeria*.

Small patches of the 'feather bed' community scraped bare by wandering albatrosses are soon covered over by the surrounding plants and no trace remained of a marked nest occupied 2 years previously.

B. Relationship of Macquarie I. Rookery Flora with that of other Latitudes

1 Stewart I. Region, S. New Zealand

Small mutton bird (*Puffinus griseus*) islands off Stewart I. (lat. 47°S.) often show dominance of *Poa foliosa* tussock in burrowed areas with a species of *Stilbocarpa* sp. (*S. lyallii*) again the most characteristic associate. This vegetation may be destroyed by grazing goats and deer just as it is destroyed on parts of Macquarie I. by grazing rabbits.

The principal floristic difference between the 2 areas is the presence of trees and shrubs on the New Zealand islands and the larger number of ferns (including the 3 species found on Macquarie I.). 58% of the Macquarie I. flora occurs also on the New Zealand islands.

The peaty substrate of the Macquarie rookeries resembles that of the sooty shearwater rookeries in the Stewart I. region rather than that of any seen in Australian rookeries. New Zealand seal colonies visited differ mainly in that the New Zealand fur seals (*Arctocephalus forsteri*) penetrate less far inland and the associated species are mainly ephemerals on the beaches—*Poa annua, Stellaria media,* etc.

2 Tasmanian Islands

The main feature in common between the Macquarie rookeries and those of the Tasmanian islands (lat. 40°-44°S.) is the predominance of *Poa* tussock. The Tasmanian *Poa* (*P. poiformis*) is more xeromorphic but forms a similar type of terrain with soil eroding from around the bases of the plants to leave the tussocks elevated on peaty 'stools'.

Higher temperatures in Tasmania give rise to a slower rate of peat accumulation and increasing variety of plant species. Many of the Macquarie annuals, both native and introduced, occur on soil bared by the fauna, but there is an increasing tendency for these to reach their maximum growth in spring and autumn rather than in summer.

3 Islands of N. New Zealand

In these regions (lat. 35°-40°S.) there is an increase of succulent herbs (mostly Aizoaceae) in the rookeries but *Poa* tussocks remain as an important element. Both broad-leaved and needle-leaved Poas are represented, *P. anceps* and *P. australis* (= *P. caespitosa*) being the commonest natives, whilst *P. annua* and other Macquarie annuals occur more or less throughout.

Other Macquarie grass genera, chiefly *Agrostis* and *Festuca,* are represented mainly by introduced species from N. temperate zones in the New Zealand rookeries. As in S. New Zealand, the chief divergence from the Macquarie type rookery is the importance of the arboreal habit.

4 Islands of Temperate Australia

In southern Australian rookeries (lat. 30°-40° S.) there is a progressive northerly change from *Poa* tussock to more drought-resistant succulents, but the tussock habit persists in sandy areas where genera such as *Spinifex, Bromus* and *Lepidosperma* are important.

The ubiquitous annuals are still present but occur mainly in winter when atmospheric conditions become sufficiently moist and the soil guano suitably diluted. Fur seals (*Arctocephalus dorifera*) in latitude 30°S. are able to bear their pups beneath the dominant succulent-leaved shrubs (*Nitraria schoberi* and *Atriplex isatidea*) so that trampling has the effect of damaging only the lower branches whilst the canopy remains almost unaffected (Gillham 1960).

The principal life form of subordinate species is again that of mat plants with a high proportion of annuals. Macquarie genera represented include *Acaena, Cotula, Crassula* and *Epilobium*.

5 Islands around Great Britain

The similar latitude and climate brings the rookery flora of Macquarie I. closer to that of the islands around Great Britain (lat. 50°–59° N.) than to that of Australian islands. Temperature modification by the warm Gulf Stream in the N., however, curtails peat formation to some extent and provides more favourable summer growing conditions.

The principal floristic features of rookeries in both areas are the lack of trees and shrubs and the predominance of mesophytic grasses and cushion plants. All the Macquarie grass genera are represented on the smaller British islands, *Agrostis, Festuca* and *Poa* being the most important.

The coprophilous annuals which have been introduced to Macquarie I. (*Poa annua, Stellaria media* and *Cerastium vulgatum*) are abundant in British bird and seal rookeries, as are the 2 cosmopolitan species found on Macquarie I. (*Montia fontant* and *Luzula campestris*). Genera with nearly related species in the 2 areas include *Callitriche, Cardamine, Carex, Epilobium, Hydrocotyle, Juncus, Ranunculus* and all the grass and Pteridophyte genera of Macquarie I., although Pteridophytes are not particularly characteristic of rookeries in either area.

Important rookery plants with closely similar habit and leaf form are 2 creeping members of the Rosaceae, *Acaena* spp. in the S. and *Potentilla* spp. in the N.. *Prasiola* is the most typical genus of algae in rookeries in both N. and S. temperate zones.

Just as locally heavy biotic pressure on the Macquarie coast causes the climatic climax of grassland (*Poetum foliosae*) to give way to a cushion plant (*Colobanthus muscoides*) and a herbaceous creeper (*Cotula plumosa*), so does locally heavy biotic pressure on the British coasts cause the climatic climax of grassland (*Festucetum rubrae*) to give way to a cushion plant (*Armeria maritima*) and various creeping herbs (Gillham 1955, 1956b).

Acknowledgements

My thanks are due to the Antarctic Division, Department of External Affairs, for allowing me to accompany the 1959 A.N.A.R.E. relief expedition to Macquarie I., and also to the Science and Industry Endowment Fund and C.S.I.R.O. Wildlife Survey Section for the provision of research grants. Information and assistance in the field were given by Miss S. E. Ingham, Dr S. E. Csordas and Mr J. Munro of the Antarctic Division and Mr K. Campbell of the C.S.I.RO. Wildlife Survey Section.

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Explanation of Plates

PLATE I

Stages in the degeneration caused by sea elephants in *Poa foliosa* grassland.

Fig. 1—Young sea elephants among *Poa foliosa* tussocks. Community open and plants fairly small but healthy.

Fig. 2—Moulting sea elephants in degenerate *Poa foliosa* community showing damage to foliage and flattening of mounds.

PLATE II

Stages in the degeneration caused by sea elephants in *Poa foliosa* grassland.

Fig. 1—Dry portion of seal wallow showing replacement of *Poa foliosa* tussocks by smoPoth mounds of dark peaty soil. Tentative colonization by *Cotula plumosa* on right of seals.

Fig. 2—Seal wallow.

PLATE III

Fig. 1—An advanced stage in the regeneration cycle on an area previously occupied by sea elephants. Non-flowering *Stilbocarpa polaris* overrunning central mat of *Poa annua* with healthy young *Poa foliosa* (the climatic climax dominant) advancing from the margins.

Fig. 2—Damage caused by a passing sea elephant to the brittle foliage of *Stilbocarpa potaris.*

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A TECHNIQUE FOR SANDISON-CLARK EAR CHAMBERS: MANUFACTURE, ASSEMBLY, AND PHOTOMICROGRAPHY

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Abstract

Difficulties for the research worker wishing to use the rabbit ear chamber technique are due in large measure to the insufficiency of published technical information. The present paper is an attempt to overcome this situation and presents—(*a*) a technique for the manufacture of ear chamber components and their assembly, (*b*) some modifications of a technique for operative installation, (*c*) design of a rabbit box suitable for ear chamber work, and (*d*) a method of 35 mm. photomicrography suitable for the rabbit ear chamber.

Introduction

The rabbit ear chamber technique has proved a useful tool in the microscopic study of living mammalian tissues under favourable optical conditions. Examples of different types of chambers which have been used appear in the literature (Sandison 1924; Clark and Clark 1932; Ahern, Barclay and Ebert 1949; Williams and Roberts 1950; Robertson 1951; Williams 1954). As well as connective tissue, Williams (1954) has shown that a variety of tissues grafted into the ear chamber may be used for detailed microscopic study. Observations can be made over extended periods under conditions approximating normality for rabbit tissues.

The limited use of the technique is due partly to its time-consuming character and also to the problems associated with production of the chambers. While the former is common to many worthwhile methods of study, the latter is aggravated by the lack of published details of simple manufacturing methods. Again, in the literature information of the applications of photomicrography to this field is limited.

This paper is intended primarily as a guide to the research worker who, before applying ear chambers to his work, must first deal with the problems of their production. The present account deals only with the particular chamber used in this department. However, once the appropriate techniques have been acquired, modifications could be developed for particular applications.

For accuracy and succinctness of statement, several technical (and even colloquial) terms employed by machinists are used. Where there is doubt as to meaning, any competent technician could provide a 'translation'.

Design and Manufacture of Chamber Components

The Sandison-Clark ear chamber makes possible the microscopic study of living connective tissue which has grown between two transparent plates. Pl. IV, fig. 1 illustrates the arrangement of the chamber parts in relation to the ear tissues.

The ear chamber described is of the round table type (Clark et al. 1930) being made from perspex and mica with perspex pins following the principle of a chamber designed by Ahern, Barclay and Ebert (1949).

The chamber consists of a perspex base with a central raised 'table', 3 threaded perspex pins, a perspex and mica top and 3 brass nuts (Pl. IV, fig. 2). Chamber dimensions are as follows:

External diameter	1·200 in.
Diameter of central table ..	0·235 in.
Height of central table ..	0·045 in.
Diameter of perspex pins ..	0·125 in.

The base and top are made from 1/8 in. and 1/16 in. perspex sheet respectively and the pins from 1/8 in. diameter perspex rod.

Chamber Bases

Pieces of perspex, 2 in. square, are sawn from 1/8 in. perspex sheet, retaining the paper on the sheet to prevent surface scratches. Using a 2 in. square metal template (Pl. IV, fig. 3), holes are drilled in each corner of the 2 in. perspex squares. A 3 in. wooden base block is used as a jig to hold the perspex whilst machining. This jig is aligned and held by the 3 jaw chuck of a standard workshop lathe (Pl. IV, fig. 4). 4 small wood screws are used to attach the perspex sheet to the jig for machining. It is advisable to wear protective glasses at all times when working in the machine shop.

A knife tool of left-hand shape with cutting edges on both sides and negative 'top rake' is set in the tool holder so that the right-hand cutting edge is at right angles to the perspex and centred on the work (Pl. IV, fig. 5).

The tool is advanced so that a disc of approximately the desired outer diameter of 1·2 in. is cut out of the perspex sheet. The diameter of this disc is measured accurately by means of a screw micrometer. It is then possible to set the micrometer collar on the cross slide so that, from the next 2 in. square of perspex, another trial disc having the nominal diameter of 1·2 in. is obtained.

Having determined the correct setting, another 2 in. perspex square is screwed to the jig. With the cross slide micrometer set for the correct outer diameter, the lathe carriage is locked with the carriage lock screw and the tool advanced slowly until it just touches the perspex surface. Noting the micrometer reading of the compound slide, the tool is advanced 0·043 in. with the lathe in motion. The tool is then moved across the face of the work 0·4825 in. removing perspex and leaving a central table of 0·235 in. diameter. Returning to the outer diameter position, the tool is advanced 0·002 in. and a finishing cut is taken across to the central table. Again the tool is returned to the outer diameter position and advanced slowly to part the chamber base from the perspex sheet. After this operation the outside diameter of the base is checked for the correct outer diameter of 1·2 in. Having ascertained the correct micrometer collar readings, it is a simple matter to produce a batch of chamber bases.

Chamber Tops

For the chamber tops the dimensions of which are shown in Pl. IV, fig. 6, 2 in. squares are sawn from 1/16 in. perspex sheet and the exact thickness of each square measured and noted. Tops are machined with the same jig, lathe tool and tool holder setting as used for the bases. After setting the cross slide micrometer for the outer diameter the tool is advanced until it just touches the perspex surface, moved across the face of the work 0·225 in. and slowly advanced the measured thickness of the sheet less 0·020 in. After this operation the tool is moved further across the face a distance of 0·125 in. before being advanced slowly 0·020 in. thus removing a disc of perspex from the middle of the perspex sheet. The tool is withdrawn and the cross slide micrometer collar set for the outer diameter of 1·2 in. before parting the top from the rest of the sheet.

Drilling of the bases and tops now takes place with the aid of a drilling jig.

Manufacture of Drilling Jig

The drilling jig (Pl. IV, fig. 7) is turned from a short length of solid mild steel rod of 1·5 in. diameter. Holding the rod securely in the 3 jaw chuck with 1·5 in. projecting, cuts are taken to reduce the diameter to 0·375 in. over a distance of 1 in. measured from the projecting end. The steel rod is removed from the chuck and the 3/8 in. shaft fitted into the 3/8 in. collet attachment of the lathe. Machining of the other end of the rod now proceeds to reduce its diameter to 1·388 in. and then cuts are taken across the 1·388 in. diameter end section to reduce its axial length to 0·205 in.

A right-hand knife tool is now set with the cutting edge at right angles to the end face of the work and the tool advanced until it just touches the surface. Having noted the micrometer collar reading and beginning at the centre of the work, the tool is advanced 0·080 in. Lateral cutting now proceeds until the internal diameter of the recess thus formed measures precisely 1·202 in. After painting the recess with engineers' blue, and allowing for 'back lash', the tool is moved back towards the centre for 0·101 in., advanced 0·001 in. and the chuck rotated once by hand. This procedure scribes a circle of radius 0·5 in. The tool is then centred, advanced 0·055 in. and moved laterally for 0·125 in. This further recess allows clearance for the central tables of the bases when these are being drilled.

Using a pair of fine engineers' dividers opened to 0·5 in. the scribed circle is divided into 6 equal parts. With the jig held firmly in a vice and using a sharp centre punch, the 6 points on the circle are marked more heavily to expedite drilling. Holding the 3/8 in. shaft of the jig vertically by means of a 3 jaw chuck and using a No. 30 drill, 0·1285 in. diameter (preceded by a somewhat finer drill), holes are drilled at alternate marks on the scribed circle. These holes act as a guide when drilling the bases for the perspex pins. Using a No. 43 drill (0·089 in. diameter) at the alternate marks on the circle, holes are drilled to act as guides when drilling the chamber tops.

Drilling the Chamber Bases and Tops

A base is fitted into the drilling jig with the central table projecting into the central recess, thereby preventing the table top from being scratched. Positioning the jig under the drill press and with the larger holes as guides, 3 holes are made using a No. 30 drill (Pl. V, fig. 8). Similarly, a top is completed by inserting it in the jig and, using the smaller holes as guides, making holes with a No. 43 drill.

Manufacture of Perspex Pins

The pins (Pl. V, fig. 9) are made from 1/8 in. perspex rod which is fitted into the 1/8 in. collet attachment of the lathe. For a distance of 5/32 in. from the projecting end, the diameter is reduced to 0·087 in. During this operation, the parting tool is held at right angles to the axis of the rod to ensure a square shoulder on the pin. Employing a suitable lubricant, the rod with the reduced diameter is threaded with an 8 B.A. die. The pin is then parted from the rod to give a total length of 13/32 in. (10 mm.). If these pins are required subsequently as a means of holding the chamber on the microscope stage, it may be convenient to allow a total length of 17/32 in. (13 mm.). Brass 8 B.A. nuts are employed to secure the chamber tops to the pins.

Assembly of Chambers

Attachment of Pins to Base

Pins are fitted into the holes in the base so that the shoulder of each pin projects 0·039 in. (1 mm.) above the top surface of the base. Using a fine brush (00, sable) dipped in a perspex solvent such as methylene chloride, the junction of pin and base is touched with the tip of the brush (Pl. V, fig. 10). The solvent runs between pin and base and after a few minutes establishes a firm seal. Pins attached in this way can be removed at a later date by moderate pressure.

Attachment of Mica Cover to Top

Mica covers are made from clear mica sheet approximately 0·004 in. thick. Taking care to avoid scratching the mica, a disc of 0·875 in. (7/8 in.) diameter is cut from the sheet with scissors or a wad punch. This disc is attached to the underside of the perspex top by means of perspex cement, the latter being applied so as to overlap the edges of the disc (Pl. V, fig. 11).

Manufacture of Perspex Buffers

The buffers or 'spacers' stand on the central table and serve to regulate the thickness of the connective tissue which will grow across the table top. To observe cellular detail, thin buffers (20-30μ) are necessary in order to obtain a sufficiently thin layer of tissue. Very thin buffers can be cut from perspex sheet (Ebert, Florey and Pullinger 1939) which is formed by pouring thin perspex solution on to a clean sheet of plate glass laid at a slight incline. After 24 to 48 hours the sheet is peeled off easily and checked for thickness with a metric micrometer. The appropriate area of thin sheet is selected and small square or oblong pieces cut with the aid of a scalpel blade. These pieces are transferred to the correct position on the table top by means of a pointed probe. Usually, buffers of equal thickness are placed equidistant from one another at the periphery of the central table. They are fixed in position by lightly touching the tip of a fine brush dipped in methylene chloride against the side of the central table opposite each buffer (Pl. V, fig. 12). This allows a small quantity of methylene chloride to be attracted in between buffer and table top, and the buffer is soon fixed. It is useful to keep a record of the thickness of the particular buffers employed.

The top can now be placed over the threaded portion of the perspex pins and screwed down with 8 B.A brass nuts to complete the assembly.

Completed chambers should be washed carefully in warm soapy water to remove all dust and grease. Afterwards it is advisable to store them in some suitable container to prevent gross contamination with dust and bacteria (Pl. V, fig. 13).

Operative Installation of Chambers

In general, the methods follow those described by Ebert, Florey and Pullinger (1939) and only modifications will be described.

On account of their increased thickness and greater length of ear, the most suitable rabbits are the lop-eared and semi-lop-eared types. However, any rabbit having an ear length of some 5 in. may be used successfully.

The fur on a rabbit's ears is cut short with electric clippers. The ear is prepared by swabbing with 1:500 Zephiran in 70% alcohol and the chambers and perspex template are sterilized by immersion in 1:1000 aqueous Zephiran for 24 hours.

The following instruments are employed (Pl. V, fig. 14):

(1) mallet;
(2) 2 pairs of fine scissors, one pair having a fine cutting edge ground on the outer side of each blade;
(3) 2 pairs of dissecting forceps, one coarse, one fine;
(4) wooden block, about 2½ in. high, to support ear;
(5) perspex template (Ebert et al. 1939);
(6) straight sided ear punches (Ebert et al. 1939);
(7) 2 scalpel handles fitted with Paragon 17 and 18 blades (Van den Brenk 1956).

Separation of skin from underlying connective tissue and cartilage is aided considerably by use of the fine scissors with a cutting edge ground on the tip and outer side of each blade. These enable one to work more rapidly and with less risk of damage to the larger blood vessels. When the dissection is completed and the chamber is being fitted to the ear, it is advisable to ensure that some fluid blood lies on the central table As the chamber top is screwed down, the correct thickness of blood film is indicated when the buffers on the table top, being pressed against the mica cover, become clearly outlined by the blood film. The shoulders on the perspex pins prevent the vessels of the connective tissue from being compressed.

Rabbit Box

It is convenient to have the rabbit in its natural sitting position in a box which allows an ear to be arranged on the microscope stage. For this purpose a wooden box constructed with a front end slide to take the rabbit's neck, following the principles described by Essex (1948) and Van den Brenk (1956), is satisfactory (Pl. VI, fig. 15).

Photomicrography

Because in photomicrography even small movements give rise to blurred images, for sharp pictures of the tissue in ear chambers it is necessary to employ very short exposures, one thousandth of a second or less. For this reason an electronic flash tube is essential as a light source. In the case of the particular flash unit employed here, the Mannesmann Multiblitz Micro, the flash tube is centred directly under the condenser (Pl. VI, fig. 16). The flash tube housing has upper and lower openings to transmit light from the standard microscope lamp so that direct observations can still be made with the flash tube in its central position. For correct exposure, variation of light intensity is made by interposing neutral density filters between the flash tube and the condenser.

The condenser, fitted to a Leitz stand B (monocular-binocular) microscope, is of the 2 diaphragm type (after Berek) with centring screws. For photomicrography with low power objectives (3·5x, 10x), even illumination is obtained by displacement of the top condenser lens, fully opening the upper diaphragm and stopping down the lower diaphragm to an optimum in order to increase contrast and depth of field. For photomicrography with higher power objectives (24x, 45x), the top condenser lens is oiled to the base of the chamber and the top (iris) diaphragm adjusted to give the best compromise between contrast and vertical resolution on the one hand and lateral resolution on the other. For the above condenser, the optimum occurs when the iris aperture is set at about 2 mm. and the field diaphragm aperture set at about 3 mm. The chamber is held firmly on the stage in a chamber holder, the position of which is adjusted by the mechanical stage controls. Such a holder has been described by Sanders, Dodson and Florey (1954).

Satisfactory photomicrographs are obtained using a 35 mm. camera which is more convenient than a quarter-plate camera. A satisfactory arrangement is a Leica 1F camera attached to the single tube of the microscope by means of the Leitz 'Mikas' attachment which employs a prism for continuous viewing. Because of the very clear image obtained through the prism, consistent accuracy in fine focussing is possible prior to exposing the film. With a reflex camera employing a ground glass screen consistent focus was not obtained.

Thin emulsion fine grain films give better definition and their contrast is valuable when photographing unstained material (Pl. VI, figs. 17-18). Satisfactory films are Ilford 'Micro Neg Pan' and Kodak 'Microfile'. Use of a Hydroquinone caustic developer is advantageous for improving contrast.

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Explanation of Plates

Plate IV

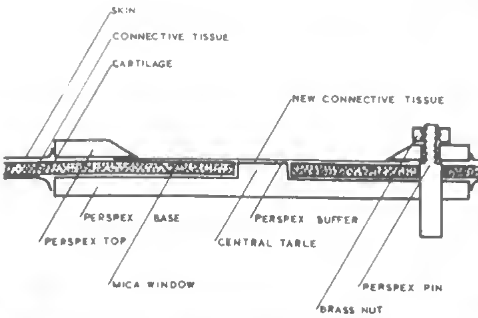
Fig. 1—Cross-section through ear chamber in rabbit's ear showing relation of chamber to tissues of the ear.
Fig. 2—Assembled chamber shown alongside chamber components.
Fig. 3—Metal template used to drill perspex squares.
Fig. 4—A wood block held on the jaws of the lathe chuck.
Fig. 5—Showing the shape and position of the cutting tool used in machining the chamber bases and tops.
Fig. 6—Cross-section of chamber top showing dimensions.
Fig. 7—Diagram showing dimensions of jig used for drilling holes in chamber bases and tops.

Plate V

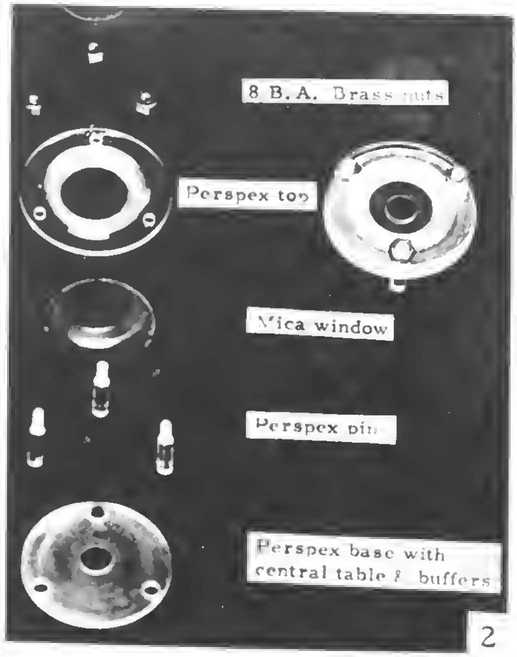
Fig. 8—Drilling jig ready for use under drill press.
Fig. 9—A completed perspex pin.
Fig. 10—Attaching perspex pins to base using perspex solvent and a fine brush.
Fig. 11—Attaching mica window to perspex top by overlapping mica with perspex cement.
Fig. 12—Attaching buffers to central table using perspex solvent and a fine brush.
Fig. 13—Completed chambers and components in a dust free box.
Fig. 14—Instruments used in operative installation of ear chambers.

Plate VI

Fig. 15—Diagrams showing dimensions of rabbit's box. S is a slide which holds the rabbit's neck to one side of the box, G is the groove in which the slide moves, L is the hinged lid.
Fig. 16—Rabbit with ear chamber, microscope with camera and electronic flash tube centred under condenser, as arranged for photomicrography.
Fig. 17 and 18—Photomicrographs of living connective tissue in the rabbit ear chamber. (Fig. 17 × 450, Fig. 18 × 600.)

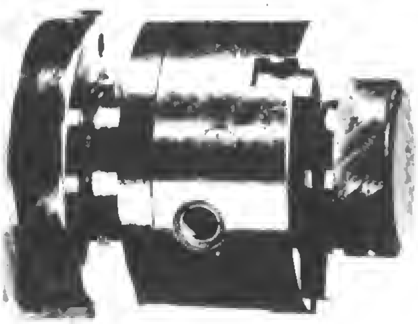

SKIN
CONNECTIVE TISSUE
CARTILAGE
NEW CONNECTIVE TISSUE
PERSPEX BASE
PERSPEX BUFFER
PERSPEX TOP
CENTRAL TABLE
MICA WINDOW
PERSPEX PIN
BRASS NUT

1


Perspex top
Perspex base with
central table & buffers

2

3



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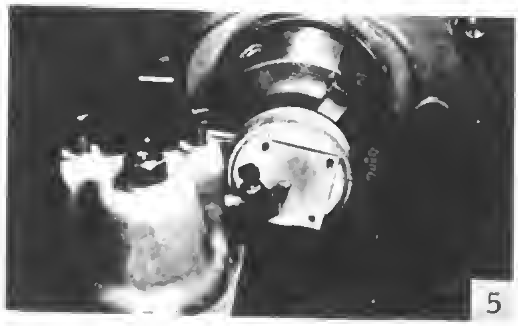

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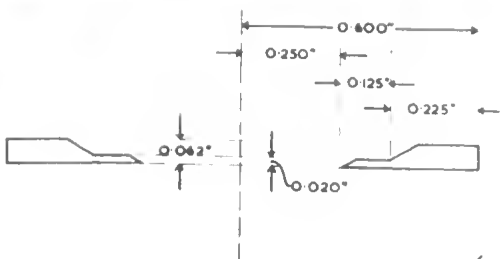
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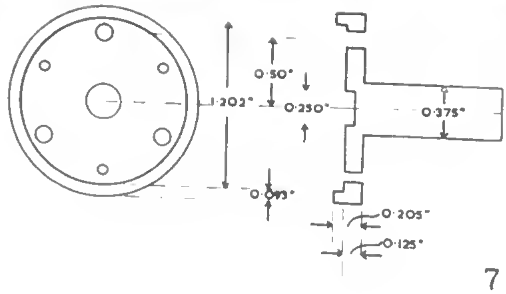
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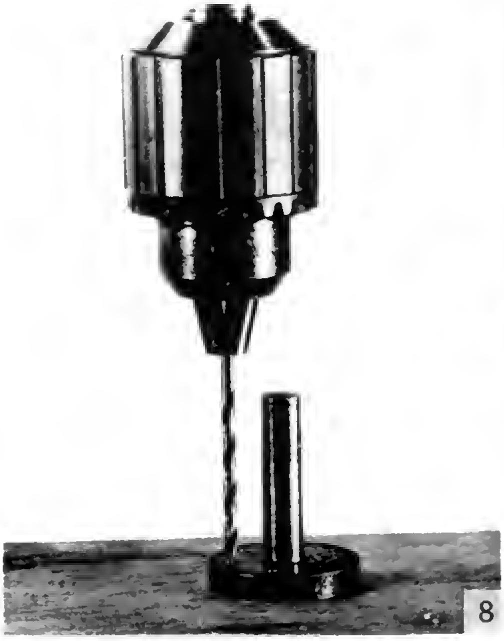
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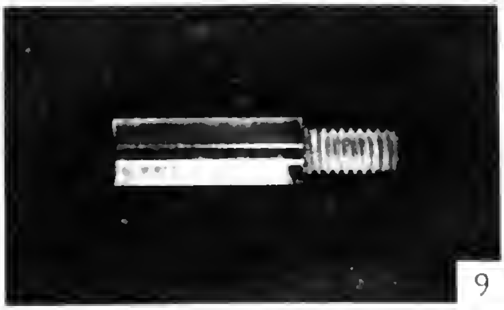
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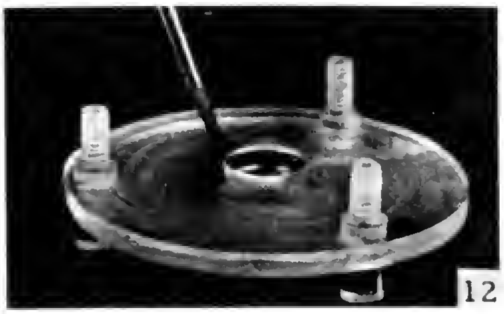
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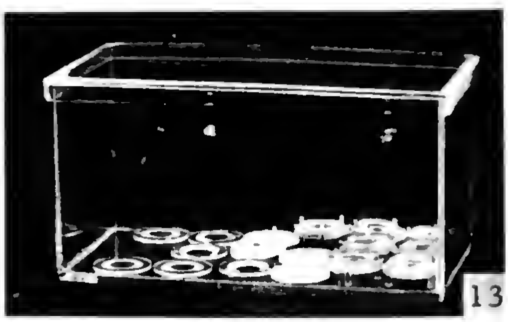
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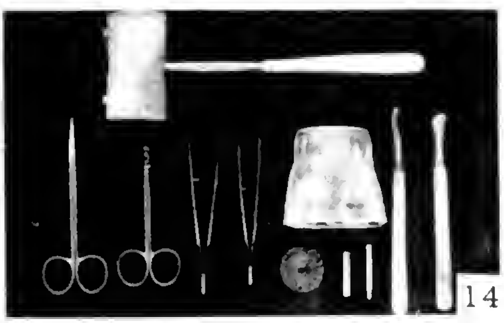
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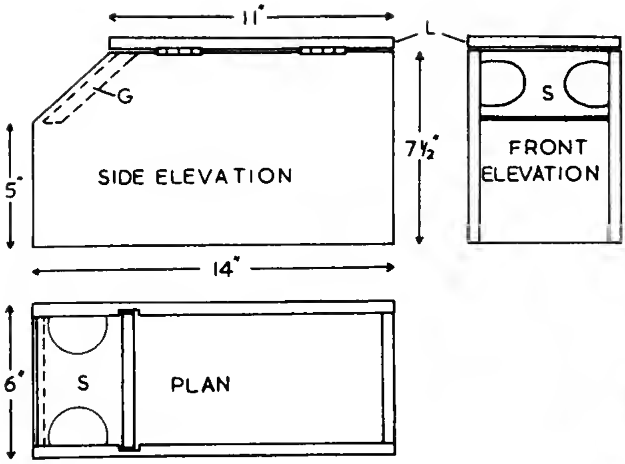

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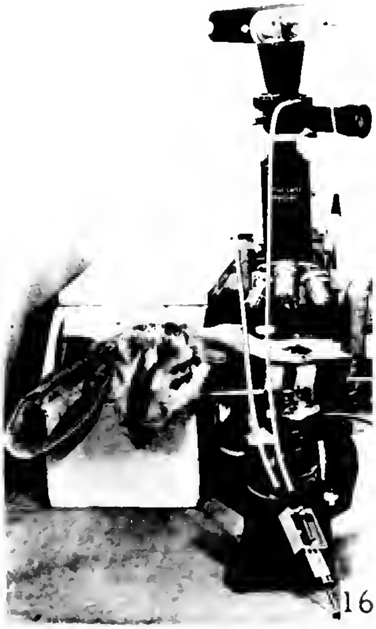

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PLANTS AND SEABIRDS OF GRANITE ISLANDS IN SOUTH-EAST VICTORIA

By Mary E. Gillham

[Communicated by A. R. McEvey 14 July 1960]

Summary

The vegetation and seabird populations of islands of porphyritic grey and medium-grained red granite off SE. Victoria are described. The range of exposure suffered on the islands varies widely from the storm-swept Glennies SW. of Wilson's Promontory to the islands in the muddy inner part of Corner Inlet, whilst Gabo I., near the New South Wales border, possesses partially stabilized dunes. Species: acreage ratio ranges from 1:8 on the most exposed island to 8:1 on the most sheltered. The paper forms an introduction to more detailed work on the biotic interrelationships on the islands (Gillham 1960a, 1960b).

Introduction

The localities investigated off the coast of SE. Victoria range from the Glennie Group 5 m. W. of the S. tip of Wilson's Promontory to Gabo I. 4 - 5 m. SW. of the N.S.W./Vic. border. They vary greatly in the degree of exposure suffered and the amount of vegetative cover present, but all show modifications of the habitat arising from the nesting and roosting activities of vast numbers of seabirds.

The bedrock in all cases is granite, a coarse-texture grey porphyritic granite containing large felspar crystals in the more westerly areas and a medium-textured red granite on Gabo I. The derived soil is a fairly coarse-grained sand with varying amounts of incorporated organic matter. In some badly eroded areas only fine granite shingle clothes the rock, and in many places the surface layers are impregnated with dry flakes of guano.

All the islands are occupied by burrowing birds, principally the short-tailed shearwater or mutton bird (*Puffinus tenuirostris*). The blue or fairy penguin (*Eudyptula minor*) occurs on all but the 3 least oceanic islands in Corner Inlet, diving petrels (*Pelecanoides urinatrix*) burrow on the Glennies and fairy prions or dove petrels (*Pachyptila turtur*) have been reported from Cliffy I. in the past but their burrows were not seen.

Silver gulls (*Larus novae-hollandiae*) nest on a few of the islands and roosts of black-faced or white-breasted cormorants (*Phalacrocorax fuscescens*) and large black cormorants (*P. carbo*) occur on inshore islands. Cape Barren geese (*Cereopsis novae-hollandiae*) graze on the outer islands, and scattered pairs of Pacific gulls (*Larus pacificus*) and sooty oyster catchers (*Haematopus fuliginosus*) occur.

The islands under consideration are Citadel I., Dannevig I. and McHugh I. in the Glennie group; Cliffy I. 12 m. E. of Wilson's Promontory and 20 m. S. of the mainland near Port Albert; Rabbit I. close to the NE. coast of the Promontory; Granite I., Benison I. and Doughboy I. in Corner Inlet N. of the Promontory; and Gabo I. in the extreme SE. of the State.

Description of Individual Islands

1 Citadel I.

Citadel I. lies at the SW. of the Glennie Group, rises to 370 ft, is about 1/3 m. in diameter and occupies approximately 70 acres. The acreage on this and other islands has been estimated from the marine charts.

It is the most exposed of the islands visited and almost all soil has been swept from the smooth granite dome. Such plants as persist are rooted in a thin layer of organic dust overlain by coarse granite shingle. The substrate resembles the skeletal soils of angular quartz grit and organic matter described for the granite mountains of Flinders I., Furneaux Group, where, as on Citadel I., erosion kept pace with soil formation in many areas (Dimmock 1957).

Vegetation is practically non-existent on the S. and W. slopes and nowhere, except in a small patch of scrub on the most sheltered E. side, does it form a ground cover of more than 5%. Only 7 species of flowering plants are recorded.

Senecio lautus is the most abundant species with a small red-leaved, exposure-tolerant type of *Disphyma australe* forming a scattered belt below on the E., and *Leptospermum laevigatum* and *Correa alba* a low scrub above. Some of the *Leptospermum* is as much as 3 metres high but most is dead, the old wood colonized by the moss *Campylopus introflexus*. Away from the E. slopes all specimens are prostrate, confined to crevices and dead.

The flat summit, 370 ft above the sea, supports a sparse cover of very reduced *Campylopus introflexus* and a little prostrate *Senecio lautus* rising no more than 5 cm. from the ground surface. Other species (*Lobelia alata, Poa poiformis, Danthonia caespitosa, Asplenium obtusatum* and the hepatic *Marchantia cephaloscypha*) are more or less confined to crevices; only the mosses (*Sematophyllum homomallum* and *Campylopus introflexus*) occur in the open.

Penguins are numerous in rock crevices, but the absence of a suitable burrowing substrate excludes shearwaters and petrels and the only evidence of these was one dead mutton bird, possibly brought by a predator. Small populations of Cape Barren geese and rabbits graze the sparse vegetation.

2 Dannevig I.

The second largest of the Glennie Group, Dannevig I. extends a little over ½ m. from N. to S., rises to 251 ft and covers approximately 80 acres.

The W. flank is as exposed as Citadel I. and consists largely of bare granite with swards of pure *Salicornia australis* reaching to more than 150 ft above sea level. *Disphyma australe* is the principal species of the exposed coasts, forming prostrate red-foliaged mats on the W. and hanging, green-foliaged curtains on the more sheltered S.

A large form of *Apium* attaining to more than 1 metre in height and with stems 2½ cm. in diameter and broad-lobed leaves 30 cm. long, occurs in crevices in this zone. It has been identified at Melbourne University as *A. graveolens* and at the National Herbarium as *A. prostratum*—the name used throughout this paper. The species resembles the garden celery (*A. graveolens*) more closely than the small native *A. prostratum* but is found only on the most oceanic islands in Bass Strait, many of which are seldom visited and show no other aliens. In such habitats it is a characteristic feature, occupying a similar ecological niche in rock crevices to that of the more widespread form of *A. prostratum*, with which it sometimes occurs, but having a more oceanic distribution and apparently not colonizing sand dunes as does the smaller type. Both types differ markedly from the erect Western Australian form of *Apium prostratum* which forms tufts 1–15 cm. high.

This community ascends to the elongated island crest where *Stipa teretifolia* dominates much of the W. and *Carpobrotus rosii* part of the E. The commonest subordinates are *Apium, Bulbine semibarbata, Calandrinia calyptrata* and *Lobelia alata*.

The more sheltered E. slopes are dominated by *Poa poiformis* tussock with patches of 1 metre high *Correa alba* and *Alyxia buxifolia*. *Rhagodia baccata* and *Tetragonia implexicoma* trail upwards through the shrubs and *Brachycome diversifolia* var. *maritima*, *Helichrysum bracteatum* var. *albidum* (the normal type and a form with dense clusters of woolly, linear leaves), *Lavatera plebeja* and *Pelargonium australe* were present. The coastal *Disphyma australe* belt is much narrower on this side, only 20–40 metres wide.

Mutton birds burrow wherever possible, but the general insufficiency of soil leads to frequent collapse of the flimsy burrow roofs. Widespread erosion has resulted in the SW., leaving former burrows as silted hollows and widely scattered *Disphyma, Poa* and *Stipa* as the only stabilizing vegetation. The number of burrows surviving was estimated at 2-3000, these being mainly in the eastern *Poa* and southern *Disphyma*. According to D. L. Serventy this is the first record of mutton birds on Dannevig I., but this is of little significance as it appears that few landings have been made there.

Several hundred small petrel burrows, apparently those of diving petrels, occur beneath the *Poa* and *Stipa* of the summit and an approximately equal number of penguins nest in burrows or rock crevices throughout the island. To judge from the number of individuals seen, and the amount of dung of both species, grazing by Cape Barren geese is of greater ecological significance than grazing by rabbits.

3 McHugh I.

McHugh I., SE. of the Glennies, is the smallest and most sheltered of the group. It rises to 215 ft and occupies about 25–30 acres.

The summit is on the W. side and affords protection to the more gentle E. slopes so that the flora is less markedly halophytic and succulents less conspicuous. The large *Apium prostratum, Disphyma australe* and *Senecio lautus* are common in the coastal belt, *Asplenium obtusatum* and *Bulbine semibarbata* less so.

Most of the island is occupied by *Poa poiformis* tussock with isolated patches of low scrub as on the E. of Dannevig I., much of it killed by salt gales. *Correa alba*, usually associated with *Rhagodia baccata*, is the most abundant shrub; others are *Acacia stricta, Leptospermum laevigatum, Olearia phlogopappa* and *Sambucus* sp., the last seriously defoliated by an invertebrate parasite. *Carpobrotus rosii*, both forms of *Helichrysum bracteatum* var. *albidum, Lavatera plebeja, Pelargonium australe* and *Tetragonia implexicoma* are associated with the *Poa*, 19 species of vascular plants being recorded in all.

No attempt was made to estimate the number of burrowing seabirds because the burrows of several species were intermingled, but it is likely that the total population is approximately equal to that of the much larger Dannevig I. Again, all possible sites are burrowed, up to 6 entrances per sq. metre being recorded, and the honey-combed ground collapses readily underfoot. Much of the protective vegetation has been destroyed by the birds and serious erosion is occurring on the upper slopes.

Mutton birds are aggregated towards the top of the island, penguins and diving petrels on the lower N. slopes, though burrows of all species are scattered throughout, mostly in *Poa* tussock, relatively few in scrub. Light grazing by Cape Barren geese is evident, but there was no sign of rabbits.

4 Cliffy I.

Cliffy I. lies 12 m. from land off the E. side of Wilson's Promontory, rises to 180 ft and occupies about 100 acres. Only 3 acres in the vicinity of the summit lighthouse carry any soil worth speaking of and much of the granite remains unvegetated.

Disphyma australe, often in pure mats, dominates the vegetation except for a small patch of *Poa poiformis* on the summit. Most is of the pink-foliaged, exceptionally succulent type characteristic of salt marshes, less red and stunted than that of severaly exposed rocks and less green and attenuated than that of sheltered hollows.

A robust form of *Apium prostratum,* intermediate between the normal and the celery-like form, is common in crevices of the *Disphyma* community and the only woody vegetation present is a small patch of *Kunzea ambigua* near the lighthouse. Man-introduced weeds are plentiful around the buildings, where the native *Lavatera plebeja* also thrives in the disturbed soil, but only a few have become generally distributed.

Asplenium obtusatum is unusually common, most of it adopting the dense, succulent, obtuse-leaved form characteristic of maritime situations. The more lax form with larger, acute leaves characteristic of inland localities was seen in crevices. Like the essentially similar *A. marinum* of British cliffs, this fern varies considerably, depending on the degree of shelter afforded by the habitat. In SE. Australia, particularly in the high rainfall areas on cliffs almost 1,000 ft high (e.g. Maatsuyker I. in the extreme SW. of Tasmania and Tasman I. in the extreme SE.) a gradual merging of *A. obtusatum* into *A. scleroprium* can be traced with increasing height above sea level. In the Stewart I. district of S. New Zealand the obtuse-leaved form reaches a larger size and grades imperceptibly into the typical woodland form of *A. lucidum.* A similar cline can be seen between the erect, succulent, maritime form of *A. flaccidum* and the large, pendulous woodland form.

A small colony of mutton birds, probably not more than 100, has attempted to burrow in the scanty soil of the island summit, but the shelter of *Poa* tussocks has had to suffice for the many which found soil depth inadequate. Scattered mutton birds and penguins occur in crevices of the main *Disphyma* zone and about 100 pairs of silver gulls nest on the N. slopes. The small population of fairy prions, reported by the Victorian Bird Observers Club to be present on the island, was not located.

5 Rabbit I.

Rabbit I., although not so sheltered as the islands in Corner Inlet, is less than a mile from the shore and protected from the prevailing south-westerlies by the mountainous country of Wilson's Promontory. It occupies an area of 80–100 acres and attains a height of 194 ft in the NE.

The greater shelter is reflected in the presence of a sandy beach on the N. side, a feature not seen on the 4 oceanic islands described above but present on 3 of the 4 inshore islands described below. A sand-filled valley leads inland from the back of this beach and the granite rises gradually from both ends to form precipitous cliffs on the S. and E. The valley soil consists of almost unchanged beach sand, elsewhere the soil is dark with humic material but still sandy.

Fire had swept the island about 18 years previously but any shrubs then existing had failed to regenerate and the only ones present in 1959 were a small patch of *Acacia longifolia* on the summit and a few small bushes of *Correa alba* in the N.

The vegetation is now unusually homogeneous, a fairly pure stand of *Poa poiformis* extending throughout the island. Very few subordinates have survived the combination of summer drought, burrowing birds and grazing rabbits on the main part of the island but introduced *Carduus tenuiflorus* and a tall, non-maritime form of *Senecio lautus* are not infrequent in the sand-filled valley where *Scirpus nodosus, Ammophila arenaria* and *Pteridium esculentum* also occur.

Many thousands of mutton birds burrow throughout the island, avoiding only the mobile valley sand and the steeper cliffs. Many hundreds of penguins are scattered through the rookery and large contingents use the N. beach as a means of access.

Black-faced cormorants occur on the NE. cliffs and silver gulls and crested terns (*Sterna bergii*) nest among *Poa* and *Disphyma* on nearby Rabbit Rock.

6 Granite I.

Granite I. is the least sheltered of the Corner Inlet mutton bird rookeries, lying 5 m. in from Entrance Point and separated from the NE. tip of Wilson's Promontory 1½ m. away by the deep water of Benison Channel. Its granite dome occupies approximately 3½ acres and slopes directly into the sea on all sides from a height of 60–70 ft.

Poa poiformis is again the dominant plant with patches of *Carpobrotus rossii, Lepidium foliosum, Pelargonium australe* and *Rhagodia baccata* around its lower fringe, particularly where nesting seabirds are plentiful. A small clump of *Pteridium esculentum* occurs on the sheltered E. side. The only woody vegetation is a single stunted specimen of *Acacia longifolia* var. *sophorae* in a summit crevice. More typical rupestral species are *Bulbine semibarbata, Gnaphalium purpureum, Crassula sieberiana* and introduced *Vulpia bromoides*.

Mutton birds occupy all suitable habitats and many unsuitable ones where the soil is of insufficient depth for adequate burrowing. Penguins do not occur on the Corner Inlet islands, but more than 100 pairs of silver gulls nest on the lower S. slopes and about the same number of black-faced cormorants roost on the lower N. slopes.

7 Benison I.

Benison I. lies in the S. part of Corner Inlet and is separated from the N. coast of Wilson's Promontory at low tide by 1¼ m. of exposed mud flats crossed by a narrow channel of open water. It occupies about 19 acres and slopes gently to a flat summit a little over 50 ft above the sea. The W. and N. sides are bordered by the deeper waters of Benison Channel and suffer a fair degree of exposure; the S. and E. are sheltered and edged with sandy beaches, grading from fine shingle in the SW. to muddy sand in the E. *Zostera muelleri* maintains a roothold on the lower part of these beaches and leads down to *Posidonia australis* below L.W.M.

Except in the W. mutton bird colony where bird activity has reduced the habitat to a typical rookery type, the vegetation is very different from that of the 6 islands considered previously—less halophytic and more diverse.

Extreme halophytes such as *Asplenium obtusatum* and the large form of *Apium* were not seen and others such as *Disphyma australe* were found to be rare and located principally near the sea on the exposed side. On a tidal islet of low-lying granite in the SW. these are associated with others more characteristic of salt marshes than of windswept cliffs, viz *Apium prostratum* (the normal small form), *Hemichroa pentandra* and *Selliera radicans*. There are no dunes but dune species such as *Cakile maritima* var. *edentula, Sonchus megalocarpus* and *Spinifex hirsutus* occur on the beaches.

The more shelter-loving *Carpobrotus rossii* replaces *Disphyma* as the dominant species of the W. coast granite and ascends through the rookery above, becoming co-dominant first with *Pelargonium australe* and further inland with *Poa poiformis*.

The main part of the island is occupied by *Melaleuca ericifolia* scrub with *Banksia integrifolia* trees rising to 3 – 4 metres and scattered *Acacia melanoxylon*. As an understorey beneath the shrubs, and a discontinuous transition zone between them and the maritime communities, is a thick growth of *Clematis microphylla, Correa alba, Lomandra longifolia, Poa poiformis* and *Pteridium esculentum*.

Carpobrotus rossii, Crassula sieberiana and *Pelargonium australe* are rupestral, as on the more exposed islands, but their fleshy-leaved associates (e.g. *Bulbine semibarbata, Brachycome diversifolia* var. *maritima* and *Calandrinia calyptrata*) are replaced by stunted mesophytes (e.g. the alien grasses *Aira caryophyllea, A. praecox* and *Bromus diandrus, Centrolepis strigosa, Hypochaeris radicata, Scirpus cernuus, Juncus bufonius, Sagina apetala, Scirpus antarcticus* and *Stellaria multiflora*).

The small population of mutton birds is more or less confined to the open area of the W. and is kept in check by foxes which cross the mud flats at low tide. In heavily burrowed patches at the scrub margin a tall etiolated *Sambucus* sp. occurs, partially dead and leaning against adjacent vegetation as though stimulated to excessive soft growth by an overdose of nitrogen in the soil. Its association with burrows, both here and elsewhere, is reminiscent of the association of *Sambucus nigra* with rabbit burrows in Britain.

There is no evidence that other sea birds nest here, although the usual silver gulls and black-faced cormorants are present in small numbers around the coast. The only sign of rabbits seen was a skull, possibly brought by a predator.

8 Doughboy I.

Doughboy I. lies in the inner NW. part of Corner Inlet about 6 m. S. of Port Franklin. The distance of fetch to the W. is only about 3 m., much of which is occupied by *Zostera* flats at low tide, so exposure is relatively slight. The island consists of a fairly steep-sided granite mound about 60 ft high and 10 acres in extent, partially surrounded by sandy beaches and offshore sand banks.

The greater shelter is reflected in the larger number of species and the ability of woodland plants such as the tree fern, *Cyathea australis*, and the liane, *Clematis aristata*, to thrive in the open on parts of the E. coast.

Only 4 succulent halophytes were recorded in 1959 and of these *Crassula sieberiana* and *Senecio lautus* had adopted the non-succulent inland form, *Salicornia* *australis* was confined to the beach, and *Chenopodium glaucum* to the guano-saturated soil of a shag roost.

Poa poiformis is rare, the species of the grass swards on the more exposed slopes including a high proportion of aliens (*Aira caryophyllea, A. praecox, Anthoxanthum odoratum, Briza minor, Bromus mollis, Holcus lanatus, Vulpia bromoides* and various pasture weeds). With them are native grasses and *Acaena anserinifolia*, these grading into stands of *Pteridium esculentum* and low*Correa alba* thickets.

Stunted *Melaleuca ericifolia* occupies much of the shallower rocky soil and reaches heights of 2–3 metres on deeper soil in the S. and E. where *Solanum aviculare* is an important member of the shrub layer beneath. A clump of tall *Eucalyptus viminalis* persists on the island summit, but the vegetation of most of the remainder has been much modified and consists principally of introduced *Vinca major* and *Carduus tenuiflorus*. These areas, which occupy most of the island summit, are densely burrowed by short-tailed shearwaters, smaller numbers of which occur in the open scrub of deeper soils and coastal *Acaena anserinifolia*. There are few burrows in the N. grass swards or beneath the bracken, *Correa* or low *Melaleuca* where the soil is often shallow.

Black-faced cormorants and large black cormorants roost on rocks in the NE. and some of the latter frequent spindly *Melaleuca* trees in the SE.

9 Gabo I.

Gabo I. lies 320 m. ENE. of the Wilson's Promontory group and is larger than any of these (*c.* 420 acres). Its sandy N. promontory approaches to within a few hundred yards of Telegraph Point on the mainland coast 4 - 5 m. from the Vic.—N.S.W. border. The island measures approximately 1½ m. from the N. tip to the lighthouse in the SE. and about 1/3 m. from W. to E. Its greatest height is 171 ft and it is the only one of the 9 islands under consideration to show sand dune and heath formations. A few cattle and sheep are grazed on the island and parts are subjected to periodic burning.

Halophytes are aggregated largely on the low red granite platforms of the S., typical species being *Disphyma australe, Apium prostratum* (normal small form) and *Lobelia alata*. In the N. the coast is sandy, low dunes covering the whole of the N. promontory from the W. landing beach and exhibiting several major examples of wind-scouring. This entire area is a vast penguin rookery, most of it occupied by almost pure *Carpobrotus rossii*, but there are numerous small patches of the introduced *Stenotaphrum secundatum* (Buffalo grass) and clumps of *Lomandra longifolia, Muehlenbeckia adpressa, Senecio lautus* and *Zieria cytisoides* (Pl. VII).

This area grades through *Lomandra longifolia, Pteridium esculentum* and *Scirpus nodosus* to native scrub which covers the major part of the island and has an understorey of typical heath species. Among the more important trees are *Acacia longifolia* var. *sophorae, Banksia integrifolia, Leptospermum laevigatum* and *Monotoca elliptica*. Among the shrubs are *Acacia suaveolens, Banksia marginata, Correa alba, Hakea* sp., *Myoporum insulare, Persoonia juniperina* and *Pultenaea daphnoides*.

On partially waterlogged, black, peaty soil in the S. the scrub gives way to a mixed community of coarse grasses and sedges.

Many thousands of penguins nest on the island, but mutton birds have reduced during recent years to little more than 100 pairs. White-faced herons (*Notophoyx novae-hollandiae*) are numerous.

Species: Acreage Ratio in Relation to Exposure

5 suppressive environmental factors affect the number of species present on the bird islands:

(a) Soil disturbance and guano deposition by seabirds
(b) Rabbit grazing
(c) Lack of soil depth
(d) Summer drought
(e) Spray-bearing winds.

(a) and (b) are discussed in a later work dealing more specifically with the interactions of plants and animals.

(c) has been referred to in the account of Citadel I. where the scanty soil covering was found to support only 9 species of vascular plants. Lack of soil depth there was aggravated by exposure, (e).

(d) was exerting its maximum effect when the islands were visited during and after the January 1959 drought. Species lists compiled at this season were very far from complete, the largest number of species being probably missed on the inshore islands where shelter was sufficient for mesophytic annuals to thrive during the moister winter season and where the source of disseminules of these was sufficiently close for them to reach the islands initially.

(e) was the most potent operative factor and can be illustrated by the species: acreage ratios in the accompanying table for the 8 islands around Wilson's Promontory. The islands have been dealt with in order of decreasing exposure and show a gradually ascending series from a ratio of 1 species to 8 acres on Citadel I. to 8 species to 1 acre on Doughboy I.. The correlation between species number and degree of exposure is remarkably close considering the number of other factors involved, and the only island far out of sequence is Rabbit I. where the number of species was severely depressed by rabbit grazing.

Only a rough comparison is possible because of the different sizes of the islands and the divergence of the total area from the 'minimal area' (i.e. the smallest area containing all recorded species) in each case, but the figures are sufficiently interesting to be included. A species: acreage ratio somewhat higher than expected was seen on the smallest island of each series (McHugh I. of the 4 exposed offshore islands and Granite I. of the 4 sheltered inshore islands) where the total and 'minimal' areas were closest.

No direct correlation with bird pressure can be made because rookeries did not always cover the entire island.

Acknowledgements

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Explanation of Plate

PLATE VII

Gabo I., N. Penguin Rookery

Fig. 1—View of part of the rookery in pure *Carpobrotus rosii* on white dune sand.

Fig. 2—Penguin burrows beneath *Carpobrotus rosii* and *Lomandra longifolia* showing one of many dead penguins in the foreground.

Fig. 3—Entrance to penguin burrow showing moulted feathers and defoliated stems and exposed roots of the dominant *Carpobrotus rossii.*

Fig. 4—Large sand blow in penguin rookery probably initiated and certainly aggravated by birds burrowing through the protective mat of vegetation. Looking N. to Telegraph Point on the mainland.

Tables

In the following tables abbreviations are used for the 9 islands discussed in this article thus—

Ben.—Benison
Cit.—Citadel
Cl.—Cliffy
Dan.—Dannevig
Dou.—Doughboy
Ga.—Gabo
Gr.—Granite
McH.—McHugh
Rab.—Rabbit

TABLE 1

Species:Acreage Ratio on 8 Islands around Wilson's Promontory, Summer 1959
(Islands listed in order of decreasing exposure)

Series	Island	Locality	A	B	C	D
Exposed offshore islands	Cit.	SW. of Glennie Group	W.	9	70	1 : 8
	Dan.	W. of Glennie Group	W.	20	80	1 : 4
	McH.	SE. of Glennie Group	W.	18	30	1 : 1¾
	Cl.	20 m. S. of mainland	E.	39	100	1 : 2½
Sheltered inshore islands	Rab.	S. of Three Mile Beach	E.	24	90	1 : 3¾
	Gr.	Outer part of Corner Inlet	N.	16	3½	4½ : 1
	Ben.	Inner part of Corner Inlet	N.	59	19	3 : 1
	Dou.	Inner part of Corner Inlet	N.	78	10	8 : 1

A — Direction from Wilson's Promontory
B — Number of species recorded
C — Approximate acreage
D — Approximate species : acreage ratio

TABLE 2

Species List — Vascular Plants

Nomenclature is that in current use at the National Herbarium, Melbourne. Names and symbols in brackets refer to species recorded on Doughboy Island in 1912 (Kershaw et al. 1913) but not in 1959, the names in several instances calling for correction. The prefixed asterisk denotes an alien plant. (H)—determined at National Herbarium, (U)—determined at Botany Department of the University of Melbourne.

Species	Cit.	Dan.	McH.	Cl.	Rab.	Gr.	Ben.	Dou.	Ga.
Cyathea australis (H)								×	
Pteridium esculentum					×	×	×	×	×
(*Pteris incisa*)								(×)	
Phymatodes diversifolium (H)								×	
(*Polypodium pustulatum*)								(×)	
Blechnum minus (H)									×
Asplenium flabellifolium (U)							×		
———— *obtusatum* (U)	×		×	×					×
———— *scleroprium* ?				×					
(*Aspidium aculeatum*)								(×)	
Zostera muelleri (H)							×	×	
Posidonia australis						×	×	×	
Imperata cylindrica (H)									×
Zoysia macrantha (H)									×
Paspalum distichum (H)									×
**Stenotaphrum secundatum*									×
Spinifex hirsutus (U)							×		×
**Anthoxanthum odoratum* (H)								×	
Microlaena stipoides (H)								×	×
Distichlis distichophylla							×		
Phragmites communis (U)									×
**Dactylis glomerata*									×
**Vulpia bromoides* (H)				×	×	×	×	×	
**Bromus diandrus* (H)				×		×	×		×
*———— *mollis* (H)								×	
*———— *unioloides*				×					×
**Catapodium rigidum*								×	×
**Briza minor*								×	
Eragrostis brownii (H)									×
Poa annua (H)								×	
(———— *australis*)								(×)	
———— *poiformis* (H)	×	×	×	×	×	×	×	×	×
*———— *pratensis*								×	
Deyeuxia quadriseta									×
Agrostis avenacea (U)								×	×
Dichelachne crinita (H)							×	×	×
(———— *sciurea*)								(×)	
**Lagurus ovatus*				×					
Stipa aphanoneura ?									×
———— *teretifolia* (U)		×					×		×
**Ammophila arenaria* (U)					×				×
**Sporobolus capensis* (H)									×
**Eleusine indica* ?									×
Cynodon dactylon (H)				×					
**Holcus lanatus*							×	×	×
**Aira caryophyllea* (U)							×	×	×
*———— *praecox*							×	×	
Danthonia caespitosa (H)	×								
———— *racemosa* (H)								×	
**Lolium perenne*				×					×
**Monerma cylindrica*									×

**Parapholis incurva*				×				×	
Agropyrum scabrum								×	
**Hordeum leporinum* ?				×					
Scirpus antarcticus (H)							×	×	
———— *cernuus* (H)							×	×	×
———— *nodosus* (U)					×		×	×	×
Carex sp.									×
Lepidosperma concavum									×
———— *gladiatum*									×
Gahnia radula (H)									×
**Zantedeschia aethiopica*								×	
Leptocarpus brownii (H)									×
Centrolepis strigosa (H)							×		×
Luzula campestris (H)							×	×	
Juncus bufonius (H)				×			×	×	
———— *caespiticius* (H)									×
(———— *communis*)								(×)	
———— *maritimus* (H)							×		×
———— *pallidus* (H)							×	×	×
Lomandra longifolia (U)							×		×
Dianella revoluta					×			×	×
Bulbine semibarbata		×	×	×	×	×		(×)	
Thelymitra sp. ? (H)									×
Microtis unifolia							×		
**Ficus carica* (H)									×
Urtica incisa								×	
Parietaria debilis								×	
Persoonia juniperina (H)									×
Banksia integrifolia (H)							×	×	×
———— *marginata* (U)									×
Lomatia ilicifolia (H)									×
Polygonum minus (H)									×
Muehlenbeckia adpressa					×		×		×
**Rumex acetosella*									×
———— *brownii* (H)								×	×
*———— *crispus* (H)				×					×
**Atriplex hastata*				×	×		×	×	×
Rhagodia baccata (U)		×	×			×			×
Chenopodium glaucum (H)								×	×
———— *trigonon* (H)									×
Salicornia australis (H)		×		×			×	×	
Hemichroa pentandra (H)							×		
Disphyma australe	×	×	×	×	×		×		×
Carpobrotus rossii (U)		×	×		×	×	×	(×)	×
Tetragonia implexicoma		×	×				×		×

**Portulaca oleracea* (H)				×					×
Calandrinia calyptrata		×	×	×	×			(×)	
**Stellaria media*					×				×
———— *multiflora* (H)							×		
**Cerastium glomeratum*							×	×	
Sagina apetala				×			×	×	
———— *procumbens*									×
Spergularia media				×	×				
**Polycarpon tetraphyllum*				×				×	
**Silene gallica*									×
Clematis aristata								×	
———— *microphylla*							×		
**Fumaria officinalis*				×					
**Nasturtium officinale*									×
Lepidium foliosum (H)						×			
Cakile maritima v. *edentula*					×		×		
Crassula sieberiana (H)		×		×	×	×	×	×	×
Billardiera scandens (U)									×
(*Pittosporum undulatum*)								(×)	
**Rubus fruticosus* agg.									×
Acanena anserinifolia							×	×	×
Acacia longifolia (H)					×				
———— *longifolia* v. *sophorae* (H)						×			×
———— *melanoxylon* (H)							×	(×)	
———— *stricta* (H)			×						
———— *suaveolens* (H)									×
**Alibizzia lophantha* (H)								×	
Pultenaea retusa (H)									×
Dillwynia glaberrima (H)									×
Lotus corniculatus (H)									×
**Trifolium campestre*									×
*———— *dubium*									×
*———— *repens*									×
**Medicago hispida*									
v. *denticulata* (H)									×
Glycine clandestina (H)									×
Kennedya prostrata									×
———— *rubicunda* (H)									×
Pelargonium australe		×	×	×		×	×	(×)	
**Geranium dissectum* ?								×	
**Erodium cicutarium*									×
(*Oxalis corniculata*)								(×)	
Correa alba (H)	×	×	×		×		×	×	×
Zieria cytisoides (H)									×

Comesperma volubile (H)									×
**Euphorbia peplus*								×	
(*Poranthera microphylla*)								(×)	
Amperea xiphoclada (H)									×
**Hibiscus trionum* (H)									×
Lavatera plebeja		×	×	×		×		×	
**Malva parivflora* ?				×					×
Viola hederacea									×
(*Eucalyptus paludosa*)								(×)	
——— *viminalis*								×	
Leptospermum laevigatum (H)	×		×					?	×
Melaleuca ericifolia (H)							×	×	×
Kunzea ambigua (H)				×					
Epilobium billardierianum (H)									×
——— *junceum*							×	×	
Haloragis tetragyna ?									×
Centella asiatica (H)									×
(*Hydrocotyle hirta*)								(×)	
——— *peduncularis* (H)									?
Apium prostratum (normal) (H)				×			×		×
——— *prostratum* (large) (H)		×	×	×					
Epacris impressa (U)									×
Monotoca elliptica (U)									×
Astroloma humifusum (U)									×
Leucopogon parviflorus (H)							×	×	
Cyathodes acerosa (H)					×			(×)	
**Anagallis arvensis*				×				×	
Samolus repens									×
Centaurium pulchellum							×	×	
Alyxia buxifolia (U)		×							
**Vinca major*								×	
Dichondra repens (H)							×	×	×
**Mentha spicata* (H)									×
Solanum aviculare (H)								×	×
——— *nigrum*								(×)	×
**Lycium ferocissimum*									×
**Physalis peruviana*									×
Myoporum insulare (H)								×	×
**Plantago coronopus*				×					×
*——— *lanceolata*									×
*——— *major*									×
——— *varia*									×

Opercularia ovata (H)									×
Galium propinquum (H)								×	
Sambucus sp.			×		×		×	×	
Wahlenbergia quadrifida ? (H)							×		
——— *tadgellii* ? (H)								×	
Lobelia alata	×	×		×	×		×	(×)	×
Selliera radicans (H)							×	(×)	×
Brachycome diversifolia var. *maritima*		×							
Brachycome graminea (H)									×
**Erigeron bonariensis* (H)									×
*——— *canadensis* ?									×
Olearia phlogopappa (H)			×						
——— *ramulosa* (H)									×
**Gnaphalium candidissimum*				×			×		×
——— *indicum* (H)								×	
——— *involucratum* (H)								×	
——— *japonicum* (H)								×	
——— *luteo-album*				×			×	×	×
——— *purpureum* (H)						×			×
Cassinia spectabilis									×
Helichrysum bracteatum var. *albidum* (H)		×	×						
Helichrysum dendroideum (H)								×	
——— *leucopsidium* (H)									×
——— *obcordatum* (H)									×
Cotula australis								×	
——— *coronopifolia*				×	×				×
——— *reptans* (H)									×
Senecio biserratus (H)								?	
——— *hispidulus* (H)								×	×
——— *lautus* (H)	×	×	×	×	×	×	×	×	×
——— *minimus* (H)								×	×
**Arctotheca calendula*									×
**Cirsium vulgare*						×	×	×	×
**Carduus tenuiflorus*					×			×	
**Hypochoeris glabra* (H)								×	
*——— *radicata*				×			×	×	×
**Leontodon hirtus* (H)								×	×
**Sonchus asper*				×					×
——— *megalocarpus*							×		
*——— *oleraceus*		×		×		×	×	×	×
Total No, of Species (219)	8	20	17	40	24	17	59	98	**134**

Table 3

Bryophytes of Bird Islands around Wilson's Promontory
(Det. J. H. Willis, National Herbarium)

Species	Cit.	Dan.	McH.	Cl.	Rab.	Gr.	Ben.	Dou.
Marchantia cephaloscypha	+							
Breutelia affinis							+	
Bryum billardieri				+		+		+
Campylopus introflexus	+	+	+		+		+	+
Rhacopilum convolutaceum						+		
Sematophyllum homomallum	+						+	
Thuidium furfurosum							+	
Tortula princeps				+				

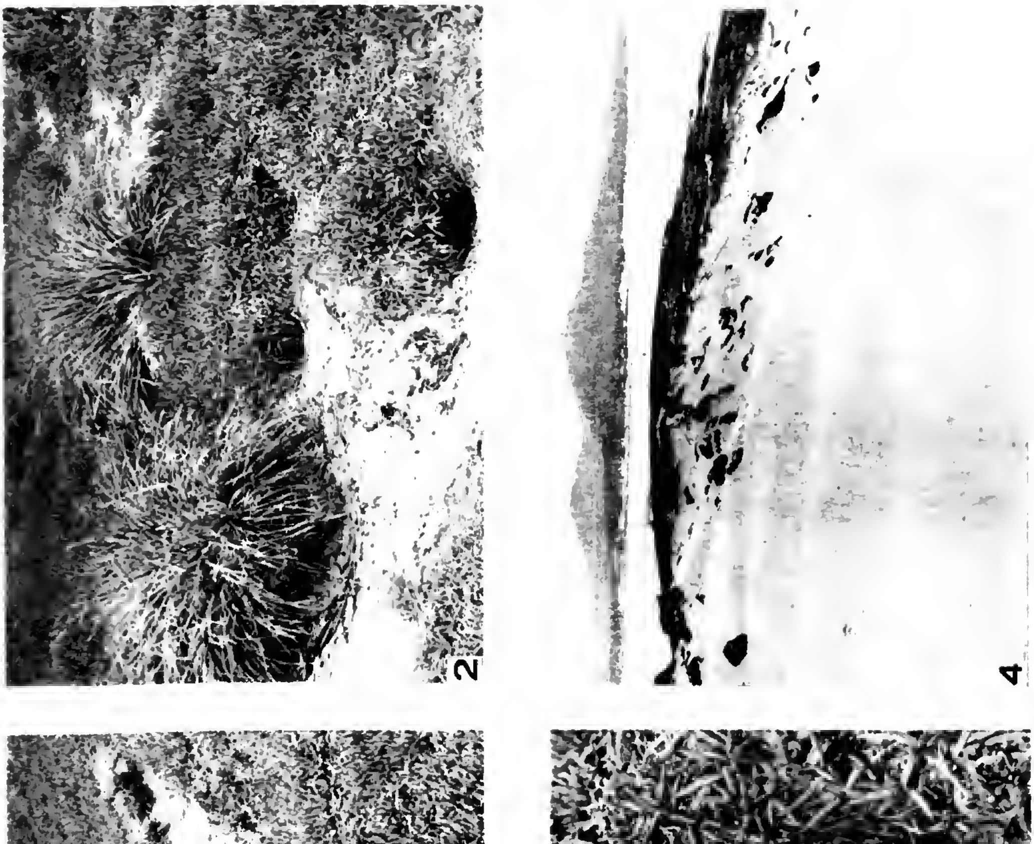
Table 4

Species List — Seabirds

Species	Cit.	Dan.	McH.	Cl.	Rab.	Gr.	Ben.	Dou.	Ga.
Eudyptula minor (Blue or fairy penguin)	B	B	B	B	B				B
Puffinus tenuirostris (Short-tailed shearwater)		B	B	B	B	B	B	B	B
Pelecanoides urinatrix (Diving petrel)		B	B						
Pachyptila turtur (Dove potrel)				B?					
Cereopsis novae-hollandiae (Cape Barren goose)	+	+	+						
Larus pacificus (Pacifie gull)	+	+							
Larus novae-hollandiae (Silvor gull)			+	B	B+	B	+	+	+
Sterna bergii (Crosted tern)					B+				
Phalacrocorax fuscescens (Black-faced cormorant)					+	+	+	+	
Phalacrocorax carbo (Large black cormorant)								+	
Haematopus fuliginosus (Sooty oyster catcher)						+	+		+
Notophoyx novae-hollandiae (White-faced heron)									+

The first 8 islands are listed in order of decreasing exposure and illustrate the preference of the true seabirds for the more oceanic islands and of the shore birds for the less oceanic islands.

+ — birds present, B — presence of a breeding colony,
B+ — breeding on Rabbit Rock, not Rabbit I. proper.



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4

OLD AND NEW STORM PETREL ROOKERIES IN PORT PHILLIP BAY

By MARY E. GILLHAM and J. A. THOMSON

[Read 14 July 1960]

Abstract

It is suggested that the breeding colony of white-faced storm petrels (*Pelagodroma marina* Latham) established on South Channel Fort Island formed from descendants of birds breeding on the Mud Is 2 m. away. The old established Mud Is rookeries are degenerating and petrel burrow density is less than in the more recent Fort I. rookery.

On the Mud Is collapse of the petrel burrows due to interference by man, grazing of vegetation by rabbits and the removal of guano in the latter half of last century have aided soil erosion. Loss of soil depth where the underlying rock is near the surface results in decrease of rookery area as burrowing becomes impossible. These factors are not important on Fort I.

The vegetation of the Mud Is in rookery areas is extremely degenerate and consists of an incomplete cover of introduced annuals. Fort I., although man-made and only 80 years old, has a much less artificial flora of native perennials.

The unfavourable areas of Fort I. were almost fully utilized by the 1959-60 breeding season, so that further transfer of the storm petrel population from the Mud Is is likely to be restricted. At least some portions of the rookeries on the Mud Is might be preserved by enclosure with rabbit-proof fencing to enable the flora to regenerate and by minimization of the disturbances occasioned by collapse of the petrel burrows due to trampling by man.

Introduction

Keble and others (1947, p. 131) write of the Mud I. Group, 30 m. S. of Melbourne—'The investigation was of peculiar importance, as it was considered that the islands are of recent origin . . . at the most little more than 3,500 years old, and that they would furnish the material for an interesting ecological survey'. Later in the same paper Willis (p. 141) states—'The Mud Islands, so relatively circumscribed and free from interference, would form an admirable subject for a detailed ecological survey'.

The present paper confirms the undoubted ecological interest of the group, but for different reasons. Although 'new' geologically, the islands may be considered 'old' biologically in regard to the age and degeneracy of both the plant and animal communities, when compared with those of the adjacent, more recent South Channel Fort Island (hereafter referred to as Fort I.). Further, the very high degree of interference now suffered is of undoubted significance in the present unstable biosystem of the islands.

Populations of seabirds have already come and gone, as shown by the old bone beds and guano beds. The existing population of white-faced storm petrels (*Pelagodroma marina* Latham), estimated at approximately 10,000 pairs in 1958 by W. R. Wheeler, appears to be decreasing in size.

The Mud Is are the only places in Port Phillip Bay where consolidated dune limestone or aeolianite is exposed above H.W.M. (Chapman 1928; Keble and others 1947). Some of this rock has been covered by sand, but the depth of this is often slight and collapse of burrow roofs serious because of lack of sufficient soil depth for burrows to be replaced or repaired.

One such extensive area (Pipit Flat) on Middle I. was the site of considerable guano gathering resulting in the removal of 'hundreds of tons of the sand and soil constituting the main petrel rookery, the birds of which have now to dig laboriously amongst the roots of the shrubs for their nesting burrows' (Chief Inspector of Fisheries and Game, May 1912, in a recommendation to the Secretary for Lands requesting the refusal of future applications for rights to operate on the islands). The burrows in this area are now sparse and confined to patches of shingly sand between exposed ridges of aeolianite. The Middle I. rookery was proclaimed a sanctuary for storm petrels in 1898 by authority of a Mr MacLean of the Ports and Harbours Branch (J. P. Larkin, personal communication). In 1902 the Game Act then in force was invoked to provide complete protection for the white-faced storm petrels breeding on the Mud Is. This was repealed in 1931 and replaced by a new proclamation declaring these islands a sanctuary for all native game.

After the cessation of guano collecting and enforcement of protection, the storm petrel rookeries on the Mud Is appear to have expanded at least until 1936, when Heathcote (1936) recorded increased numbers of the birds, and new rookery areas as compared with earlier observations. Tarr (1954) considered that the population of storm petrels had still further increased by 1953, and attributed this tentatively to a decline in the rabbit numbers on the islands. The more recent decrease, apparent during banding work, has probably been occasioned by progressive destruction of vegetation and denudation of soil resulting in collapse of burrows on the Mud Is.

Contemporaneous with these changes has been the initiation and spread of a new storm petrel colony on the 80-year-old man-made Fort I., and it is suggested

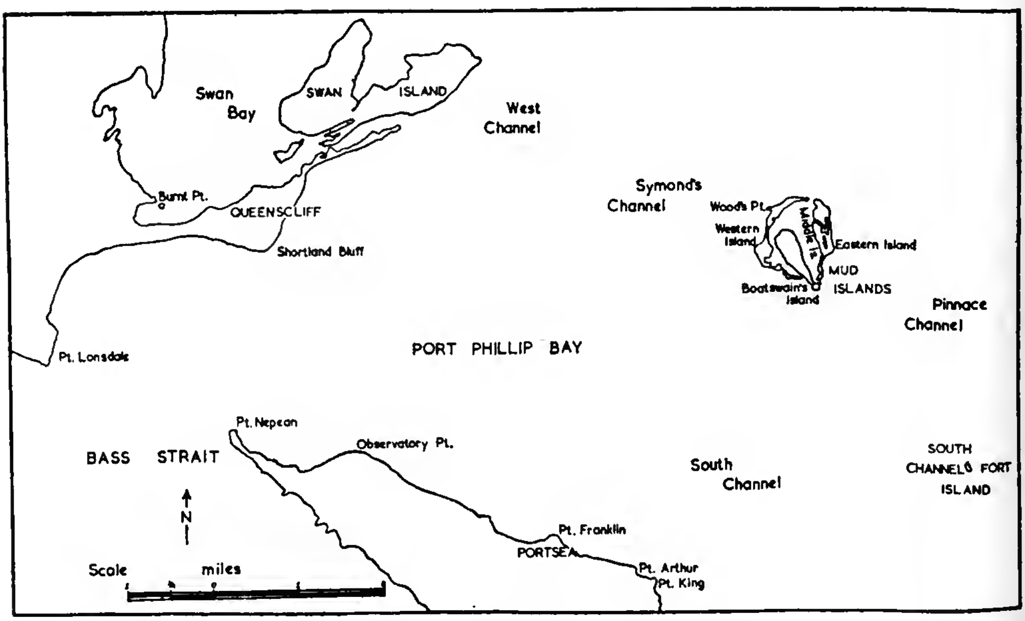

Fig. 1—Sketch map showing positions of the Mud Is and South Channel Fort I. in Port Phillip Bay.

in this paper that this represents a transfer of population. Mud and Fort Is are only 2 statute miles apart (Fig. 1); the nearest known breeding colonies of storm petrels to these two islands are in the Furneaux Group off NE. Tasmania, 250 m. away. The recent discovery of diving-petrels (*Pelecanoides urinatrix*) and short-tailed shearwaters (*Puffinus tenuirostris*) on islands of the Glennie group (Gillham 1960a, b, c) suggests, however, that unrecorded colonies of storm petrels may exist on some of the lesser known islands S. of Wilson's Promontory.

The colonization of a completely new breeding habitat is of particular interest in the case of burrowing birds, these tending to return more habitually to the ancestral site than do many surface-nesters—probably because of the smaller likelihood of their guano, trampling, etc., rendering the rookery untenable (Gillham 1961). There are instances in SE. and NW. Tasmania, however, where short-tailed shearwaters (*Puffinus tenuirostris*) have spread from island rookeries onto adjacent arms of the mainland.

Approximately 4,000 petrels have been banded during the past 4 - 5 years on the Mud Is by members of the Altona Survey Group and it would be of interest to see if any of these could be recovered on Fort I. to indicate if a transfer is still in progress. The first record obtainable is of a well-established colony on Fort I. in 1932 (J. P. Larkin, personal communication). By 1947, when the island was visited by Tarr (1948) who estimated the population as 2,000 birds (suggesting 1,000 burrows), the colony had grown considerably. Colonization may have ceased some years ago and the present population may be substantially home-bred.

Degeneration of Petrel Colonies of the Mud Island Group

Factors Contributing towards Degeneration

1 Marine Erosion

Keble (in Keble and others 1947, p. 133) comments on the changes in surface level occurring in this part of Port Phillip Bay and (p. 135) on the fact that the islands are level and rise only about 5 ft above H.W.M. except at their outer fringes. Petrel burrows are scarce or absent in the mobile sand of the dunes which reach to heights of up to 12 ft—almost all occurring on the low-lying flats. A high proportion lie below the upper drift line and are thus vulnerable to inundation by the sea.

Old stumps of *Leucopogon parviflorus* standing in the water at both ends of the islands show where former scrub communities have been destroyed. At least 3 shrub species observed by Campbell (Mattingley 1907) are thought by Willis (in Keble and others 1947) to have been exterminated by marine erosion. As most of the rookeries occur in areas which are not stabilized by scrub, they are even more subject to soil movement but leave no trace to indicate where they might formerly have existed.

Wheeler (personal communication) points out that eggs or chicks in the entire rookery of 5,000 burrows on Boatswain's I. (half the number of burrows on the whole group) could be destroyed by a spring high tide.

2 Inhibition of Plant Growth on Old Guano Beds

Guano beds were previously exploited on the islands (Ports and Harbours Branch, Public Works Department 1959), and, although they are estimated to have been only 1–2 ft thick (Keble, in Keble and others 1947), their presence indicates a destruction of any protective cover of vegetation which might have existed in the old rookeries. Destruction would have occurred and the substrate consequently become exposed to erosive forces both at the time of guano deposition and at its subsequent removal.

There is no record of the species of bird responsible for the guano. The burrowing petrels are never responsible for building up such deposits but large numbers of black swans (*Cygnus atrata*) and pelicans (*Pelecanus conspicillatus*) were present when the islands were first sighted in 1802 by John Murray (Lee 1915). The fish-eating pelicans are more likely to be responsible for excreta deserving of the term 'guano' than are the herbivorous swans. The deposits were described by MacIvor (1879) as containing 23·64% of non-nitrogenous organic matter consisting chiefly of vegetable debris, so it is possible that both species contributed. The extensive, partially exposed bone beds of Boatswain's I. are composed virtually entirely of the bones of pelicans, both adults and juveniles being represented.

3 Wind Erosion and Degeneration of Flora following Denudation of the Soil by Rabbits

The flora is rabbit-dominated and so much of the perennial vegetation has been eaten off that large areas of soil are exposed to wind erosion. Burrowing by both rabbits and petrels exposes more ground and increases the amount of soil lost.

Many of the succulent plants such as *Disphyma australe* and *Tetragonia implexicoma* (the dominant species on Fort I.) which would be expected in this maritime habitat are absent and *Spinifex hirsutus*, previously unrecorded, was but a tentative colonist in 1960.

Cakile maritima, Tetragonia expansa and *Carpobrotus rosii* are succulents recorded in 1906 (Mattingley 1907) but not in 1945 (Willis and others 1947) nor by the present investigators in 1960. The first two are palatable, the third is normally avoided but is eaten by quokkas (*Setonix brachyurus*) on Rottnest I., W.A., for its moisture in later summer when little else is available (Storr 1957). The poor water-retention of the porous aeolianite on Mud Is creates a waterless habitat similar to that of the Rottnest aeolianite and may present the rabbits with a similar thirst problem to that experienced by the Rottnest quokkas, so that even the unpalatable *Carpobrotus* has been grazed out.

The succulent *Rhagodia baccata* is rare and nibbled off almost flush with the ground, and much of the area, including all the larger rookeries, is occupied by annuals, predominantly introduced ones. Of these *Cucumis myriocarpus*, one of the most widespread, is poisonous and probably avoided. *Cucumis* was green and thriving during the summer food shortage of January 1960, when more palatable members of the now prevalent rookery flora were dead. Many of the latter are characteristic of heavily rabbited country in Britain (e.g. *Anagallis arvensis, Carduus tenuiflorus, Cerastium glomeratum, Chenopodium murale, Sonchus oleraceus, Urtica urens* and *Vulpia bromoides*).

The increase of alien plants which has accompanied the floristic degradation is indicated by the following figures—

1906—12% aliens (25 sp. recorded) Mattingley (1907).
1945—33% aliens (30 sp. recorded) Willis (in Keble and others 1947).
1960—61% aliens (18 sp. recorded). This investigation rookeries only.

Other aliens observed in 1959 for the first time but not seen in the rookeries are *Ammophila arenaria* and *Glaucium flavum*.

30% of the total recorded flora are aliens and 37·5% annuals.

4 Human Disturbance Resulting in Widespread Collapse of Burrow Roofs

Disturbance by man is thought to have increased since 1945 when Willis (Keble and others 1947) described the islands as being 'so relatively free from interference'.

Trampling by picnickers and fishermen has an important detrimental effect on the rookeries when the petrels are in residence during the summer, and as many as 70 visitors at a time have been counted on the islands (Wheeler 1959). It is impossible to walk through the rookeries without breaking through the fragile burrow roofs and there must be heavy mortality among the eggs and chicks, apart from mechanical damage to the burrows themselves .

Members of the Altona Survey Group have banded approximately 4,000 petrels on the islands during recent years, 30 members having spent 3 days there during January 1957, 1958, 1959 and 1960. The impression was gained in 1960 that far fewer burrows were occupied although no change was noticed in burrow frequency (possibly because a collapsed roof may simulate the entrance to a second burrow). Gradual dwindling of the colony is also indicated by the estimate made in January 1928 by A. G. Campbell that 22,000 burrows, almost all occupied, were present in the 4½ acres of rookery.

Because of the recognized vulnerability of burrows to damage, banding was carried out only in areas of compacted sand or where the aeolianite cropped out on the surface. Damaged burrows were repaired and artificially roofed where necessary, the chick being placed as near as possible to the original position in the newly constructed burrow (Wheeler, personal communication). Desertion and mortality were not estimated, but the British storm petrel (*Hydrobates pelagicus*) is known to desert readily if the nest is disturbed. However, the time of banding, when the chicks are almost ready to leave the burrows, would minimize the importance of this factor.

Degenerate Rookery Flora

1 Burrows among Saltbushes (*Arthrocnemum* and *Atriplex*)

Arthrocnemum arbusculum dominates some of the lowest-lying rookeries where birds nest fairly sparsely (Pl. VIII, fig. A). Most burrows lie below one or more algal drift lines and the moist soil bears a weft of filamentous green algae. The only subordinate species seen were *Rhagodia baccata, Suaeda maritima* and *Samolus repens*, all rare.

Atriplex cinerea is dominant on the looser sand of low dunes and such areas are mostly unburrowed, although a few petrels nest beneath it in places. No subordinate species were recorded.

Rookeries on aeolianite are uncommon in SE. Australia and the vegetation bears a more striking resemblance to that of the aeolianite rookeries of temperate W.A. over 2,000 m. away than to the average Victorian rookery (Gillham 1960a, b, c, 1961). The flora of both is markedly halophytic, due primarily to occasional inundation by sea-water on the Mud Is and to concentration of soil solutes by evaporation during summer droughts in W.A. The porosity of the non-retentive aeolianite would increase the salt concentration in both regions.

Arthrocnemum is represented in W.A. rookeries by *A. arbusculum* and *A. halocnemoides, Atriplex* by *A. isatidea* and *A. paludosa,* which latter also occurs on the Mud Is. Important aliens common to aeolianite rookeries on both sides of the continent are *Vulpia, Urtica, Chenopodium* and *Anagallis.*

2 Extensive Rookeries Dominated by Introduced Annuals

(i) The most extensive rookeries investigated, including that occupying Pipit Flat, possess a degenerate plant community in which 68% of the recorded species are introduced and the remaining 32% represented by few indivdiuals, 68% of the species (again including all but some of the poorly represented ones) are annuals.

Anagallis arvensis is dominant, *Vulpia bromoides* seasonally so earlier in the year in places; *Atriplex hastata* is abundant. The sparse *Rhagodia baccata* is a relict of a former community and grazed to ground level by rabbits.

(ii) The second community type which is extensively burrowed is also floristically degenerate. 3 annuals succeed each other to dominance as the season advances. Tall *Senecio* sp? (*Erechthites* group) appears to be dominant in winter and early spring, being represented by dead stems in January. This is followed by mats of *Anagallis arvensis* which have begun to die off by January when new growths of *Cucumis myriocarpus* are becoming established as the autumn dominant (Pl. VIII, fig. B). The alien *Carduus tenuiflorus* and *Sonchus oleraceus* are the only other species recorded apart from marginal *Samolus repens.*

(iii) In a third type of rookery the annual mats of *Anagallis* and *Cucumis* are mingled with *Samolus*. Although perennial, it is likely that the native *Samolus* is never completely dominant as the 2 aliens appear to have their peak growing seasons at different times of the year.

Species represented in these 3 degenerate rookery floras are tabulated below.

Species (Aliens marked *)	Rookery type			Occurrences
	i	ii	iii	
**Vulpia bromoides*	ld			1
Agrostis avenacea	r			1
**Urtica incisa*	r			1
**Atriplex hastata*	a		r	2
Rhagodia baccata	r			1
**Chenopodium murale*	r			1
Salsola kali			r	1
**Cerastium glomeratum*	r			1
*?*Lavatera* sp.	r			1
**Anagallis arvensis*	d	cd	cd	3
Samolus repens	r		cd	2
**Cucumis myriocarpus*	r	cd	cd	3
Senecio sp.?		cd		1
**Carduus tenuiflorus*		o		1
**Sonchus oleraceus*		r		1
Aliens 63%	68%	80%	60%	
Annuals 70%	68%	100%	70%	

d—dominant, ld—locally dominant, cd—co-dominant, a—abundant, o—occasional, r—rare.

Note—The following species observed by the McCoy Society in November 1959 (unpublished), and the authors in January 1960, do not appear in earlier lists for the island (Mattingley 1907, Keble and others 1947).

Spinifex hirsutus (1960)
Agrostis avenacea (1960)
**Ammophila arenaria* (1959)
**Chenopodium* sp.? *album* (1959)
**C. murale* (1960)
**Glaucium flavum* (1959, 60)
*?*Lavatera* sp. (1960)
Wilsonia humilis (1959)
Senecio sp.? (1960)

(Aliens marked *)

New Petrel Rookery of South Channel Fort Island

Fort I. was constructed on a sand bank over which the minimum depth of water at low tide was about 3 ft 6 in. Contemporary press accounts (*The Argus* 28 April 1880, *Australian Sketcher* 1880) describe placement of the stone foundations on which work commenced on 4 August 1879. These were completed in February 1880 at a cost of £8,996. 14,000 tons of bluestone were transported from Walsh's Quarries, Laverton, by sailing craft and lighters and placed to form an annulus surrounding the site of the fort proper. Temporary wooden gun emplacements were in use in 1885 (*Australian Sketcher* 1885) and a small casemented stone fort had been built by 1891. This was subsequently replaced by a larger concrete structure with protective earthworks on which a garrison was maintained until 1919. In 1923, Fort I. was taken over by the Ports and Harbours Branch of the Public Works Department to serve as an explosives magazine.

Absence of Disturbing Factors

Of the 4 factors contributing to floristic degeneration on the Mud Is rookeries, none is of importance on Fort I. The man-made island is walled around the periphery with large rocks and none of the soil is subjected to inundation by the tide. No recent large scale disturbance of surface vegetation has occurred and rabbits are absent. There are few signs of interference by man with the storm petrel rookeries on the island.

Colonization by Plants

Fort I. as it appears today is oval in shape, being about 200 yds wide. The earth embankments protecting the gun emplacements reach a height of 23 ft above sea level (Ports and Harbours Branch, Public Works Department 1959). It seems likely that the sand used in construction of the earthworks was dredged from nearby shipping channels and in that case could not have contained viable seeds of land plants. Further, such seeds were probably not transported with the rock used for foundations.

In view of its artificial origin, it is remarkable how little of the island is occupied by alien plants, particularly when the flora is compared with the predominantly alien rookery flora of the Mud Is. The only important aliens present are *Coprosma repens* and *Stenotaphrum secundatum*.

Only 19 species were recorded in January 1960, and these are as follows (aliens marked *). No previous records of the flora have been located.

**Stenotaphrum secundatum*	*Rhagodia baccata*
**Bromus diandrus*	*Carpobrotus rossii*
Sporobolus virginicus	*Tetragonia implexicoma*
Poa australis?	**Fumaria officinalis*
**Lagurus ovatus*	**Melilotus indica*
Scirpus nodosus	*Leucopogon parviflorus*
Lepidosperma gladiatum	**Lycium ferocissimum*
Dianella revoluta	**Coprosma repens*
Muehlenbeckia adpressa	**Sonchus oleraceus*
Atriplex cinerea	Moss spp.

Coprosma, Tetragonia implexicoma which dominates the vegetation as a whole, and several other important species have succulent fruits known to be eaten by silver gulls (*Larus novae-hollandiae*). These birds are common in Port Phillip Bay and it seems likely that they are at least partly responsible for the introduction of the following 5 species—*Coprosma repens, Tetragonia implexicoma, Rhagodia baccata, Leucopogon parviflorus, Lycium ferocissimum*; possibly *Dianella revoluta* may also have been transported in this way.

Arable 'weed' seeds are commonly found in gull pellets mixed with the elytra and cuticular fragments of beetles, etc., and it is conceivable that any of the following might have arrived in this way—*Bromus diandrus, Lagurus ovatus, Fumaria officinalis, Melilotus indica, Sonchus oleraceus.*

Stenotaphrum secundatum is a useful sand binder which forms a close sward on the central mound within the main fortification and is likely to have been introduced by man as a stabilizer. It was not found in the native communities away from this central area and a more random distribution might be expected if it had been introduced by gulls.

The fruits of salt-resistant species such as *Sporobolus virginicus* and *Atriplex cinerea* may have drifted to the island in tidal currents. Such dispersal is assisted in the case of the latter species by the extra buoyancy resulting from spongy swellings on the broad fruit valves.

Any comments on the initial colonization of such an area must remain purely conjectural, but the importance of species known to be transported by gulls is of significance. Mr J. P. Larkin, formerly Marine Surveyor of Victoria, states that the island was fully vegetated at least as early as 1932.

Rookery Flora

Much of the island is burrowed by the storm petrels. 2 main types of rookery vegetation may be distinguished.

1 Predominant Vegetation of Succulent Native Species

Tetragonia implexicoma is an important element throughout and is widely dominant. It forms fairly pure mats a few inches deep with a burrow density of approximately 1 per sq. yd. Ground cover in 2 typical areas (A and B) in rookery with predominantly succulent native vegetation is tabulated below.

Species	Percentage ground cover	
	A	B
Bare sand	20	25
Tetragonia implexicoma	75	65
Atriplex cinerea	5	5
Carpobrotus rossii	–	5
Rhagodia baccata	rare	–
Coprosma repens	rare	–
Sonchus oleraceus	rare	–

A small patch of 6–12 in. high *Rhagodia baccata* has *Tetragonia* trailing through it and gives protection to approximately 1 burrow per 2 sq. yd. A few burrows occur under marginal *Coprosma repens*, an introduced shrub common throughout the island and attaining heights of 6–8 ft. *Coprosma* is the most guano-tolerant shrub of bird islands in N. New Zealand and has risen to local dominance during recent years on some of the Bass Strait bird islands.

Part of the marginal slopes support a 3 – 5 ft high scrub of *Atriplex cinerea* beneath which burrows occur at the rate of approximately 1 per 1 - 2 sq. yd. *Tetragonia* forms an understorey throughout but the canopy is too dense to allow growth of other species apart from an occasional *Lycium ferocissimum* bush up to 5 ft high.

2 Perennial Sward of Alien Grass Providing a Stable Burrowing Medium

Buffalo grass (*Stenotaphrum secundatum*) forms a mat 3-6 in. high with *Tetragonia implexicoma* trailing through and over it and becoming locally dominant in parts. Burrows are somewhat less numerous than in the native communities and there is comparatively little bare sand at the burrow entrances. The floristic composition of 4 such rookery areas (C–F) is set out below, E and F representing intermediate community types between native and alien.

Species	C	D	E	F
Stenotaphrum secundatum	d	d	sub-d	co-d
Tetragonia implexicoma	a	sub-d	d	co-d
Atriplex cinerea	a	-	-	-
Lagurus ovatus	a	o-f	o-f	-
Sonchus oleraceus	r	r	r	-
Lepidosperma gladiatum	-	lf	-	-
Bromus diandrus	-	r	-	-
Dianella revoluta	-	r	-	-
Muehlenbeckia adpressa	-	-	lf	-
Melilotus indica	-	-	-	o
Poa australis?	-	-	-	r
Scirpus nodosus	-	-	-	vr

d—dominant, a—abundant, f—frequent, lf—locally frequent, o—occasional, r—rare, vr—very rare.

Discussion

The storm petrel has a wide range in both E. and W. Australia but breeding colonies are known only from the Mud Is and South Channel Fort I. in Victoria. It would thus seem to merit a certain degree of protection in these localities.

The small area of Fort I. is insufficient to support a large population of birds and it is doubtful if the non-organic sand of which it is composed could be burrowed very much more closely than it is now without the danger of local collapse and erosion of the surface. At present the ground is well vegetated and the rookery in good condition.

An appeal was made in 1947 to have the gun pits covered with wire netting to prevent the 'tremendous mortality' among birds falling into them. This was done, but the wire netting was stolen and the gun pits are still trapping the petrels due to their inability to rise in flight without adequate take-off area.

Human interference should be discouraged both here and on the Mud Is where it is undoubtedly causing serious damage. Enclosure of some of the Mud Is rookeries by rabbit-proof fencing and extermination of the rabbits would give the vegetation a chance to regenerate and stabilize the ground sufficiently to support a greater number of burrows. Even areas subject to inundation by the tide might thus be protected from mechanical damage, although there seems no practicable remedy to combat the possible loss of chicks by drowning.

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Explanation of Plate

Plate VIII

Fig. A—General view of the Mud Is showing *Atriplex cinerea* on dune crest of Boatswain's I. and *Arthrocnemum arbusculum* on dune slopes and saline flats. January 1960.

Fig. B—Seasonal aspect of annual vegetation in degraded storm petrel rookery on the Mud Is, showing dead stems of a composite (*Senecio* sp.) which is being succeeded by *Anagallis arvensis* and *Cucumis myriocarpus.* Note low mounds of bare sand excavated from burrows. January 1960.


A


B

5

A COMPLETE OVAL AUSTRALITE

By GEORGE BAKER, DSc

[Read 14 July 1960]

Abstract

A rare, button-like, exceptionally well-preserved australite with oval outline and a complete, perfectly developed circumferential flange, reveals excellent structures that lend strong support to the Aerodynamical Control Theory of the secondary shaping and sculpturing of primary forms of australites.

The anterior surface of the specimen has a clockwise spiral flow ridge, pronounced radial flow lines, and a dimple-like depression that represents a remnant of an internal cavity exposed and modified by front surface ablation. These phenomena testify to sculpture of the leading surface of a primary oblate spheroid of extraterrestrial glass during aerodynamically orientated flight at high speeds through the earth's atmosphere.

The posterior surface of the lens-like body portion of the australite reveals primary flow swirls and occasional bubble pits whereas the posterior surface of the secondarily developed circumferential flange is generally smooth apart from a few narrow flow lines with a concentric trend.

The excellent state of preservation of the specimen indicates its short geological history.

Introduction

The perfect, flanged oval australite described herein from Port Campbell is one of the very few known excellently preserved complete oval-shaped australites in which flange and core are entire and firmly attached together. Numerous oval-shaped forms are known from which the flanges have been partially or entirely removed by erosion.

The term 'perfect' is here used to imply that the australite is an especially well-developed form, the primary shape having been modified by secondary processes involving atmospherical flight sculpturing that led to the production of a secondary shape that has been preserved in its entirety without being affected by tertiary processes of subaerial erosion. Compared with perfectly preserved australite buttons which are circular in plan aspect, this oval form has one diameter slightly longer than the other. In the Port Campbell collection containing this specimen, the ratio of perfectly preserved, well-developed flanged button-shaped circular forms to perfectly preserved, well-developed flanged oval form, is 27:1, and it is the only member of the oval shape group with the flange preserved entire.

Occurrence

The perfect oval was collected on 27 December 1936 from the cliff edge above Rutledge's Creek Beach near Bumpy Rock, 3½ m. SE. of Port Campbell township on the S. coast of Victoria. It occurred approximately 10 ft from the edge of 80 ft vertical marine cliffs cut in Miocene sediments (Port Campbell Limestone), and rested on aphanitic limestone amid the weathering products of the stripped zone (cf. Baker 1958a) that forms a bevelled edge at the top of the cliffs. The anterior surface of the specimen faced upwards, this being the normal position of rest of australites after landing on the earth's surface from an extraterrestrial source, but there is no evidence clearly revealed at the site of discovery that would indicate the precise level of the earth's surface upon which the specimen landed, nor of any effects produced on impact with the ground. Associated materials at the site are normal terrestrial products.

The specimen was washed out of the top 6 in. of surface soil of Recent age some time during 1936, for the same spot had been searched thoroughly in January of the same year. The Recent soil here rests upon post-Miocene sandy clay that forms a veneer on the limestone along the landward fringes of the stripped zone, and which, like the Recent soil, has largely been removed by subaerial agencies from the edges of the cliff tops. The perfect oval had evidently not been moved more than a foot or so laterally, and less vertically, since exposure, and its well-preserved condition bears testimony to the virtual absence of the effects of both abrasive agents and etching solutions. The area is in a temperate region subject to an average annual rainfall of 30 in.

Shape, Weight, Specific Gravity and Radii of Curvature

The oval shape of the specimen in plan aspect arises from one diameter being 2 mm. longer than in a direction at right angles. This contrasts with the perfect, flanged button-shaped australites which typically are more or less circular in plan outline. Although this difference in diameter is relatively small and represents only 8·5% of the overall diameter measurements, it is sufficient to reveal the oval outline to the unaided eye. The longer diameter is 24 mm., the shorter diameter 22 mm., and the depth, which is the thickness measured along the polar axis, is 8·5 mm.

The specimen weighs 5·115 gm., and its specific gravity is 2·376 (T. water = 22°C.); this is significantly lower than the average specific gravity (2·400) for australites from SE. Australia.

Whereas the radius of curvature of the posterior surface (R_B) as determined in the polar regions, is 13·93 mm. for the direction containing the shorter diameter, the value for R_B in the direction at right angles, containing the longer diameter, is 17·23 mm., so that the arc of curvature is slightly flatter across the longer axis of the specimen (cf. Baker 1955, p. 201). The radius of curvature of the anterior surface (R_F) is 13·20 mm. along the shorter diameter, and 16·00 mm. along the longer diameter, and the arc of curvature is thus also flatter across the longer axis of the lens-like core portion of the specimen. The intercept of the radical line (cf. Baker 1955, p. 168) on the polar axis in this specimen is such that the front and rear poles are each spaced approximately 4·5 mm. from the centre of the lens-like core of the flanged oval, and since R_B and R_F values are not very different, the core is fairly regularly biconvex and lenticular in side aspect (cf. core portion, Fig. 1B). The lens-like character is evident for directions through the polar axial plane taken across both the longer and shorter diameters, although the radical line is slightly longer along the longer axis of the specimen. Circles constructed around the two arcs of curvature revealed in silhouette traces taken at right angles, are not truly in accord with the surface curvatures of the specimen; this is due to front polar and rear polar regions being slightly flatter, while the curvature approaching the equatorial edges of the two surfaces is slightly steeper. This means that the arcs of curvature of neither surface are truly circular, but the departures are of small amount in not exceeding 1 mm. at any one point.

Circumferential Flange

The circumferential flange (Fig. 1A) is a secondary structure as regular in character and developed in precisely the same way as the perfectly formed circumferential flanges on the button-shaped australites which are more nearly circular in plan aspect. The same applies to other types of elongated australites in which the two diameter measurements, width and length, show greater differences in value; i.e. forms such as narrower ovals, boat-shaped forms and dumbbell-shaped forms.

When observed against a strong light, the relatively thin flange (thickness 1 to 2 mm.) is translucent throughout and reveals some internal flow lines but no internal bubbles can be detected in either flange or the thinner edges of the lens-like core The relatively low specific gravity (2·376) of the specimen is therefore not likely to be due so much to internal bubbles in the more opaque parts of the lens-like core, as to composition variations. Since the SiO_2 tenor of tektite glass increases sympathetically with decrease in specific gravity, the lower specific gravity value compared with the average for australites (2·400) is more likely a reflection of a higher silica content.

The flange was formed by accumulation of melt glass forced from the stagnation point of the front polar regions to the equatorial periphery of the lens-like core as a result of secondary processes of front surface heating. It formed relatively late in the phase of melting and ablation which was brought about by the effects of aerodynamical phenomena operating for a limited period of time on the forwardly directed surface of an oblate spheroid. This was the primary form that traversed the earth's atmosphere at ultrasupersonic velocities and which maintained an aerodynamically stable position of flight while these high speeds prevailed (cf. Baker 1944, 1955, 1956, 1958b, 1959).

Posterior Surface

The posterior surface (Fig. 1A) is that surface which remained at the back of the fast-moving australite during its ultrasupersonic flight through the earth's atmosphere. It reveals (Pl. IX, A) primary flow-lined patches of smoother glass, known as 'flow swirls' (Baker 1959, p. 40), and a few small bubble pits on the lens-like core which impart a vesicular appearance to part of the surface. The lens-like core is girdled by a relatively smooth surfaced circumferential flange of constant width (3 mm.) and free of bubble pits. A few fine flow lines on the posterior surface of the flange principally trend parallel with its inner and outer edges, and hence are essentially concentric (Fig. 1A).

The primary flow swirls have been preserved because of insufficient aerodynamical heating to cause secondary melting at the rear of the form at any stage throughout ultrasupersonic flight. Their production as original sculptural elements when the oblate spheroid initially consolidated in an extraterrestrial environment, is substantiated by the fact that similarly flow swirled areas on posterior surfaces of fragmented specimens broken normal to the surface, are observed to be surface expressions ('outcrops') of an internal flow pattern that penetrates to the central regions of the lens-like core. Had they been due to localized secondary melting at the onset of, or during, rapid transit through the earth's atmosphere, the flow lines constituting the swirls would have been entirely superficial in precisely the same way as those in the secondary melting phenomena revealed in the 'seat' regions close to the bases of the flanges (cf. Baker 1959, p. 40) and on the

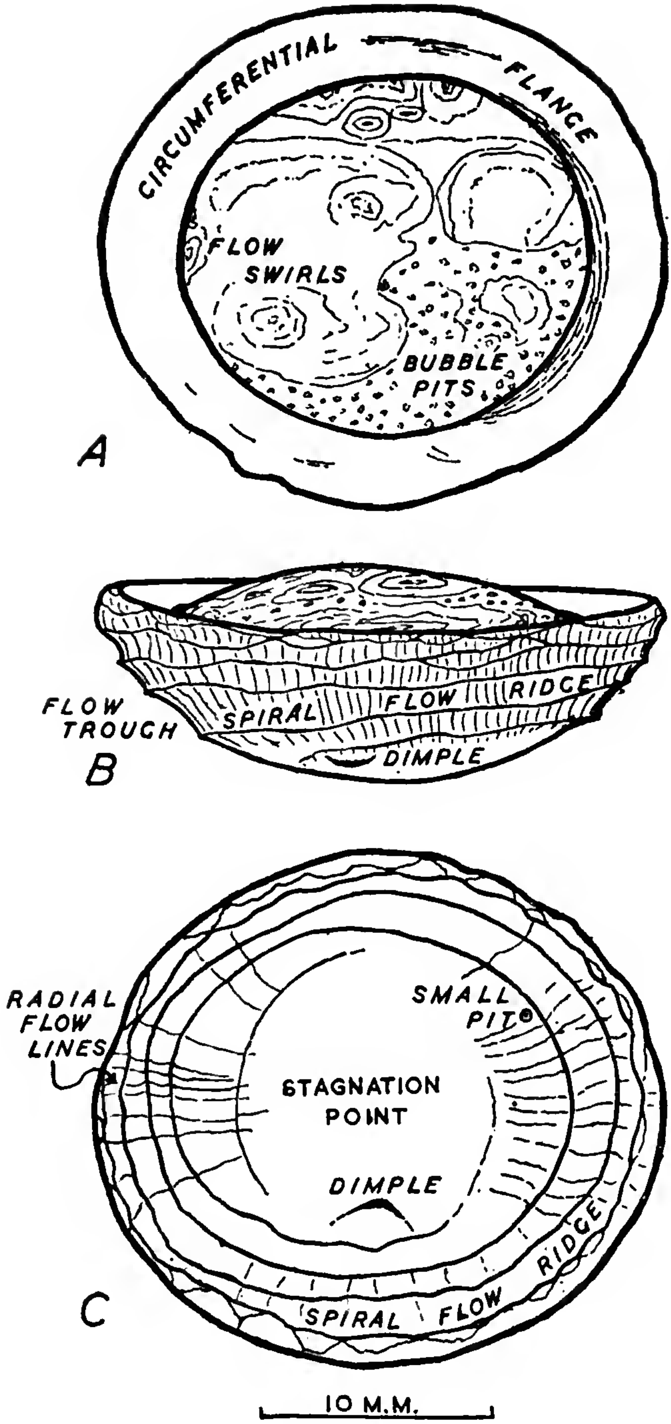

Fig. 1—Sketch diagram of complete oval australite from Port Campbell, Vic.

A—posterior surface showing body core with flow swirls and bubble pits, and circumferential flange with occasional concentric flow lines.

B—side aspect showing flow troughs between spiral flow ridge with radial flow lines. The posterior surface of the flange dips inwards at 14°.

C—anterior surface showing dimple, small pit, radial flow lines and clockwise spiral flow ridge in relationship to the stagnation point. The flow ridge becomes rippled approaching the periphery of the anterior surface of the flange.

anterior surfaces in these regions. The flow swirled patches of glass are of a streaky nature and almost free of bubble pits, and are set in a surround of tektite glass that was the site of more abundant gas bubble escape which gave rise to surface vesicularity (cf. Pl. IX, A).

Anterior Surface

The anterior surface (Fig. 1C) was the forwardly directed surface of the oblate spheroid during the ultrasupersonic and later supersonic phases of atmospheric flight. As a consequence it has been secondarily modified all over by the effects of ablation, progressive thin film superficial melting, and some fusion stripping. This was achieved during phases of increased pressures and temperatures generated in the shock wave phenomena created in a resisting atmospheric medium.

It reveals a well-developed, perfectly preserved clockwise spiral flow ridge (cf. Baker 1959, p. 38) which has its origin nearly midway (see Fig. 1C) between the stagnation point (point of origin of boundary layer flow in the air in contact with the front polar regions) and the equatorial edge of the specimen (Pl. IX, B). The ridge is essentially in the form of a descending helical spiral with its apex in the vicinity of the front pole; it becomes rippled approaching its base at the outer edge of the circumferential flange. Near the periphery of the anterior surface, complexities arise in the rippled flow ridge due to interference and a dimpled effect results (see edge of Pl. IX, B). The dimples are situated in a region where turbulent airflow supervened, and were evidently produced as a consequence of the dominance of frictional over pressure forces in the boundary layer flow. An effect of these dimpled areas becoming more pronounced is to produce minor irregularities in the configuration of the flange as seen in plan and side aspects of the anterior surface of the specimen (e.g. top left-hand portion of Pl. IX, B). The spiral ridge represents the last melt glass to be forced from the stagnation point regions and frozen in place; this occurred at a stage when the processes of aerodynamical ablation and melting had moderated at decreased speeds of atmospheric transit.

The depressed area (see 'dimple' in Fig. 1C) near the stagnation point on the anterior surface (Pl. IX, B—bottom centre) is a remnant of an internal bubble that was exposed by the progressive ablation and thin film melting of tektite glass. Its exposure occurred at a stage when it could have interrupted the regular development of the normally produced concentric type of flow ridge, and its presence no doubt controlled the ultimate clockwise spiral nature of the flow ridge (cf. Baker 1956, pp. 42-43). This conclusion is based on the evidence provided by other perfectly preserved specimens of flanged australites. In these, it is observed that the best developed concentric flow ridges are produced when ablation levels are completely free of exposed internal bubbles. Spiral ridges, whether clockwise or counter-clockwise in sense, are usually found on specimens at which the ablation level had penetrated to a depth below the original front surface where internal bubbles were encountered around the stagnation point area. On some specimens, pitting by aerodynamical etching out of rather more readily removed tektite glass, rather than the presence of internal bubbles, may have controlled the development of the spiral ridges. The spiral ridges trend around the outer edges of such exposed internal bubbles, i.e. around the sides remote from the stagnation point; some have remained even though the last traces of the depression have gone, but some may have ultimately passed back to the concentric type of flow ridges provided no further irregularities appeared on the progressively ablating and melting surface.

An important feature of the dimple referred to, is its noticeably shallower side nearest the equatorial periphery of the specimen, i.e. on the side remote from the stagnation point. This condition is to be expected, because once exposed, the original internal bubble cavity would temporarily act as an energy trap, and most impinging particles of both the air and the melt glass moving outwards from the stagnation point, would be reflected from its side walls. Inasmuch as the boundary layer flow trends radially outwards from the stagnation point, that portion of the rim of the exposed cavity situated furthest from the stagnation point would receive the more direct impacts, and hence would be subjected to more intensive melting and ablation than the lip of the cavity nearest the stagnation point.

The size of the internal cavities exposed at various levels of ablation can vary from a fraction of a millimetre to 25 mm. or more across. Exposure of the smallest cavities has but minor effects, while exposure of the larger cavities results in major complexities. The phenomena discussed herein arise more commonly when the exposed cavities are 2 to 5 mm. in diameter. The effects of their exposure on the aerodynamical stability of the specimen are at present difficult to assess, but it is to be expected that exposure of the largest internal cavities will have the more profound effects, while those of smaller size like the one under discussion may only cause slight wobbling or tipping as a phenomenon associated with drag and buffeting during high speed flight. Wobbling, or tipping slightly to one side, could provide the bias necessary to cause glass moving away from the stagnation point and away from the lip of the exposed cavity to spiral away towards the equator of the specimen. The direction or amount of tipping relative to the position of the exposed cavity at the ablation level reached on the front surface at that particular instant, might well determine whether the outward spiralling motion develops in a clockwise or in a counter-clockwise sense.

Exposure of the smallest internal cavities, i.e. those under 1 or 2 mm. in diameter, is likely to create less important effects, but they would act as centres of small amounts of aerodynamic etching. The minute example shown on the stagnation point side of the flow ridge in Pl. IX, B (centre top right) is only 0·75 mm. across, but it has remained circular in outline and its walls still reveal a high degree of 'hot polish' compared with the dimple (Pl. IX, B—bottom centre) of larger size that has been considerably modified by aerodynamical heating. The opening of the small cavity is still slightly less than its maximum diameter; it is thus to be regarded as a minute pit that was exposed by the final phases of thin film anterior surface melting. Its rim is rather more sharply defined on the side nearest to the stagnation point, and slightly rounded off on the side furthest away.

Narrow flow lines and slightly broader, shallow flow channels trend radially outwards from the vicinity of the stagnation point on the anterior surface (Pl. IX, B), and can be traced uninterruptedly across the clockwise spiral flow ridge (Fig. 1B and 1C). These are secondary flow structures of entirely superficial character. They and the minute bubble pits are sites for initial etching out of the tektite glass by a tertiary process of solution etching that commences after the form has landed on the earth's surface. This process has begun to make itself evident on parts of the anterior surface of the aerodynamically modified oblate spheroid, but has not advanced to any marked degree. The fact that these flow streaks ('schlieren') etch out rather more readily, is a pointer to their chemical composition being a little different from that of the tektite glass between the channeled portions.

Although several of these radial flow lines cut right through the flow ridges, slightly interrupting the continuity of their crests, this is evidently not a true effect of the sculpturing by the aerodynamical phenomena. Close inspection of other flow lines under a binocular microscope reveals their occurrence in bundles that appear to terminate abruptly near the stagnation point side of each flow ridge and reappear on the side remote from the stagnation point, after which they continue their trend across the surfaces of the flow troughs (Fig. 1B) that intervene between the crests of the ridges. These features can be just detected on the left-hand side of the photograph of the specimen (Pl. IX, B).

When bundles of flow lines become directions of etching by soil solutions and other subterranean waters, differential attack frequently results in undermining on a micro-scale of the glass occurring along the trends of the flow lines. The sub-surface spaces so formed sometimes become occupied by thin films of very fine-grained terrestrial mineral matter. This is often a fine ferruginous clay substance of dark brown, red or yellow colour resembling ochre, but sometimes it is leached and then appears buff-coloured or may be whiter, more especially when minute particles of detrital quartz are also carried in along the small 'solution tunnels'. Diurnal temperature changes resulting in differential expansion between the introduced mineral matter and the remnant portions of the tektite glass, lead to minute fracturing away and further slight lifting of thin films of the glass, so that by progressive solution etching followed by thin sliver fracturing and further solution etching along these pre-determined directions, overdeepening can occur, accompanied by lesser amounts of lateral widening. In this manner, narrow, relatively deeply penetrating so-called 'cracks' arise, and these sometimes reach from the equatorial edges of otherwise perfectly preserved australites right through to the central regions, and they can extend also from pole to pole as well as from edge to centre. They have been regarded in some quarters as contraction cracks, but the evidence points to an origin by solution etching during burial in soils and sliver fracturing as an outcome of diurnal temperature changes affecting already partially etched out channelways. This process can be traced in a sequence of events starting from initial undermining of the flow ridge glass and passing through the stage of the appearance of mineral matter under the flow ridge crests, through the stage when parts of the glass on the crests of the flow ridge are etched out to form a minute notch, and on to progressively deeper channeling with the ultimate production of what at first sight might be taken as deep contraction cracks. Many fragments of australites have apparently resulted from the operation of these processes, and the parallel surfaces, which are by no means always straight, of the overdeepened 'gutters', invariably reveal the complex internal flow line pattern of both circumferential flange and of lens-like core. Another important effect of this differential etching phenomenon, brought about by the process concentrating all around the 'seat' region (cf. Baker 1959, p. 40) of the flanged australites, is that planes of contact between flange and lens-like core become considerably weakened, so that the flange eventually becomes detached either as a complete entity (cf. Baker 1946, Pl. XIII; 1956, Pl. I) or in fragments.

It becomes evident that in the newly formed condition, the flow ridges consist of rather less streaky glass 'frozen in' and perched on top of radially flow lined glass which is some 0·25 mm. and less below the levels of the crests of the ridges. The radially flow lined glass is thus most prominently displayed on the surfaces of the troughs between the ridges, and the width ranges from 4 mm. between the crests of ridges nearest the stagnation point to under 1 mm. between the ridges nearest the periphery of the flange (Fig. 1C). In thin sections through these structures in australites (cf. Baker 1958, p. 377) subsurface flow line patterns in the ridges are parallel with the trends of the superficial flow lines generally, and under higher magnifications the flow lined regions of the intervening troughs are seen to be sharply truncated (cf. Baker 1944, Pl. III, fig. 1). Any anticlinal patterns that might be expected if the glass had flowed into and up and over the flow ridges, are thus apparent only when viewed under lower magnifications, and do not represent the true state of affairs.

Conclusions

The secondarily developed configuration of the complete, flanged oval australite described, the detailed structures on the posterior and anterior surfaces of its circumferential flange, and the sculpture pattern of the whole of the anterior surface of the australite, are all consonant with formation from a primary oblate spheroid of tektite glass that entered the earth's atmosphere at ultrasupersonic velocity and became modified by ablation, melting and some fusion stripping of its forwardly directed surface during aerodynamically orientated flight. The oblate spheroid was evidently of the biaxial ellipsoidal type rather than triaxial.

The well-preserved character of the perfectly developed flanged oval form is no doubt due to its relatively young age in terms of the time of arrival upon the earth's surface, and to its occurrence in a milieu where processes of abrasion, insolation and solution etching have been at a minimum during the 5,000 years or so that it has lain in a terrestrial environment.

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Explanation of Plate

Plate IX

Posterior surface (A) and anterior surface (B) of complete oval australite from Port Campbell, Vic. (×4) (Photo by A. A. Baker)

A

B

6

MYLONITES OF THE UPPER KIEWA VALLEY

By F. C. Beavis

[Read 14 July 1960]

Abstract

Mylonites which occur in the metamorphic complex of the Upper Kiewa Valley are invariably associated with faults. Greywackes, schists, gneisses, granodiorites and lamprophyres have been involved.

Comparison of the mineral associations of the parent rocks with those of the mylonites indicates mylonitization under hydrous conditions with moderately high pressure and temperature, and the application of intense shearing stress. Felspars, sillimanite, almandine, amphibole and pyroxene are the most unstable of the minerals under these conditions.

The fabric of all the rocks examined is one due to flattening. The fabric of secondary, post-deformation quartz has been controlled by the orientation of quartz nuclei in the matrix of the mylonites.

Introduction

Previous studies (Tattam 1929, Crohn 1949) of the metamorphic complex of NE. Victoria have indicated that the rôle of shearing stress in the regional metamorphism was insignificant. Howitt (1892), however, in a study of the boundary between the Ordovician sediments and schists in the Upper Dargo, found evidence of the development of strong shearing stresses in this area.

Crohn (*op. cit.*) commented on the asymmetry of the schist belts flanking the core gneisses of the complex in the Omeo–Kiewa area. No explanation of this asymmetry was suggested. During mapping of the Upper Kiewa Valley, the writer found that the rocks of the narrow W. schist belt are, in fact, mylonites, formed as a result of shearing during movement on the West Kiewa Thrust which here forms the boundary between the metamorphic rocks and the normal Upper Ordovician sediments. The mylonites of this belt contrast strongly with the normal schists of the very wide E. belt.

While the mylonite belt of the West Kiewa Thrust is the dominant one of the area, a number of others of somewhat lesser dimensions occur, all associated with faulting. Mylonitization of Ordovician greywackes, schists, 'permeation gneiss' (migmatite), granodiorite, and lamprophyre has been observed. The present study has attempted to trace both textural and mineralogical changes which occurred during cataclasis, and from this, following the work of Hsu (1955), to determine the physical conditions of the faulting.

Nomenclature and Previous Literature

Lapworth (1885) defined mylonites as 'microscopic friction breccias, with fluxion structure, in which the interstitial . . . paste has recrystallized in part'. Knopf (1931) considered that the development of mylonite was not to be considered as synonymous with fault brecciation or with the development of fault gouges. The essential difference is that gouge and breccia are incoherent or recemented, while mylonite has been formed under such conditions that coherence was not lost. Knopf believed that while mylonitization is essentially a cataclastic process, there is a variable amount of recrystallization, dependent on the conditions of deformation and the composition of the original rock. Where, due to recrystallization, the original cataclasis is recognizable only with difficulty, Knopf refers to the rock as a blastomylonite. Sander (cited by Knopf) has claimed that a blastomylonite is produced by a deformation that is partly ruptural and partly crystalloblastic, not by the rehealing crystallization of a mylonite.

Waters and Campbell (1935) considered that mylonites were coherent at all stages of their formation, with any recrystallization insignificant. The work of Adams and Bancroft (1917) who experimentally produced mylonitic textures, is cited by these authors in support of their ideas.

Turner and Verhoogen (1951) stated that mylonites are the product of almost pure cataclasis, and that as chemical processes enter more and more into the deformation, there is a continuous transition to augen gneiss, mylonite gneiss, flaser rock, and blastomylonite

The most important recent work on cataclasis is that of Hsu (1955). Hsu considered that frequently the evidence available is inadequate to determine the rôle of recrystallization in the formation of mylonites. Hsu recognized two main classes of cataclastic rocks: mylonites, which are foliated, and cataclasites which show neither foliation nor lineation. On the basis of the relative proportion of aphanitic matrix present, Hsu recognized protocataclasites and protomylonites (less than 50% aphanitic material), and ultracataclasites and ultramylonites (more than 90% aphanitic material). True mylonites and cataclasites were defined to comprise between 50% and 90% aphanitic matrix.

Distribution of Cataclastic Rocks in the Upper Kiewa Valley

The most important mylonite belt, that associated with the West Kiewa Thrust, has been traced from the Upper Dargo R., along the West Kiewa Valley, to near the township of Mt Beauty. At Mt Beauty, the belt terminates on the Tawonga Fault, N. of which no certain evidence of the belt has been found. The West Kiewa mylonite has an outcrop width of almost one mile. Contained within the belt are schist lenses of small dimensions. In age, this mylonite predates the granodiorites, since the Niggerheads granodiorite is in part intrusive into it. Mylonitization of this granodiorite is restricted to very narrow zones which transgress the West Kiewa belt also, and are therefore younger than both the granodiorite and the West Kiewa mylonite.

The mylonite and cataclasite of the Tawonga Fault post-date the granodiorites, since rocks of this type on the West Kiewa and East Kiewa R. have been involved. The Tawonga Fault mylonite is less well defined as a belt than that of the West Kiewa Thurst, and is also narrower; the maximum outcrop width of any one belt is not more than 200 ft. Renewed movement on the Tawonga Fault during the Tertiary (Beavis 1960) resulted in brecciation of this mylonite. No recementation of the breccia has taken place.

The other important mylonites are those associated with the Nelse and Spion Kopje Faults. These have a maximum outcrop width of 50 ft. All other mylonites examined are of restricted extent (Fig. 1) and occupy zones of less than 5 ft width.

Gouge and breccia occur on the younger faults. These are known mainly from exposures in excavations; natural exposures, restricted to stream beds developed on the crush zones, are generally obscured by debris.

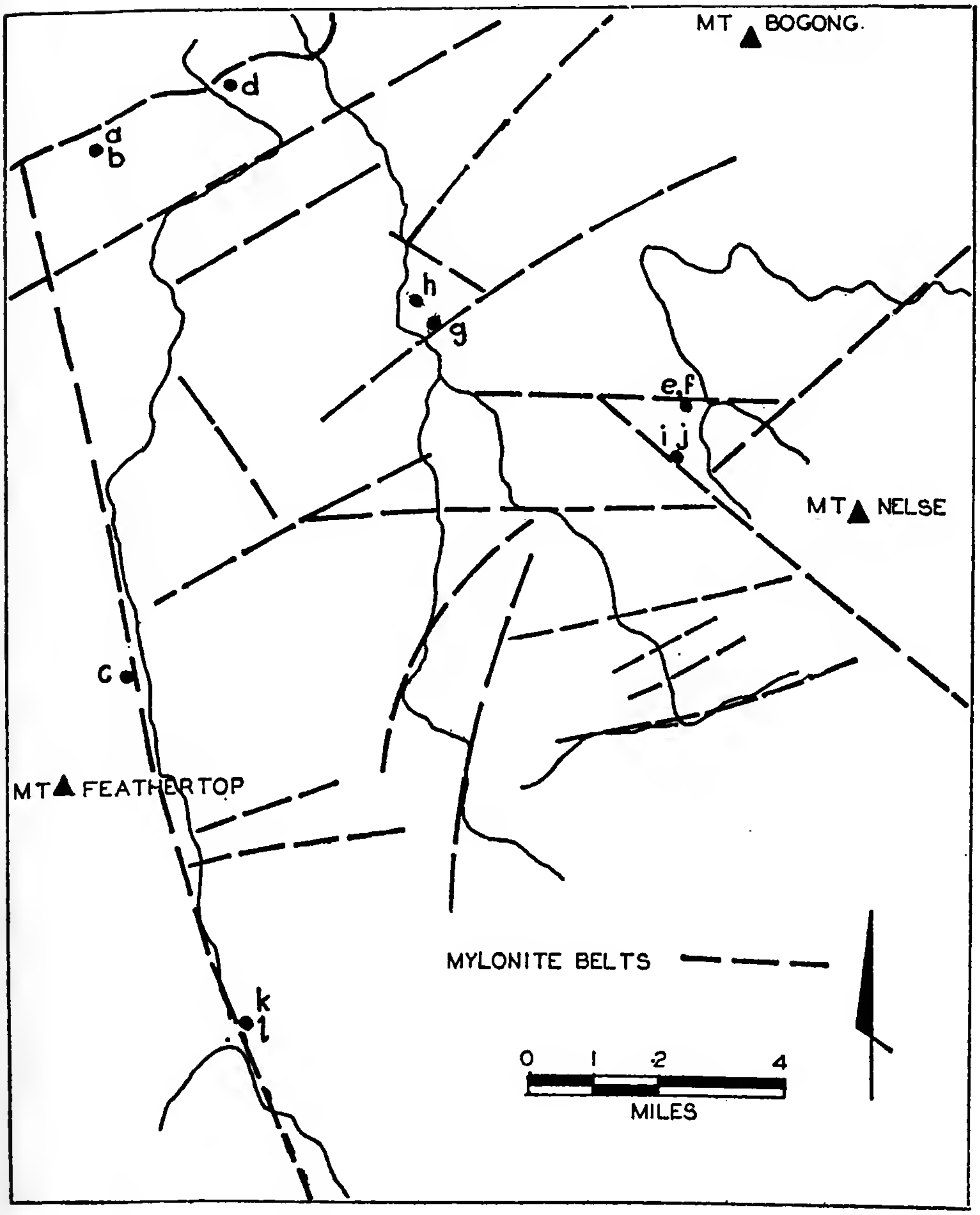
MT BOGONG.
d
a
b
h
g
e,f
i j
MT NELSE
c
MT FEATHERTOP
MYLONITE BELTS
k
l
0 1 2 4
MILES

Fig. 1

Petrology of the Cataclastic Rocks

Greywacke Mylonites

Apart from restricted development on the Tawonga Fault, mylonites derived from the Upper Ordovician greywackes are found chiefly as narrow zones between Mt St Bernard and Mt Hotham. The texture of the original greywacke is medium with maximum grain size 1·5 mm. Grading is poor. Angular to subangular grains of quartz, with rare marginal recrystallization, oligoclase, and rare alkali felspar occur in a fine matrix of quartz, felspar, chlorite, sericite and kaolinite, the matrix comprising from 20% to 70% of the whole. Detrital almandine, tourmaline, magnetite, biotite, zircon, and andalusite are accessory.

In the cataclastic derivatives, which have a protocataclastic texture, quartz occurs as crushed aggregates, together with oligoclase, less crushed, but partially sericitized. The original matrix appears to have undergone some reconstitution, with the production of sericitic aggregates and small porphyroclasts of quartz. Any alkali felspar originally present has been sericitized.

Any slates interbedded with the greywackes have been occasionally reduced to extremely fine grained ultramylonites. Failure in the slates, however, is more typically by pure flow, with very little textural or mineralogical variation.

Schist Mylonites

Generally only high grade schists occur in the area examined. Restricted lenses of a low grade quartz-biotite-felspar schist and quartz-albite-epidote schist occur on the W. margin of the West Kiewa mylonite belt, at Cobungra Gap. The high grade schists include the knotted schist of Mt Bogong, which has a mineral assemblage characteristic of the Hornblende Hornfels Facies of Fyfe, Turner and Verhoogen (1958). These rocks are quartz-cordierite (-pinite)-felspar schists, in which pinite occurs as elliptical knots after cordierite.

On Mt Bogong, and in the Mt Nelse area, normally foliated schists as well as knotted schists occur with the assemblage of the Hornblende Hornfels Facies transitional to the Almandine Amphibolite Facies. These include quartz-biotite-cordierite (-pinite)-sillimanite-muscovite schists, quartz-hornblende-almandine-oligoclase-cordierite schist, and quartz-felspar-sillimanite-cordierite-almandine-biotite schist.

Mylonites developed from low grade schist occur at Cobungra Gap (Pl. X, fig. 1). The biotite has undergone severe deformation, and has been sheared into fine foliae which curve around small lenses of quartz and felspar; both the quartz and felspar are strained, and sericitization of the felspar is advanced. In a specimen of a more arenaceous type from the same locality, the lenses do not consist of single crystals, but of aggregates of crushed quartz and felspar, the latter strongly sericitized. The texture of this rock is protomylonitic.

A high grade schist mylonitized by the West Kiewa Thrust movement has a distinct foliated mylonitic texture. The aphanitic matrix is composed essentially of fine quartz, with rare felspar almost completely sericitized, and fine flakes of light brown, strongly pleochroic biotite. Porphyroclasts, up to 0·3 mm. in diameter, consist of dark brown biotite, quartz showing irregular strain lamellae, and strongly poikiloblastic almandine, often severely cracked, invariably with corroded margins, and showing replacement by magnetite and cordierite. Sillimanite is absent.

Gneiss Mylonites

The permeation gneiss at Kiewa is a migmatite which is markedly heterogeneous in texture, as well as showing quite wide variations of composition. Quartz, orthoclase, orthoclase microperthite, microline, andesine, biotite, sillimanite, and cordierite are the main constituents. Almandine is frequently, but not invariably, present. The quartz encloses needles of sillimanite, and near the crystal boundaries may show intergrowth with alkali felspar. Biotite may be replaced wholly or in part by sillimanite.

Cataclastic derivatives of the gneiss have been studied from the West Kiewa Thrust, and the Spion Kopje (Pl. X, fig. 2), Nelse (Pl. X, fig. 3) and Tawonga Faults. Most are true mylonites, but protocataclasites occur on the Tawonga Fault, and ultramylonite on the Spion Kopje Fault. The mylonites have thin aphanitic bands composed of quartz, sericite, and finely divided biotite. Porphyroclasts are of quartz, felspar, rare white mica, and cordierite. Crushing of the felspar varies from slight in the Nelse mylonite, to extreme, with advanced sericitization, in the Spion Kopje mylonite

In the West Kiewa Thrust, it is possible to trace increasing severity of mylonitization of the gneiss. The micas were first affected, with elongation of the flakes, and the development of a selvedge of isotropic material along the crystal boundaries, and sometimes along the cleavage planes. Granulation of quartz and then felspar followed, with marginal sericitization of the felspar, and more intense deformation of the micas. At this stage, the sillimanite was converted to a fine sericitic material. The final stage was marked by the more or less complete crushing of the felspars and the development of the true mylonite texture.

The protocataclasite from Mt Beauty, developed on the Tawonga Fault, is coarse textured, with the average diameter of crystals 2 mm. The quartz has been granulated, the micas reduced to a fine powder, and the felspars completely replaced by green waxy micaceous aggregates which X-ray studies showed to be pyrophyllite.

In the crush zone of the Spion Kopje Fault, at Bogong township, a fine mylonite, with dense cryptocrystalline material constituting 70% of the rock, passes into a glassy ultramylonite, with a few small aggregates of recognizable sericite.

Granodiorite Mylonite

The granodiorite of the Kiewa area is fine to medium grained, and even textured. It is composed essentially of quartz, andesine in excess of orthoclase and orthoclase microperthite, biotite, occasionally hornblende, and muscovite, with cordierite, apatite, sphene, and zircon accessory.

A granodiorite protomylonite from the Tawonga Fault (Pl. X, fig. 5) at Young's Gap consists of aphanitic bands of quartz and felspar, with relatively large flakes of white mica. Quartz and felspar occur also as single crystal porphyroclasts, as well as granulated aggregates. Sericitization of the felspar has occurred, but has not been severe. Similar protomylonites were observed at Clover Dam, and at Bogong.

In these rocks, the first evidence of deformation is the development of strain shadows in the quartz. This is followed by shearing of the biotite, and the development of intergranular isotropic material, producing mortar structure. Cracking of the quartz and felspar follows, with an increase in the amount of aphanitic material until the more or less uncrushed crystals remain as porphyroclasts.

Lamprophyre Mylonites

Both augite and hornblende lamprophyres occur in the area, together with a number of variants. These are characterized by panidiomorphic texture, with phenocrysts of augite and/or hornblende, and plagioclase set in a fine groundmass of felspar and ferromagnesian minerals.

Several examples of mylonitized lamprophyre have been studied. In all cases, the resultant rock is an aggregate of sericite and chlorite. Most of these mylonites show advanced replacement by secondary minerals, introduced during post-deformation metasomatism.

Mineralogical Changes due to Cataclasis

The main mineralogical changes associated with mylonitization are summarized in Table 1.

Table 1

Mineralogical Changes with Mylonitization

Parent rock	Mineral assemblage	Mineral assemblage of cataclastic derivatives
Greywacke	Quartz, felspar, sericite.	Quartz, sericite, felspar.
Schist (Albite-epidote Hornfels Facies)	Quartz, biotite, felspar, epidote.	Quartz, sericite, biotite.
Schist (Hornblende Hornfels Facies, transitional to Almandine Amphibole Facies)	Quartz, biotite, cordierite, almandine, sillimanite, felspar, hornblende.	Quartz, sericite, almandine, cordierite, biotite, iron ore.
Granodiorite	Quartz, felspar, biotite, muscovite.	Quartz, sericite, muscovite, felspar, biotite. Quartz, sericite.
Permeation Gneiss	Quartz, felspar, cordierite, sillimanite, almandine.	Quartz, sericite, muscovite, cordierite, biotite, felspar. Quartz, cordierite, muscovite, felspar, sericite. Quartz, pyrophyllite.
Lamprophyre	Augite, hornblende, felspar.	Sericite, chlorite.

The most unstable minerals during mylonitization of the rocks examined were the felspars, sillimanite, almandine, augite, and hornblende. Since both augite and hornblende are unstable, it is apparent that mylonitization of the lamprophyres occurred with the development of high temperatures under somewhat hydrous conditions (see Table 2). The instability of almandine is of interest. Tilley (1926) recorded the breakdown of almandine to cordierite and magnetite in contact aureoles. Such breakdown, whether conditions were 'wet' or 'dry', shows that the stability field of garnet has been exceeded (Yoder 1955), and it is probable that both temperature and pressure were high.

The felspars are invariably replaced by fine micaceous aggregates such as sericite and pyrophyllite. The replacement of sillimanite by sericite and quartz indicates some reaction between the sillimanite and felspar. Biotite, except for a slight colour change, shows no breakdown.

Cordierite, with quartz, is one of the most stable of the minerals; there is no evidence of change in this mineral, while the evidence of the narrow 10A line in X-ray powder patterns of the pinite supports the ideas of Tattam (1929) that the pinitization of the cordierite was not influenced by shearing stress.

Chemical analyses of the mylonites and of the parent rocks were made, but were of little value because of wide variations in compositions of both sets. This is reflected in the SiO_2 and Al_2O_3 particularly, where analyses 5 and 6 are typical of slates and analyses 1 and 2 of subgreywackes. The only reasonably consistent change recorded was gain in H_2O+ during mylonitization, but a loss of this constituent was also recorded in one case. Any loss of K_2O is associated with mylonitization of potash felspar.

TABLE 2

Chemical Analyses

	1	2	3	4	5	6	7	8
SiO_2	75·45	70·49	65·50	79·42	58·35	56·15	67·81	25·75
Al_2O_3	13·76	17·73	14·75	10·75	21·45	21·55	14·96	4·10
Fe_2O_3	1·21	1·04	3·13	3·75	0·79	0·55	0·76	0·16
FeO	2·09	1·56	2·20	0·12	4·51	5·55	0·60	5·60
TiO_2	0·51	0·36	0·34	0·51	0·80	0·85	0·45	0·05
CaO	0·24	0·04	3·28	0·29	0·78	0·93	2·95	21·36
MgO	1·40	0·03	1·06	0·21	2·15	3·10	1·70	5·01
Na_2O	0·45	1·40	3·80	0·40	0·90	0·98	3·44	0·75
K_2O	3·47	1·31	3·12	2·11	5·30	6·15	0·59	0·64
MnO	0·03	1·60	0·07	0·02	0·06	0·20	0·02	0·25
P_2O_5	0·08	2·80	0·13	0·05	0·15	0·14	0·10	0·05
CO_2	-	-	-	-	-	-	5·19	30·12
H_2O-	0·12	0·13	0·12	0·37	0·86	0·41	0·35	0·10
H_2O+	2·01	1·30	0·83	2·90	3·55	3·35	0·41	0·80
S	-	-	-	-	-	-	-	5·01
Total	100·82	99·79	99·33	100·90	99·66	99·91	99·33	99·75

Analyst: S. Biskupsky

1. Low grade schist, Cobungra Gap.
2. Permeation gneiss, Timm's Lookout.
3. Granodiorite, Bogong.
4. Schist mylonite, Cobungra Gap.
5. Gneiss mylonite, Dibbin's Lookout.
6. Gneiss mylonite, Diamantina R.
7. Granodiorite mylonite, Bogong.
8. Metasomatized granodiorite mylonite, Bogong.

NEOMINERALIZATION OF THE MYLONITES

Apart from the recrystallization which sometimes accompanied cataclasis, many of the mylonites show some post-deformation recrystallization and metasomatic replacement. The most important has been the recrystallization of sericite in the aphanitic matrix, the introduction of secondary quartz, pyrite, and epidote to the matrix, and along s planes, and the widespread introduction of calcite.

A mylonite derived from low grade schist in the West Kiewa Thrust has been recrystallized during post-deformation intrusion of the Niggerheads granodiorite. The mylonitic texture has not been appreciably modified, but much of the sericite has been recrystallized to muscovite, while pale brown biotite is strongly developed. Small crystals of pale mauve cordierite are abundant; this mineral is absent from the mylonite some distance away from the contact. The quartz shows evidence of recrystallization in as much as the strain phenomena, typical in the mylonite away from the contact, are absent. The few felspar grains present have cores of zoisite, replacing the calcic cores of the felspar.

Petrofabric Analyses

Petrofabric analyses were completed for 8 mylonites from sections cut parallel to the ab and bc fabric planes. Practical difficulties were encountered because of the smallness of the grains. Moreover, the few porphyroclasts did not permit the desirable statistical comparison of the orientation of the porphyroclasts and that of the grains forming the matrix. Where possible, both quartz and mica fabric were examined.

Turner and Verhoogen (1951) considered that the dominant movement concerned in the formation of mylonites was sliding on a single set of s planes, with some rotation of the larger surviving grains about b occurring simultaneously. Sander (1930) and Knopf and Ingerson (1938) showed that from a study of quartz fabrics, 'single group slip', with some rotation, occurs in zones of intense shearing and mylonitization. The simplest form of tectonic flow is explicable as displacement along a single group of slip planes; where these planes are equally developed and symmetrically disposed about their axes of intersection, the two planes of each pair develop as a result of flattening. Due to the flattening movement, the deformed grains become progressively flatter and lie in the surface of flattening which is the visible s of the fabric. This dimensional orientation, shown particularly in Pl. X, fig. 1-5, is the result of shearing slip along planes oblique to the visible s. The optic axes of quartz grains are not parallel to the long axes of the grains, but, statistically, form a maximum on h01 planes, symmetrically disposed about ab. The deformation responsible for the flattening is a compression normal to ab. This restricts the forward movement parallel to a, with little or no rotation about b.

Lineation parallel to b is present in all the mylonites. This is due to the flattened quartz and mica exposed on the foliation planes, and has the appearance of slickensides. One slickensided face (Fig. 2d) was examined. Sander (1930) restricts the term slickenside to individual surfaces of slipping, characterized by a lineation that coincides with the a fabric axis, i.e. the direction of movement. Sander described a slickensided mylonite from Melibokus, and found that biotite crystals showed a tendency to lie with 001 parallel to the lineation, giving a girdle pattern in the fabric diagram which identified the lineation as parallel to b. Grains of quartz were found to be elongated at right angles to the lineation, thus giving a microscopic second lineation. The quartz grains showed a preferred orientation with the optic axes parallel to s and normal to the lineation, parallel to the a fabric axis.

The slickensided mylonite examined from Kiewa was less than 1 mm. thick. Lineation was parallel to b. Study of the biotite was not possible, because of the intense deformation of this mineral. The quartz diagram (Fig. 2d) is of some interest. Two maxima occur; one parallel to a, as found by Sander, and a second which may be regarded as lying on a h01 plane which makes an angle of 40° with the ab of the fabric. This is almost certainly of no real significance, probably representing the fabric of the normal gneiss observed in analyses of such rocks. In

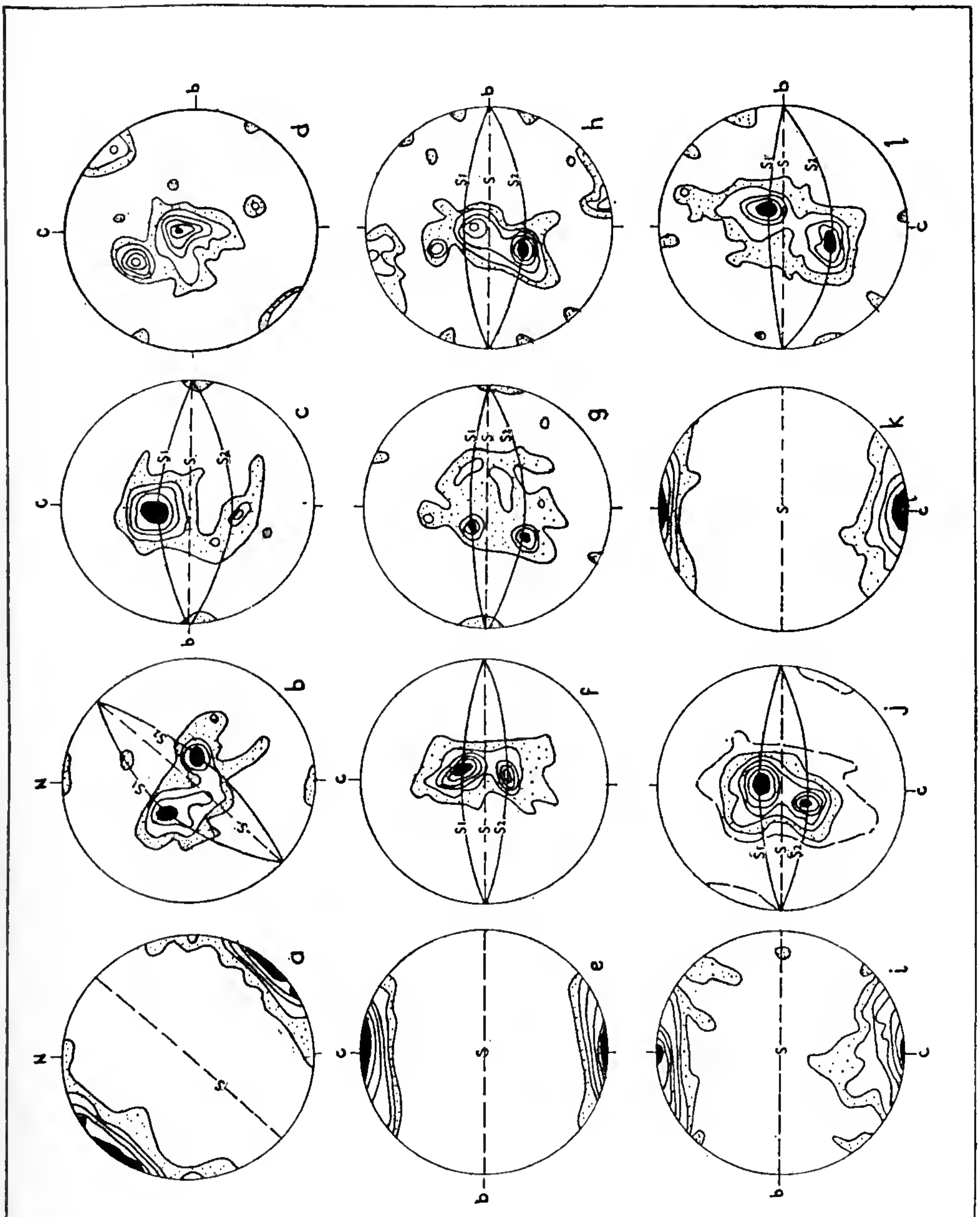

Fig. 2

cutting the section from the thin mylonite, some of the undeformed rock was probably included.

Where study of the biotite fabric of the mylonites was possible, it was found that maxima of the poles to cleavage planes occurred in c normal to the visible s. All of the quartz diagrams show the orthorhombic symmetry of the flattening movement, with two intersecting sets of h01 planes. Maxima on each of these planes may be equally developed, but usually one is slightly stronger than the other. Mylonitization in every case appears effectively to have destroyed any earlier fabric, evidence of which was found only in isolated cases.

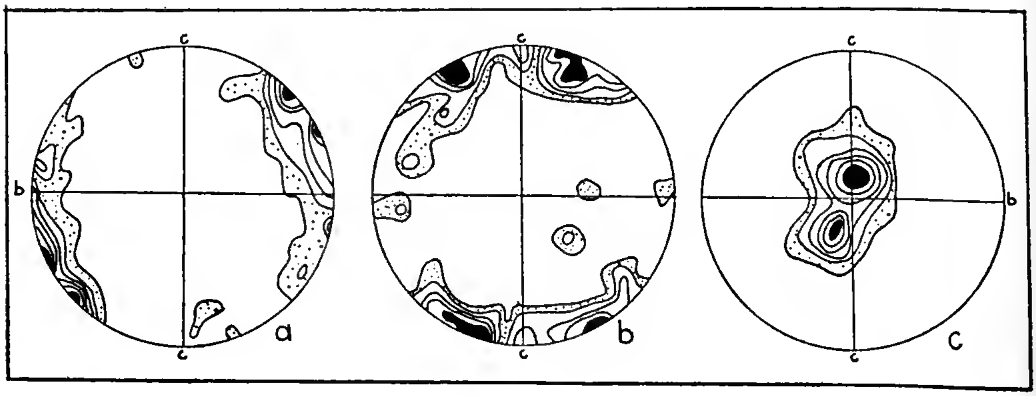

Fig. 3

The fabrics of secondary quartz (Pl. X, fig. 3) and calcite (Pl. X, fig. 6) introduced into the mylonites during post-deformation metasomatism are shown on Fig. 3. The calcite crystals show no evidence of deformation. In each of the two cases examined, different patterns were obtained for the orientation of the optic axes. The orientations do not agree with control by shear planes, or by the walls bounding the veins (cf. Knopf and Ingerson *op. cit.*), and no explanation of the orientation can be offered. For the quartz vein in mylonite (Fig. 3c) the orientation is identical for the quartz of the mylonite. There is no evidence of deformation of the quartz grains of the vein. Turner (1942) in a study of quartz veins in schist, found that the orientation was controlled by the walls of the vein. No such control exists here, and it is considered that the grains developed in optical continuity with nuclei of fine quartz in the matrix of the mylonite.

Discussion

Hsu (1955), in discussing the mylonites from the San Gabriel Mountains, California, found that mylonitization involved a retrograde metamorphism, thus confirming the earlier work of Knopf (1931). Hsu believed that the composition of a rock is important in determining its mode of deformation. Rocks of different composition when subjected to a shearing stress, under a given set of P (hydrostatic pressure), T (temperature), and X (partial pressure of hydrous phase) conditions, may undergo different modes of deformation, just as under differing PTX conditions rocks of the same composition may undergo different modes of deformation. On this basis, Hsu concluded that mylonitic textures alone give no indication of either PTX conditions, or the intensity of the shearing stress at the time of deformation. The PTX conditions can only be assessed by a study of mineral associations in the mylonites and the granoblastic rocks associated with the mylonites, while the intensity of the shearing stress can be estimated only by comparing textures of rocks of the same composition formed under the same PTX conditions.

The Kiewa mylonites are invariably associated with faults, the movement on which, responsible for the mylonitization, can be dated at, as youngest, late middle Palaeozoic. The younger fault movements produced breccia and gouge. Work in progress by the writer has shown that only one folding (Benambran) has affected the area, and that the stresses of the younger orogenies have resulted in faulting and jointing, without the superposition of folds. This indicates that, at the time of stress application, the rocks were not in a plastic condition, and that therefore the depth was not great. Both the mineral associations of the mylonites and the lack of any evidence that these rocks were other than coherent at all stages of their formation, suggest moderate pressure and temperature conditions. The evidence of the mineral associations suggests conditions approximating to those of the Hornblende Facies, so that, using the criteria of Hsu, it can be concluded that the mylonitic textures here represent the localized application of intense shearing stress.

Although shearing has been most effective in the zones of mylonitization, fabric studies of the normal rocks show some evidence of the effects of shear, traces of a flattening fabric being found in a number of cases, superimposed on the original fabric. The effect on the mineralogy of the normal rocks has been negligible; in fact, on this basis alone there is virtually no evidence of shear.

Conclusions

Mylonites and cataclasites occur in association with both wrench and thrust faults of Palaeozoic age in the Upper Kiewa Valley. Petrographic and petrofabric studies, as well as the field evidence, suggest that these rocks were derived from the parent sediments, schists, gneisses and igneous rocks, under conditions of moderate pressure and temperature, and high shearing stress. There is evidence of slight recrystallization accompanying cataclasis; similarly, the evidence indicates coherence of the rock during mylonitization. The study of neomineralization of the mylonites showed that the secondary quartz crystallized on nuclei within the matrix of the mylonites, and adopted the orientation of these nuclei. No control of the orientation of the secondary calcite can be suggested, and further work to investigate this aspect will be necessary.

Acknowledgements

The assistance of Professor E. S. Hills, who first suggested the work, and of Dr R. J. W. McLaughlin, who made valuable suggestions and critically reviewed the manuscript, is gratefully acknowledged. Dr C. M. Tattam also read the manuscript. Dr J. McAndrew assisted with the X-ray studies, and Mr M. A. H. Marsden with the earlier stages of the petrofabrics. My wife assisted in the field, particularly in the study of the sediments and granodiorites. Mr A. Taylor prepared the plates.

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Explanation of Plate

PLATE X

Photomicrographs of Mylonites

Fig. 1—Schist mylonite, West Kiewa Thrust.
Fig. 2—Gneiss mylonite, Spion Kopje Fault.
Fig. 3—Gneiss mylonite, with secondary quartz vein, Nelse Fault.
Fig. 4—Granodiorite mylonite, Niggerheads.
Fig. 5—Granodiorite protomylonite, Tawonga Fault.
Fig. 6—Metasomatized granodiorite mylonite, Bogong.

All photographs in ordinary light.

Explanation to Figures

Fig. 1—Faults in the Kiewa Area. Small letters (a, b, c etc.) refer to localities of specimens analyzed—see Fig. 2.

Fig. 2—Petrofabric Diagrams, Mylonites.

a. Granodiorite protomylonite, Tawonga Fault, Young's Gap. Poles to 200 cleavage planes, mica. Contours 9–7–5–3–1%.
b. Same specimens as a. Optic axes of 207 quartz crystals. Contours 8–6–4–2%.
c. Schist mylonite, West Kiewa Thrust, Diamantina R. Optic axes 110 quartz crystals. Contours 10–8–6–4–2%.
d. Slickensided mylonite, West Kiewa. Optic axes of 200 quartz crystals. Contours 12–10–8–6–4–2%.
e. Gneiss mylonite, Spion Kopje Fault, Timm's Lookout. Poles to 300 cleavage planes of biotite. Contours 10–8–6–4–2–1%.
f. Same specimen as e. Optic axes of 106 quartz crystals. Contours 12–10–8–6–4–2%.
g. Granodiorite mylonite, Bogong. Optic axes of 200 quartz cystals. Contours 8–6–4–2%.
h. Neomineralized granodiorite mylonite, Bogong. Optic axes of 83 quartz crystals. Contours 8–7–5–3–2–1%.
i. Gneiss mylonite, Nelse Fault, Spion Kopje ridge. Poles to 121 cleavage planes of biotite. Contours 13–11–9–7–5–3–1%.

j. Same specimen as i. Optic axes of 298 quartz crystals. Contours 12–10–8–6–4–2–(½)%.

k. Schist mylonite, West Kiewa Thrust, Cobungra Gap. Poles to 105 cleavage planes of biotite. Contours 9–7–5–3–1%.

l. Same specimen as k. Optic axes of 314 quartz grains. Contours 9–7–5–3–1%.

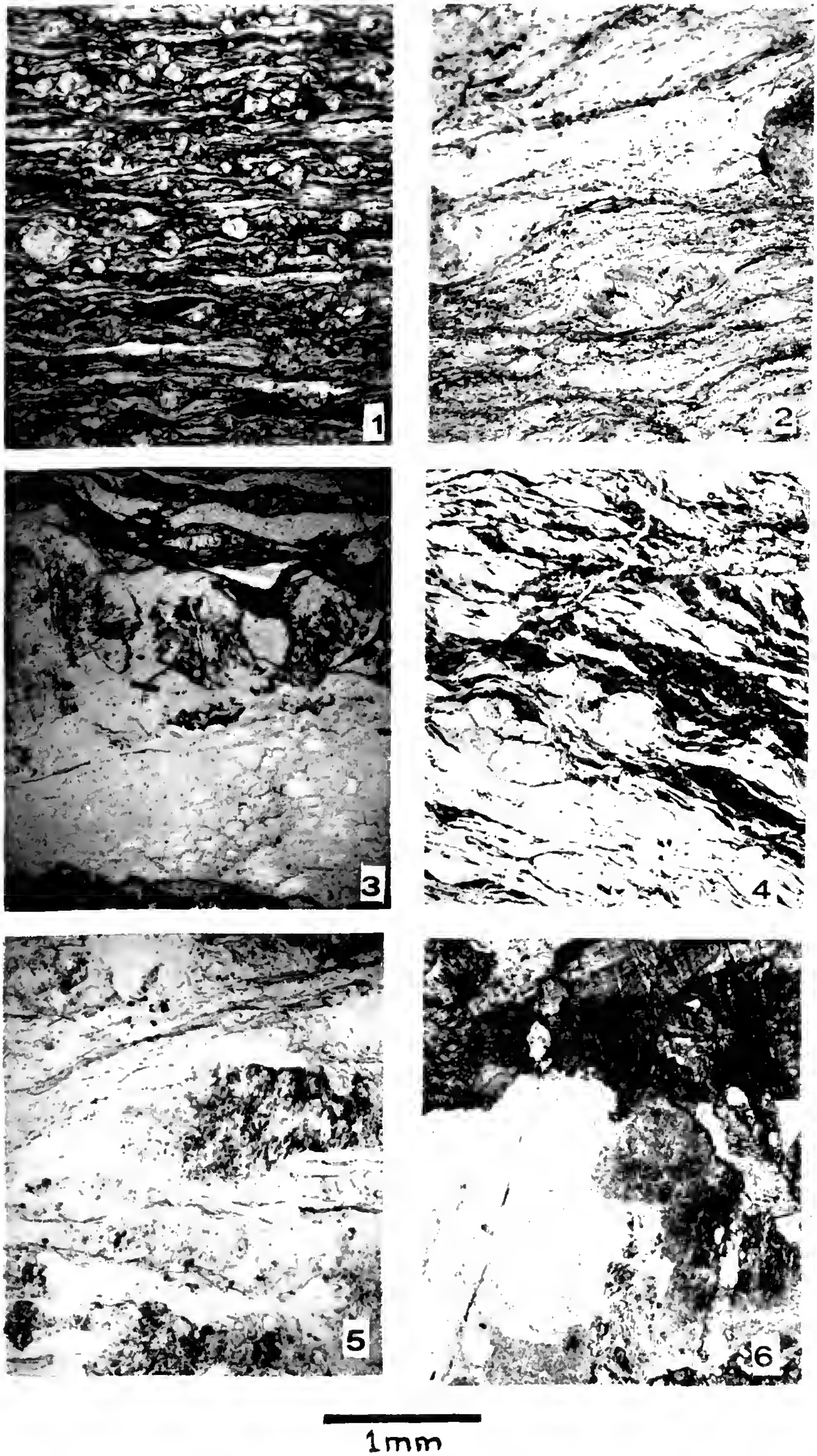
Fig. 3—Secondary Veins in Mylonite.

a. Same specimen as Fig. 2g. Optic axes of 110 calcite crystals. Contours > 11–9–7–5–3–1%.

b. Same specimen as Fig. 2h. Optic axes of 200 calcite crystals. Contours > 9–7–5–3–2%.

c. Same specimen as Fig. 2i. Optic axes of 306 quartz crystals. Contours > 11–9–7–5–3–1%.

The fabric axes of the diagrams are those of the mylonites containing the veins. Walls of veins are parallel to ab.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UPPER CRETACEOUS MICROPLANKTON FROM THE BELFAST No. 4 BORE, SOUTH-WESTERN VICTORIA

By ISABEL C. COOKSON* and A. EISENACK†
*University of Melbourne; †University of Tübingen

[Read 14 July 1960]

Abstract

11 species of microplankton are recorded from the lower section of the Belfast No. 4 Bore. One new genus and 5 new species are described. The age of the deposits is discussed with the conclusion that they are Upper Cretaceous, probably Senonian.

Introduction

The occurrence of Cretaceous deposits in the lower section of the Belfast No. 4 Bore drilled by the Mines Department of Victoria near Port Fairy was recently recorded by Kenley (1958-59). Although at the time of publication a more precise dating was said to be difficult, Kenley pointed out that the shelly fossils and ammonites preserved in the core between 4,645 and 4,655 ft favoured an Upper rather than a Lower Cretaceous age.

Through the generosity of the Chief Geologist, Dr D. E Thomas, one of us (I.C.C.) was enabled to examine the microplankton content of a black ammonite-containing siltstone from 4,652 ft and a mudstone between 4,492 and 4,499 ft. The examination was conducted with a view to establishing a closer age approximation by correlation with dated deposits which, elsewhere in Australia, contain distinctive microplankton assemblages.

The total microplankton content of these beds is fairly high but the number of individual types present is relatively small. However, some of these appear to have sufficiently restricted vertical distribution in other areas to confirm the Upper Cretaceous age postulated by Kenley and, in addition, to suggest that the sediments examined are probably Senonian.

In addition to microplankton there is a considerable amount of woody tissue and a relatively high percentage of pollen grains and spores. Some of the pollen grains are dicotyledonous types; this suggests that the containing sediments are unlikely to be Lower Cretaceous. The pollen and spore content of the Belfast No. 4 Bore as a whole is being studied by Mr John Douglas of the Mines Department.

Systematic Descriptions

DINOFLAGELLATES

Family GYMNODINIDAE

Genus **Gymnodinium** Stein 1878

Gymnodinium westralium, Cookson and Eisenack

Gymnodinium cf. *heterocostatum* Oeflandre and Cookson 1955, *Aust. J. Mar. Freshw. Res.* 6: 248, Pl. 1, fig. 7.

Gymnodinium westralium Cookson and Eisenack 1958, *Proc. Roy. Soc. Vic.* 70: 25, Pl. 1, fig. 9.

A single example of this species was observed in the Belfast No. 4 deposit between 4,492 and 4,499 ft. *G. westralium* has been recorded from Upper Turonian to Senonian deposits in Western Australia (Cookson and Eisenack 1960).

Family Deflandreidae

Genus **Deflandrea** Eisenack 1938

Deflandrea tripartita Cookson and Eisenack

(Fig. 1)

Deflandrea tripartita Cookson and Eisenack 1960a, p. 2, Pl. 1, fig. 10.

D. tripartita is far from rare in the Belfast No. 4 Bore between 4,492 and 4,499 ft and at 4,652 ft. It was originally recorded from West Australian Petroleum Co.'s (Wapet) Seismic Shot Hole B 1, N. of Gingin, W.A., at 160 ft, the age of which appears to be Upper Turonian to Middle Senonian.

D. tripartita is closely similar in form to *D. cooksoni* Alberti (1959) from the Upper Senonian of Central Germany. However, the girdle, which is so clearly developed in *D. tripartita,* is not represented in *D. cooksoni.*

The Belfast specimens illustrate very clearly an apparently constant feature of the girdle noticed in the type but not mentioned in the description, namely that it is not continuous on the dorsal surface, but interrupted near both lateral margins (Fig. 1).

The ornamentation of the Belfast examples is very clearly developed and consists of minute rods rather than 'granules' as was given in the original description.

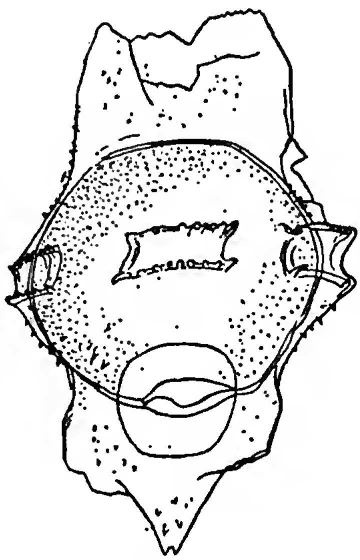

Fig. 1—*Deflandrea tripartita* Cookson and Eisenack. Belfast No. 4 Bore Vic., between 4,492 and 4,652 ft × *c.* 1000.

Deflandrea cretacea Cookson

(Pl. XI, fig. 1-2)

Deflandrea cretacea Cookson 1956, p. 184, Pl. 1, fig. 1-5, non 6, 7.

The Belfast specimens show an even greater variation in size and shape than those from the type locality in the Nelson Bore, Victoria. However, there is no doubt that the 2 sets of specimens are specifically identical.

The frequent displacement of the internal body in the Belfast population, probably during fossilization, shows very clearly that the granulate to vermiculate pattern of the shell-membrane is restricted to those parts of the shell beyond the limits of the internal body.

Deflandrea belfastensis n. sp.

(Pl. XI, fig. 4-6; holotype fig. 4; Nat Mus. Vic. P20544)

Occurrence: Belfast No. 4 Bore, Vic., between 4,645 and 4,655 ft.

Description: Shell considerably longer than broad, sides convex in the middle region slanting slightly towards both apex and antapex. At the apex there is a short but decided bluntly-pointed horn which occasionally ends in a minute solid process which may be turned inwards. The antapex is broadly truncate or slightly concave with 2 short laterally placed, approximately equal, blunt horns. There is no indication of a girdle, longitudinal furrow or tabulation. The surface of the shell is distinctly and rather coarsely granular in the apical and antapical regions smooth in the vicinity of the internal body.

The internal body is oval to nearly circular in surface view, its longer axis being perpendicular to the longitudinal axis of the shell. It does not extend to the lateral margins of the shell but projects prominently on the ventral surface. The pylome is rather large and hoof-shaped.

Dimensions: Type—length 109μ, breadth 63μ, internal body 48 x 56μ. Range —length 94-120μ, breadth 54-68μ.

Comments: This species is closely related to *D. bakeri* Deflandre and Cookson (1955). It differs from this species in (1) the narrower shape of the shell and its more sloping sides, (2) the more constant and stronger development of the apical horn, (3) the more prominent antapical horns, (4) the complete absence of a girdle which Deflandre and Cookson mention as being developed in *D. bakeri*. *D. belfastensis* is the older species and it seems likely that *D. bakeri* was derived directly from it.

D. belfastensis also seems close to *D. cretacea* Cookson. The general build and ornamentation is the same but in *D. cretacea* the apical and antapical horns are only occasionally slightly represented and the shell is considerably less elongated.

Deflandrea thomasi n. sp.

(Pl. XI, fig. 7-10; holotype fig. 8, Nat. Mus. Vic. P20545; paratype fig. 9, Nat. Mus. Vic. P21305)

Occurrence: Belfast No. 4 Bore, Vic., between 4,492 and 4,499 ft.

Description: Shell longer than broad, roughly oval with a median girdle with low borders which, sometimes, is only indicated at the lateral margins. The epitheca has a short, solid pointed horn which terminates in a minute hyaline prominance.

The antapex is variable in outline, it may be indented, obliquely truncate with a single short, pointed, lateral horn or broadly rounded. The shell membrane is 2 layered; the inner layer is thin and hyaline, the outer is formed of densely arranged minute granules or rods; it is from this layer that the apical horn is formed. In poorly preserved specimens the outer layer tends to be destroyed. The internal body is oval in outline and thin-walled; it appears to be absent from some specimens. The pylome is trapezoid in shape.

DIMENSION: Type—length 108μ, breadth 82μ. Range—length 85-114μ, breadth 50-90μ.

COMMENTS: The specimens of this species, though not rare, have been invariably badly preserved in contrast to those of *D. cretacea* with which it is associated. This may be due to the thinner walls of both the shell and internal body of *D. thomasi*.

D. thomasi can be distinguished from other species of *Deflandrea* by the finely and densely patterned surface and the construction of the solid apical horn.

The specific name is after Dr D. E. Thomas, Department of Mines, Victoria.

Genus **Amphidiadema** Cookson and Eisenack 1960

Amphidiadema denticulata Cookson and Eisenack

(Pl. XI, fig 3)

Amphidiadema denticulata Cookson and Eisenack 1960a, p. 4, Pl. 1, fig. 11.

Well preserved specimens of *A. denticulata* are relatively frequent in the Belfast No. 4 Bore between 4,492 and 4,499 ft and at 4,652 ft. This species has been recorded previously from (1) Wapet's Seismic Shot Hole B 1 near Gingin, W.A., at 160 and 170 ft, the age at this depth probably approximates to Upper Turonian–Middle Senonian, and (2) the Brickhouse Station Bore (sunk in 1950) at 455 ft, the age of which is given by Edgell (1957) at Campanian.

Family INCERTA

Genus **Canningia** Cookson and Eisenack 1960

Canningia rotundata n. sp.

(Pl. XIII, fig. 1-5; holotype fig. 1; Nat. Mus. Vic. P20546)

OCCURRENCE: Belfast No. 4 Bore between 4,492 and 4,499 ft.

DESCRIPTION: Shell nearly spherical in outline, mostly somewhat broader than long, flat in the present state of preservation, usually with a short broadly rounded apical horn. Antapex rounded or with a slight median prominance. Wall of variable thickness, *c* 2-5μ, closely covered with a dense indistinctly vermiculate pattern.

The shell opens by the complete detachment of the apex along an approximately straight line.

DIMENSIONS: Type—length 87μ, breadth 90μ. Range—length 87-105μ, breadth 90-132μ.

COMMENTS: A slight enlargement of the genus *Canningia* Cookson and Eisenack (1960b) is necessary if the Belfast specimens referred to as *C. rotundata* are to be accommodated in it. In the original generic description the base of the shell is described as 'indented' whereas in the Belfast specimens the base of the shell is rounded and sometimes even bears a small median prominence. However, their agreement in all other respects with *Canningia* is so close that little doubt is left as to their relationship with the Upper Jurassic species *C. reticulata* Cookson and Eisenack and the Lower Cretaceous species *C. colliveri* Cookson and Eisenack.

Genus **Odontochitina** Deflandre 1935

Odontochitina porifera Cookson

Odontochitina porifera Cookson 1956, p. 188, Pl. 1, fig. 17.

O. porifera occurs in the Belfast No. 4 Bore between 4,492–4,499 ft and at 4,652 ft. This species, originally described from the Nelson Bore, Vic., at 6,233 ft, has since been recorded from several Upper Cretaceous deposits in W. Australia which range in age from Upper Turonian to Santonian-Lower Maestrichtian (Cookson and Eisenack 1960).

HYSTRICHOSPHERES

Genus **Hystrichosphaeridium** Deflandre 1937

Hystrichosphaeridium heteracanthum Deflandre and Cookson

Hystrichosphaeridium heteracanthum Deflandre and Cookson 1955, p. 276, Pl. 2, fig. 5, 6, Fig. 40, 41.

H. heteracanthum has been recorded previously from Upper Cretaceous and Paleocene to Lower Eocene deposits in Victoria (Deflandre and Cookson 1955) and Upper Cretaceous deposits in W. Australia (Cookson and Eisenack 1960). It occurs in the Belfast No. 4 Bore between 4,492 and 4,499 ft and at 4,652 ft.

The shell opens as the result of a clean-cut break and the removal of a cap-like sector.

Hystrichosphaeridium complex (White)

Xanthidium tubiferum complex White 1842. *Micr. J.* 2, Pl. IV (3), fig. 11. 1844. *Trans. Micr. Soc.* 1: 83, Pl. VIII, fig. 10.

Hystrichosphaeridium elegantulum Lejeune-Carpentier 1940. *Ann. Soc. Geol. Belg.* 63: B 222, figs. 11-12.

Hystrichosphaeridium complex (White) Deflandre 1946. *C.R. Soc. Geol. Fr.* 111.

H. cf. *tubiferum* sec. Cookson 1953. Pl. II, fig. 24.

H. complex, originally recorded from the European Upper Cretaceous, has been observed occasionally in residues of the Belfast No. 4 sediments between 4,492 and 4,652 ft. It appears to have been widely distributed in Australian waters during both the Lower and Upper Cretaceous eras (Deflandre and Cookson 1955, Cookson and Eisenack 1958).

INCERTAE SEDIS

Genus **Hexagonifera** n. gen.

DESCRIPTION: Shell oval, wall of variable thickness, smooth or ornamented. Pylome formed by the removal of a 6-sided lid at one pole.

Type species *Hexagonifera glabra* n. sp.

COMMENTS: A comparison of *Hexagonifera* with the 2 genera *Pyxidiella* Cookson and Eisenack 1958 and *Fromea* Cookson and Eisenack 1958 shows it to be distinct from *Pyxidiella* in having a terminal instead of the sub-polar opening of this form and from *Fromea* in the presence of a distinct 'lid' and the absence of a girdle.

Hexagonifera glabra n. sp.

(Pl. XII, fig. 9-13; holotype fig 11; Nat. Mus. Vic. P20547)

OCCURRENCE: Belfast No. 4 Bore, Vic. at 4,052 ft.

DESCRIPTION: Shell thick walled, smooth, homogenous, occasionally perforated by straight narrow pores. Lid 6-sided, usually with 3 short and 3 long sides in alternation.

DIMENSIONS: Type—length 66μ, breadth 58μ. Range—length 62-77μ, breadth 57-65μ.

COMMENTS: The shells of *H. glabra* have invariably shown definite signs of the suture by which the opening is made. Often the 'lid' is in position but so loosely that it becomes detached during mounting. Detached 'lids' occur frequently in our preparations. The plane along which the detachment occurs is either perpendicular or somewhat oblique to the long axis of the shell.

The pores found in a few examples are reminiscent of those of *Tasmanites punctatus* Newton and *T. huronensis* (Dawson). Occasionally transparent fragments of what may possibly have been an outer membrane are attached to the shell.

Hexagonifera vermiculata n. sp.

(Pl. XII, fig. 6-8; holotype fig. 6; Nat. Mus. Vic. P20548)

OCCURRENCE: Belfast No. 4 Bore, Vic. between 4,492 and 4,499 ft and at 4,652 ft.

DESCRIPTION: Shell oval to almost circular in outline, surface ornamented with close and rather heavy vermiculate thickenings or a small-meshed thin-walled reticuloid pattern. The lid is seldom seen in position but the 6-sided shape of the opening indicates its shape. Remains of an outer transparent membrane are sometimes present.

DIMENSIONS: Type—length 67μ, breadth 58μ. Range—length 56-76μ, breadth 47-70μ.

Conclusions

On present knowledge, 4 of the microplankton species which occur in the Belfast No. 4 Bore between 4,652 and 4,492 ft are of stratigraphical significance. They have been recorded from deposits of Upper Cretaceous age in W. Australia, which have been dated by means of foraminifera.

(1) *Deflandrea tripartita* was originally described from a carbonaceous sand at 160 ft in Western Australian Petroleum Co's (Wapet) Seismic Shot hole B 1 N. of Gingin. On the basis of microplankton correlation with deposits in Wapet's Rough Range South No. 1 Bore, the age of this deposit approximates to Upper Turonian to Middle Senonian (Cookson and Eisenack 1960).

(2) *Amphidiadema denticulata*. The type locality for this form is the deposit intersected by the Brickhouse Bore, W.A., at 455 ft; the age of which is given by Edgell (1957) at Campanian. *A. denticulata* is associated with *Deflandrea tripartita* in the carbonaceous sand at 160 and 170 ft from Wapet's Seismic Shot hole B 1. The parallel association of these 2 species in the Belfast No. 4 Bore sediments is regarded by us as especially significant and as fully supporting the Senonian age suggested herein.

(3) *Odontochitina porifera* has been recorded by Cookson and Eisenack (1960) from (a) the Upper Gearle Siltstone between 2,505 ft and 2,511 ft in Wapet's Rough Range South No. 1 Bore, the age of this horizon being determined by Dr M. F. Glaessner (unpublished report to Wapet) as Turonian; (b) the Toolonga Calcilutite between 2,393 ft and 2,447 ft in Rough Range South No. 1 Bore, Wapet geologists believe this to be of Senonian age (probably Santonian to Campanian); and (c) at 160 ft and 170 ft in Wapet's Seismic Shot hole B 1.

(4) *Hystrichosphaeridium heteracanthum* occurs in (1) the Toolonga Calcilutite intersected between 2,447 and 2,393 ft in the Rough Range South No. 1 Bore, this being Senonian in age (probably Santonian to Campanian); (2) the Molecap Greensand, W.A., of probable Upper Turonian to Middle Senonian age (Cookson and Eisenack 1960); and (3) Upper Cretaceous and Lower Tertiary deposits in SW. Victoria (Deflandre and Cookson 1955).

The above evidence clearly shows that (1) the Belfast No. 4 Bore sediments between 4,492 ft and 4,652 ft are Upper Cretaceous in age, as suggested by Kenley (1958-59), and (2) that they are probably Senonian.

Acknowledgements

We wish to thank Dr D. E. Thomas for providing the samples upon which this paper is based. One of us (I.C.C.) is greatly indebted to Professor O. Arbo Höeg for accommodation in the Institute for Geology, Blindern, Oslo, where the preparations necessary for this study were made. In addition, she wishes to acknowledge receipt of financial assistance from the Commonwealth Scientific and Industrial Research Organization.

Addendum

As the generic names *Codonia* and *Trigonopyxis* (Cookson and Eisenack 1960a, p. 11) are preoccupied, the substitute names *Codoniella* and *Trigonopyxidia* respectively are herein proposed.

By a printer's error 'gen. and' was omitted in *Actinotheca aphroditae* gen. and sp. nov' (Cookson and Eisenack 1960a, p. 9). *Actinotheca* is a new monotypic genus. It may be diagnosed as 'shell roughly circular in outline consisting of a flat somewhat hexagonal box-like body and a broad 2-layered wing which is supported by a series of radially directed fibres'.

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Explanation of Plates

Plate XI

Fig. 1-2—*Deflandrea cretacea* Cookson. Fig. 1, a nearly oval form × *c.* 425; fig. 2, a specimen showing indication of antapical horns × *c.* 500.

Fig. 3—*Amphidiadema denticulata* Cookson and Eisenack showing apical 'lid' and the pylome in the outer wall slightly out of focus × *c.* 700.

Fig. 4-6—*Deflandrea belfastensis* sp. nov. Fig. 4, holotype × *c.* 450; fig, 5, 6, other examples × *c.* 500 and 400 respectively.

Fig. 7-10—*Deflandrea thomasi* sp. nov. Fig. 7, an example without an interior body showing girdle and pylome × *c.* 450; fig. 8, holotype, showing antapical horns, interior body and pylome, × *c.* 450; fig. 9, example with a large interior body × *c.* 500; fig. 10, example without interior body, apical horn with small tip, girdle and pylome present × *c.* 450.

Plate XII

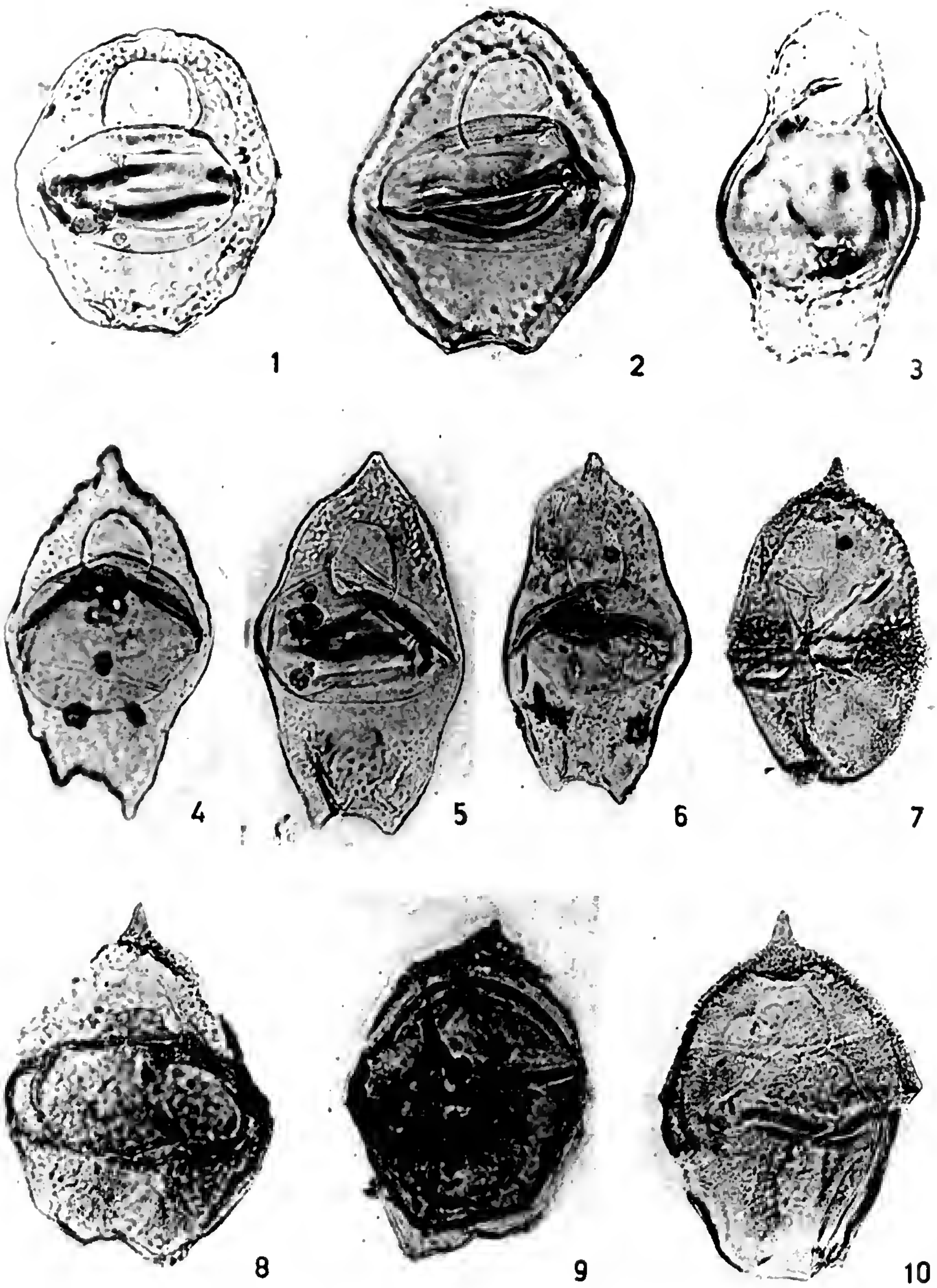
Fig. 1-5—*Canningia rotundata* sp. nov. Fig. 1, holotype, showing partially detached apex, apical horn with small tip and a slightly indicated antapical horn × *c.* 410; fig. 2, example with low, bluntly-rounded apical and antapical horns and a partially detached apex × *c.* 425; fig. 3, a thick-walled, strongly patterned example, with an almost circular outline and no horns × *c.* 465; fig. 4, example with a slightly developed apical horn and no antapical horn × *c.* 425; fig. 5, example with a blunt antapical horn, apical part detached, pattern faintly developed × *c.* 425.

Fig. 6-8—*Hexagonifera vermiculata* sp. nov. Fig. 6, holotype in optical section, 'lid' in position, an outer layer indicated × *c.* 500; fig. 7, 8, optical section and surface views of another specimen.

Fig. 9-13—*Hexagonifera glabra* sp. nov. Fig. 9, a thick-walled specimen without 'lid' showing pores in wall, × *c.* 500; fig. 10, a complete specimen showing distinct apical suture × *c.* 500; fig. 11, holotype × *c.* 500; fig. 12, 13, detached 'lids' × *c.* 500.

Fig. 14—*Hystrichosphaeridium heteracanthum* Deflandre and Cookson open shell × *c.* 400.

—*Eisenack photos.*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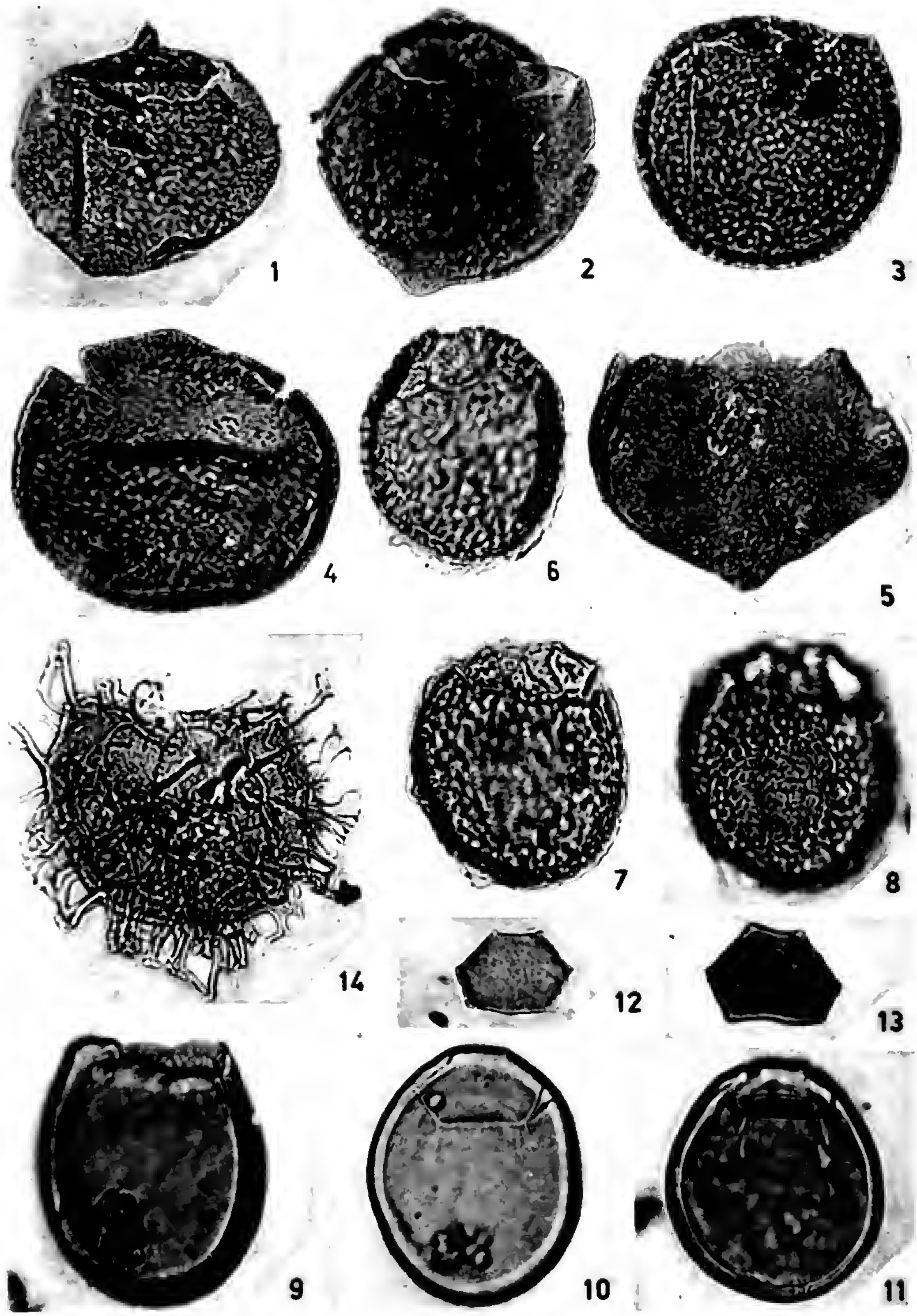
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DIAGENESIS IN THE WAHGI VALLEY SEQUENCE, NEW GUINEA

By Keith A. W. Crook

[Communicated by Dr A. B. Edwards 14 July 1960]

Abstract

The Wahgi Valley sequence consists of Permian and Upper Jurassic to Miocene sediments on a Palaeozoic basement. In the Chim and Wahgi Valleys 24,800 ft of strata are present below the base of the Miocene, and these were once overlain by a probable 10,000 ft of Miocene sediments. The Cretaceous portions of the sequence contain andesitic tuffs and greywackes which have been diagenetically modified as a result of deep burial.

The sediments which have been buried to 13,000-28,000 ft exhibit modifications characteristic of the laumontite facies of diagenesis. Plagioclase is albitized and locally replaced by laumontite, which also replaces radiolaria and organic carbonate and acts as a cement. At depths in excess of 28,000 ft prehnite is found as a cement, and replaces radiolaria and plagioclase. This represents the prehnite-pumpellyite facies of diagenesis. Throughout the sequence rock fragments are modified to chlorite and albite, often without destruction of fabric.

Load pressures of 2-2·5 kilobars appear to be necessary for strong development of the prehnite-pumpellyite facies under normal conditions of epigenetic diagenesis. An accurate estimate of the temperatures obtaining is impossible.

Introduction

The Wahgi Valley sequence was first examined by Noakes (1939), and subsequently the stratigraphy was described in some detail by Rickwood (1955), who recognized the following sequence in the Chim and Wahgi Valleys:

Miocene:	Marls	300 ft + (top faulted)
Eocene-Oligocene:	Chimbu Limestone	2,000 ft
Upper Cretaceous:	Chim Group	12,000 ft
Lower Cretaceous:	Kondaku Tuffs	6,000 ft
Upper Jurassic:	Maril Shales	4,000 ft
Permian:	Kuta Formation	800 ft
	Palaeozoic Basement (metamorphics)	

80 miles NW. of the Chim Valley, but only 8 miles across the regional strike, the Miocene is represented by the Gai Group, 10,600 ft of shales and greywackes.

The Kondaku Tuffs are described by Rickwood (1955) as consisting of 'well bedded volcanic breccia, tuff, conglomerate, greywacke, siltstone and shale'. The Chim Group is described as 'shales with occasional cone-in-cone structure, greywackes and tuffaceous mudstones'.

Edwards and Glaessner (1953) have described in some detail a suite of sediments collected from the Chim Group, Kondaku Tuffs and Maril Shales. Through the kindness of Dr A. B. Edwards, to whom the author is deeply indebted, the author was able to examine thin sections cut from this suite of sediments. Hand specimens were unfortunately not available. These thin sections formed the basis of Edwards's and Glaessner's paper.

In view of the thoroughness of Edwards's and Glaessner's descriptions repetition of petrographic descriptions here would be superfluous. The arenites are mainly lithic labile greywackes (Crook 1960a) of andesitic derivation, with some quartz admixture. There are also some andesitic tuffs.

Although Edwards and Glaessner recorded many of the diagenetic features of these sediments, they were not primarily interested in the distribution of the various features with depth. It is with this aspect of the diagenesis that the present paper primarily deals.

Depth of Burial

It is apparent from the stratigraphic sequence that the basement in the Wahgi Valley region has been buried to a depth in excess of 24,000 ft. Assuming that the Gai Group once extended SW. into the Wahgi-Chim area, without appreciable loss of thickness, one concludes that the basement has been at a depth of the order of 34,000 ft. It is conceivable that this figure may be too low, by a few thousand feet, as the top of the Gai Group is missing due to erosion. However, it is equally conceivable that there has been some thinning of the Gai Group towards the Wahgi-Chim area, for Rickwood (1955, p. 77) considers that the Miocene marls on the Chim R. were deposited in shallower water than their equivalents in the Gai Group. The figure of 34,000 ft would thus seem a good first approximation. This is referred to as the 'present stratigraphic depth of burial' of the basement

Diagenesis

The suite of samples covers a range of present stratigraphic depths from 13,500 ft to 33,000 ft. Unfortunately the lithologies represented between 17,000 ft and 22,500 ft and below 30,000 ft do not yield useful information on diagenesis, and it is therefore necessary to extrapolate certain data across the central part of the sequence.

Data on depth distribution of the various diagenetic modifications are summarized in Fig. 1. Throughout the sequence the plagioclase is albitized—very slightly clouded and sparsely flecked with sericite—and volcanic rock fragments are modified, usually without destruction of fabric, to similar albite and chlorite. The composition of the albite was not determinable from the material available, but it seems unlikely that it is different from that in the Parry Group of N.S.W. (Crook 1960b)—An_{2-4}, to which it is morphologically closely similar.

In those parts of the sequence above a present stratigraphic depth of 28,000 ft, the plagioclase is, in addition, partly replaced by a zeolite which is usually laumontite, but other species may also be present. Laumontite, at times accompanied by another undetermined zeolite, is found replacing shell fragments and radiolaria, and acting as a cement throughout the same region of the sequence. These instances are similar to those in the Parry Group of N.S.W. (Crook 1960b) (replacement of plagioclase, and cement) and the Southland sequence, Otago (Coombs 1954) (replacement of plagioclase, shell material, and cement). Laumontite replacement of shell material has also been observed by the author in fossils from Watts, Babinboon, N.S.W., at the top of the Parry Group.

This portion of the sequence is also characterized by small granules of authigenic sphene, which occur between the detrital grains, associated with other diagenetic products. These granules are again matched by occurrences in Southland and the Parry Group, N.S.W.

In specimens from present stratigraphic depths in excess of 28,000 ft prehnite appears as a cement and as a replacement of plagioclase. Occurrences are closely similar to those in the Parry Group, N.S.W. Prehnite also occurs replacing radio-

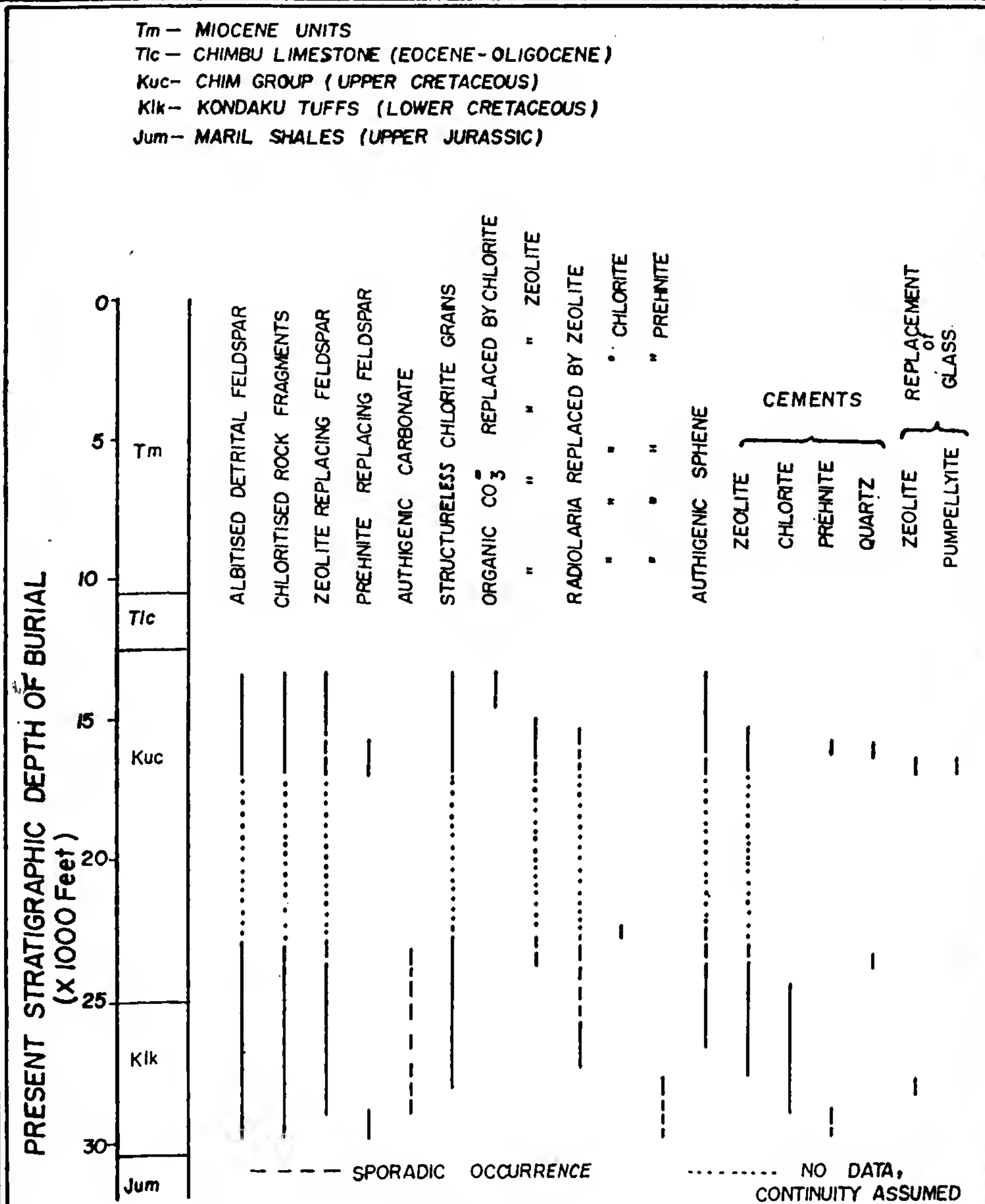

FIG. 1

DISTRIBUTION OF DIAGENETIC EFFECTS IN THE WAHGI VALLEY SEQUENCE, NEW GUINEA.

laria, a phenomenon noted in certain radiolarian argillites from the Tamworth Group, N.S.W. (Crook 1960b).

Prehnite also appears locally higher in the sequence, at 16,000-17,000 ft, replacing plagioclase and acting as a cement. One specimen, 9022, shows it strongly developed, and associated with quartz as veins. In another specimen within this depth-range, 9026, there is a fibrous pleochroic green mineral, already noted by Edwards and Glaessner (1953, p. 106), which is apparently pumpellyite.

Discussion

The overall similarity between the Wahgi Valley sequence and parts of the Southland, N.Z. sequence (Coombs 1954) and the Tamworth Trough sequence, N.S.W. (Crook 1960b) is obvious. The already described diagenetic depth sequences have been ascribed by Coombs et al. (1959), Coombs (1960) and Packham and Crook (1960) to the effects of elevated temperatures and pressures attendant on deep burial. There seems little doubt that the Wahgi Valley depth-sequence is of similar origin.

The application of the facies principle to these rocks (Coombs et al. 1959, Packham and Crook 1960) leads to the conclusion that the Wahgi Valley sediments from present stratigraphic depths between 13,000 and 28,000 ft can, for the most part, be assigned to the zeolite facies (laumontite diagenetic facies). Those from depths in excess of 28,000 ft can be assigned to the prehnite-pumpellyite diagenetic facies. The Wahgi Valley sequence, then, is the third described example of a diagenetic depth sequence in sediments which still retain their original clastic fabric.

The stratigraphic depths at which the prehnite-pumpellyite facies is first encountered and at which it becomes dominant in these three sequences (Table 1), give approximate values for the load pressures obtaining, assuming a density averaging 3 g/cm^3 for the overlying rocks (see Fyfe et al. 1958, p. 34).

TABLE 1

Depth of appearance of prehnite in diagenetic depth sequences

Locality	Reference	Depth of first appearance	Inferred pressure	Depth of maximum development	Inferred pressure
1. Southland, N.Z.	Coombs 1954	23,000 ft	2100 bars	—	—
2. Tamworth Trough, N.S.W.	Crook 1960	18,000 ft	1650 bars	28,000 ft	2500 bars
3. Wahgi Valley, N.G.	herein	16,000 ft	1450 bars	28,000 ft	2500 bars

It is interesting that the Tamworth Trough and Wahgi Valley sequences should yield such similar data, for the sequences are petrographically very similar. As the load pressure at any depth is constant, and the water pressure may be assumed to equal the load pressure at the depths in question, it seems likely that similar geothermal gradients have obtained. This is in good accord with Fyfe and Verhoogen's point (Fyfe et al. 1958, p. 195) that the temperature in a sequence undergoing modification is dependent, among other things, on the rock types present in the sequence. The differences between the Tamworth and Wahgi sequences and the Southland sequence are possibly due to differences in geothermal gradient which may be a reflection of the different rock types present.

The data in Table 1 suggest that load pressures of 2-2·5 kilobars are necessary for strong development of prehnite-pumpellyite facies modifications under normal conditions of epigenetic diagenesis. Occurrences at shallower depths could be ascribed to local elevation in temperature, or to decrease in the activity of water (i.e. decrease in the partial pressure of water) in the manner suggested by Ellis and Fyfe (Coombs et al. 1959, pp. 81-83).

No estimate can be made of the temperatures at which the prehnite developed. Tuttle and Bowen's data on geothermal gradient measurements (1958, p. 188) cover a wide range of values, and the most that can be said is that the minimum temperature of formation of prehnite experimentally (300°C.) observed by Ellis and Fyfe (Coombs et al. 1959) is a not impossible temperature for the natural formation of prehnite in the sequences under discussion.

Acknowledgements

This study was commenced while the author was on the staff of the Geology Department, University of Melbourne, and was completed at the University of Alberta during the tenure of a Postdoctorate Fellowship of the National Research Council of Canada. The author wishes to thank Professors E. S. Hills and R. E. Folinsbee for making facilities for study available, and to Drs A. B. Edwards, J. F. Lerbekmo and F. A. Campbell for helpful criticism of the manuscript.

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9

NEW ROTATORIA (ROTIFERA) FROM VICTORIA, AUSTRALIA

By Bruno Berzins

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[Communicated by A. Neboiss 14 July 1960]

In a large number of samples, collected and sent to me by Mr A. Neboiss, Melbourne, I found 3 new *Lepadella* species of which descriptions follow.

Lepadella neboissi sp. nov.

(Fig. 1-3)

The outline of the lorica is broadly ovate, the greatest width is slightly posterior of the middle of body. The lorica strongly dorso-ventrally flattened, without ridges. The anterior dorsal margin is straight, ventral margin with a wide V-shaped sinus and short fold present on each side. The lorica rounded posteriorly. A sinus and a fold, slightly behind the middle of the body, on each side of lorica, with corresponding pores on dorsal side.

The foot groove is nearly as long as wide. The foot is rather short; terminal segment longer than the first and second segments, somewhat longer than their combined length. The toes are relatively long, divergent and pointed at apex.

Total length	105–108μ
Length of lorica	78–81μ
Width of lorica	63–66μ
Anterior width of lorica	30μ
Depth of ventral sinus	11–13μ
Length of foot groove	18–19μ
Width of foot groove	12μ
Length of foot	14–16μ
Length of toes	30μ

Some individuals were found in King Parrot Creek, near Kinglake West, Victoria, on 18 October 1953.

This species somewhat resembles *Lepadella monodi* Berzins from Senegal, Africa, but differs in the form of the lateral sinus and in the pores for lateral antennae on the border.

Lepadella ptilota sp. nov.

(Fig. 4-6)

The body is ovoid in outline; the ventral surface slightly, the dorsal surface very strongly, medially convex; dorsal median line with a sharp, uneven longitudinal ridge. The frontal margin dorsally convex, with a blunt projection in the middle; ventrally with a rounded sinus. Laterally, the lorica is enlarged with 3 pairs of thin and transparent flappers, the latter being without any contact with muscles. The lorica prolonged posteriorly to a rounded lobe. The cross section of body is somewhat triangular.

The foot groove is wide; foot short; toes straight, rather short and thin.

Length of lorica . . .	72–75μ
Width of lorica . . .	60–67μ
Depth of ventral sinus . .	8μ
Length of foot groove . .	12–15μ
Length of toes . . .	12μ

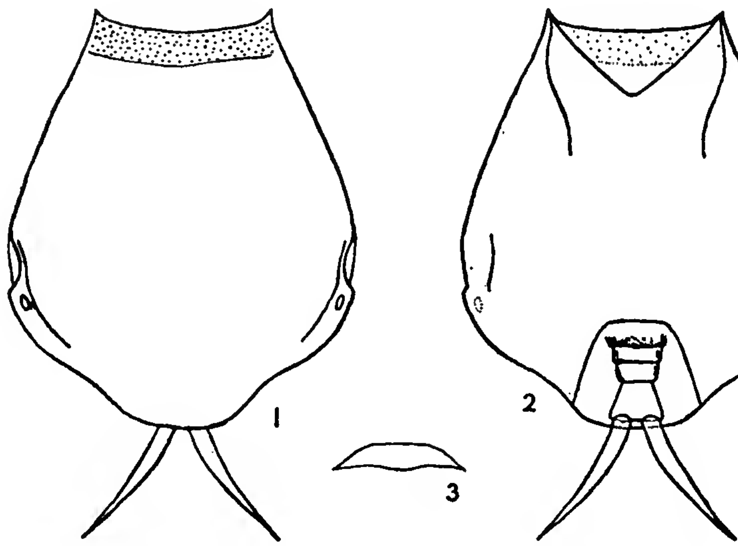

Fig. 1-3—*Lepadella neboissi* sp. nov.: 1, dorsal view; 2, ventral view; 3, cross section of lorica.

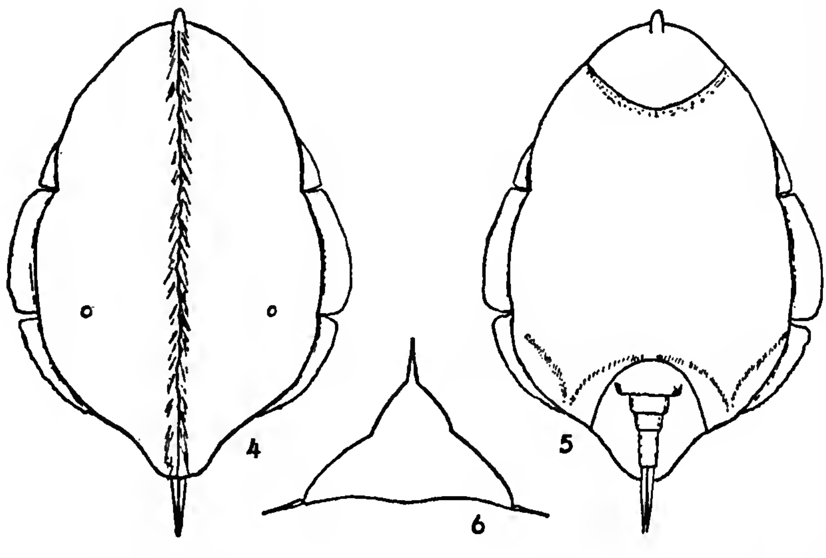

Fig. 4-6—*Lepadella ptilota* sp. nov.: 4, dorsal view; 5, ventral view; 6, cross section of lorica.

Some specimens were found in Creswick Creek, near Clunes, Victoria, on 11 June 1953.

This species in form and tallness very much resembles *Lepadella triptera* (Ehrenberg), but differs in the form of the frontal margin of the lorica, the sharp dorsal ridge, and especially in the presence of lateral lamellary flappers.

Lepadella angusta sp. nov.

(Fig. 7-12)

The lorica is very long and narrow, almost cylindrical; ventrally flat, dorsally rather convex. The anterior margin with dorsal sinus deep and broadly u-shaped, ventral sinus somewhat deeper and v-shaped; dorsal lorica sparsely punctate. The dorsal pores are placed unusually far forward, not far from the dorsal sinus.

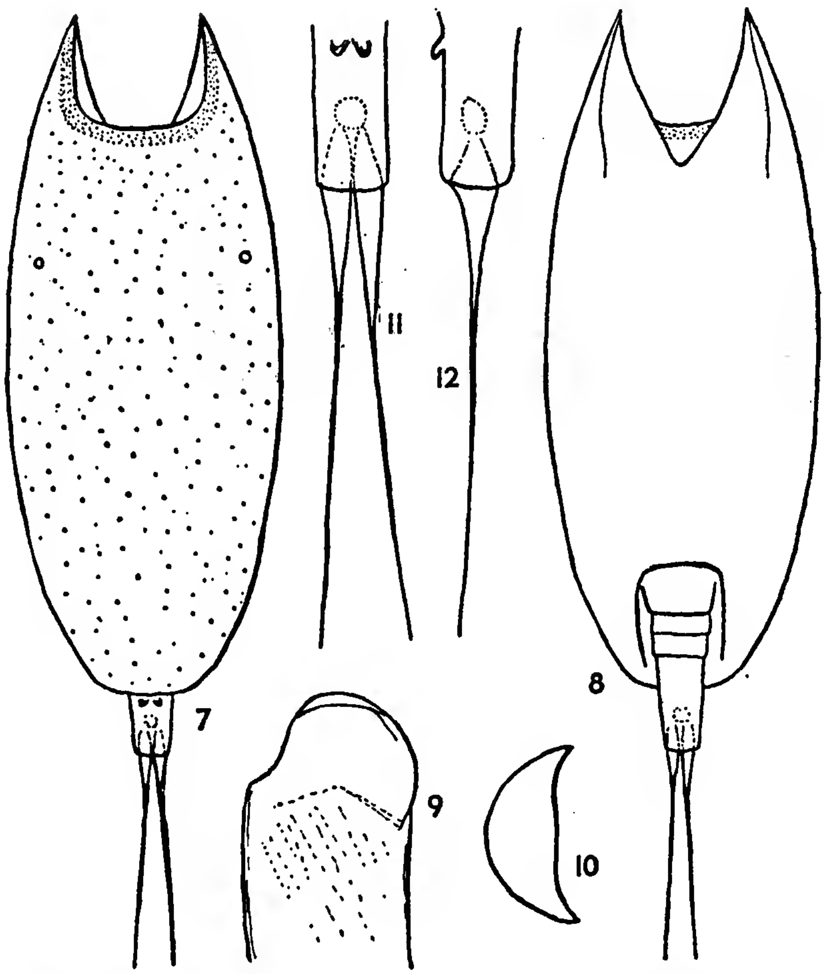

Fig. 7-12—*Lepadella angusta,* sp. nov.: 7, dorsal view; 8, ventral view; 9, lateral view, frontal part; 10, cross section of lorica; 11, terminal segment of foot and toes, dorsal view; 12, lateral view.

The foot groove is broad, not reaching the rounded posterior margin of the lorica. The foot is long; terminal segment the longest, and longer than the combined length of the 2 proximal segments together. Terminal segment with 2 small dorsal projections; toes rather long, thin, acute but widened at the proximal part.

Total length . . .	155μ
Length of lorica . . .	105μ
Width of lorica . . .	46μ
Width of dorsal sinus . .	34μ
Depth of dorsal sinus . .	18μ
Width of ventral sinus . .	34μ
Depth of ventral sinus . .	23μ
Length of foot groove . .	25μ
Width of foot groove . .	18μ
Length of foot with toes .	65μ
Length of terminal segment .	16μ
Length of toes . . .	41μ

Some individuals from Plenty River, Morang, Victoria, on 6 December 1953.

Somewhat resembles *Lepadella elliptica* Wulfert, but is more elongate. Differs especially in the very far forward placed dorsal pores.

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10

STUDIES OF THE POLLEN GRAINS OF PLANTS NATIVE TO VICTORIA, AUSTRALIA

1. GOODENIACEAE (INCLUDING *BRUNONIA*)

By SUZANNE L. DUIGAN PhD

Botany School, University of Melbourne
[Read 8 December 1960]

Abstract

The pollen morphology of the Victorian members of the Goodeniaceae is described, and it is shown that three different types of pollen grain can be distinguished. Variation in the pollen within a species, and particularly that variation which is associated with differences in locality and treatment, is examined. The extent to which members of the family can be identified from their pollen grains and the relation of pollen type to classification are discussed.

Introduction

With the increasing interest in pollen analysis in Australia, the need for detailed studies of the pollen grains of Australian plants is becoming more and more evident. There is a certain amount of information already available in the few works which deal specifically with the pollen morphology of Australian groups, in general works on pollen morphology, in comparative studies of recent Australian pollen grains and their relation to Tertiary ones and in papers on the life history and cytogenetics of Australian plants. However, this is only a beginning, and the success of pollen analysis when applied to Australian deposits (particularly those of Quaternary age, which have been almost completely neglected) will depend on the availability of much more information about the pollen of Australian plants. The lack of a widespread and varied wind-pollinated tree flora (which has been the basis of pollen analysis in the northern hemisphere) means that attention will have to be given to plants which do not come into this category, as even one or two pollen grains of a particular type in a deposit may be of importance. Furthermore, the fact that many families and genera are widely distributed throughout Australia indicates that the identification of pollen grains at a specific level may be particularly desirable.

An attempt is now being made to determine the extent to which Victorian plants can be identified by detailed studies of their pollen grains. It is intended to deal first of all with families which are strongly represented in Australia but are less common in, or absent from, the northern hemisphere, as these are usually the ones about which least information is available. The first family to be treated is the Goodeniaceae, where most genera and all but a few species are Australian endemics.

Species examined

The pollen of *Brunonia* has been included in these studies in spite of the fact that many systematists place this genus in a separate, monotypic family, the

Brunoniaceae. However, as indicated by Erdtman (1952), there are many points of similarity between the pollen of *Brunonia* and that of some members of the Goodeniaceae, and hence it is desirable to consider them together, irrespective of the true systematic position of *Brunonia*.

Most of the names used for the plants from which pollen was obtained are those given by Ewart (1930). However, *Dampiera purpurea R.Br.* replaces *D. brownii* F.v.M. (Court 1957), and certain members of staff (cited below) of the National Herbarium, Melbourne, have kindly permitted me to use the following information regarding species which were not recorded by Ewart:

Goodenia affinis De Vriese. Black (1948-57) noted that *G. Primulacea* Schlechtd. occurs in W. Victoria, but, according to J. H. Willis and R. V. Smith, the correct name for the plant in question (as it occurs in Victoria) is *G. affinis*.

Goodenia lunata J. M. Black. The record of the extension of this species into Victoria is authenticated by R. V. Smith.

Scaevola depauperata R.Br. The record of the extension of this species into Victoria is authenticated by J. H. Willis.

The full list of the species from which pollen was obtained and of the localities from which they were derived is given in Table 1. The list is comprised only of the species known to occur naturally in Victoria, and all such species are included. Pollen of each species was obtained from plants growing in one or more Victorian localities, and in a few cases plants from other states are also represented.

Terms and methods

Unless otherwise stated, the terms used in the following descriptions are as defined by Erdtman (1952). As a matter of convenience, the polar diameter of the pollen grains is referred to as the length and the equatorial diameter as the width It seems desirable to have a method of indicating the exact position of the pollen grain when seen in equatorial view, and the terms which are used to refer to the orientation of the grain with respect to the colpi (in a typical tricolporate grain). Front view is used for grains which have a single colpus lying in the centre of the grain towards the observer (e.g. *Goodenia barbata* Pl. XIV, fig. 17-18), back view for those in which two colpi are uppermost (e.g. *G. barbata* Pl. XIV, fig. 13-15) and side view for those in which one colpus is in optical section when the middle of the grain is in focus (e.g. *Vellcia paradoxa* Pl. XVII, fig. 5-7). The polar area index is the measurement used by Iversen and Troels-Smith (1950) and Faegri and Iversen (1950) to express the latitude reached by the ends of the colpi on the surface of the grain; it is the ratio of distance between the adjacent ends of two colpi to the width of the pollen grain. The width of the os (the inner part of the compound aperture) is the diameter at right angles to the polar axis of the pollen grain.

The figures given in Table 1 are not all based on the same number of measurements. The pollen of *Goodenia ovata* from Mt Dandenong was used to find out whether 25 measurements would give satisfactory values for the mean length (P), width (E) and length/width ratio (P/E). The means of 25 and 50 pollen grains were as follows:

	P	E	P/E
25 grains	37·5μ	33·5μ	1·1
50 grains	37·8μ	34·0μ	1·1

This confirmed the view that 25 measurements would be adequate for these dimensions, and this number was used for all examples. However, as the range is obviously of great importance if any attempt is made to use the size and shape in identifying the pollen grains, the measurements of any particularly large, small, wide or narrow grains seen when examining the slides were included in the records of the range of the length, width and length/width ratio. Other measurements are either less important or were more difficult to make, and the figures for the mean of the polar area index, the width of the exine and the width of the ora are based on only 10 measurements in each case. The exact outline of the ora could not be distinguished in the pollen grains of *Dampiera*, and hence measurements of the width of the ora are omitted for this genus.

With the exception of figures for the width of the exine, measurements were made to the nearest μ. Measurements of the width of the exine were estimated to the nearest $\frac{1}{4}\mu$; they are probably not completely accurate to this degree, but such estimates are necessary in order to obtain figures for the range.

The methods used in making preparations of pollen grains are essentially those described by Erdtman (1952). Stamens from fresh or herbarium material were placed in glacial acetic acid and squashed with a glass rod to release the pollen. The pollen was then acetolysed, and part of it mounted in unstained glycerine jelly and part in glycerine jelly stained with safranin. Wherever possible, some of the material which had been acetolysed was retained and subsequntly chlorinated, and mention of chlorinated grains in this paper always refers to grains which were acetolysed prior to chlorination. The chlorinated grains were mounted separately, in stained and unstained glycerine jelly, and were not mixed with those which had only been acetolysed. Measurements of acetolysed pollen grains and of chlorinated grains were recorded separately. With few exceptions, half the number of measurements in each group were taken from stained and half from unstained grains (or, in the case of 25 measurements, 12 and 13 respectively). These were recorded separately, but were put together when means, etc. were calculated.

Pollen of the Victorian species

In addition to a general account of the pollen of the Goodeniaceae (and *Brunonia*), Erdtman (1952) gives a list of previous publications dealing with the pollen of this family, and Selling (1947) gives some additional references as well as an account of the early work on this subject. As the present work covers only the pollen of Victorian species, and deals with them in greater detail than has hitherto been given, it is not considered necessary to discuss previous descriptions of the pollen of the family or to review the literature further.

The pollen grains of the Victorian species are typically tricolporate, with colpi which do not meet at either pole. Table 2 shows the species in which grains with two, four or more colpi and parasyncolpate grains have been observed but, with the exception of those relating to *Dampiera rosmarinifolia* from the Wimmera, all other figures and discussion refer only to tricolporate grains which are not parasyncolpate. This restriction has been made because parasyncolpate grains and those without three colpi form only a small percentage of the total number of pollen grains, and in some ways are not directly comparable with what are regarded as typical grains. The parasyncolpate grains (e.g. *Goodenia lanata* Pl. XVII, fig. 18) are similar in size and shape to those without joined colpi, but they do not have a polar area index in the normal sense, although it is common to find that the colpi bifurcate and join only at one pole of a given grain, remaining separate at the other. In pollen with two colpi (e.g. *Scaevola pallida* Pl. XV, fig. 9-10), the colpi are joined to form a ring passing through the poles (so that there is no polar area index), and owing to this arrangement the shape is somewhat different from that of tricolporate grains. Furthermore, ora may be absent from the pollen with two colpi. In grains with four or more colpi, the grains may be more or less normal in size and shape, although the colpi on opposite sides of the grain are often at an angle to one another (e.g. *Goodenia lunata* Pl. XIII, fig. 17). In many cases, grains with four or more colpi are of irregular shape and may be up to twice as large as the tricolporate ones of the same species. The difference between grains of *Goodenia subintegra* with three and four colpi is shown in Pl. XVII, fig. 11-12.

The pollen of *Dampiera rosmarinifolia* from the Wimmera is exceptional in that 4-colporate grains predominate, 80% of the pollen being of this type. Because of this, 4-colporate grains were measured when pollen of this species from the Wimmera was being examined. However, the 4-colporate condition is not a character of the species as a whole, as grains with four colpi were not observed in the pollen from Bendigo and only a few were found in the Lake Albacutya material. Work on polyploid races of a number of species has shown that their pollen tends to be larger and to have more apertures than the diploids, and hence it may be suggested tentatively that the material of *D. rosmarinifolia* from the Wimmera represents a polyploid.

Examination of the other morphological features of the pollen of the Victorian Goodeniaceae shows that the pollen can be divided into three distinct types, which will now be described separately. Measurements of the pollen of individual species are given in Table 1, and details of other morphological features shown in Table 2. Illustrations of one or two species representing each genus are given in the plates. These show front, back, side and polar views of *Brunonia australis* (Pl. XIII, fig. 1-16), *Dampiera stricta* (Pl. XIV, fig. 1-9), a large and a small example of *Goodenia* (*G. barbata* Pl. XIV, fig. 13-20; *G. heteromera* Pl. XV, fig. 1-8) and *Scaevola* (*S. ramosissima* Pl. XVI, fig. 1-8, 10-12; *S. pallida* Pl. XV, fig. 9-19), *Selliera radicans* (Pl. XVI, fig. 9, 13-22) and *Velleia paradoxa* (Pl. XVII, fig 1-10). Photographs of grains of other species demonstrate specific points discussed in the text. Where illustrations are cited in brackets after mention of a particular feature, they refer only to the fact that the example shows the feature in question, and are not intended to be exhaustive.

Goodenia-type

This type of pollen is found in all the Victorian species of *Goodenia, Scaevola, Selliera* and *Velleia*.

Size: The length of the pollen grains in this group shows a wide range and the width a somewhat smaller one. In acetolysed grains, the length is from 24μ in several species from Victorian localities (22μ was recorded for *Goodenia humilis* from Tasmania) to 59μ (*Scaevola calendulacea*), and the width is from 21μ in *Goodenia humilis* from Victoria (20μ from Tasmania) to 51μ (*Scaevola depauperata*). In chlorinated grains, the length is from 25μ (*Goodenia amplexans* and *Velleia montana*) to 71μ (*Scaevola depauperata*) and the width from 21μ (*Goodenia humilis*) to 47μ (*Scaevola depauperata*).

Shape: In polar view, the pollen grains are most commonly more or less hexagonal in outline (*Goodenia heteromera* Pl. XV, fig. 2; *Velleia connata* Pl. XV, fig. 26). The sides which do not include the colpi may be straight (*Goodenia robusta*

Pl. XIII, fig. 18; *Velleia connata* Pl. XV, fig. 26), slightly curved (*Velleia paradoxa* Pl. XVII, fig. 9; *Selliera radicans* Pl. XVI, fig. 9) or more strongly curved, giving an approximately circular (*Velleia montana* Pl. XV, fig. 21) or almost lobed shape (*Goodenia pusilliflora* Pl. XV, fig. 28).

In equatorial view, the grains are from approximately circular to elliptical. The length may be greater or less than the width, and the grains range from suboblate to perprolate, with a length/width ratio of from 0·8 (in acetolysed grains of a number of species) to 2·1 (chlorinated grains of *Scaevola aemula*). In front and back view, the curve of the sides is usually quite smooth (*Goodenia barbata* Pl. XIV, fig. 13), but in some cases there is a bulge at the equator in the position of the os (*Scaevola ramosissima* Pl. XVI, fig. 7). In side view, the side which includes the colpus may show a smooth curve (*Goodenia barbata* Pl. XIV, fig. 19) or a slight bulge at the equator (*Velleia montana* Pl. XV, fig. 30), or it may be angular in outline (*Velleia connata* Pl. XVII, fig. 17).

Exine: The exine is divided into an inner, apparently homogeneous nexine and an outer sexine consisting of a thin, homogeneous ectosexine and an endosexine of branched or unbranched baculae (*Goodenia ovata* Pl. XVII, fig. 14). Thus the sexine is tegillate. The pattern, which forms a conspicuous feature in most grains (particularly when seen in polar view), seems to be due to the trunks of the baculae. The pattern at low focus (where it is most clearly defined) consists of dark spots or patches separated by light areas (*Selliera radicans* Pl. XVI, fig. 13); at a higher focus, the pattern is less distinct and the position of the light and dark parts is reversed (*Selliera radicans* Pl. XVI, fig. 14).

For purposes of comparing the pattern with that of pollen grains in other families, it is desirable to have a descriptive term which is independent of the structure, but this does not seem to be available. Erdtman (1952) illustrates sexines of this type and labels them tegillate-baculate or tegillate-ramibaculate (with the baculae unbranched and branched respectively), while Iversen and Troels-Smith (1950) and Faegri and Iversen (1950) either use or indicate the term intra-baculate for them. However, these terms are related to structure and not only to pattern. It is proposed to use the word mottled to describe the pattern (i.e. the appearance of the pollen grain, without reference to the structure of the exine), and to use this as a general term to cover a pattern which, when most clearly defined, consists of dark patches or spots surrounded by lighter areas.

The pattern is not equally coarse over the whole surface of the individual grain. The colpi are bounded by a zone in which the pattern is much finer than elsewhere (*Velleia paradoxa* Pl. XVII, fig. 3; *Scaevola pallida* Pl. XV, fig. 15). This is particularly conspicuous in polar view, and gives a characteristic appearance to the grains in this group. The pattern over the ora is also extremely fine (*Velleia paradoxa* Pl. XVII, fig. 3). The pattern at the poles is usually coarser than at the equator between the fine zones bounding the colpi (*Goodenia elongata* Pl. XVII, fig. 20), but the degree to which this character is developed varies with the species.

The pattern at the poles and at the equator between the colpi varies both within a species and between species. In order to describe this variation, a series of grades of pattern has been established. The main grades which can be distinguished are fine, medium and coarse, but these are connected by intermediates (fine/medium and medium/coarse) and the pattern may also be very coarse. The grades apply only to the pollen of the family as discussed in this paper. Examples of the grades which are illustrated in the plates are:

Fine—
Goodenia barbata (Pl. XIV, fig. 16)
G. elongata (Pl. XVII, fig. 20)
G. heteromera (Pl. XV, fig. 6)

Fine/medium—
Goodenia amplexans (Pl. XIII, fig. 21)
G. barbata (Pl. XIV, fig. 15)
G. gracilis (Pl. XIV, fig. 26)
G. paniculata (Pl. XIV, fig. 24)
Scaevola ramosissima (Pl. XVI, fig. 8)
Velleia paradoxa (Pl. XVII, fig. 8)

Medium—
Goodenia barbata (Pl. XIV, fig. 20)
G. pusilliflora (Pl. XV, fig. 29)
Scaevola pallida (Pl. XV, fig. 17)
S. ramosissima (Pl. XVI, fig. 6)
Velleia montana (Pl. XV, fig. 22)
V. paradoxa (Pl. XVII, fig. 10)

Medium/coarse—
Goodenia barbata (Pl. XIV, fig. 22)
G. gracilis (Pl. XIV, fig. 28)
G. heteromera (Pl. XV, fig. 3)
G. ovata (Pl. XV, fig. 25)
Selliera radicans (Pl. XVI, fig. 16)

Coarse—
Goodenia ovata (Pl. XV, fig. 23)
G. robusta (Pl. XIII, fig. 19)
Scaevola pallida (Pl. XV, fig. 19)
S. ramosissima (Pl. XVI, fig. 11)
Selliera radicans (Pl. XVI, fig. 13)
Velleia connata (Pl. XV, fig. 27)

Very coarse—
Scaevola aemula (Pl. XVII, fig. 15)

The pattern discussed above is the most obvious one. In some species a second, very fine and very uniform pattern can be discerned (using an objective of 45:1, N.A. 0·65) at a slightly higher level. This pattern (which will be called the outer pattern to distinguish it from the one already discussed) consists of minute dark spots surrounded by light areas (*Scaevola aemula* Pl. XVII, fig. 16; *S. ramosissima* Pl. XVI, fig. 12). It is not clear whether the outer pattern is due to the branches of the baculae or whether it is an ectosexinous feature, but the fact that the dark spots are light (if very indistinct) at a higher focus suggests that they may represent the branches of the baculae.

There is either a gap or a very thin place in the nexine at the ora, but, apart from this, the nexine is of approximately even thickness in all parts of a given pollen grain. On the other hand, the thickness of the sexine varies considerably in different parts of the grain, this variation being paralleled by changes in the coarseness of the pattern. Each colpus is bounded by a zone in which the sexine is thin, and it is considerably thicker in the areas between these zones (*Goodenia barbata* Pl. XIV, fig. 21; *Selliera radicans* Pl. XVI, fig. 9). Furthermore, the sexine between the thin zones thickens from the equator towards the poles in most species. This is usually apparent even in side view (*Goodenia heteromera* Pl. XV, fig. 7), but is more conspicuous in front or back view (*G. subintegra* Pl. XVII, fig. 12) because the sexine is very thin over the ora. The effect may be emphasized by a flattening of the nexine at the poles (*G. barbata* Pl. XIV, fig. 13), and in a few instances the thickenings at the poles stand out as distinct bumps (*G. paniculata* Pl. XIV, fig. 23) which appear to correspond with the structure termed a polar cap by Selling (1947). The extent to which the sexine is thickened at the poles is rather variable. When seen in side view, the grains vary from those showing little or no thickening at the poles (*Velleia montana* Pl. XV, fig. 30) to those where the thickening is very considerable (e.g. *Scaevola aemula*, where the sexine is up to 6μ thick at the poles). Even when seen in front or back view, the thickening may be inconspicuous or absent (as is the case with many grains of *Goodenia pusilliflora*), but in these positions it can be seen in some grains of all species from all localities.

In some pollen grains the sexine is thickened at the poles and tapers gradually towards the equator, but in others there is a second area of thickening below the poles (*Scaevola ramosissima* Pl. XVI, fig. 3; *Goodenia pinnatifida* Pl. XV, fig. 20).

It lies approximately mid-way between the poles and the equator. This thickening may be only very slight (*Scaevola calendulacea* Pl. XVII, fig. 13), but in some examples (as seen in the illustration of *S. ramosissima* just cited) it is so great that, when seen in side view, the side of the grain which does not include the colpus is concave. The thickening occurs chiefly in the areas between the colpi, and is not shown, or is less evident, in front or back view.

APERTURES: The pollen grains are typically colporate, with three long colpi equally spaced around the equator and with a transversely placed os in the centre of each colpus. However, as previously pointed out, there may be two, four or more colpi and, although the ends of the colpi are not usually joined, the grains can be syncolpate or parasyncolpate. The colpi are in the form of grooves from which the sexine is absent, the floor of the colpus being formed by the nexine (*Goodenia barbata* Pl. XIV, fig. 21). When seen in polar view, the nexine beneath the colpus varies from more or less flat or slightly convex (*G. barbata* Pl. XIV, fig. 21) to strongly concave (*Scaevola ramosissima* Pl. XVI, fig. 10). There is some suggestion that the shape of the nexine in this position may be characteristic of particular species, but it also seems to be related to the degree of expansion of the grains, and hence has not been included in the tables.

The ora are formed by a gap or a very thin place in the nexine (*Selliera radicans* Pl. XVI, fig. 22; *Velleia paradoxa* Pl. XVII, fig. 6) but are covered by the sexine. Their ends may be rounded or pointed; both these shapes may be found in the one preparation. Although ora are probably always present (except in grains with only two colpi), it is not uncommon to find that their outline is indistinct, so that it is difficult to distinguish their shape or to measure their width.

Brunonia-type

This type of pollen, which is basically similar to the *Goodenia*-type, is found only in *Brunonia australis* (at least, as far as Victorian members of the Goodeniaceae are concerned).

SIZE: The pollen grains are relatively large. Acetolysed grains range from 43μ (36μ in material from Western Australia) to 56μ in length and from 32μ (30μ for W.A.) to 44μ in width. In the case of chlorinated grains, the range in length is from 50μ (39μ for W.A.) to 67μ and the range in width is the same as that for acetolysed grains.

SHAPE: In polar view, the shape is somewhat variable, ranging from more or less triangular, with the apertures in the middle of the sides of the triangle (Pl. XIII, fig. 1), through slightly lobed (Pl. XIII, fig. 3) to approximately circular (Pl. XIII, fig. 5). In equatorial view, the grains are elliptical, ranging from prolate sphaeroidal to prolate and having a length/width ratio of from 1·1 (1·0 for W.A.) to 1·7 (1·8 for W.A.). The curve of the sides is smooth, without bulges at the equator. In side view, there is often a tendency for the side which does not include the colpus to be more strongly convex than the opposite side, so that the grain has a lop-sided appearance.

EXINE AND APERTURES: The exine shows the same structure as that found in the *Goodenia*-type, although the baculae, particularly in parts of the grain other than the poles, are sometimes less distinct (Pl. XIII, fig. 8). The pattern is mottled. It varies from fine (Pl. XIII, fig. 11) to medium (Pl. XIII, fig. 10) at the equator between the colpi, and from fine to very coarse at the poles. The examples of polar views which are illustrated show patterns which are medium

(Pl. XIII, fig. 4), medium/coarse (Pl. XIII, fig. 6) and very coarse (Pl. XIII, fig. 2). In a given grain, the pattern is finest over the ora and in the vicinity of the colpi (Pl. XIII, fig. 6, 16), and is usually coarser at the poles than at the equator. An outer pattern (Pl. XIII, fig. 12) was discernable only in the material from Kingston.

The sexine is thickened, usually quite considerably, at the poles, and sometimes this thickening forms a fairly distinct polar cap (Pl. XIII, fig. 8). There may be a slight sexinous thickening below the poles, but this is usually absent.

The apertures are of the same general structure as those found in the *Goodenia*-type, and consist of long, equatorially placed colpi (usually three), each with a transverse os (Pl. XIII, fig. 7). The colpi are formed by a gap in the sexine, the ora by a gap in the nexine. The only important difference between the *Goodenia*-type and the *Brunonia*-type lies in the structure of the sexine in the vicinity of the colpi. Instead of tapering to a very thin band at the edges of the colpi, as in the *Goodenia*-type, the sexine forms two ridges on either side of each colpus in the *Brunonia*-type (Pl. XIII, fig. 1, 5, 6, 15). The inner of these ridges is always clearly evident, but the outer one may be inconspicuous.

Dampiera-type

The only Victorian member of the Goodeniaceae to show this type of pollen (which is rather different from the *Goodenia*-type and *Brunonia*-type) is *Dampiera.*

Size: The grains are small. In acetolysed grains, the length ranges from 12μ (*D. marifolia*) to 21μ (*D. rosmarinifolia* and *D. stricta*) and the width from 13μ (*D. marifolia* and *D. stricta*) to 23μ (*D. rosmarinifolia* and *D. stricta*). In chlorinated grains, the length ranges from 13μ (*D. lanceolata* and *D. marifolia*) to 26μ (*D. rosmarinifolia*) and the width from 15μ (*D. marifolia* and *D. stricta*) to 23μ (*D. purpurea* and *D. rosmarinifolia*). In the special case of the 4-colporate grains of *D. rosmarinifolia* from the Wimmera, the acetolysed grains may be slightly larger than those of the other examples (to 22μ long and 25μ wide).

Shape: In polar view, the pollen grains are from more or less triangular (*D. purpurea* Pl. XIV, fig. 11), with straight or slightly convex sides, to circular (*D. stricta* Pl. XIV, fig. 3) or slightly lobed. The 4-colporate grains of *D. rosmarinifolia* from the Wimmera (Pl. XIV, fig. 10) are square or rectangular.

In equatorial view, the pollen grains are elliptical or circular, ranging from oblate to subprolate and having a length/width ratio of from 0·7 (acetolysed grains of several species) to 1·3 (acetolysed grains of *D. rosmarinifolia,* chlorinated grains of this species and *D. stricta*). In front and back view, the sides are smoothly curved or more or less angular. In side view, the side including the colpus may be curved but is more usually angular (*D. stricta* Pl. XIV, fig. 5).

Exine: The exine is thin. It is divided into nexine and sexine, both of which appear to be homogeneous; there is no indication of the individual baculae which characterize the *Goodenia*-type and *Brunonia*-type pollen.

The pollen grains all show a pattern, although it is so fine that, at least in the case of *D. marifolia,* it can only be distinguished with the aid of an oil immersion objective. It consists of minute dark spots surrounded by lighter areas (*D. stricta* Pl. XIV, fig. 9), but the exact structure responsible for the pattern cannot be determined. In comparison with the grades of pattern found in the *Goodenia*-type and *Brunonia*-type, the pattern in *Dampiera* can be classed as very fine. There is little or no difference between the pattern at the poles and at the equator between the colpi, but it becomes even finer or absent along the margins of the colpi.

The nexine is of even thickness wherever it occurs in a given grain. The sexine is also more or less uniform over most of the grain, but it tapers to an extremely thin zone around each colpus (*D. purpurea* Pl. XIV, fig. 11).

APERTURES: The grains are colporate. They usually have three equatorially placed apertures, but the material of *D. rosmarinifolia* from the Wimmera shows a predominance of grains with four apertures (Pl. XIV, fig. 10). The apertures differ from those of the *Goodenia*-type and *Brunonia*-type in that the os is apparently little or no wider than the colpus instead of being an elongated structure. The os is marked by a break or thin place in the nexine (*D. stricta* Pl. XIV, fig. 8) and, although the interruption of the colpus at the equator is quite clear (*D. stricta* Pl. XIV, fig. 2), the exact outline of the os is indistinguishable and the width cannot be measured. The colpus itself is formed by a gap in the sexine.

Variation in the pollen grains

Before discussing the use of the characters of the pollen grains, as given in the tables and described in the text, in the identification of the plants concerned, it is important to consider the variation in these characters in each species, as it is this variation which determines the limits within which descriptions and measurements can be regarded as accurate and constant. The variation to be assessed is that which occurs in the pollen of any species from one locality and from more than one locality, and also which is induced by different treatments when preparing the pollen for examination. The features which will be discussed are the size, shape and pattern of the pollen grains. These are probably the most important features, they may be regarded as representative of the other group given in Tables 1 and 2, and size and shape are the only characters for which a relatively large number of measurements is available. As a matter of convenience, the word 'example' in the following discussion is used to indicate pollen of one species from one locality treated by one method, so that, for instance, the acetolysed and chlorinated pollen of a species from two localities would constitute four examples.

VARIATION IN A SPECIES FROM ONE LOCALITY

The variation in the pollen, whether acetolysed or chlorinated, of a given species from a single locality tends to be appreciable. The range of the length may be up to 23μ (*Brunonia australis* from Lake Austin, W.A.), and the average range for the 123 examples is approximately 9μ. The range of the width is not quite so great; the maximum is 14μ (*Scaevola aemula*) and the average range is 7μ. The range in shape (as measured by P/E) is usually moderate to large, the maximum range for P/E being 0·7 (which occurs in a number of species) the average being approximately 0·4.

Except in the case of the pollen of *Dampiera*, there is usually an appreciable variation in the pattern (particularly at the poles) of the pollen of each example. Excluding *Dampiera* and ignoring treatment (which does not seem to affect the pattern), 62 examples were available for examination, and of these only four show a single grade of pattern at the poles, while 14 show three grades. The pattern is less variable at the equator, as half the examples show only one grade and only three examples show three grades; *Selliera radicans* is exceptional in that it may show four grades in a single example. The variation in the pattern at the equator in one example is shown for *Goodenia barbata* in Plate XIV, where fig. 16 shows a fine pattern, fig. 15 fine/medium and fig. 20 medium. The variation at the poles is also illustrated in Plate XIV, where fig. 26 shows a fine/medium pattern and fig. 28 a medium/coarse pattern in the pollen of *G. gracilis*. Although it is not common, there may be an appreciable variation between the pattern at one pole of a pollen grain and that of the other pole; an example of this is seen in the case of *G. ovata*, where one pole of a grain may be medium/coarse (Pl. XV, fig. 25) and the other pole coarse (Pl. XV, fig. 23).

Preparations of the pollen of each species from each locality were made up without reference to whether one or more plants were used as a source of the pollen. In the case of *G. ovata* from Tidal River, the pollen from two different plants was kept separate to find out whether there were any differences between their pollen grains. When the features from Tidal River (1) and (2) are compared, it is seen that they are almost identical, the only difference of any magnitude being the wider variation in polar pattern of the pollen of Tidal River (2).

Variation with Locality

On the whole, there is good agreement between the pollen of a species from one locality and that of the same species from other localities. Acetolysed pollen from each of 21 species was prepared from two or more localities, and these show an average difference in the mean length of each species from different localities (measured as the greatest difference when more than two localities are concerned) of 3μ. The lower and upper ends of the range of the length also show a difference of 3μ. The difference in mean width averages 2μ, the lower end of the range in width 2μ and the upper end of the range 3μ. The difference in the mean and both ends of the range of P/E averages 0·1. Figures for chlorinated grains (where only 14 species are concerned) are the same as the ones for acetolysed pollen, except for the fact that the average difference in the upper end of the range in length is 4μ.

It might be expected that comparisons between Victorian localities would show less variation in the pollen of a species than when Victorian and interstate localities are compared. This is true of the length, where the differences in the mean, the lower and upper ends of the range all average 2μ for Victorian localities and 4μ when Victorian localities are compared with interstate ones, but the width and P/E seem unaffected by the position of the localities concerned.

It must be pointed out that, although there is not in general a great deal of variation in the pollen grains of a species from two or more localities, in some cases the variation (particularly in the length) may be considerable. Thus the mean length of acetolysed grains of *Brunonia australis* is only 40μ in material from Lake Austin, W.A., compared with 52μ for the pollen from Lake Hindmarsh, and the complete range in length of chlorinated grains from these sources is 28μ. As far as other species are concerned, comparison of localities within Victoria shows that the difference in mean length may be up to 6μ and in either end of the range in length up to 9μ (both shown in chlorinated grains of *Scaevola hookeri*).

The possible variation in the polar pattern of a given species with locality can be summed up by comparing the smallest range in pattern recorded from any of the localities with the complete range in pattern (i.e. when all localities are taken into consideration). The same technique can be used for the pattern at the equator. When both the polar and equatorial patterns are studied, it is found that the complete range of the pattern is the same as the smallest range in 31% of the cases, it is greater than the smallest range by one grade in 45%, by two grades in 17%

and by three or four grades in 7% of the cases where comparison is possible. In essence, this means that the pattern usually shows only a small variation or no variation at all with locality, but that in a few instances the variation may be considerable. The greatest variation is seen in the polar pattern of *Brunonia australis,* where the complete range is of six grades (from fine to very coarse) compared with the smallest range of two grades.

Variation with Treatment

The fact that certain characters (particularly the size) of pollen grains are influenced by the treatment to which they are subjected is well known, and the pollen of the Goodeniaceae is no exception. In the present case, the pattern appears to be unaffected by treatment, and hence size and shape are the only characters which will be considered further.

When differences between pollen which has been acetolysed only and that which has also been chlorinated are examined, it is found that the length of the chlorinated grains is in general greater than that of the acetolysed ones. The 55 examples in which the two treatments can be compared show an average increase of 4·3μ, or 13%, in the mean length with chlorination, the lower end of the range is increased by an average of 2·9μ (9·5%) and the upper end by 6·5μ (17%). Unfortunately, the length of chlorinated grains cannot be predicted accurately from that of acetolysed ones, as the increase in length with chlorination is not uniform, and indeed does not always take place; the mean length is unchanged in 6% of the examples, and the increase, when shown, varies from 3-34% of the mean. The change in the lower end of the range varies from 0-12μ (or 0-31%) and the upper end from 0-17μ (0-42%). The increase in length with chlorination is usually accompanied by an increase in the width of the exine at the poles. The increase in exine width averages 9% (and may be up to 29%) of the mean width, but it involves an average change of only 0·3μ and is in no real sense responsible for the increase in length of the whole pollen grain.

The effect of chlorination on the width of the pollen grains is considerably less than on the length, and it is much more variable in direction. There is a general increase in the width, but it is small (an average increase in the mean of 0·4μ, or 2%), and only 49% of the examples show an increase in the mean width, 36% remaining unchanged and 15% showing a decrease. The change in the mean varies from a decrease of 5μ or 11% to an increase of 4μ or 14%. The effect on the range of the width is similar to the changes noted in the mean. On the whole, it appears that the differences between the width of acetolysed and chlorinated pollen grains are so small and erratic that they may be disregarded.

The points made above suggest that chlorinated grains will tend to be longer in relation to their width than acetolysed ones, and this is borne out by the figures for P/E. The mean P/E for chlorinated grains averages 0·1 (12·5%) more than that of acetolysed ones, and an increase is shown by 80% of the examples, 18% remaining unchanged and 2% showing a decrease. The change varies from a decrease of 0·1 (or 8%) to an increase of 0·4 (or 36%). Figures for the range show the same general trend.

As the figures for stained and unstained grains were recorded separately for 102 examples, the effect of staining on the size and shape of the pollen grains could also be investigated. Although there is an overall decrease in the mean length, width and P/E with staining and a decrease is more common than an increase, the effect is so small that it is of no consequence. The only appreciable difference noted for any of the figures was in the case of *Goodenia grandiflora,* where the mean length of the unstained grains was more than 5μ greater than that of the stained ones.

The identification of genera and species from the pollen

As seen in the preceding section, the characters of the pollen of a species are reasonably constant, so that they can be used as a basis for the identification of taxa should only the pollen be available. However, due allowance must be made for the variation that does exist, particularly in view of the fact that such variation may be considerable in some instances. Figures and observations for the pollen of a species which has been prepared from one locality cannot be regarded as necessarily representing the complete range of the characters to which they refer, and it is desirable that pollen grains from different sources should be treated by the same methods before they are compared. When attempting to separate pollen on the basis of size, the range is more important than the mean, and the width, which is less variable, may be more useful than the length. Separation on any basis, and particularly on the basis of size or pattern, can only be made when the pollen grains compared differ appreciably.

As far as the identification of genera is concerned, there is no difficulty in separating pollen grains of *Dampiera* and *Brunonia* from one another and from the group of genera included in the *Goodenia*-type. The main differences between the three types may be summed up as follows. Pollen of the *Goodenia*-type is characterised by an exine with distinct baculae, colpi with an elongated, transversely placed os at the equator and by a zone around each colpus in which the sexine is very thin. The pollen of *Brunonia* is like that of the *Goodenia*-type, but there are two sexinous ridges along each margin of the colpus. *Dampiera* pollen has no evident baculae, it lacks an elongated os and sexinous ridges, and the pattern is finer than that of the other Victorian members of the Goodeniaceae.

As there is only one species of *Brunonia,* the pollen can be identified at a specific level. *Dampiera* pollen appears to be very uniform, and *D. marifolia* seems to be the only species with pollen which is at all distinctive. In this pollen, the pattern is finer and the size and distance between the ends of the colpi are usually smaller than is the case with the other species examined. Pollen of *D. marifolia* could be identified under favourable circumstances, and in certain cases a tentative identification of other species might be made—e.g. a chlorinated pollen grain of this type in which the polar exine measured 2·3μ would probably be *D. purpurea.* However, it is clear that the identification of species in this genus would be the exception rather than the rule, particularly if only a few grains were available.

Within the *Goodenia*-type, there is no feature or group of features which can be used to separate the genera, and it is not possible to draw up a key to identify the species. However, it is believed that, by taking into consideration all the features recorded in the tables, identification of a genus, a group of species or an individual species may be possible in some circumstances. For instance, a pollen grain of the *Goodenia*-type which was more than 65μ long, with strong sexinous thickenings at and below the poles, would be referable to *Scaevola,* while one which exceeded 60μ in length but lacked conspicuous sexinous thickenings below the poles would probably be *Scaevola calendulacea.*

The most convenient method of using the characters described and measured in this paper in the identification of pollen would be to transfer the records to a punch-card system. This has not been done here because it seems probable that most palynologists have their own systems, but it is hoped that sufficient information has been given to satisfy the requirements of such systems.

It is not possible at present to discuss the separation of the pollen grains of Victorian members of the Goodeniaceae from those of a similar type which may occur in other families. This matter will be dealt with as descriptions of the pollen of other families are accumulated.

The relation of pollen morphology to classification and phylogeny

In his recent work on the Goodeniaceae, Carolin (1959) uses the floral structure and anatomy as a basis for the division of the family into four subfamilial groups, the *Brunonia* group (*Brunonia* only), the *Dampiera* group (*Dampiera* and *Anthotium*), the *Leschenaultia* group (*Leschenaultia* only) and the *Goodenia* group (all other genera). The findings of Jackson (1958) regarding the chromosome numbers in Tasmanian representatives of the family are in line with this classification. The results of the present study of the pollen morphology of the Victorian species also fit in with the division into three of the four groups mentioned, while the tetrads of *Leschenaultia,* with poroid apertures (Erdtman 1952), obviously support the suggestion that this Western Australian genus should be placed in a separate group.

Carolin, in agreeing with those who retain *Brunonia* within the Goodeniaceae, states that, although it does stand somewhat apart, the generalized structure conforms fairly well with that of the rest of the family. As pointed out by Erdtman (1952), this is also true of the pollen. As far as the Victorian species are concerned, the pollen of *Dampiera* differs more from that of the four genera in the *Goodenia* group than does *Brunonia* pollen.

Carolin suggests that, in the light of his investigations, the scheme of affinities put forward by Krause (1912) must be modified, and Carolin produces his own phylogenetic scheme for members of the family. The present studies cannot do a great deal towards assisting in the solution of phylogenetic problems, but they do support Carolin's view that there are four main lines of development from an ancestral type rather than Krause's six lines leading from *Goodenia.* They are also in agreement with the way in which he places *Dampiera* in an almost completely separate line of development rather than, like Krause, deriving it from *Goodenia* through *Seaevola.*

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Tables

See pages following.

TABLE 1

Dimensions of the Pollen Grains of Victorian Species of the Family Goodeniaceae

Localities are in Victoria unless otherwise specified. Each set of three figures shows the mean (in bold type) and the range. All direct measurements are in μ. The terms used are explained at greater length in the text.

P = Length (polar diameter) of pollen grain; E = Width (equatorial diameter) of pollen grain; P/E = Length/width ratio of pollen grain; PM = Distance between the ends of adjacent colpi; PAI = Polar area index; WO = Width of ora; WPX = Width of the exine at the pole.

(A) = Acetolysed pollen grains; (C) = Acetolysed and chlorinated pollen grains.

Species		P	E	P/E	PM	PAI	WO	WPX
BRUNONIA								
B. australis Sm.								
(A)	Kingston	43–**50**–56	32–**39**–43	1·1–**1·3**–1·5	11–**13**–14	0·2–**0·3**–0·4	12–**16**–18	5·0–**5·1**–5·7
	L. Hindmarsh	45–**52**–56	32–**37**–44	1·1–**1·4**–1·6	12–**16**–21	0·2–**0·4**–0·5	13–**16**–18	6·3–**6·8**–7·7
	L. Austin, W.A.	36–**40**–45	30–**34**–36	1·0–**1·2**–1·4	10–**10**–12	0·2–**0·3**–0·4	12–**14**–18	5·0–**5·6**–6·4
	Perth, W.A.	41–**45**–49	32–**35**–39	1·1–**1·3**–1·5	8–**10**–11	0·2–**0·3**–0·3	11–**13**–16	5·0–**5·7**–6·4
(C)	L. Hindmarsh	50–**58**–67	32–**38**–44	1·3–**1·5**–1·7	13–**16**–21	0·3–**0·4**–0·5	12–**16**–18	6·3–**7·4**–8·9
	L. Austin, W.A.	39–**51**–62	30–**34**–37	1·1–**1·5**–1·8	7–**11**–13	0·2–**0·3**–0·4	12–**14**–18	6·3–**7·1**–7·7
	Perth, W.A.	44–**50**–56	32–**36**–41	1·1–**1·4**–1·6	8–**10**–12	0·2–**0·3**–0·3	11–**14**–16	5·0–**5·9**–6·4
DAMPIERA								
D. lanceolata A. Cunn.								
(A)	L. Hattah	13–**16**–18	15–**18**–21	0·7–**0·9**–1·0	2– **3**– 6	0·1–**0·2**–0·3		1·0–**1·3**–1·8
(C)	L. Hattah	13–**17**–19	16–**18**–21	0·8–**1·0**–1·1	2– **3**– 6	0·1–**0·2**–0·3		1·0–**1·4**–1·8
D. marifolia Bth.								
(A)	Nhill	12–**14**–16	13–**16**–18	0·7–**0·9**–1·0	2– **3**– 4	0·1–**0·2**–0·3		1·0–**1·2**–1·6
(C)	Nhill	13–**15**–18	15–**16**–20	0·8–**0·9**–1·1	2– **3**– 4	0·1–**0·2**–0·3		1·0–**1·3**–1·6
D. purpurea R.Br.								
(A)	Snowy R.	15–**16**–18	17–**19**–21	0·8–**0·9**–1·0	3– **5**– 6	0·2–**0·3**–0·4		1·2–**1·4**–1·8
(C)	Snowy R.	16–**20**–23	17–**19**–23	0·8–**1·1**–1·2	3– **5**– 7	0·2–**0·3**–0·3		1·2–**1·8**–2·3
D. rosmarinifolia Schlech.								
(A)	Bendigo	15–**18**–21	15–**18**–23	0·8–**1·0**–1·3	2– **4**– 6	0·1–**0·2**–0·4		1·0–**1·3**–1·8
	L. Albacutya	16–**18**–20	15–**19**–21	0·8–**0·9**–1·1	2– **4**– 6	0·1–**0·2**–0·3		1·0–**1·3**–1·8
	Wimmera (4 colpi)	17–**20**–22	17–**21**–25	0·8–**1·0**–1·1	7– **9**–10	0·4–**0·5**–0·6		1·2–**1·5**–1·8
(C)	Bendigo	17–**20**–26	16–**18**–21	0·9–**1·1**–1·3	3– **4**– 6	0·2–**0·2**–0·3		1·0–**1·4**–1·8
	L. Albacutya	17–**19**–23	17–**19**–23	0·9–**1·0**–1·3	2– **4**– 6	0·1–**0·2**–0·3		1·2–**1·5**–1·8
	Wimmera (4 colpi)	19–**22**–26	17–**20**–23	1·0–**1·1**–1·3	7– **9**–11	0·3–**0·4**–0·5		1·2–**1·5**–1·8

DAMPIERA—continued							
D. stricta R.Br.							
(A) Tambo Crossing	15–18–21	17–20–23	0·7–0·9–1·0	3– 6– 7	0·2–0·3–0·4		1·0–1·3–1·6
Gembrook	13–15–21	13–17–21	0·8–0·9–1·0	3– 4– 6	0·2–0·2–0·3		1·0–1·2–1·6
(C) Gembrook	15–18–23	15–18–22	0·8–1·0–1·3	3– 4– 6	0·1–0·2–0·3		1·2–1·4–1·8
GOODENIA							
G. affinis De Vr.							
(A) Dimboola	27–31–36	24–26–31	1·0–1·2–1·4	6– 7– 9	0·2–0·3–0·4	10–12–14	2·2–2·5–2·8
(C) Dimboola	30–33–39	24–28–33	1·0–1·2–1·5	6– 8– 9	0·2–0·3–0·4	10–12–14	2·2–2·6–2·8
G. amplexans F.v.M.							
(A) Shire of Dimboola	25–29–33	24–26–28	1·0–1·1–1·3	5– 6– 8	0·1–0·2–0·3	10–12–14	2·2–2·5–2·8
(C) Shire of Dimboola	25–32–39	22–26–31	1·0–1·3–1·5	5– 6– 8	0·1–0·2–0·3	10–12–14	2·2–2·5–2·8
G. barbata R.Br.							
(A) E. Victoria	39–43–46	31–34–37	1·1–1·3–1·4	10–13–14	0·3–0·4–0·4	12–16–18	3·5–4·1–4·6
Mt Finlay, N.S.W.	38–40–45	30–33–39	1·0–1·2–1·4	8–10–14	0·2–0·3–0·4	15–17–18	3·0–4·1–4·6
(C) E. Victoria	43–48–54	30–33–37	1·3–1·5–1·6	10–13–16	0·2–0·3–0·4	12–16–18	3·8–4·4–4·9
Mt Finlay, N.S.W.	40–45–51	30–33–36	1·2–1·4–1·6	8–10–12	0·2–0·3–0·4	12–15–18	3·2–3·7–4·4
G. elongata Labill.							
(A) Wangaratta	34–38–45	30–33–39	0·9–1·1–1·3	7– 8– 9	0·2–0·2–0·3	15–16–18	2·5–2·8–3·1
(C) Wangaratta	36–41–49	27–31–36	1·0–1·3–1·5	7– 8– 9	0·1–0·2–0·3	12–17–19	2·5–3·1–3·3
G. geniculata R.Br.							
(A) Steiglitz	25–31–36	22–26–28	1·0–1·2–1·4	6– 8– 9	0·2–0·3–0·3	10–11–13	2·2–2·4–2·5
Melbourne	30–32–37	24–27–31	1·0–1·2–1·4	7– 8–10	0·2–0·3–0·4	10–13–14	2·2–2·6–2·8
(C) Melbourne	32–35–42	26–29–33	1·1–1·2–1·4	6– 9–11	0·2–0·3–0·4	12–14–16	2·5–2·7–3·1
G. glauca F.v.M.							
(A) Shire of Borung	27–31–36	22–25–30	1·0–1·2–1·4	6– 7– 8	0·2–0·3–0·4	10–11–13	2·5–2·7–2·8
(C) Shire of Borung	27–34–41	22–26–31	1·0–1·3–1·5	6– 7– 8	0·2–0·3–0·3	10–12–13	2·5–2·7–3·1
G. gracilis R.Br.							
(A) Shire of Dimboola	27–31–36	22–26–28	1·0–1·2–1·5	5– 7– 9	0·2–0·2–0·3	10–11–13	2·2–2·6–2·8
(C) Shire of Dimboola	30–34–37	25–27–32	1·0–1·3–1·4	6– 7– 8	0·2–0·2–0·3	10–11–13	2·2–2·6–2·8
G. grandiflora Sims							
(A) Melb. Botanic Gardens	32–36–44	29–34–39	0·8–1·1–1·4	7– 8–11	0·2–0·2–0·3	12–15–18	2·5–2·8–3·1
(C) Melb. Botanic Gardens	35–43–50	27–33–39	0·9–1·3–1·5	7– 9–11	0·2–0·3–0·3	13–16–18	2·5–3·1–3·9

TABLE 1 (*continued*)

Species		P	E	P/E	PM	PAI	WO	WPX
GOODENIA—continued								
G. hederacea Sm.								
(A)	Mt Nelse	24–**27**–31	22–**28**–32	0·8–**1·0**–1·2	5– **6**– 8	0·1–**0·2**–0·3	11–**13**–14	2·0–**2·4**–2·6
(C)	Mt Nelse	30–**34**–41	29–**32**–39	1·0–**1·1**–1·2	7– **8**–11	0·2–**0·3**–0·4	11–**13**–16	2·2–**2·8**–3·1
G. heteromera F.v.M.								
(A)	Minyip	24–**26**–28	22–**23**–26	1·0–**1·1**–1·3	6– **7**– 9	0·2–**0·3**–0·4	10–**12**–14	2·5–**2·8**–3·1
(C)	Minyip	26–**30**–35	20–**23**–26	1·1–**1·3**–1·5	6– **8**– 9	0·2–**0·3**–0·4	10–**12**–13	2·7–**3·2**–3·9
G. humilis R.Br.								
(A)	Grampians	26–**29**–33	21–**23**–26	1·0–**1·3**–1·5	5– **6**– 7	0·1–**0·2**–0·3	7–**10**–13	2·0–**2·4**–2·6
	Orbost	25–**27**–31	21–**24**–30	1·0–**1·1**–1·3	5– **6**– 8	0·2–**0·2**–0·3	10–**12**–14	2·2–**2·4**–2·6
	L. St Clair, Tas.	22–**25**–31	20–**23**–28	0·8–**1·1**–1·3	5– **6**– 8	0·1–**0·2**–0·4	10–**12**–13	2·2–**2·5**–2·8
(C)	Grampians	26–**30**–33	21–**24**–28	1·0–**1·3**–1·5	5– **6**– 7	0·1–**0·2**–0·3	8–**10**–12	2·2–**2·5**–2·6
	Orbost	27–**31**–36	21–**24**–28	1·1–**1·3**–1·7	5– **7**– 8	0·2–**0·3**–0·3	10–**11**–13	2·5–**2·6**–2·8
	L. St Clair, Tas.	25–**30**–37	21–**25**–31	1·0–**1·2**–1·5	5– **7**–11	0·2–**0·3**–0·5	10–**12**–14	2·5–**2·7**–3·1
G. lanata R.Br.								
(A)	Ballarat	40–**43**–49	29–**33**–37	1·2–**1·3**–1·5	7– **8**–11	0·2–**0·2**–0·3	15–**17**–21	2·5–**2·8**–3·3
	Lilydale	36–**41**–45	30–**33**–36	1·0–**1·2**–1·4	7–**10**–11	0·2–**0·3**–0·4	15–**17**–19	2·5–**2·6**–3·1
(C)	Ballarat	40–**48**–55	30–**33**–40	1·2–**1·4**–1·6	7– **9**–11	0·2–**0·3**–0·3	12–**16**–20	2·7–**3·1**–3·3
	Lilydale	39–**46**–51	29–**34**–39	1·1–**1·4**–1·5	7–**10**–11	0·2–**0·3**–0·4	15–**16**–18	2·5–**3·1**–4·1
G. lunata J. M. Black								
(A)	Shire of Borung	28–**32**–35	25–**28**–31	1·0–**1·1**–1·3	7– **9**–11	0·2–**0·3**–0·4	10–**13**–16	2·2–**2·5**–2·8
(C)	Shire of Borung	31–**35**–42	26–**30**–33	1·0–**1·2**–1·3	7– **9**–11	0·2–**0·3**–0·4	10–**13**–16	2·2–**2·6**–2·8
G. ovata Sm.								
(A)	Mt Dandenong	33–**38**–42	29–**34**–39	1·0–**1·1**–1·4	12–**14**–17	0·3–**0·4**–0·5	12–**15**–18	2·5–**2·6**–3·1
	Tidal R. (1)	30–**34**–39	27–**31**–33	1·0–**1·1**–1·3	7– **8**–11	0·2–**0·3**–0·4	12–**15**–18	3·0–**3·5**–3·9
	Tidal R. (2)	31–**35**–41	29–**32**–33	0·9–**1·1**–1·3	7– **8**–11	0·2–**0·3**–0·4	12–**15**–16	2·5–**3·3**–3·9
	Waterloo Bay	34–**38**–41	25–**29**–31	1·1–**1·3**–1·5	7– **8**–11	0·2–**0·3**–0·4	12–**14**–16	3·0–**3·9**–4·6
	Mt Oberon	27–**35**–39	25–**31**–36	0·9–**1·1**–1·4	7– **8**– 9	0·2–**0·2**–0·3	12–**14**–16	2·5–**2·9**–3·3
(C)	Mt Oberon	30–**40**–46	26–**32**–37	1·0–**1·3**–1·7	7– **8**–11	0·2–**0·2**–0·3	12–**14**–16	2·7–**3·4**–4·4
G. paniculata Sm.								
(A)	Bruthen	26–**29**–31	25–**29**–32	0·9–**1·0**–1·1	6– **7**– 8	0·2–**0·2**–0·3	11–**13**–14	2·2–**2·6**–3·1
(C)	Bruthen	34–**36**–41	25–**28**–32	1·1–**1·3**–1·5	7– **9**–11	0·2–**0·3**–0·4	11–**13**–16	2·5–**3·0**–3·3

GOODENIA—continued							
G. pinnatifida Schlech.							
(A) St Albans	26–29–32	25–29–31	0·9–1·0–1·1	5– 7– 8	0·1–0·2–0·3	10–13–16	2·5–2·9–3·3
Lower Lockton	27–30–32	22–24–27	1·0–1·2–1·4	6– 7– 8	0·1–0·3–0·3	10–12–16	2·5–2·7–2·8
(C) Lower Lockton	27–30–35	22–25–28	1·0–1·2–1·3	5– 7– 8	0·2–0·3–0·4	10–13–16	2·5–2·8–3·1
G. pusilliflora F.v.M.							
(A) Nhill	30–34–39	24–29–31	1·0–1·2–1·4	8–10–11	0·2–0·3–0·4	10–11–12	2·5–3·0–3·6
Dimboola district	29–32–35	24–26–28	1·0–1·2–1·4	8– 9–11	0·2–0·3–0·4	6– 8–11	2·2–2·4–2·6
Mildura	27–30–33	25–27–30	0·9–1·1–1·2	7–10–13	0·2–0·4–0·5	7–10–12	2·2–2·3–2·6
(C) Dimboola district	30–32–39	25–27–31	1·0–1·2–1·3	7– 9–12	0·2–0·3–0·5	6– 8– 9	2·2–2·4–2·6
Mildura	30–33–36	24–28–31	1·0–1·2–1·4	7– 9–11	0·2–0·3–0·4	9–10–12	2·2–2·5–2·8
Shire of Borung	32–36–40	26–29–32	1·1–1·3–1·4	7– 9–11	0·2–0·3–0·4	10–11–12	2·2–2·7–3·1
G. robusta Krause							
(A) Wimmera	30–33–36	25–28–31	1·0–1·2–1·4	7– 9–11	0·2–0·3–0·4	10–12–14	2·5–2·7–3·1
(C) Wimmera	32–36–41	26–30–35	1·0–1·2–1·4	8–10–11	0·2–0·3–0·4	10–13–16	2·5–2·8–3·1
G. stelligera R.Br.							
(A) Cann R.	35–37–41	29–33–36	0·9–1·1–1·4	10–12–16	0·3–0·4–0·5	17–19–21	2·5–2·8–3·1
Hastings R., N.S.W.	32–36–41	27–32–36	0·9–1·1–1·3	8– 9–11	0·2–0·3–0·4	13–16–18	2·7–3·3–3·6
(C) Cann R.	35–42–46	29–32–36	1·1–1·3–1·5	10–12–14	0·3–0·4–0·4	15–17–20	2·7–2·9–3·3
Hastings R., N.S.W.	41–45–46	30–32–35	1·3–1·4–1·5	8– 9–11	0·2–0·3–0·3	11–15–18	3·2–3·5–3·9
G. subintegra F.v.M.							
(A) Mildura	32–36–40	25–27–28	1·1–1·3–1·5	8– 9–11	0·2–0·3–0·4	13–17–18	2·7–3·0–3·3
Booroorban, N.S.W.	30–34–37	25–29–33	0·9–1·2–1·4	6– 8–12	0·1–0·3–0·4	12–14–18	2·7–3·2–3·9
(C) Mildura	32–36–42	25–29–33	1·1–1·2–1·4	8–10–12	0·2–0·4–0·5	15–17–18	2·7–3·2–3·6
Booroorban, N.S.W.	32–35–41	26–30–35	1·0–1·2–1·4	6– 8–11	0·2–0·3–0·4	11–13–17	2·7–3·2–3·9
G. varia R.Br.							
(A) Wedderburn district	32–36–40	29–31–35	1·0–1·2–1·3	7– 9–11	0·2–0·3–0·4	11–13–17	2·7–3·2–3·9
(C) Wedderburn district	34–38–46	27–32–36	1·0–1·2–1·4	7– 8– 9	0·2–0·2–0·3	11–13–16	2·7–3·3–3·9
SCAEVOLA							
S. aemula R.Br.							
(A) Wimmera	45–49–54	32–35–39	1·2–1·4–1·7	10–12–13	0·2–0·3–0·4	15–16–18	5·0–5·2–5·9
(C) Wimmera	48–58–69	30–34–44	1·4–1·7–2·1	10–11–13	0·2–0·3–0·4	12–16–18	5·0–5·9–7·1
S. calendulacea Druce							
(A) Port Fairy	48–52–59	32–37–41	1·2–1·4–1·6	7–10–13	0·1–0·2–0·3	13–16–18	3·2–4·3–5·1
(C) Port Fairy	48–57–66	32–38–45	1·4–1·5–1·7	5–10–12	0·1–0·2–0·3	12–14–16	3·8–4·6–5·1

TABLE 1 (*continued*)

Species		P	E	P/E	PM	PAI	WO	WPX
SCAEVOLA—continued								
S. depauperata R.Br.								
(A)	Mildura	45–**50**–54	40–**47**–51	0·9–**1·1**–1·3	7–**11**–14	0·1–**0·2**–0·4	17–**21**–23	4·0–**4·7**–5·1
(C)	Mildura	55–**61**–71	38–**42**–47	1·2–**1·5**–1·6	10–**11**–13	0·2–**0·2**–0·3	15–**18**–21	5·0–**5·6**–6·4
S. hookeri F.v.M.								
(A)	Marlo	31–**35**–39	25–**28**–30	1·1–**1·3**–1·5	7– **8**–10	0·2–**0·3**–0·4	10–**11**–13	2·5–**2·9**–3·1
	Mt Nelse	33–**35**–38	30–**32**–33	1·0–**1·1**–1·3	7–**10**–11	0·2–**0·3**–0·4	12–**14**–16	3·0–**3·8**–4·6
(C)	Marlo	38–**41**–45	25–**29**–33	1·3–**1·4**–1·6	7– **9**–11	0·2–**0·3**–0·4	10–**12**–16	3·0–**3·2**–3·6
	Mt Nelse	40–**47**–54	27–**33**–38	1·2–**1·4**–1·6	7–**11**–13	0·2–**0·3**–0·4	11–**14**–17	4·5–**4·9**–5·1
S. microcarpa Cav.								
(A)	Portland	32–**34**–36	27–**30**–33	1·0–**1·1**–1·3	7– **8**– 9	0·2–**0·2**–0·3	12–**13**–16	2·5–**2·8**–3·6
	Airey's Inlet	26–**29**–33	24–**26**–28	1·0–**1·1**–1·3	6– **7**– 8	0·2–**0·3**–0·3	10–**12**–14	2·2–**2·6**–2·8
(C)	Airey's Inlet	30–**34**–40	22–**26**–30	1·0–**1·3**–1·5	6– **7**– 8	0·2–**0·3**–0·3	11–**13**–16	2·5–**2·9**–3·1
S. pallida R.Br.								
(A)	Portland	27–**29**–31	22–**25**–27	1·1–**1·2**–1·4	5– **7**– 8	0·2–**0·3**–0·4	10–**12**–13	2·5–**2·8**–3·0
	S. Victoria	27–**30**–36	25–**27**–29	1·0–**1·1**–1·3	5– **7**– 8	0·2–**0·3**–0·3	10–**12**–13	2·5–**2·9**–3·3
(C)	S. Victoria	30–**34**–44	25–**27**–32	1·0–**1·3**–1·5	6– **8**– 9	0·2–**0·3**–0·4	10–**12**–13	2·5–**2·8**–3·3
S. ramosissima (Sm.) Kraus.								
(A)	Mt Drummer	42–**45**–49	30–**36**–41	1·1–**1·2**–1·5	7–**12**–14	0·2–**0·3**–0·4	17–**20**–23	4·5–**5·0**–5·4
	Orbost	45–**48**–52	31–**36**–40	1·1–**1·3**–1·6	10–**11**–13	0·2–**0·3**–0·4	15–**17**–21	4·5–**4·8**–5·1
(C)	Mt Drummer	50–**53**–61	30–**34**–42	1·3–**1·6**–1·8	7– **9**–11	0·1–**0·2**–0·4	15–**17**–21	5·0–**5·2**–5·9
	Orbost	48–**53**–61	32–**36**–45	1·2–**1·5**–1·7	10–**12**–13	0·2–**0·3**–0·4	12–**15**–18	4·0–**4·5**–5·1
S. spinescens R.Br.								
(A)	Mildura	32–**37**–44	26–**29**–32	1·1–**1·3**–1·5	7– **9**–11	0·2–**0·3**–0·4	12–**14**–16	3·5–**4·1**–4·6
	Mt Squires, W.A.	38–**42**–47	30–**32**–36	1·2–**1·3**–1·5	10–**12**–13	0·3–**0·4**–0·5	12–**16**–20	3·2–**3·9**–4·6
(C)	Mildura	36–**40**–47	27–**29**–33	1·2–**1·4**–1·5	7– **9**–11	0·2–**0·3**–0·4	11–**13**–16	4·3–**4·6**–4·9
	Mt Squires, W.A.	40–**48**–55	30–**32**–37	1·3–**1·5**–1·7	11–**12**–14	0·3–**0·4**–0·4	11–**14**–17	3·2–**4·2**–4·9
SELLIERA								
S. radicans Cav.								
(A)	Frankston	32–**36**–39	27–**30**–33	1·0–**1·2**–1·5	7– **9**–11	0·2–**0·3**–0·4	10–**12**–16	2·5–**2·8**–3·1
	Wimmera R.	31–**37**–42	24–**27**–31	1·2–**1·4**–1·5	6– **8**–11	0·2–**0·3**–0·3	10–**13**–16	2·5–**3·2**–3·9
(C)	Frankston	32–**42**–46	27–**30**–35	1·0–**1·4**–1·7	7– **9**–11	0·2–**0·3**–0·4	10–**12**–14	2·5–**3·0**–3·3
	Wimmera R.	32–**39**–46	25–**28**–33	1·3–**1·4**–1·5	7– **9**–11	0·2–**0·3**–0·4	10–**13**–16	2·7–**3·5**–3·9

VELLEIA							
V. connata F.v.M.							
(A) Kattyoong	27–**32**–35	25–**28**–31	1·0–**1·1**–1·3	7– **8**– 9	0·2–**0·3**–0·4	9–**10**–12	3·0–**3·6**–4·1
Hamilton Downs, N.T.	27–**28**–31	29–**31**–33	0·8–**0·9**–1·0	7– **8**– 8	0·2–**0·3**–0·3	11–**13**–14	3·0–**3·4**–3·9
(C) Kattyoong	32–**35**–41	25–**28**–33	1·0–**1·3**–1·4	7– **8**–11	0·2–**0·3**–0·4	10–**12**–14	3·5–**4·0**–4·6
Hamilton Downs, N.T.	31–**34**–40	30–**33**–39	0·9–**1·1**–1·3	7– **8**– 9	0·2–**0·2**–0·3	11–**14**–16	3·2–**3·9**–4·6
V. montana Hk.f.							
(A) Bogong High Plains	24–**27**–32	22–**26**–30	0·9–**1·0**–1·2	5– **7**–11	0·2–**0·3**–0·4	10–**11**–13	2·2–**2·5**–2·8
Snowy R.	25–**27**–31	22–**26**–28	0·9–**1·0**–1·2	7– **8**– 9	0·2–**0·3**–0·4	10–**13**–14	2·2–**2·6**–3·1
(C) Bogong High Plains	25–**29**–39	24–**26**–30	1·0–**1·1**–1·3	5– **7**–11	0·1–**0·3**–0·4	10–**11**–13	2·2–**2·6**–2·8
Snowy R.	27–**32**–41	25–**27**–31	1·0–**1·2**–1·3	7– **9**–11	0·2–**0·3**–0·4	10–**13**–16	2·5–**2·8**–3·1
V. paradoxa R.Br.							
(A) St Albans	30–**34**–41	27–**32**–36	0·9–**1·1**–1·4	7– **8**–11	0·2–**0·3**–0·4	15–**16**–18	2·5–**2·8**–3·1
Donald	35–**40**–44	29–**32**–36	1·0–**1·2**–1·5	6– **8**–11	0·1–**0·2**–0·3	11–**13**–16	2·7–**2·9**–3·3
(C) Donald	39–**44**–51	30–**33**–39	1·0–**1·3**–1·5	7– **8**– 9	0·2–**0·2**–0·3	10–**13**–16	2·5–**2·9**–3·1

TABLE 2

Certain details of the Shape, Apertures and Exine of Victorian Species of the Family Goodeniaceae

The terms used are explained at greater length in the text. Eq. Bul. = Bulges at the equator when seen in front or back view; Pol. > Eq. = Pattern coarser at the poles than at the equator.

\+ = present or positive; × = developed to a slight extent; − = absent or negative.

Shape in polar view (shapes are approximate): C = circular; H = hexagonal; L = slightly lobed; R = rectangular; S = square; T = triangular.

Grades of pattern (these are placed in order in the table, so that the most common grade is first): VF = very fine; F = fine; F/M = fine/medium; M = medium; M/C = medium/coarse; C = coarse; VC = very coarse.

Species	Shape		Colpi		Sexine			Pattern			
	Polar View	Eq. Bul.	Number	Parasyncolpate	Thickened: At Poles	Thickened: Below Poles	Thickened: Polar Cap	Grade at Poles	Pol. > Eq.	Grade at Equator	Outer Pattern visible
BRUNONIA											
B. australis											
Kingston	T,L	−	3	−	+	−	+ −	F,F/M	+ −	F	+
L. Hindmarsh	T	−	2,3,>3	−	+	− ×	+ −	C,VC,M/C	+	M,F/M	−
L. Austin, W.A.	C,T	−	3	−	+	−	+ −	M/C,M	+	F	−
Perth, W.A.	T,C	−	3	−	+	−	+ −	M/C,M	+	F/M	−
DAMPIERA											
D. lanceolata											
L. Hattah	C,T	−	3,>3	− +	−	−	−	VF	−	VF	−
D. marifolia											
Nhill	T,C	−	3	−	−	−	−	VF	−	VF	−
D. purpurea											
Snowy R.	T,C	−	2,3	−	−	−	−	VF	−	VF	−
D. rosmarinifolia											
Bendigo	T,C,L	−	2,3	−	−	−	−	VF	−	VF	−
L. Albacutya	T	−	3,>3	− +	−	−	−	VF	−	VF	−
Wimmera (4 colpi)	R,S	−	3,>3	− +	−	−	−	VF	−	VF	−
D. stricta											
Tambo Crossing	T	−	3,>3	−	−	−	−	VF	−	VF	−
Gembrook	T,C	−	3,>3	− +	−	−	−	VF	−	VF	−
GOODENIA											
G. affinis											
Dimboola	H	− ×	3	− +	− ×	− ×	−	F/M,F	+ −	F	+
G. amplexans											
Shire of Dimboola	H	− ×	2,3	−	− ×	× +	−	F/M,F,M	+ −	F	+ −
G. barbata											
E. Victoria	H,C	−	3	− +	+	− ×	−	M/C,C	+	F/M,M	+ −
Mt Finlay, N.S.W.	H,C	−	2,3,>3	− +	+ ×	− ×	−	M/C,M	+ −	F/M	+ −
G. elongata											
Wangaratta	H	− ×	2,3,>3	− +	× +	× −	−	M/C,C	+	F	−
G. geniculata											
Steiglitz	H,L	−	3	−	×	×	−	M/C,C	+	F/M	−
Melbourne	H,C	−	3,>3	− +	− +	× −	−	F/M,M,M/C	+	F,F/M	+ −
G. glauca											
Shire of Borung	H,L,C	−	2,3,>3	− +	+	× +	−	C,M/C	+	F	+ −
G. gracilis											
Shire of Dimboola	H,C	− ×	2,3	− +	+ −	+ ×	− +	F/M,M,M/C	+	F	+ −
G. grandiflora											
Melbourne Botanic Gardens	H,C	− ×	3	− +	× −	− ×	−	F/M,M	+ −	F/M,M	+ −
G. hederacea											
Mt Nelse	H,L,C	− ×	2,3,>3	− +	× −	− +	−	M,F/M	+ −	F/M,F,M	+ −
G. heteromera											
Minyip	H	− ×	3	− +	+	− +	−	M/C,C	+	F	−
G. humilis											
Grampians	H	− ×	3,>3	− +	+ −	× −	−	F/M,M	+	F	+ −
Orbost	H	−	3,>3	−	+ −	× −	−	M,F/M	+	F/M,F	−
L. St Clair, Tas.	H	−	2,3,>3	−	+ −	× −	−	M,M/C,F/M	+	F	−
G. lanata											
Ballarat	H,C	−	2,3,>3	− +	×	+ ×	−	M,F/M	+	F/M,F,M	+ −
Lilydale	H,C	−	2,3,>3	− +	− +	+ −	−	M,F/M	+ −	F/M,F	+ −

TABLE 2 (*continued*)

Species	Shape		Colpi		Sexine			Pattern			
					Thickened						
	Polar view	Eq. Bul.	Number	Parasyncolpate	At Poles	Below Poles	Polar Cap	Grade at Poles	Pol. >Eq.	Grade at Equator	Outer Pattern visible
GOODENIA—continued											
G. lunata											
Shire of Borung	H,L	−	3,>3	−+	×−	−	−×	M/C,C,M	+	F	−
G. ovata											
Mt Dandenong	H	−	3	−	×−	−×	−	M/C,C	+	F/M	−
Tidal R. (1)	H	−	2,3	−	+×	×−	−	M/C	+	F/M,F	−
Tidal R. (2)	H	−	2,3	−	+×	×−	−	M/C,C,M	+	F/M,F	−
Waterloo Bay	H	−	3	−	+	×	−	C,M/C	+	F/M,F	−+
Mt Oberon	H	−	3	−	+−	×+	−	M/C,C,M	+	M,F/M,M/C	−
G. paniculata											
Bruthen	H	−	3	−	+−	×	−+	M/C,M,C	+	F	−+
G. pinnatifida											
St Albans	H	−	3	−	+×	+×	−+	M,M/C	+	F	+
Lower Lockton	H	−	3	−+	+	×−	−+	M,M/C	+	F	−
G. pusilliflora											
Nhill	C	−	3	−	+×	−	−	M,F/M	−	F/M	−
Dimboola district	C,L	−	3,>3	−+	−×	−	−	M,F/M	+−	F,F/M	−
Mildura	C,L	−	3,>3	−	−	×−	−	F,F/M	−	F/M,F	−+
Shire of Borung	C,L	−	3	−+	−+	×	−	F/M,M	+−	M	−
G. robusta											
Wimmera	H	−×	3	−+	×+	×−	−	C,M/C	+	F/M,M	+−
G. stelligera											
Cann R.	H	−	3	−+	+×	−×	−	M/C,M,C	+	F/M,F	−
Hastings R., N.S.W.	H,C	−×	3,>3	−+	+×	−×	−	M/C,C	+	F/M,F	+−
G. subintegra											
Mildura	H	−×	3,>3	−	+	×−	−	M/C	+	F	−
Booroorban, N.S.W.	H,L	−×	2,3,>3	−	+	+−	−	M/C,C	+	F	−
G. varia											
Wedderburn district	H	−	3,>3	−	+	−×	−	M	+	F/M	−
SCAEVOLA											
S. aemula											
Wimmera	H,C,L	+	3,>3	−	+	+	−	C,VC	+	F/M,M	−
S. calendulacea											
Port Fairy	H,C,L	−	2,3	−+	+	−×	−	M/C,C,M	+−	M,M/C	+−
S. depauperata											
Mildura	H,C,	−×	3,>3	−+	+	+	−+	M/C	+	F/M	−
S. hookeri											
Marlo	H,C	−×	3	−	+	−×	−	M,M/C	+	F/M,M	−
Mt Nelse	H,C	−	3,>3	−+	+	−×	−	M,M/C	+	F/M,M	−
S. microcarpa											
Portland	H,C	×	3	−	+	×	−	M/C,C	+	F	−
Airey's Inlet	H,C	−+	3,>3	−+	+	+	−	M/C,M	+	F,F/M	+−
S. pallida											
Portland	H,C	+	3	−	+	×	−	C,M/C	+	F/M,F	+
S. Victoria	H,C	×−	2,3	−	×+	+	−+	C,M/C	+−	F/M,M	−
S. ramosissima											
Mt Drummer	H	+	3	−	+	+	−+	C	+	F	+−
Orbost	H,C	+	3	−+	+	+	−	C,VC,M/C	+	M,F/M	−
S. spinescens											
Mildura	H,C	−×	2,3	−+	+	−+	−	C,M/C	+	F/M,F	−
Mt Squires, W.A.	H,L	−×	2,3,>3	−	+	−×	−	M,M/C	+	F/M	−
SELLIERA											
S. radicans											
Frankston	H	−	3,>3	−+	+×	−×	−	M,M/C,F/M	+−	M,F/M	+
Wimmera R.	H,C	−	3,>3	−+	+×	−×	−	C,VC	+	M/C,M,C,F/M	+−
VELLEIA											
V. connata											
Kattyoong	H	−	3,>3	−	+	×	−	C	+	F	−
Hamilton Downs, N.T.	H	−×	3,>3	−	+	−×	−	C,M/C	+	F/M	−
V. montana											
Bogong High Plains	H,C	−	2,3,>3	−	−×	×−	−	F/M,M	+−	F/M,F	−+
Snowy R.	H	−	2,3,>3	−	×	−×	−	M,M/C,F/M	+−	F/M,F	−
V. paradoxa											
St Albans	H,C	−	3,>3	−	×	−	−	M,M/C	+	F,F/M	+−
Donald	H	−	3,>3	−+	+×	−×	−	F/M,M	+	F	+−

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Explanation of Plates

All photographs, except the one shown in Pl. XVII, fig. 14, are magnified by approximately 650. The illustrations represent pollen grains which have been acetolysed and ehlorinated unless they are specifically stated to have been acetolysed only. Where two or more photographs represent the same pollen grain, the successive figures show the grain at a progressively higher focus.

PLATE XIII

Fig. 1-16—*Brunonia australis.*
- Fig. 1, 2—Lake Hindmarsh. Polar view. Acetolysed only.
- Fig. 3, 4—Kingston. Polar view. Aeetolysed only.
- Fig. 5, 6—Lake Austin, W.A. Polar view. Acetolysed only.
- Fig. 7—Kingston. Front view. Aeetolysed only.
- Fig. 8, 11, 12—Kingston. Baek view. Acetolysed only.
- Fig. 9, 10—Lake Hindmarsh. Back view.
- Fig. 13—Lake Hindmarsh. Side view.
- Fig. 14-16—Lake Hindmarsh. Front view.

Fig. 17—*Goodenia lunata,* Shire of Borung. Equatorial view of grain with four eolpi.
Fig. 18,19—*Goodenia robusta,* Wimmera. Polar view. Acetolysed only.
Fig. 20, 21—*Goodenia amplexans,* Dimboola. Polar view.

PLATE XIV

Fig. 1-9—*Dampiera stricta,* Gembrook.
- Fig. 1, 2—Front view.
- Fig. 3, 4—Polar view.
- Fig. 5, 6—Side view.
- Fig. 7-9—Back view.

Fig. 10—*Dampiera rosmarinifolia,* Wimmera. Polar view of grain with four eolpi.
Fig. 11, 12—*Dampiera purpurea,* Snowy R. Polar view.
Fig. 13-20—*Goodenia barbata,* E. Victoria.
- Fig. 13-15—Baek view.
- Fig. 16—Back view.
- Fig. 17, 18—Front view.
- Fig. 19—Side view.
- Fig. 20—Back view.
- Fig. 21, 22—Polar view.

Fig. 23, 24—*Goodenia paniculata,* Bruthen. Baek view.
Fig. 25, 26—*Goodenia gracilis,* Shire of Dimboola. Polar view.
Fig. 27, 28—*Goodenia gracilis,* Shire of Dimboola. Polar view.

PLATE XV

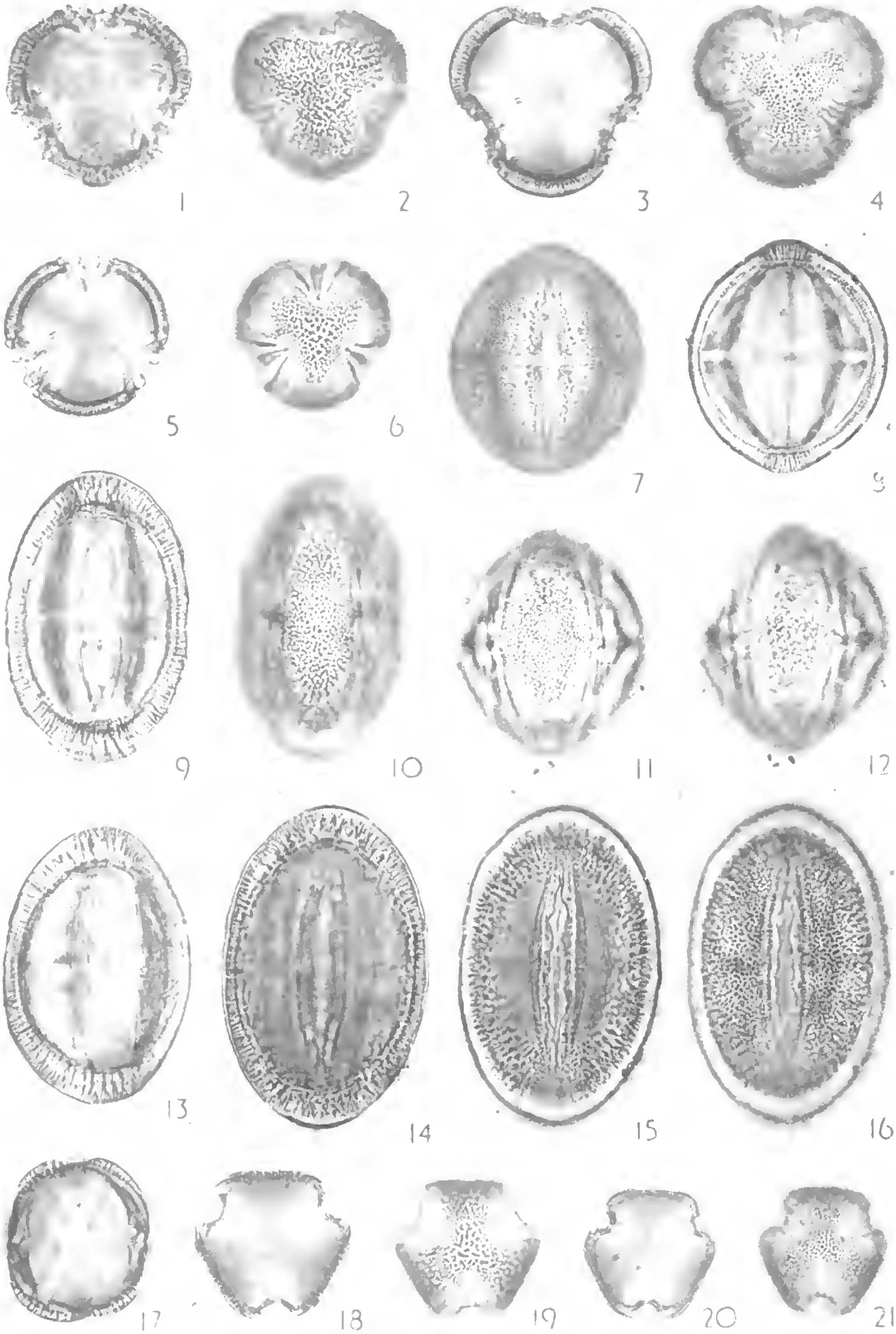
Fig. 1-8—*Goodenia heteromera,* Minyip.
Fig. 1, 6—Back view.
Fig. 2, 3—Polar view.
Fig. 4, 5—Front view.
Fig. 7, 8—Side view.
Fig. 9-19—*Scaevola pallida,* S. Victoria.
Fig. 9, 10—Equatorial view of grain with two colpi.
Fig. 11, 12—Side view.
Fig. 13—Side view.
Fig. 14, 15—Front view.
Fig. 16, 17—Back view.
Fig. 18, 19—Polar view.
Fig. 20—*Goodenia pinnatifida,* St. Albans. Side view. Acetolysed only.
Fig. 21, 22—*Velleia montana,* Bogong High Plains. Polar view. Acetolysed only.
Fig. 23-25—*Goodenia ovata,* Tidal R. Polar view. Acetolysed only.
Fig. 26, 27—*Velleia connata,* Kattyoong. Polar view.
Fig. 28, 29—*Goodenia pusilliflora,* Dimboola. Polar view.
Fig. 30—*Velleia montana,* Bogong High Plains. Side view. Acetolysed only.

PLATE XVI

Fig. 1-8, 10-12—*Scaevola ramosissima.*
Fig. 1, 2—Orbost. Front view.
Fig. 3—Mt Drummer. Side view.
Fig. 4—Orbost. Side view.
Fig. 5, 6—Orbost. Back view.
Fig. 7, 8, 12—Mt Drummer. Back view. Acetolysed only.
Fig. 10, 11—Orbost. Polar view.
Fig. 9, 13-22—*Selliera radicans,* Wimmera R.
Fig. 9, 13, 14—Polar view.
Fig. 15, 16—Back view.
Fig. 17, 21, 22—Side view.
Fig. 18-20—Front view.

PLATE XVII

Fig. 1-10—*Velleia paradoxa,* Donald.
Fig. 1-3—Front view.
Fig. 4, 8—Back view.
Fig. 5-7—Side view.
Fig. 9, 10—Polar view.
Fig. 11—*Goodenia subintegra,* Mildura. Equatorial view of grain with four colpi.
Fig. 12—*Goodenia subintegra,* Mildura. Back view.
Fig. 13—*Scaevola calendulacea,* Port Fairy. Side view.
Fig. 14—*Goodenia ovata,* Waterloo Bay. Part of section, more or less longitudinal. Acetolysed only. x *c.* 1300.
Fig. 15, 16—*Scaevola aemula,* Wimmera. Polar view.
Fig. 17—*Velleia connata,* Kattyoong. Side view.
Fig. 18—*Goodenia lanata,* Ballarat. Polar view.
Fig. 19, 20—*Goodenia elongata,* Wangaratta. Back view.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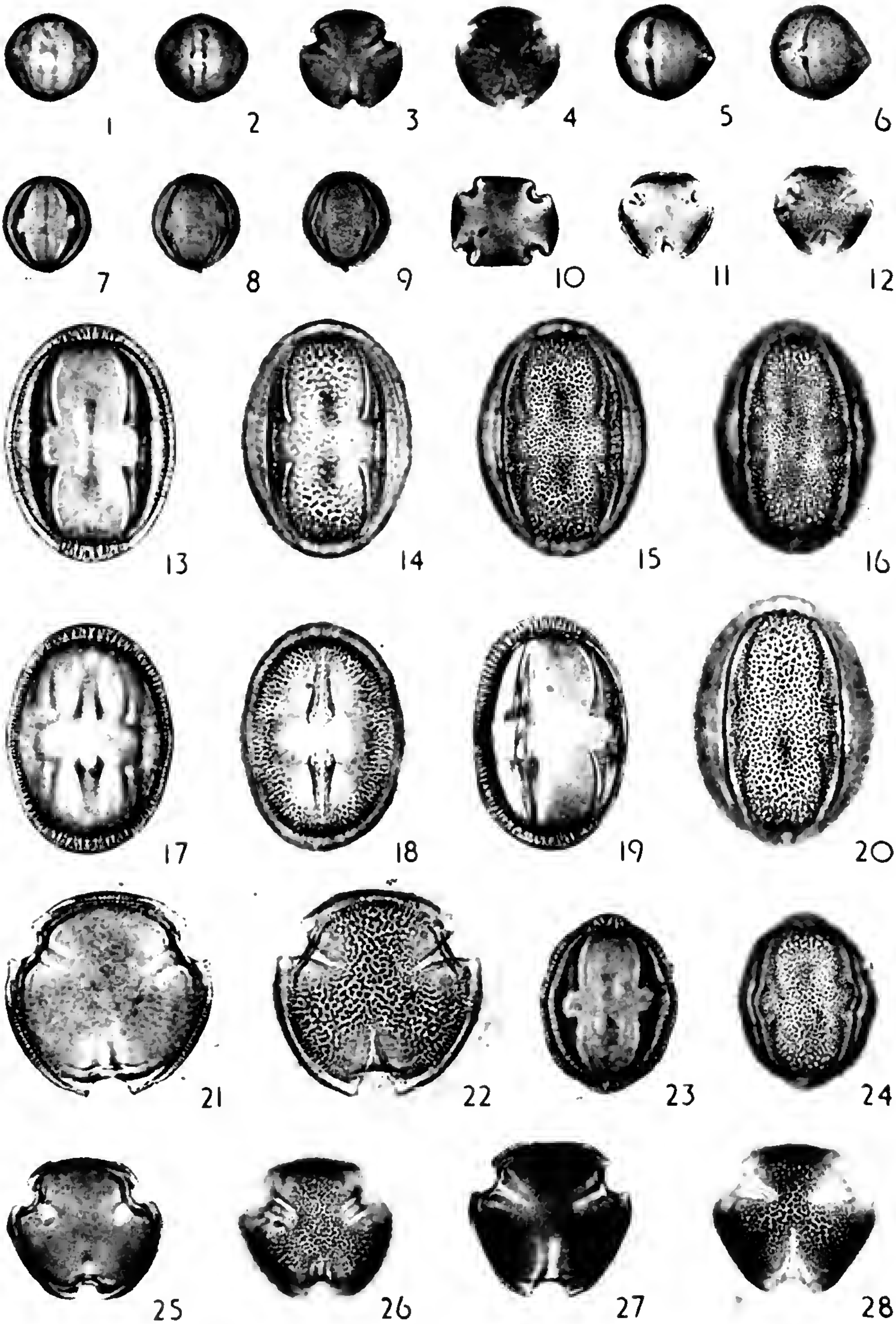
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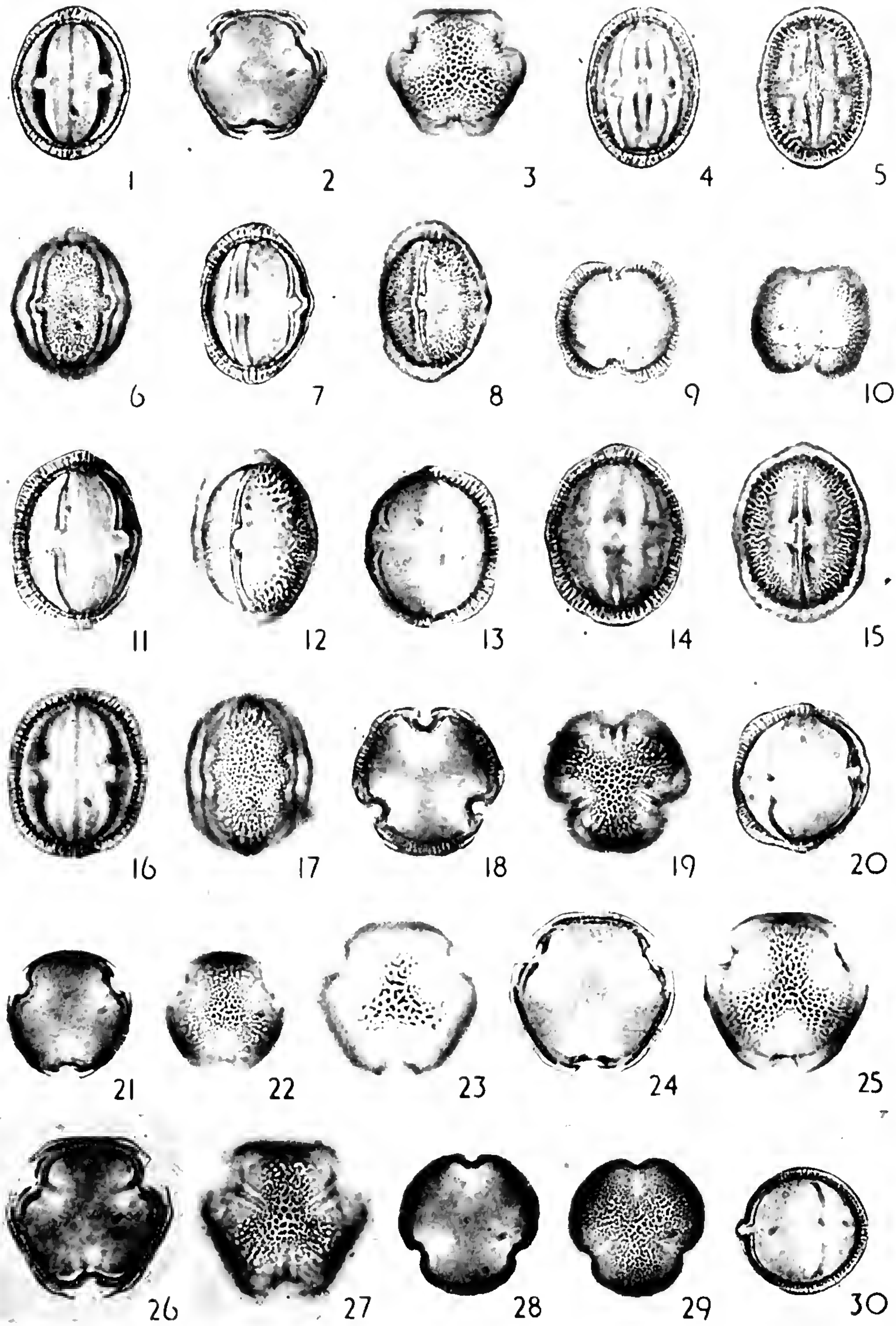
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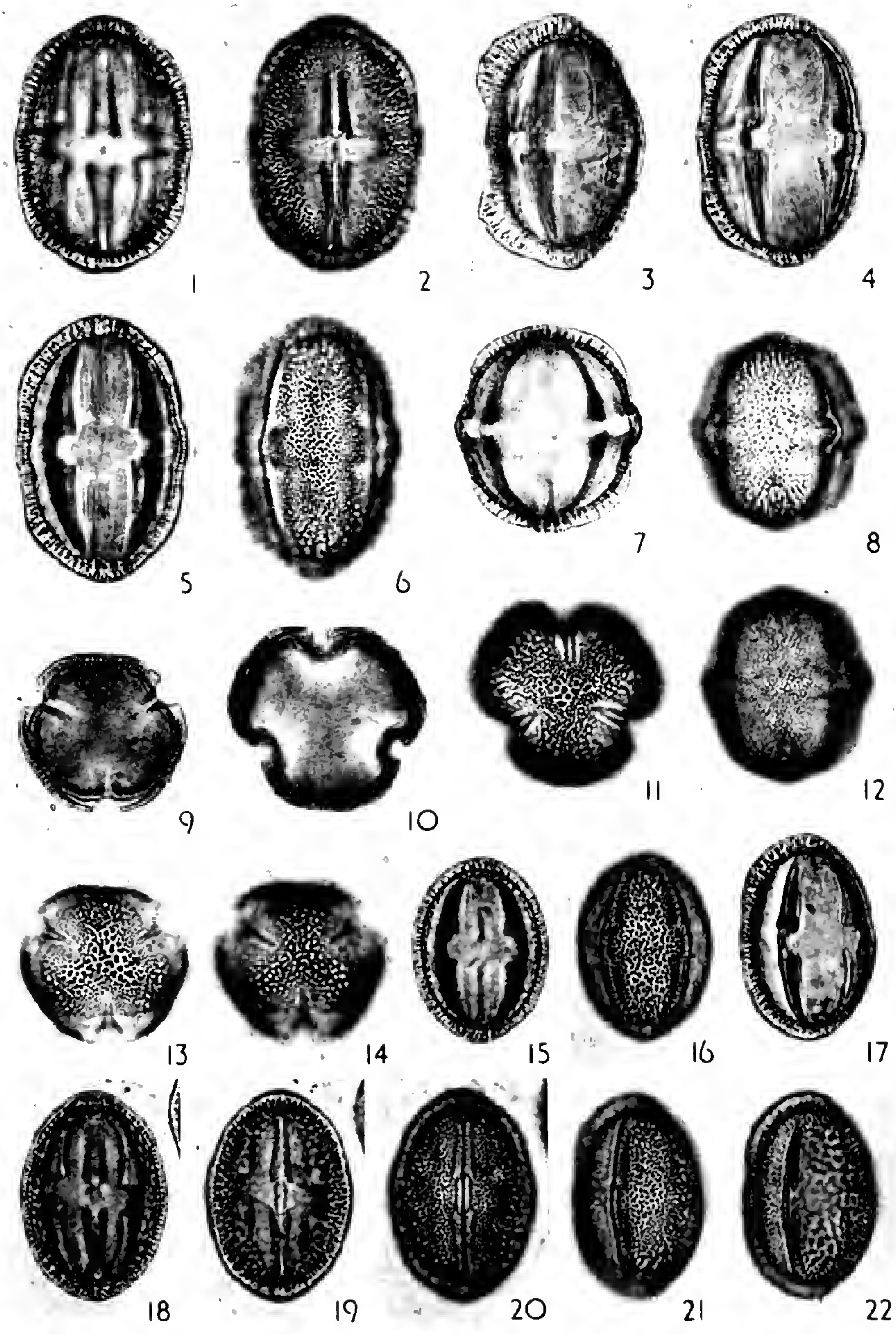
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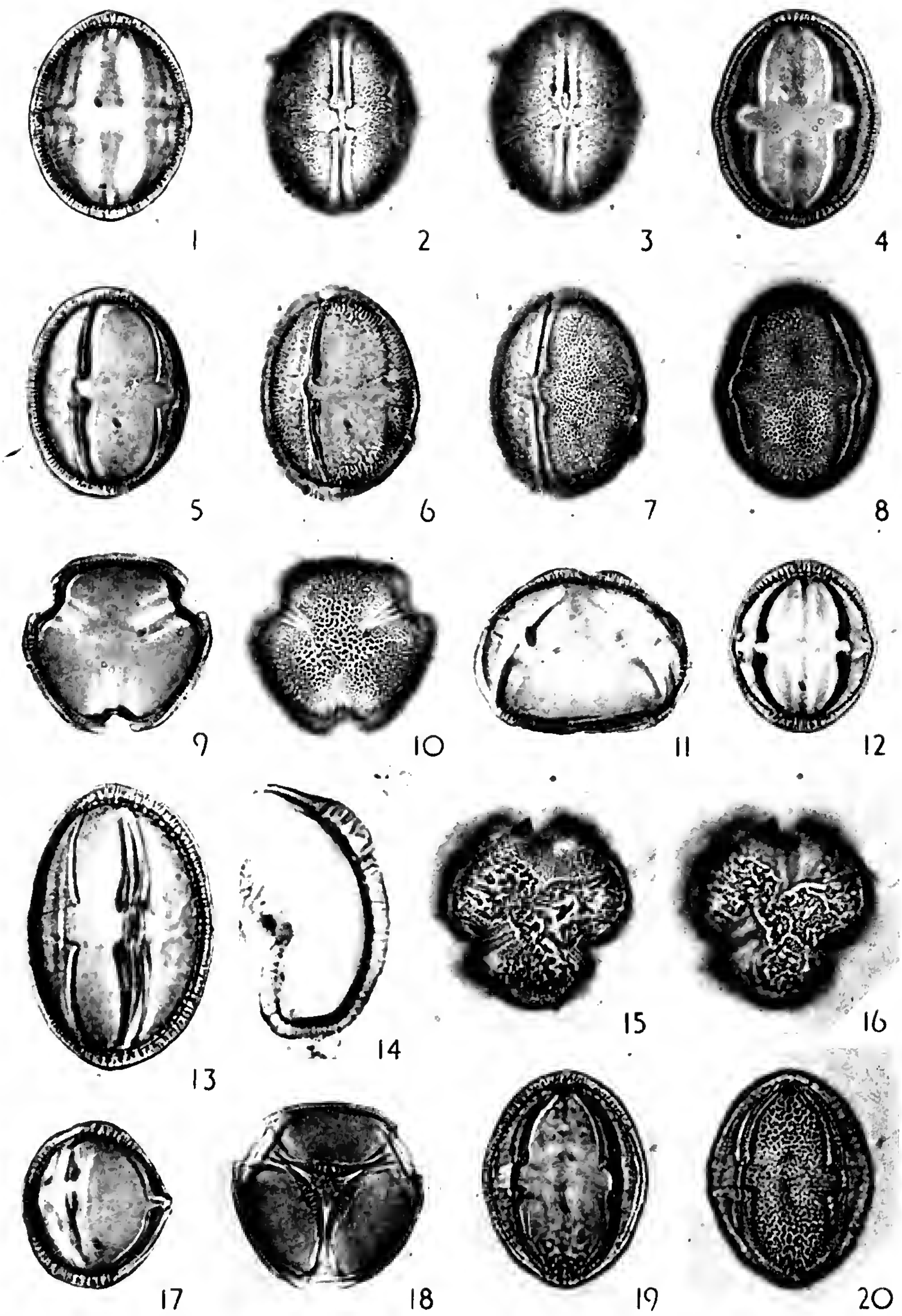
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AUSTRALIAN TUBERALES

By E. I. McLennan

[Read 8 December 1960]

Abstract

An account is given of the Australian representatives of the Tuberales. It includes nine genera with a key to their identification. A new genus *Elderia* has been erected to accommodate a fungus found in the desert of central Western Australia. Two genera occur in Victoria—*Hydnotrya* and *Mukagomyces*. The presence of this latter genus in southern Australia markedly extends its geographic range as previously it has been found only in one province in Japan.

Introduction

The first record of the so-called 'truffle fungi' (Tuberales) in Australia was made by Cooke and Massee (1892). The specimens on which this record was based were collected by members of the Elder expedition (1892-1896) from sandy soil in South Australia and were named *Stephensia arenivaga* Cooke and Massee. In the next year Bresadalo (1893) named some Tasmanian fungi, which had been sent to him for examination, *Genea pazschkei*. McAlpine and Rodway (1896), in a paper dealing with Australian fungi, included a description of a Tasmanian member of the Tuberales under the name *Hydnocystis convoluta* McAlp. Rodway (1897) made the next contribution to this flora when he named specimens of a Tasmanian subterranean fungus *Stephensia varia*. Massee (1898) working with Tasmanian material established *Hydnocystis cyclospora* as present in that State when he elevated *Berggrenia aurantiaca* var. *cyclospora* Cooke to specific rank. In the same year Massee (1898) gave the name *Genabea tasmanica* to some material collected by Rodway in Tasmania. Massee's herbarium is now housed at the New York Botanic Gardens. According to Gilkey (1954), the specimen bearing this epithet, shows no asci nor ascospores of the 'host' fungus, but does bear spores of a parasite which were identified by Dr W. W. Diehl of the Bureau of Plant Industry as *Melanospora zobelli* (Corda) Fckl. Similar spores were wrongly ascribed by Massee and Rodway to the 'host' fungus, so the name *Genabea tasmanica*, as Gilkey remarks, must be regarded as a 'nominum confusum'. In 1925, Rodway described *Terfezia tasmanica* from Tasmanian material in his collection.

Then followed a long interval before any further records were made for Australia. Gilkey (1954) established a new genus *Hydnoplicata* with the type species *Hydnoplicata whitei* on material from Pennant Hills, N.S.W. sent to her by Dr N. H. White of Sydney. These specimens were obtained in 1949 from virgin bushland soil under *Eucalyptus* spp. Another specimen was found in the same area by White (1956) but this proved to be *Labrinthomyces steenisii* Boedijin. Up to this time, this monotypic genus was known only from the type collection from Indonesia; however, Cribb has later (1957) recorded three collections of this species from Queensland as well as the occurrence of the genus *Hydnobolites* in the same State. The distribution of this latter genus was thought previously to be Europe, North America and Indonesia. *Hydnobolites herbertianus* Cribb provided the first record for the genus in Australia.

This account includes all the 'truffle fungi' so far recorded for the Australian continent, with no Victorian representatives. However, Gilkey (1954) discusses a single specimen in Dr G. Massee's collection, reputed to be a Victorian fungus. The notation on the sheet is '*Leucangium readeri* Cke. et Mass., type, Victoria (Dimboola) Reader, damp clay soil'. A description of this species was never published. Gilkey examined the specimen and she states that the spores figured on the sheet by the authors do not depict those of the host fungus but represent spores of the parasite *Melanospora zobelli* and, indeed, perithecia were visible. Although the host ascocarp was immature, Gilkey could discern hyaline globose spores in asci arranged in a palisade. This arrangement would exclude the specimen from the genus *Leucangium* (now regarded as *Picoa*) and the record is regarded by Gilkey as another example of 'nominum confusum'.

Present Investigation

Family TUBERACEAE

Genus **Elderia** McLennan

Dr Donald Thomson sent to me some specimens of Tuberales which he had gathered in August 1958 in the western region of the Central Australian desert area. They were found in loose sand at the base of trees and were partly exposed at maturity. They were eagerly sought by the aborigines and much relished by them as food. The ascocarps varied in size, but the majority are large, 5-6 cm. high, 4-5 cm. broad, soft pale cream to white in colour, and they taper somewhat to the basal region. When they develop in close proximity the apposed surfaces appear flat, otherwise the outer surface is folded in a cerebral-like pattern. Running both across and down the ascocarps are fissures, extending deeply into the tissues and the soft fruit bodies can readily be separated into lobes along these lines (Pl. XVIII, fig. 1). When cut the exposed surface shows very sinuous *venae externae* surrounded by sharply defined *venae internae* (Pl. XVIII, fig. 2-3). The *venae externae* eventually open into the wider fissures which end on, or close to, the exterior surface of the fruit body.

Microtome sections show the presence of a distinct narrow cortical layer of pseudo-parenchymatic tissue, the hyphae composing it are larger in diameter towards the outside, smaller and more compact in the inner layers. The *venae externae* are conspicuous, 1-2 mm. wide, the canals in young fruit-bodies are occupied by spongy hyphal tissue often showing a reticulate appearance, this tissue tends to break down in older ascocarps; only remnants of it remaining in the canals. The *venae internae* lining the canals, consist of a densely compacted tissue which stains deeply. The hymenium is composed of a palisade arrangement of asci and paraphyses; the paraphyses extend into the canals and merge with the spongy hyphal contents. As the asci mature, there is a certain disorganization of this inner tissue, so that the hymenium then appears to line the borders of much convoluted cavities (Pl. XVIII, fig. 3). The asci are long, clavate, and eight-spored, the spores are distichously arranged in the ascus, they are globose, ranging in size from 8·5-12μ, the average size being 11μ, hyaline with a thick (1μ) smooth wall, when fully mature the wall under oil immersion appears minutely pitted.

As the asci form a distinct hymenium bordering *venae externae*, and there is no fusion of the paraphyses to form a secondary cortex, these specimens must be placed in the family Tuberaceae (Gilkey 1954) of the Tuberales. Gilkey presented a key to this family for those representatives of it that are found in North America and as she states, 'because of our imperfect knowledge of this group', she has included in the keys certain genera not known to occur in that geographical area. In an attempt to place our fungus, attention was given to this key. As the ascocarp cavities (the *venae externae*) were filled with hyphae when young, although breaking raggedly at maturity, it seemed that the genus *Stephensia* might accommodate it.

Gilkey, in correspondence with me, agreed that the specimens showed similarities with some of the characters denoting the genus *Stephensia*, more particularly in possessing the indefinite extension of the paraphyses to form at first a hyphal web in the *venae externae* and in the smooth, globose spores. However, this genus was originally based on its macroscopic ascocarp characters, the distinguishing feature being the presence of a basal or, indeed, even a central cavity from which radiate the *venae externae*, or a least an indication of such radiation even when a cavity is scarcely apparent. As there is no evidence of such a feature in the material under discussion, to extend the description to include these fungi would mean destroying the integrity of the genus.

The first record for Australia of any member of the order, had been made under the name *Stephensia arenivaga* by Cooke and Massee. A fragment of the type specimen is located at the National Herbarium of Victoria, Australia. An examination of this showed me that Cooke and Massee's fungus was similar to our material. Gilkey (in correspondence) had access to the type collection in America and she agreed that the two collections were similar. In her key for the identification of the genera of the Tuberaceae, Gilkey separates sharply those forms in which the 'ascocarp cavities are empty' from those in which they 'are filled with hyphae, these sometimes breaking raggedly at maturity'. If this is a good keying character, our fungus, using this key, would run out to the genus *Densocarpa* Gilkey (1954). In the description of this genus, the ascocarp is described as firm (the generic name is evidently derived from this character), and the peridial characters as given are different from those of the Australian specimens. The microscopic features of the gleba from the description appear to resemble those of our form. As Gilkey has examined some of our material, and is of the opinion that it represents a hitherto unknown type, presumably it cannot fit into the genus *Densocarpa* as understood and established by her.

For these reasons it is proposed to establish a new genus to accommodate this fungus and the name *Elderia* has been chosen as it was first collected by a member of the Elder expedition in 1891.

ELDERIA *E. I. McLennan*

Genus novum Stephensiam Tulasne maxime accedit, sed. venis externis ascocarpi irregulariter dispositis (haud a cavo centrali radiantibus)

Ascocarpus pallidus (albus vel isabellinus), permollis, radicem versus gradatim contractus, longitudinaliter et transverse penetratus a fissuris profundis in quas venae externae patescunt, superficie cerebriformiter plicata. Peridium a pseudo-parenchymate impletum. Gleba ex venis internis multiplicibus consistens; venae gerentes hymenium, cuius textus dis-ponitur in vallo ascorum et paraphysium; paraphyses in venas externas protrudentes, in his canalibus textum reticulatus formantes (canales ad maturitatem dissolvuntur). Venae externae irregulariter dispositae. Asci sporis 8. Sporae globosae, leves vel perleniter foveolatae.

Ascocarp pale coloured white to isabelline hypogaeous becoming epigaeous when mature, **very soft,** tapering towards the basal attaching region, traversed longitudinally and transversely by deep fissures, into which the *venae externae* open, flattened on the sides by mutual pressure of adjacent ascocarps. The upper surface folded in a cerebral pattern. Peridium pseudo-parenchymatic, the hyphae small and compact in the inner layers. The gleba consists of much folded *venae internae* bearing the hymenial tissue which is arranged in a palisade of asci and paraphyses, the latter projecting into the *venae externae* and forming a reticulate tissue in these canals, which disorganizes in the mature stages of the ascocarp. The *venae externae* open into the deep external fissures. The asci are clavate eight spored, the spores are globose smooth to faintly pitted.

Type species **Elderia arenivaga** (Cooke) McLennan

syn. *Stephensia arenivaga* Cooke

Ascocarps up to 7 cm. high, 3-4 cm. across, deeply lobed, pale, upper surface cerebriform the lower part of the peridium with closely adherent sand particles. Asci clavate, spores eight, irregularly arranged in the ascus, hyaline, globose, average diameter 10μ (range 8·6-12μ).

TYPE: Collected in sandy soil, South Australia.

HABITAT: In sandy desert areas.

DISTRIBUTION: NW. of South Australia (near Everard Range) and central W. of Western Australia (near Lake Hazlett).

Genus **Hydnotrya** Berk. et Br.

Some specimens gathered by the author a few years ago at Narbethong, Victoria, Australia, were placed provisionally as *Hydnocystis convoluta* McAlp. (1896). McAlpine described his specimens as 'entirely white, an irregular convoluted hollow sac about 2 x 2 inches and narrowing towards the ground, wall about one line thick and composed of an outer layer of sub-cartilaginous, or brittle fleshy substance and an inner one of compact hymenium. Asci cylindrical up to 256μ long, intermixed with slender filamentous paraphyses. Spores spherical or oval, slightly verrucose, about 9μ in diameter or 10-11 x 8·5μ. On ground in woods, Hobart, Tasmania.'

This description adequately fits the Victorian specimens.

Massee (1898), discussing some Tasmanian fungi, lists *Hydnocystis cyclospora* (Cooke) Massee with its synonym *Berggrenia aurantiaca* var. *cyclospora* Cooke (1886). He noted that Cooke gave the measurements of the variety *cyclospora* as 18μ. However, examination of the type material by him proved this to be incorrect and showed the spore range to be from 9-12μ. I have examined some of the co-type material of *Hydnocystis cyclospora* from the Rodway herbarium and it has proved to be similar to the fungi found at Narbethong, Victoria, with rough spores, although, Rodway (1924) in his description of this fungus states that the spores are smooth.

Massee placed *H. convoluta* McAlp. into synonymy when he erected the varietal name of *Berggrenia aurantiaca* var. *cyclospora* Cooke to specific rank. According to the rules of nomenclature this is not permissible, so *H. cyclospora* (Cooke) Massee must yield to *H. convoluta* McAlp. Gilkey, however, interprets the genus *Hydnocystis* as possessing smooth spores in contrast to *Hydnotrya* with sculptured spores. As the Australian fungi have verrucose spores they should be placed in the latter genus and the nomenclature becomes—

Hydnotrya convoluta (McAlp.) McLennan

syn. *Berggeneria aurantiaca* Cooke var. *cyclospora* Cooke (1886)
Hydnocystis convoluta McAlp. (1896)
Hydnocystis cyclospora (Cooke) Massee (1898).

As already noted, the original description by McAlpine of *H. convoluta,* based on Tasmanian material fits the characters of the Victorian specimens. The spores were described as spherical or oval, slightly verrucose about 9μ in diameter or 10-11 x 8·5μ. The spore measurements of the co-type material from Rodway's collection are approximately 12 x 8μ and for the Victorian samples 12 x 8·4μ.

The only other Australian record of *Hydnocystis* is Rodway's species *H. echinospora* (1924). Examination of the type material now housed in the herbarium of the Tasmanian University (No. 374) shows that he was mistaken in referring it to the Tuberales. The hymenium clearly covers the outer surface of these small fruiting bodies, which are hemispheric and somewhat convoluted with a hollow interior. Rodway described the spores as uniseptate (probably in error for uniseriate) ; specimens preserved in his herbarium under this name show no signs of spore septation, they are elliptical and, as he states, the spore surface is ornamented with rather coarse blunt spines. It is interesting to note that he originally named and described the specimens as *Sphaerosoma tasmanica,* a genus with the hymenium completely clothing the exterior surface of the ascocarp, although Rodway (1919) describes the hymenium of his specimens as covering the internal surface!

The name *Hydnocystis echinospora* Rod. must be regarded as superfluous.

Family Terfeziaceae

Genus **Mukagomyces Imai**

During the autumn of 1955, the writer collected a number of specimens of a Tuberales at Footscray (a suburb of Melbourne), Victoria. They were growing in a municipal gardens close to the roots of *Populus canadensis* Moench, and, at that time, the mycelium was traced to the roots of this tree. Later the rootlets were shown to possess a mycorrhizal association, probably the fungal partner was the truffle fungus although no actual proof of this was possible. These fungi were members of the Terfeziaceae, for the ascocarps were very compact and lacked any internal cavities, i.e. *venae externae* were absent. However, the fertile tissue was divided by sterile veins into many nest-like areas containing clavate to spherical asci. The asci were few spored, the spores were ellipsoid and conspicuously alveolate.

Using Gilkey's key in an attempt to identify these fungi, they ran out to the genus *Mukagomyces* Imai (1940), a genus so far known only from Japan. The ascocarps were subterranean, compact, very variable in size, the larger 3·5 cm. broad by 2-2·5 cm. high, opaque and whitish externally. The surface of some is much folded in a cerebriform pattern, while others are smoother and plicate towards the base. The gleba is pinkish-cinnamon traversed by sterile veins of a lighter colour. The outer coat is white, 1 mm. thick, and covers the ascocarp completely, there are no openings to the exterior of the fruit body (Pl. XIX, fig. 2).

In section the periderm shows as a densely parenchymatic structure becoming slightly more prosenchymatous, but still dense towards the glebal region. The gleba is separated into pockets by a less compact sterile tissue. The asci are globular to elliptical and 4-8 spored. The spores are variable in shape oval to elliptical and range in size from 30-40 x 20-28μ. The spore coat is brown and shows an alveolate pattern, the ridges forming the boundaries of the network are deep so that a conspicuous wing surrounds the spore when it is viewed in optical section. In surface view the alveolae are mostly pentagonal to hexagonal in outline and measure approximately 7μ across (Pl. XIX, fig. 1).

A comparison of Imai's description for the Japanese fungus with the above description of the Australian forms makes it clear that we are dealing with the same genus and species. It is a monotypic genus and Imai has named the type species *Mukagomyces hiromichii.* The occurrence of this species in southern Australia (Victoria) markedly extends its geographic range for until now it has been known only from one province in Japan.

The other member of the Terfeziaceae to be considered for Australia is *Terfezia tasmanica* Rod. (1925). This genus differs from *Mukagomyces* in having an 8-spored ascus. The material in the Rodway herbarium of *T. tasmanica* shows the typical generic characters. Rodway gives the spore characters as 'globose-pyriform, minutely echinulate, coat thick forming a double contour hyaline till old, then brown, 20μ diameter'.

Examination of the type material, as well as some slides prepared by Rodway in my possession, shows the spores to be markedly thick-walled, with many narrow pits, the orifices of which in surface view show as small circular areas over the spore surface (Pl. XIX, fig. 3). The spores are not echinulate as the original description states.

Key to the Australian Tuberales*

*Adapted from the key prepared by Professor Gilkey (1954) for the North American Tuberales

KEY TO THE FAMILIES

(A) Asci forming a distinct hymenium

(a) Hymenium in the form of a paliside the paraphyses fused beyond the tips of the asci to form an epithecium .. .. GENEACEAE

(b) Hymenium irregularly arranged, or if in palisade the paraphyses not fused to form an epithecium .. .. TUBERACEAE

(B) Asci not forming a distinct hymenium, but borne in nest-like areas separated by sterile tissue .. .. TERFEZIACEAE

KEY TO THE GENERA

Family GENEACEAE

(A) Mycelial tuft present

(a) Ascocarp opening single, spores sculptured .. .. *Genea*
G. pazschekei (Tas.)

(B) Mycelial tuft absent

(a) Ascocarp openings one to several, spores smooth .. .. *Hydnoplicata*
H. whitei (N.S.W.)

Family TUBERACEAE

(A) Hymenium with asci and paraphyses in palisade lining the walls of cavities

(a) Ascocarp cavities empty, paraphyses only one-third as long as the asci .. .. *Labrinthomyces*
L. steenisii (N.S.W. and Qld.)

(b) Ascocarp cavities empty, paraphyses as long as the asci .. *Hydnotrya*
H. convoluta (Vict. and Tas.)

(c) Ascocarp cavities containing hyphae which become pulled apart at maturity

(i) Ascocarp with a basal cavity from which radiate the venae externae .. *Stephensia*
S. varia (Tas.)

(ii) Ascocarp lacking this radiate structure. The venae externae form a much convoluted system of canals .. .. .. *Elderia*
E. arenivaga (E. and W. Central W.A.)

(B) Hymenium without palisade structure, the asci irregularly arranged .. *Hydnobolites*
H. herbertianus (Qld.)

Family Terfeziaceae

(A) Asci 8-spored, spores globose .. .. *Terfezia*
T. tasmanica (Tas.)

(B) Asci 4-spored (rarely more) spores ellipsoid .. .. *Mukagomyces*
M. hiromichii (Vict.)

Acknowledgements

My thanks are due to Dr Donald Thomson of the Anthropology Department of the University of Melbourne for bringing the material of *Elderia* to me, and to Mr J. Willis of the National Herbarium for the Latin description of this fungus.

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Explanation of Plates

Plate XVIII

Fig. 1—Ascocarps of *Elderia arenivaga* nat. size.

Fig. 2—L.S. through an ascocarp of *E. arenivaga.* The *venae externae* are irregularly arranged nat. size.

Fig. 3—A section through an ascocarp of *E. arenivaga* x35.
1. *venae internae,* 2. palisade hymenium, 3. paraphyses in *venae externae.*

Plate XIX

Fig. 1—An ascus of *Mukagomyces hiromichii* Imai.
1. alveolate pattern of spore coat x1200.

Fig. 2—Ascocarps of *Mukagomyces hiromichii* Imai nat. size.

Fig. 3—Ascospores of *Terfezia tasmanica* Rod. x1800.


fig.1

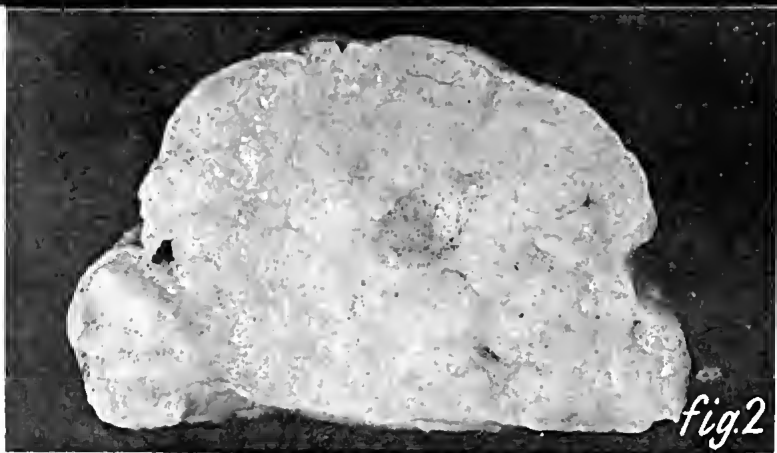
fig.2

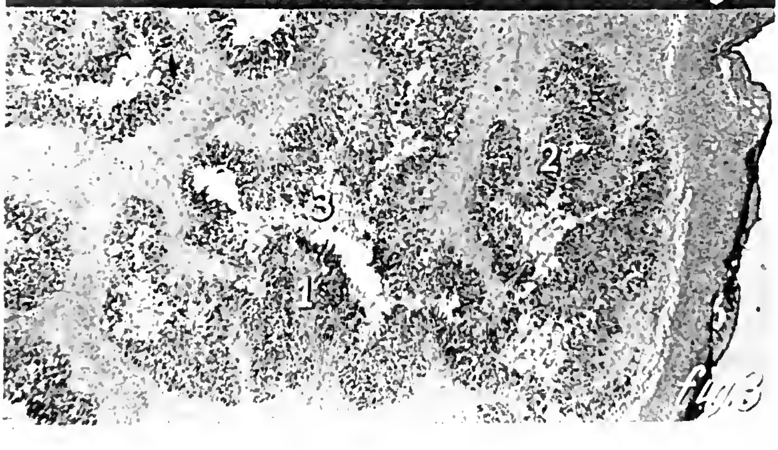

fig.3

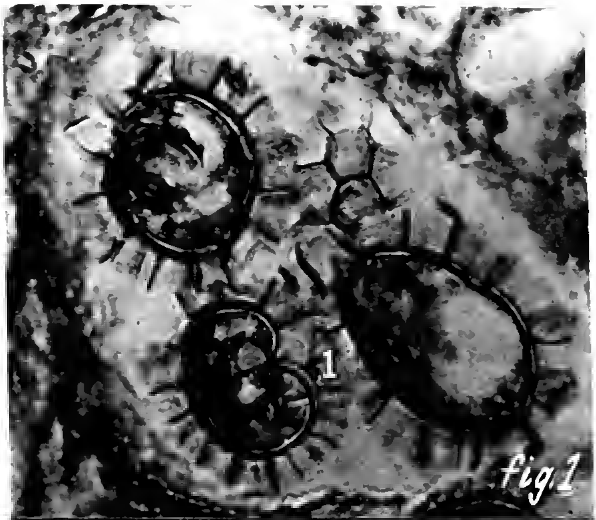
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fig.1


fig.2

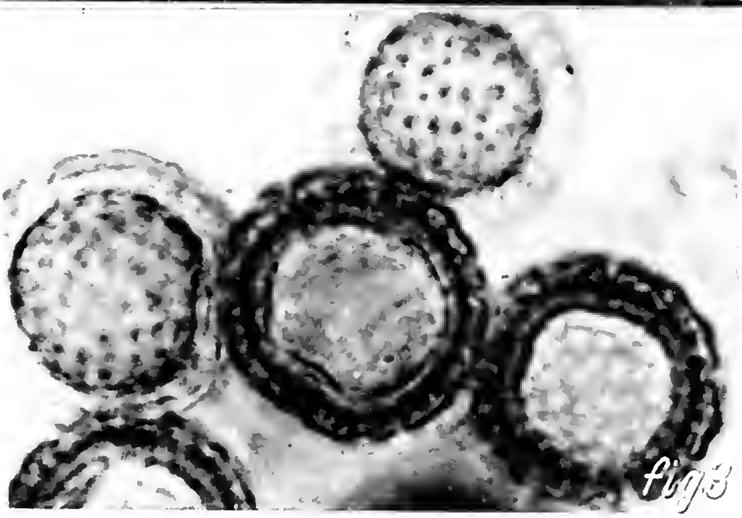
fig.3

12

THE HIGHLY REFRACTIVE PROTONEMA OF *MITTENIA PLUMULA* (MITT.) LINDB. (MITTENIACEAE)

By Ilma G. Stone MSc

[Read 8 December 1960]

Abstract

The discovery of a highly refractive protonema belonging to the moss *Mittenia plumula* is reported. The peculiar protonema which produces lens-like cells is described, and a comparison of the moss made with *Schistostega pennata* (Hedw.) Hook. and Tayl., the only other moss known to possess a similar protonema.

Introduction

A green filamentous growth with a luminous appearance was found in the Sherbrooke Forest in the Dandenong Ranges near Melbourne. It was growing on the floor of a dimly lit cavity under a fallen tree fern.

The material was thought at first to be the protonema of the moss *Schistostega pennata* which is not recorded for Australia.

The protonema was found later in a number of similar situations in the same locality, in many cases with attached gametophores of a moss identified as *Mittenia plumula.*

A detailed examination of the gametophore and the sporophyte revealed some differences from previous descriptions (Sainsbury 1955) and these, with details of the development of the peristome, will be the subject of a second paper on *Mittenia plumula.*

The Protonema

As in *Schistostega pennata* (Goebel 1905), the protonema of *Mittenia plumula* has two phases, the highly refractive stage with lens-like cells (Pl. XX, fig. 1-2) which reaches its highest development when the moss is growing where light is dim and unilateral, and the normal moss type of protonema with cylindrical cells (Pl. XX, fig. 2) which is found in the same situations as the previous stage, but is better developed where the light intensity is greater. Aerial branches of both phases and the base of an attached gametophore are shown in Fig. 1. Between the two extreme phases intermediate stages are found (Fig. 2-3) and one phase frequently passes over to the other. Either phase may also produce colourless finely branching rhizoids (Fig. 4).

A stoloniferous type of filament which is sometimes very robust and thick-walled extends over the substratum for a considerable distance and gives rise to the aerial branches, rhizoidal branches and gametophores. Pl. XXI shows a sterile shoot and Pl. XXII a very young shoot attached to the protonema.

Although there is considerable variation, the system of branching of aerial filaments is frequently the same in both phases and, when growth is luxuriant, the branches generally arise practically opposite to each other just behind a cross wall. The tips of the cells in the cylindrical type are rounded.

In the specialized highly refractive stage the branches are composed of lenticular cells spread out in a plane at right angles to the light and sometimes appearing like

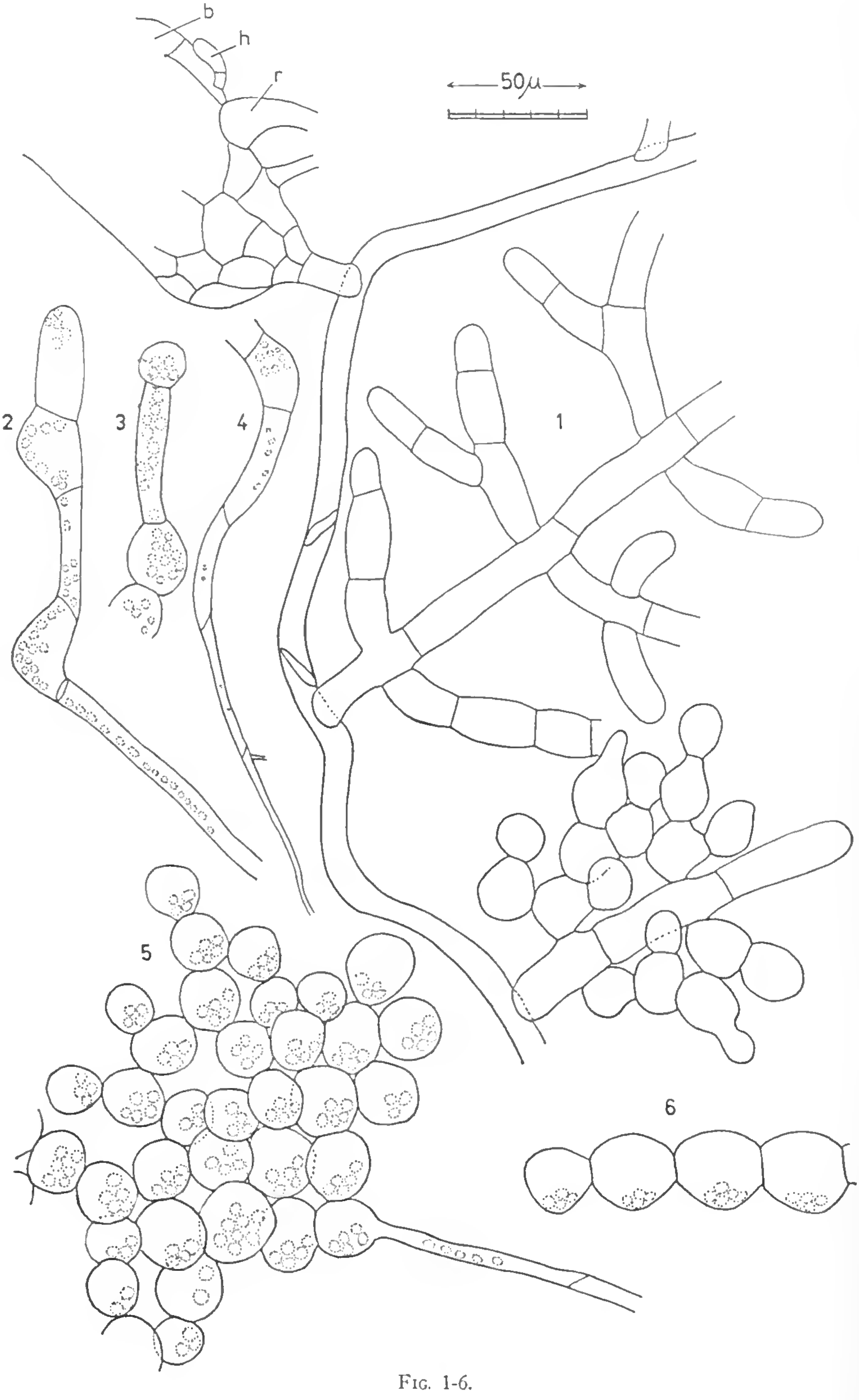

Fig. 1-6.

plates of tissue as shown in Fig. 5 and Pl. XX, fig. 1. Fig. 6 shows the shape of the cells and the position of the chloroplasts which are massed near the more highly convex underside of the cell. Light rays falling on the lens-shaped cells are concentrated on the chloroplasts. As with *Schistostega* the apparent luminosity is produced by the light rays, which are not absorbed by the chloroplasts, being reflected back and when this reflected light is of sufficient intensity the protonema exhibits a striking green lustre. Pl. XX, fig. 3 is a photograph of the protonema on a piece of earth, at which a light was directed. The bright areas are regions of the lenticular protonema which received the incident light from a suitable direction.

The spores of *Mittenia plumula* germinated on mineral solution, sending out a germ tube (Fig. 7-8) in a few days, but further development was slow and Fig. 9-12 show stages reached after several weeks on mineral solution in dim light. Many spores developed two germ tubes.

Fig. 19 shows aerial branches with lenticular cells which were grown on moist clay in a room facing south. The terminal cell of one branch has grown out into a narrow filament. This was characteristic of the protonema. Fig. 13-15 show early stages in the development of the lenticular protonema. Each new lens-shaped cell arises as a papilla into which a few chloroplasts pass (Fig. 15). Nuclear details were not observed.

Stout protonemal filaments may grow out from the apex of injured shoots, and also develop from the surface of the stem usually above the insertion of a leaf. Dark green gemmae of two to four cells in a row were formed by some of these filaments.

Fig. 16 shows a gemma attached to the tip of a specialized cylindrical cell, Fig. 17 a germinating gemma and Fig. 18 a gemma which had brown walls and dense green contents detached from the parent cell.

Occasionally brown gemmae were found on rhizoids (Fig. 20). Aerial protonema of both types may develop from the rhizoids of the gametophore.

Discussion

Schistostega pennata is the only member of the order Schistostegales and the refractive protonema is stressed as a character of the order. *Mittenia plumula,* which is the only member of the family Mitteniaceae in the order Eubryales, now also has been found to have a refractive protonema.

The discovery of a second moss with a highly refractive protonema leads to speculation as to whether it is a similar response on the part of two unrelated species, that is, that the lenticular condition arose independently in *Schistostega* and *Mittenia,* or whether there is actually a close relationship between the two mosses.

It is interesting and possibly significant that early descriptions of the gametophore of *Mittenia plumula* (formerly *Mniopsis plumula* Mitt.) (Hooker 1860, Muller 1901) are accompanied by a comparison with the gametophore of *Schistostega* to which it seemed most closely related morphologically. In each case there is a vertical insertion and distichous arrangement of the decurrent leaves on mature sterile shoots, although the leaves are primarily transversely inserted and radially arranged.

In *Schistostega* the leaves have no costa and the cells are very large and elongated. In *Mittenia,* although the lower leaves often have elongated cells and no costa, the cells are never as large as those of *Schistostega,* and the leaves higher on the stem have isodiametric cells and a costa which vanishes above midleaf.

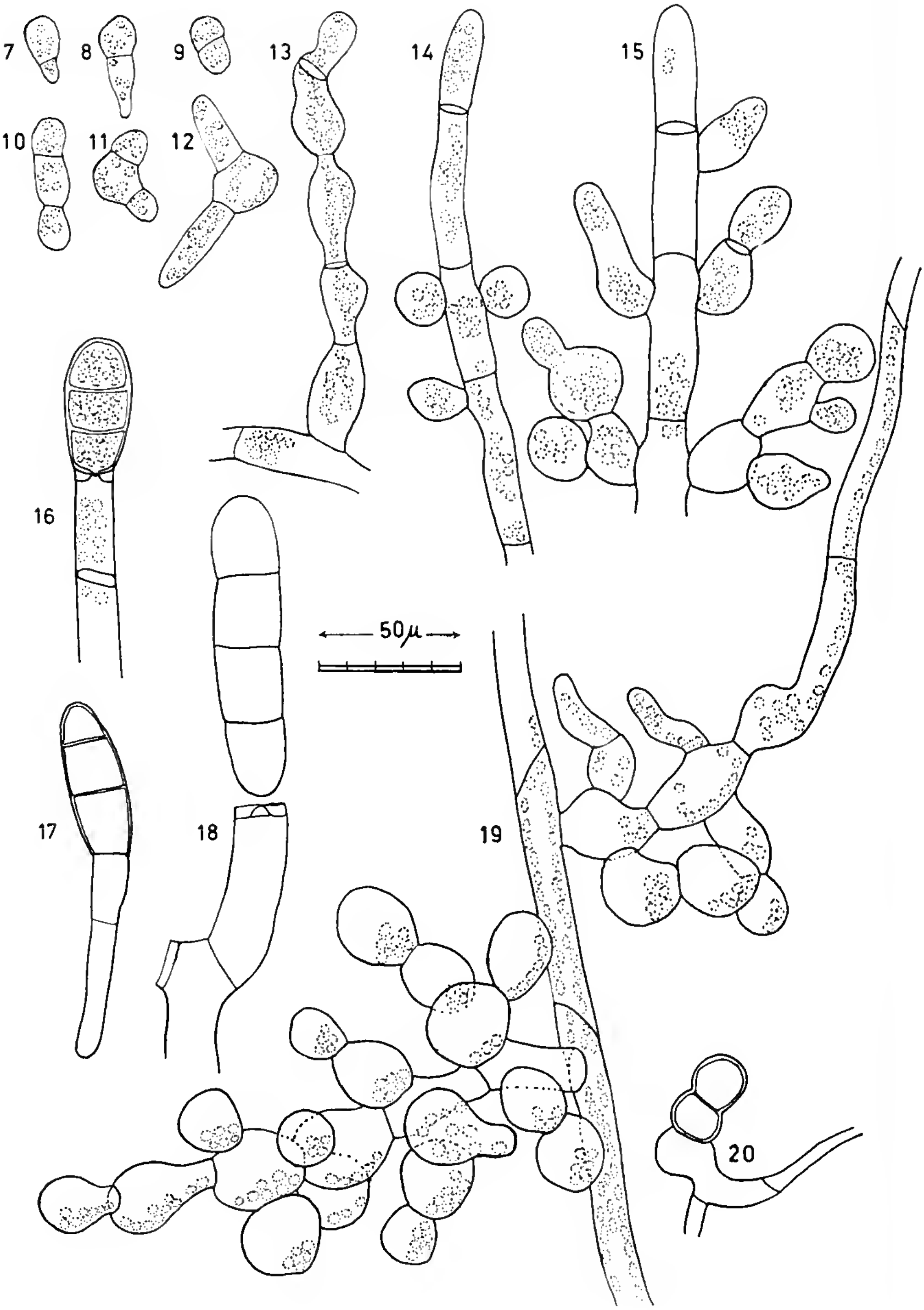

FIG. 7-20.

These differences would not necessarily debar relationship between the two mosses, as such differences are present in the species of certain other genera, e.g. *Fissidens* Hedw.

The fertile shoots in both mosses have a radial arrangement of leaves with transverse to oblique insertion. Some of the male shoots in *Mittenia* resemble those of *Schistostega* in having few or no leaves on the stem with a tuft at the top.

Goebel (1905) reports that hairs are present in the axils of leaves on female shoots of *Schistostega* and, although *Mittenia* was reported in the Latin description (Hooker 1860) as having no paraphyses, club-shaped hairs are present particularly in the axils of the upper leaves on fertile shoots. Brotherus in Engler and Prantl (1924) describes *Schistostega* with no paraphyses and *Mittenia* with paraphyses assosciated with antheridia and archegonia, but these are not shown in the illustrations.

Mittenia forms gemmae on protonemal filaments and these have also been mentioned (Goebel 1905) for *Schistostega*.

There is a difference in the mode of social growth in the two mosses. In *Schistostega* new shoots form from short protonemal filaments arising from the base of the old shoot (Goebel 1905). In *Mittenia* a bud associated with hairs is formed at the base of a gametophore giving rise to a new shoot and the early stage of one of these buds is seen in Fig. 1.

The sporophyte in both mosses is terminal but the complicated capsule of *Mittenia* shows no resemblance to the capsule of *Schistostega* which is extremely simple and has no peristome. Plants which have undergone reduction present problems in assessing affinities, and presence or absence of a peristome does not necessarily indicate a lack of relationship, as witnessed by the genus *Orthotrichum* Hedw., in which one species has no peristome while other species have a double or a single peristome.

Acknowledgements

The protonema was first found in April 1960 by Mrs J. S .Turner. Thanks are due to Professor Turner for introducing the author to the subject, to Dr Ethel McLennan for advice and encouragement, to Mr J. H. Willis for confirming the identification, and to Mr E. J. Matthaei for the photographs. The author is in receipt of a research grant from the University of Melbourne, and the work was carried out in the Botany Department.

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Explanation of Plates

PLATE XX

Protonema of *Mittenia plumula*

Fig. 1—Highly refractive phase of the protonema x *c.* 230.
Fig. 2—Refractive phase and a small portion of protonema showing cylindrical cells x *c.* 230.
Fig. 3—Highly refractive protonema on a piece of earth at which a light was directed x *c.* 15.

PLATE XXI

Sterile gametophore of *Mittenia plumula* attached to protonema. Many of the rhizoids of the moss plant have been removed. A stout one remains at the right of the plant. x *c*. 50.

PLATE XXII

Part of an extensive protonema with a young gametophore attached. Note stoloniferous filament giving off branches. x *c*. 70.

Legend to Figures 1-20

FIG. 1–6—(1) Stoloniferous filament with aerial branches of both phases of the protonema and the base of a gametophore (h hair, b bud, r rhizoid). (2, 3) Intermediate stages between the two phases of the protonema. (4) Gradual transition of green protonemal cells to fine colourless rhizoidal cells. (5) Maximum development of the highly refractive protonema. All the cells are lens-shaped. (6) A few lens-shaped protonemal cells showing the aggregation of chloroplasts in the underside of the cells.

FIG. 7–20—(7, 8) Germinating spores on mineral solution a few days. (9-12) Germinating spores on mineral solution for several weeks. Spores with one or two germ tubes. (13-15) Early stages in the development of the lenticular protonema. Fig. 15 shows stages in the formation of the lens-shaped cells. (16) Gemma at the tip of a filament which grew out from the surface of the stem of a gametophore. The cylindrical cell which bears the gemma is a specialized cell. (17) Germinating gemma. (18) Gemma detached from its parent cell. (19) Protonema grown on moist clay. The terminal cell of one branch has grown out into a filament, a characteristic feature of the protonema. (20) Thick-walled gemma on a rhizoid.


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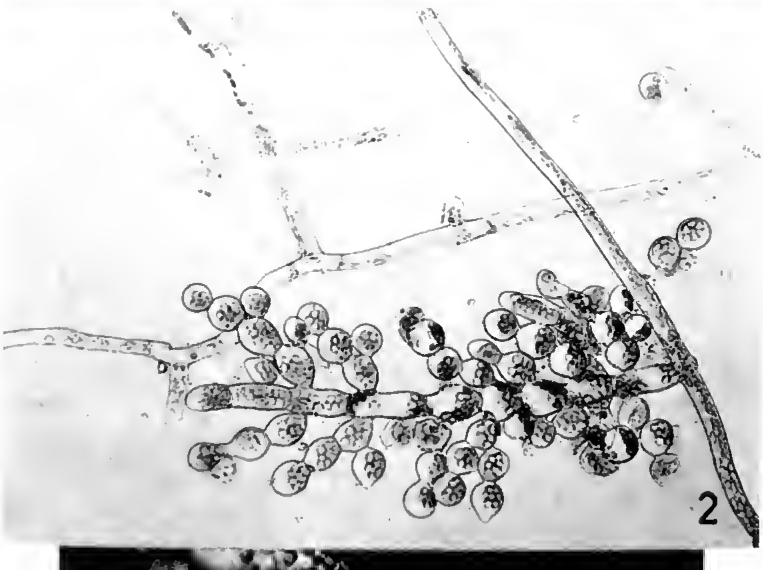
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13

EUSTASY AND THE YARRA DELTA, VICTORIA, AUSTRALIA

By Edmund D. Gill
National Museum of Victoria

[Read 14 July 1960]

Abstract

Radiocarbon dating and oxygen isotope palaeotemperature measurements have provided considerable support for the hypothesis of glacial control of Quaternary sea level changes. On the world temperature graph for the past 100,000 years, the local radiocarbon datings have been plotted. The inferences from this graph are considered in relation to geological observations on the Yarra Delta.

Two warmer periods of higher sea level (the Riss/Würm 25 ft and the postglacial 10 ft) are separated by a long period of lower temperatures and lower sea level when considerable erosion of the delta took place. The postglacial rise in sea-level has been dated by C14.

The possibility that tectonic movement has effected these emergences is examined. No evidence is found of late Quarternary uplift in this sunkland environment.

Introduction

As deposition on the floors of deep oceans is so slow, relatively thin deposits represent great periods of time. Cores from such deposits can span the whole of Quaternary time. Pelagic foraminifera (that once lived at the surface of the ocean) taken at intervals in such cores have been analysed for their oxygen isotope palaeotemperatures, so that graphs have been constructed of the changing ocean surface temperatures of the past (*Emiliani* 1956, 1957, 1958 a, b). Palaeoecologic analyses (Ericson and Wollin 1956) and sedimentational analyses (Broecker, Turekian and Heezen 1958) have given comparable results.

By means of radiocarbon analyses the palaeotemperature curve has been calibrated for time within the range of that method. Thus palaeoclimatic changes have been dated precisely over the past 45,000 years, and with some reliability by extrapolation to 100,000 years. Such a curve is given in Fig. 1, taken from Emiliani, but with the temperature scale adjusted to the local range (i.e. the curve begins on the local mean temperature). On this curve, radiocarbon dates of local sites have been inserted.

Radiocarbon and Glacio-eustasy

Radiocarbon dating has shown that late Quaternary climatic changes have been synchronous in the northern and southern hemispheres. They have also shown that low sea levels accompanied the low temperatures. Moreover, evidence is accumulating for similar low levels in many parts of the world at the same time (e.g. Godwin, Suggate and Willis 1958). Radiocarbon and oxygen isotope palaeotemperature measurements (Emiliani, op. cit.) have thus greatly strengthened the glacio-eustatic or glacial control hypothesis, i.e. that the Quaternary low sea levels were due chiefly to colder temperatures resulting in accumulation of ice caps on the poles and a contraction of oceanic waters, while higher sea levels were due to warmer temperatures resulting in the melting of polar ice and the expansion of oceanic waters.

If the glacial control hypothesis be correct (and the available evidence now strongly supports it), then the palaeotemperature graph in Fig. 1 provides an indication also of the changes of sea level. From this graph the following inferences may be made:

1. A mid-Holocene warmer period occurred approximately 4,000-6,000 years ago (the Postglacial Thermal Maximum). Local evidence of this, and a radiocarbon dating, have been obtained (Gill 1955a).
2. The Riss/Würm Interglacial (about 100,000 years ago) was the only other time in the period covered when the climate was warmer than the present (see Fig. 1). This is the time of the 25 ft sea (= Sangamon), and far beyond the present range of radiocarbon. Thus emerged shell beds of this age at Port Fairy have proved to be beyond the range of C_{14} (Gill 1953, 1955b); they are more lithified than the postglacial emerged beds.
3. The ocean level has been considerably lower than at present for most of the period of nearly 100,000 years between these two higher levels. This would mean a prolonged period of erosion, and would account for the deep and wide valleys with their thalwegs extending below present sea level. Many of these valleys are considerably infilled with Flandrian sediments. This prolonged period of low sea level would also have considerable significance for the distribution of plants and animals, e.g. between the Australian mainland and Tasmania.
4. A colder climate characterized this long period, and must have been another factor in the distribution of plants and animals. *Homo sapiens* emerged in the earlier part of this period, and so has spent most of his time in a colder climate. *Homo sapiens* is a glacial period species but recently accommodated to higher temperatures. The oldest C_{14} date for man in Australia is *c.* 18,000 years for charcoal from a hearth low in the Keilor Terrace (6 ft 9 in. below the diastem) at the Keilor Cranium site (Gill 1954). This date falls in the time of lowest temperatures, which on the glacial control hypothesis would also be the time of lowest sea-level. It may be that the entry of man to Australia may be connected with this time of lowest sea-level, when New Guinea would be linked with the mainland, and the sea crossing from the west was much shorter. Ancient hominids are known from China and Java (Vallois and Movius 1953). and *Homo sapiens* is known from many sites near Australia. Radiocarbon dates for a cave site in Borneo of *c.* 32,600 and *c.* 39,600 years ago are known.
5. The graph suggests two glaciations in the period concerned rather than the three divisions of Würm classic in Europe. Emiliani (1958) so interprets his graph. The Interglacial between these two glacials did not attain temperatures as high as the present, and so on the glacial control hypothesis, a sea level as high as now is not to be expected. Sea-levels higher than now which have been referred to Würm Interglacials (Gill 1953, Fairbridge and Teichert 1953) should probably be otherwise dated.

The Yarra Delta and Eustasy

The foregoing concepts (derived from the palaeotemperature graph calibrated by C_{14}) are now applied to the sediments of the Yarra Delta, and of the Maribyrnong R. terraces with which they interdigitate. Three river terraces have been distinguished so far (Gill 1955c) viz:

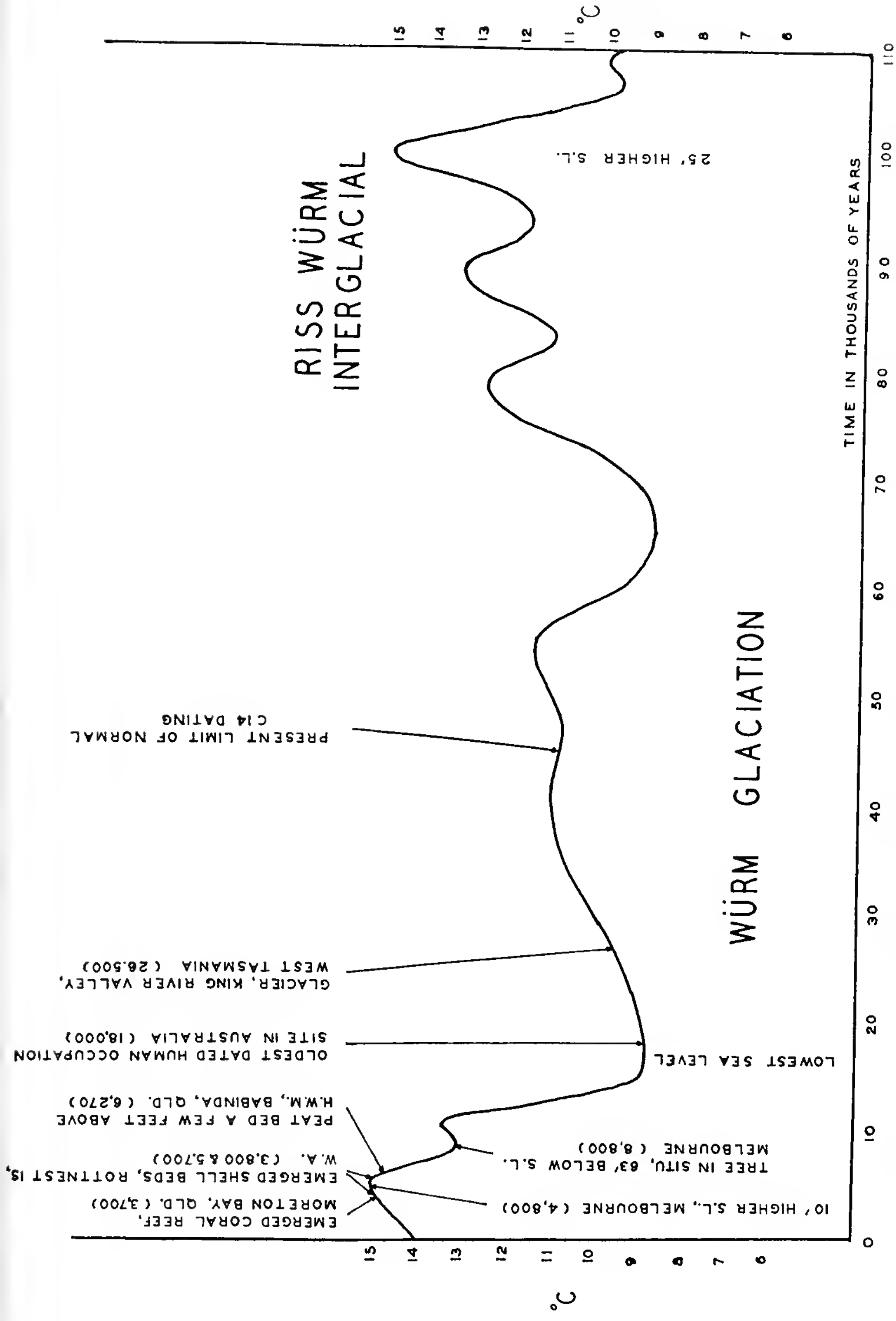

Fig. 1—Palaeotemperature curve of Emiliani adjusted to local conditions by commencing the curve on the local mean temperature. It is indicated where relevant Australian events dated by radiocarbon fit into this curve.

Oldest	Arundel Terrace
	Keilor Terrace
Youngest	Maribyrnong Terrace.

The Maribyrnong Terrace is covered (or mostly so) by present floods. The Keilor Terrace reaches some 12 ft above present flood levels. Charcoal from the higher part of the latter terrace has been dated at *c.* 8,500 years (Gill 1955d), from just below the diastem at *c.* 15,000 years, and from 6 ft 9 in. below the diastem at *c.* 18,000 years. The oxidised material of this terrace runs below present sea level. A red gum stump in position of growth 63 ft below low tide level has a similar C_{14} age to the upper part of the Keilor Terrace (Gill 1955b). This terrace belongs to the period immediately preceding and to part of the time of the Flandrian Transgression. There is evidence that the climate was wetter and cooler than now (Gill 1955b, Willis 1955, Duigan and Cookson 1957, Dorman and Gill 1959, p. 81).

A long period of time separates the Keilor Terrace from the Arundel Terrace. The top of the latter is higher in the valley, and its soil is a deep red earth. All carbonaceous matter has been destroyed, and any bones leached away. The only fossils found are some wombat teeth in a calcareous soil nodule. The sediments of the Arundel Terrace are much more consolidated than those of the Keilor Terrace. The sediments of the latter occupy a valley cut in the sediments of the Arundel Terrace, which in places underlie them.

When the Arundel Terrace is traced into the Yarra Delta (evidence to be published elsewhere) it is almost certainly associated with the consolidated, oxidized, eroded marine formation (Dorman and Gill 1959, Fig. 4) in the same way as the Keilor Terrace is associated with the overlying unoxidized, unconsolidated marine formation laid down during the Flandrian Transgression. The extent and nature of the underlying formation shows it was the result of a transgression like the Flandrian one. Its marine fossil content shows that it likewise was laid down in waters slightly warmer than the present. In this formation at North Melbourne some bones of the extinct marsupial *Diprotodon* have been found. The formation belongs to a warmer period a considerable time before the present, and prior to the last glaciation. On Emiliani's palaeotemperature curve (Fig. 1) this can only be Riss-Würm (Sangamon). The formation contains *Anadara trapezia* which is an Upper Pleistocene and Holocene lamellibranch.

Eustasy and Tectonics

The question now arises as to whether these emergences were effected to any significant degree by tectonic movements. This aspect has been referred to previously (Gill 1956, p. 137), but is now treated in greater detail. Thomas and Baragwanath (1950, Fig. 35) have outlined the structure of the Port Phillip Sunkland, including the Gellibrand Fault across the SW. margin of Hobson's Bay. This fault was originally described by Condon (1951) who believed it to be of Palaeozoic age, but still operative in the Tertiary. Movement on this fault and Selwyn's Fault, if appreciable in the past 100,000 years, would affect the formations of the Yarra Delta now under consideration.

1. The Gellibrand Fault is shown in Condon's section (1951, p. 4) as off-setting the bedrock between the Newport and Spotswood bores. The Newport bore (Stirling 1895, p. 60; 1899, p. 81) was revised by Hunter (1903) who made

an error of addition of 100 ft. Hunter also recorded the Spotswood bore. The corrected depth for bedrock removes the evidence for a fault in this section. The dip of the bedrock surface on the upthrow side of the Gellibrand Fault is determined from the Spotswood and Yarraville bores, but the latter was a private bore on which the information available is conflicting (Stirling 1899, p. 81; Bayly 1908, Fig. 3). In the writer's sections (Fig. 2, 3), Altona No. 1 bore is used (because it reached bedrock), clay and brown coal are included together (because they both belong to the stillwater ecology and they merge into one another), and the basalt is interpreted as having a flat base (because resting on clay in a sunkland environment).

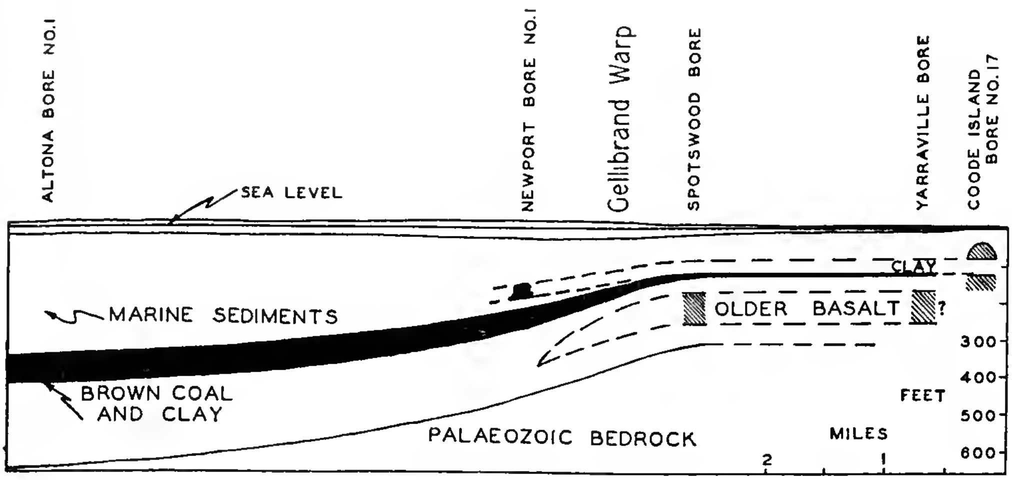

Fig. 2—Geological section from Altona to Coode Island, Melbourne, Victoria.

Owing to the uncertain character of the Yarraville bore, the section in Fig. 2 is extended to Coode Island where Bore 17 of the Melbourne Harbor Trust is included. The writer personally followed the progress of the Coode Island bores. Most were less than 100 ft in depth, but the Chairman of the M.H.T. Commissioners, Mr A. D. McKenzie, kindly had Bore 17 extended to 130 ft in the hope of reaching the Silurian bedrock, but the bore finished at that depth in Older Basalt. Lignitiferous clay found between two flows of Older Basalt in Bore 24 at 105 to 106 ft was examined by Dr Isabel Cookson, who reported that the deposit is rich in *Nothofagus* pollen, but that conifers (including *Dacrydium Mawsonii*), *Casuarina, Triorites Harrisii* and ferns are also present. The age is the same or similar to that of the brown coals of Altona and Yallourn (Oligocene).

The re-drawing of Condon's section leaves no reason for retaining at present the Gellibrand Fault, but between the Newport and Spotswood bores there is a small change in the declivity of the bedrock, so the name could be retained as the Gellibrand Warp. As both the bedrock and the brown coal are involved, the structure is a Tertiary one. The declivity of the bedrock between Spotswood and Newport is approximately 1 in 46, but 1 in 114 between Newport and Altona. Both are low declivities, but as they continue over some miles their effect is considerable. There is no evidence available yet that this structure has affected the Yarra delta in the past 100,000 years.

2. SELWYN'S FAULT is still active, as shown by occasional earth tremors with epicentres on or near this fault. However, the Yarra Delta is on the hinge side of this movement, and there is no evidence that the Yarra Delta has been affected over the past 100,000 years. If there were movement, it would be downwards.

3. ALTONA SHELL BEDS. These should be discussed in this connection. Pritchard (1909) rejected the usual explanation of tectonic uplift to explain the emergence of these beds, and regarded the deposits as due to 'the joint action of wind and tide' 'on a shelving shallow shore-line' building a sand bar then infilling behind it. Jutson (1931) also considered tectonic uplift doubtful, stating that 'Those deposits could easily be laid down by high tides'. Hills (1940) showed that the beds are not storm wave deposits, and interrupted them as uplifted submarine banks.

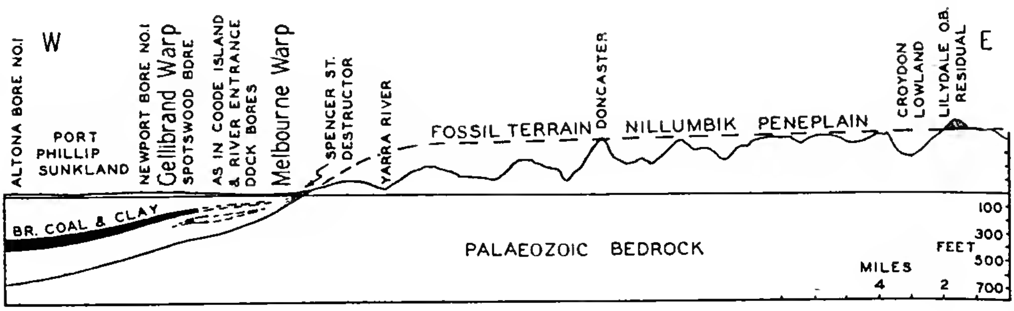

FIG. 3—Geological section from Altona to Lilydale, Victoria.

In the writer's view, two formations are present—the shell beds, and the overlying sands—and the ridges are formed by the sand, having little to do with the underlying shell beds. The latter are horizontal, poorly stratified in some places but well stratified in others. The sediments are poorly sorted, marine, shallow water, and in places current-bedded. Shells vary from complete to well-worn; occasionally the paired valves of lamellibranchs are found still together. Throughout most of the shell-bed formation, the percentage of terrigenous material is low, suggesting conditions during a transgression of the sea. Except for some marginal deposits, the formation was laid down below low water, and it constitutes a thanatocoenose. The fossils represent a mixture of facies—rock molluscs such as *Haliotis naevosa,* sand molluscs such as *Macoma deltoidalis,* weed molluscs such as *Phasianella australis,* mud molluscs such as *Anadara trapezia,* salt marsh and estuarine forms such as *Salinator fragilis,* and the calcareous-tube worm *Galeolaria* from the lower part of the intertidal space. In some beds, molluscs of one species predominate. During the excavation of a deep stormwater drain along Nellie St, S. of Lake Altona, it was noted that the shell beds are horizontal over a considerable distance.

Stratified marine beds well above high water level cannot be explained by natural reclamation as suggested by Pritchard, nor by high tides as mentioned by Jutson. The mixed facies of the fossils and the continuity of horizontal beds do not fit the theory of emerged submarine banks proposed by Hills. The shell bed formation is interpreted as a normal shallow water marine one, and is to be compared with the shell beds at Point Lonsdale and Warrnambool. Its emergence is thought to be due chiefly at least to eustatic change of sea-level; any tectonic movement would be expected to be downwards and tending to negate any emergence due to eustasy. The sand ridges are interpreted as a series of beach ridges formed during the retreat of the sea from the postglacial higher eustatic level (cf. Davies 1958). The lobate extensions on the inland sides of the ridges (mentioned by Hills) are interpreted as homologues of the blowouts on sand dunes. Similar ridges once covered Port Melbourne, which was for this reason first called Sandridge.

The Melbourne Warp

The eastern part of the City of Melbourne is built on a platform of Silurian rocks 150-200 ft above the sea. In the western part of the city, the bedrock dips down below sea level and the outcrops are of Older Basalt. The foundations for the Batman Exchange in Flinders Lane between Market St and Queen St, Melbourne, show Older Basalt resting on Silurian siltstones (observed by E. F. Halkyard). About 45 chains W. of this point, the foundations of the Lonsdale St destructor near Spencer St showed clay and sand with lenticles of gravel underlying Older Basalt. These sediments were near the shore of the lake or swamp in which the clays and lignitiferous sediments were laid down. These sediments must have been horizontal or almost so when deposited, but they are now tilted towards the S. The base of the basalt at the destructor near Spencer St is from low tide level to about 10 ft below it, while on Coode Island it is in excess of 130 ft as shown by M.H.T. Bore 17. The declivity is of the order of 32 ft per mile. The warped terrain (see Fig. 3) is the pre-Older Basalt one that forms the Nillumbik Peneplain further E., as is shown on a cross-section from Melbourne to Lilydale (Gill 1949, Fig. 3).

The increase in thickness of the Oligocene non-marine sediments to the SW., the interbedding of basalt flows in them, and the encroachment of the Miocene sea over them, suggests that the majority of the movements concerned was in those geological periods. Evidence is available of movement also during the Kosciusko Period (mainly Upper Pliocene to Pleistocene), e.g. the oxidized Pliocene sediments underlying the basalts of the Keilor and Werribee Plains are flexed far below sea level.

Maribyrnong River Valley

Keble and Macpherson (1946) claimed two warps across the Maribyrnong R. valley that are called the Keilor Warp and the Footscray Warp. That this country has been warped as a whole towards Port Phillip Bay is patent, but the degree to which these local warps are real is uncertain for the following reasons. The Keilor Warp coincides with an Older Basalt valley that runs approximately E.-W. across the path of the river. Over this basalt is Newer Basalt, so that there is a strong barrier to the river's progress. Thus there is a narrow water gap at Keilor with a very wide valley upstream from it and rapids below it. In Tertiary time the Older Basalt bar apparently caused a similar change in declivity. It is therefore possible that the change in declivity noted by the above authors is due to the basalt bar and not to a warp.

Similarly, the Footscray Warp happens to be in an area complicated by older valleys infilled with basalt. In the Standard Quarries excavation at Footscray, Newer Basalt rests almost directly on the sloping surface (presumably the wall of a valley) of the Older Basalt. On Steele Creek at Niddrie, Fowler's Quarry shows a deep Pleistocene valley infilled with flows of basalt. This same valley can be observed at Braybrook where it causes a large loop in the Maribyrnong R., and the Newer Basalt descends below sea level. Green and Irving (1958) show that the basalt in this valley has different palaeomagnetic characters from the surrounding basalts. In view of this complexity of the geology which was unrecognized at the time, the Keilor and Footscray Warps cannot yet be accepted as proved. In any case, the movement would be downwards and so tending to negate any eustatic emergence.

Conclusion

In the Port Phillip Sunkland no evidence has yet been found of measurable post-Sangamon movements affecting the Yarra Delta. If any have taken place, it may be expected that they were downwards in keeping with the sunkland pattern. The emerged marine shellbeds are therefore considered to be chiefly at least eustatic in origin; tectonic movements alone cannot explain them.

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Mackay, R. R., FInstREAust FAIM, Royal Melbourne Institute of Technology, Latrobe St, Melbourne, C1 1958
Macpherson, J. Hope, MSc, National Museum of Victoria, Russell St, Melbourne, C1 .. 1940
Manning, Mrs. J. M., PhC MPS, 15 Riversdale Ct, Hawthorn, E2 1960
Manning, N. C., BSc PhC FPS, Flinders Street Railway Station, Melbourne, C1 1960
Martin, M. J., 5 Cooba St, Canterbury, E7 1957
Martin, Sir Leslie H., CBE, PhD *Cantab.*, FRS FAA FInstP, Walpole St, Kew, E4 .. 1959
Massola, A., FRAS, National Museum of Victoria, Russell St, Melbourne, C1 1956
Matheson, J. A. L., MBE, MSc PhD, MICE MIStructE, Monash University, Clayton .. 1960
Mathews, A. G., BSc, 'Booligal', Boundary Rd, Braeside, S12 1961
Matthaei, E., Microscopy Laboratory, University, Parkville, N2 1959
McAndrew, J., BSc PhD, C.S.I.R.O. Mineragraphic Investigations, University, Parkville, N2 1953
McCausland, M. E. R., 15 Millicent St, Toorak, SE2 1953
McEvey, A. R., BA, National Museum of Victoria, Russell St, Melbourne, C1 1959
McLaren, A. C., BSc PhD *Cantab.*, 29 Loch St, Camberwell, E6 1960
McLennan, I. M., CBE, BEE, c/o Broken Hill Pty Ltd, 500 Bourke St, Melbourne, C1 .. 1960
McLister, H. D., 2 Lucan St, Caulfield, SE8 1959
McNally, I., BSc, 3 Arcadia St, Box Hill, E11 1950
Miller, L. F., 'Moonga', Power Av., Malvern, SE4 1920
Millikan, C. R., DSc, Plant Research Laboratory, Swan St, Burnley, E1 1941
Milne, Angela A., BSc PhD, 570A Inkerman Rd, N. Caulfield, SE7 1957
Mitchell, A. W. L., BSc, 'Willowmede', Taggerty 1946
Mitchell, L. J. C., MD, 23 Grange Rd, Toorak, SE2 1954
Montgomery, J. N., c/o Australasian Petroleum Co., 37 Queen St, Melbourne, C1 1945
Moore, K. B., 11 Mona Pl., S. Yarra, SE1 1945
Morgan, D. G., BSc DipEd, Secondary Teachers' College, University, Parkville, N2 .. 1959
Morgan, W. G., BCE, 18 Nan St, Box Hill, E11 1961
Morrison, J. D., PhD DSc, C.S.I.R.O. Division of Chemical Physics, Box 4331, G.P.O., Melbourne, C1 1958
Mulvaney, D. J., MA, History Dept, University, Parkville, N2 1957
Mushin, Mrs Rose, MSc PhD, Bacteriology Dept, University, Parkville, N2 1942
Neboiss, A., MSc, National Museum of Victoria, Russell St, Melbourne, C1 1957
Nielsen, Miss B. J., MSc, 45 Summerhill Rd, Glen Iris, SE6 1954
Nye, E. E., BSc, College of Pharmacy, 38 Royal Pde, Parkville, N2 1932
Olsen, C. O., BA DipEd, Federation Military College, Port Dickson, Malaya 1945
Orr, R. G., MA BCh, 9 Heyington Pl., Toorak, SE2 1935
Osborne, A. G. A., BAgrSc, 'Lowestoft', Warrandyte 1957
Osborne, N. A., 53 Flemington Rd, N. Melbourne, N1 1930
Parker, C. D., BSc DipBact *Lond.*, FRACS, 47 Outlook Dr., Eaglemont, N22 1957
Parry, R. H. G., BCE MESc PhD, C.S.I.R.O. Soil Mechanics Section, Coleman Pd., Syndal 1959
Perdrix, J. L., 43 William St, Box Hill, E11 1961
Pescott, R. T. M., MAgrSc, FRES MIBiol, Royal Botanic Gardens, S. Yarra, SE1 .. 1944
Peterson, G. T., PhC FPS, 'Carinya', E. Boundary Rd, E. Bentleigh, SE15 1958
Philip, G. M., MSc, Sedgwick Museum, Cambridge, England 1955

Potter, W. I., BEc, 30 Sargood St, Toorak, SE2 1957
Preston, H. E., 47 Haig St, Box Hill, SE11 1949
Purnell, Miss H. M., MSc, Botany Dept, University, Parkville, N2 1957
Purnell, W. E., FRACI, 30 Currajong Av., Camberwell, E6 1960
Radford, W. C., MBE, MA MEd PhD, 236 Belmore Rd, Balwyn, E8 1958
Rayner, J. M., BSc, FInstP, 5 Tennyson Cr., Forrest, Canberra, A.C.T. 1957
Read, T. A., FSTC FRACI MAusIMM, 15 Chatfield Av., Balwyn, E8 1960
Rees, A. L. G., DSc PhD, C.S.I.R.O. Division of Chemical Physics, Box 4331, G.P.O., Melbourne, C1 1956
Reid, J. T., 'Sherwood', 3 Tregarron Av., Kew, E4 1954
Resch, C. E., BSc PhD, 16 Bouverie St, Carlton, N3 1957
Richardson, Mrs J. R., MA PhD, Zoology Dept, University, Parkville, N2 1958
Rigby, J. F., 5 Banool St, Keiraville, N.S.W. 1953
Rowney, G., BSc, 4 Riddle St, Bentleigh, SE14 1952
Sauve, N. B., 7 Mervyn Cr., Ivanhoe, N21 1955
Sayce, E. L., BSc, FInstP, 16 Maleela Av., Balwyn, E8 1924
Scott, A. R., BE, AMIE, 10 Verdant Av., Toorak, SE2 1958
Seeger, R. C., 56 Jenkins St, Northcote, N16 1946
Selby, B. A., BSc, ARACI, 19 Chesterfield Av., Malvern, SE4 1958
Simpson, H. P., 8 Knutsford St, Balwyn, E8 1948
Sinclair, A. Q., c/o Commonwealth Fertilisers and Chemicals Ltd, 65 William St, Melbourne, C1 1959
Skinner, G., LLB, 111 Charles St, Prahran, S1 1960
Slack-Smith, R. J., BSc, Alice St, Sassafras 1960
Smith, L. H., MSc DPhil, FRACI, 36 Duke St, Kew, E4 1958
Somerset, H. B., MSc, MAIMM, c/o A.P.P.M. Ltd, 360 Collins St, Melbourne, C1 .. 1957
Spicer, P. O., 13 Riverside Av., N. Balwyn, E9 1946
Styles, D. F., BSc, AMIE *Aust.*, 14 John St, Blackburn 1958
Sullivan, W., 37 Strathallan Rd, Macleod 1943
Sutton, P. R. N., DDSc, LDS, 24 Wellington St, Brighton, S5 1959
Tattam, Assoc. Prof. C. M., PhD DSc, Geology Dept, University, Parkville, N2 1945
den Tex, Prof. E., PhD *Leyden*, State University, Leyden, Netherlands 1952
Ternouth, S. T., BSc DipEd, 50 Hatfield St, N. Balwyn, E9 1957
Thomas, D. E., DSc, Mines Dept, Melbourne, C2 1929
Thomas, F. J. D., BSc (Hons), ARCS, I.C.I.A.N.Z. Biological Research Station, Croydon 1955
Thompson, G. D., AMIE *Aust.* HonMIBF *Lond.*, Royal Melbourne Institute of Technology, Latrobe St, Melbourne, C1 1959
Thompson, G. T., 43 Weybridge St, Surrey Hills, E10 1953
Thomson, D., DSc PhD DipAnthrop, Anthropology Dept, University, Parkville, N2 .. 1958
Thomson, J. A., MSc, Zoology Dept, University, Parkville, N2 1958
Thorn, W., MEE MIE *Aust.*, 132 Canterbury Rd, Canterbury, E7 1958
Thrower, L. B., MSc, 23 Laver St, Kew, E4 1961
Timcke, E. W., 15 Faircroft Av., Glen Iris, SE6 1950
Tindale, B., FRMS, Yarra Junction 1951
Townsend, Prof. S. L., MD MS, FRCS *Edin.*, Obstetrics and Gynaecology Dept, University, Parkville, N2 1951
Tuedehope, N. A., BSc, 22 St James Av., Mont Albert, E10 1960
Turner, Prof. J. S., MA PhD MSc, FAA, University, Parkville, N2 1938
Tylee, A. N., Jindivick North 1951
Vale, W. H., 11 Edgar St, Brighton, S5 1961
Wadham, Prof. Sir Samuel M., MA LLD AgrDip, 220 Park St W., W. Brunswick, N12 1932
Wakefield, N. A., BSc, 30 Douglas St, Noble Park 1961
Weickhardt, L. W., MSc, FRACI, 125 Canterbury Rd, Canterbury, E7 1959
Wettenhall, H. N. B., MD BS, MRCP FRACP, 41 Spring St, Melbourne, C1 1959
White, Sir A. E. Rowden, CMG, MD, FRACP, 14 Parliament Pl., Melbourne, C2 .. 1938
White, Prof. M. J. D., DSc *Lond.*, FRS FAA, Zoology Dept, University, Parkville, N2 1958
White, R. K., FIPAA, 360 Collins St, Melbourne, C1 1958
Whiting, R. G., BME, 7 Barkly Ter., Mitcham 1959
Wickens, T. W., 27 Narrak Rd, Balwyn, E8 1957
Wilcock, A. A., BSc BEd, Geography Dept, University, Parkville, N2 1934
Willis, A. G., MSc, Zoology Dept, University, Parkville, N2 1949

Wiltshire, A. R. L., CMG DSO MC VD, 35 Evans Ct, Toorak, SE2 1955
Wishart, R. M., MB ChB *N.Z.*, FRACS, Flat 12, 7 College Pd., Kew, E4 1958
Woodburn, J. L. F., BA, Flat 2, 9 Corsewall Close, Hawthorn, E2 1958
Worcester, R. G., MD DGO, FRCS FRACS FRCOG, 106 North Rd, Brighton, S5 .. 1958

Country Members

Adams, H. G. C., 'Danedite', Weerite 1945
Baldwin, J. G., BSc BAgrSc, 33 Walnut Av., Mildura 1949
Bishop, J. J., BA, High School, Queenscliff 1950
Burn, R., 34 Autumn St, Geelong W. 1956
Casey, Mrs D. A., 'Murraba', Coldstream 1953
Condon, M. A., MSc, Bureau of Mineral Resources, Canberra, A.C.T. 1937
Conley, W. R., High School, Heathcote 1956
Corney, Mrs A. D., BSc, 17 Ratho St, New Town, T. 1945
Dawes, L. F., BSc, 43 Hopetoun Gr., Ivanhoe, N21 1954
Dickins, J. MacG., BSc, Bureau of Mineral Resources, Canberra, A.C.T. 1952
Forrest, J. M., Metropolitan Farm, P.O., Werribee 1954
Glaessner, M. F., PhD DSc, FAA, Geology Dept, University of Adelaide, S.A. 1939
Hill, Prof. Dorothy, DSc PhD, FAA, Geology Dept, University of Queensland, St Lucia, Q. 1939
Hope, G. B., BME, 'Carrical', Hermitage Rd, Newtown, Geelong 1918
Howe, Mrs A. W., BSc, 18 Devoncourt St, South End, Mt Isa, Q. 1948
Kershaw, R. C., BSc, 'Manorama', c/o Lyetta P.O., W. Tamar, T. 1956
Lindholm, J. D. E., c/o High School, Shepparton 1952
McWhae, Mrs J. R. H., MSc, 262 St Georges Ter., Perth, W.A. 1948
Mack, G., BSc, Queensland Museum, Brisbane, Q. 1943
Massey, C. H., 11 Church St, Ashfield, N.S.W. 1957
Merigan, Janice E., BSc, 2 Minawa St, Cooma N., N.S.W. 1957
Murphy, H. D., Mornington 1950
Netherway, G. C., 606 Dana St, Ballarat 1958
Payne, T. E. N., 'Woodburn', Kilmore 1945
Schleiger, N. W., BSc BEd, 6 Tehan St, Seymour 1949
Searle, S. S., Metropolitan Farm, P.O., Werribee 1954
Thomas, G. A., BSc, 39 Duffy St, Ainslie, A.C.T. 1944
Trebilcock, Lieut-Colonel R. E., MC, Wellington St, Kerang 1921
Yates, H., MSc, School of Mines, Ballarat 1943

Associates

Autry, W. C., BSc, Senior Mess, Woomera, S.A. 1957
Bage, Miss F., OBE, MSc, Grove Cr., Toowong, Brisbane, SW1, Q. 1906
Baker, A. A., 53 Carlisle St, Preston, N18 1946
Bartlett, A. H., 38 Kent Av., Croydon 1952
Bell, G., BSc, 13 Kent Rd, Surrey Hills, E10 1955
Bock, P. E., BSc, 78 Hickford St, Reservoir, N19 1957
Bollen, P. W., BSc, 60 Mann Ter., N. Adelaide, S.A. 1957
Bowler, J. M., BSc (Hons), Geology Dept, University, Parkville, N2 1960
Brunn, Mrs. T. H., 605 Malvern Rd, Toorak, SE2 1960
Burns, D., 11 Robertson St, Colac 1960
Butler, L. S. G., 3 Los Angeles Ct, St Kilda, S2 1929
Buttery, S. H., 146 Highfield Rd, Camberwell, E6 1952
Carr, Mrs D. J., MSc, Queen's University, Belfast, N. Ireland 1937
Carter, A. N., MSc PhD, Mining Dept (Geology), University of N.S.W., Kensington, N.S.W. 1947
Clarke, W. G., BSc DipEd, 67 Willis St, Hampton, S7 1957
Clifford, H. T., MSc PhD, Botany Dept, University of Queensland, St Lucia, Q. 1949
Coats, R. P., BSc, South Australian Dept of Mines, 169 Rundle St, Adelaide, S.A. .. 1951
Cobbett, A. M., Oxford Close, Moorabbin, S20 1951
Cochrane, G. W., MSc, Sura Dungun, Trengganu, Malaya 1945
Cormack, M. G., 168 Mica St, Broken Hill, N.S.W. 1960
Court, A. B., MSc, National Herbarium, Royal Botanic Gardens, S. Yarra, SE1 1949
Dempster, Miss P. B., BSc, c/o 751 Canterbury Rd, Surrey Hills, E10 1957
Douglas, J. G., BSc, 76 Sunhill Rd, Mt Waverley 1957

Ducker, Mrs S. C., 36 Percy St, Balwyn, E8	..	1959
Elford, F. G., BSc BEd, 76 New St, Brighton, S5	..	1929
English, J. R., 302 Lower Heidelberg Rd, E. Ivanhoe, N21	..	1956
Esplan, W. A., BSc, 37 Barnes Av., Burwood, E13	..	1951
Finlay, Miss C. F., BSc, Geology Dept, University, Parkville, N2	..	1950
Fisher, Eileen E., PhD, 1 Balwyn Rd, Canterbury, E7	..	1949
Frostick, A. C., 9 Pentland St, N. Williamstown, W16	..	1933
Gale, J. C., 154 Mont Albert Rd, Canterbury, E7	..	1959
Hewett, D. C., BSc DipEd, 77 Agg St, Newport, W15	..	1959
Holdaway, E. A., BSc, 3 Patricia St, Box Hill, E11	..	1957
Hounslow, A. W., BSc, 28 Georgiana St, Sandringham, S8	..	1958
Johns, M. W., BSc, 355 Upper Heidelberg Rd, Ivanhoe, N21	..	1958
Jones, D. S., BSc, 31 Winmalee Rd, Balwyn, E8	..	1952
Kenley, P. R., BSc, Flat 3, 'Warleigh Court', 26 Warleigh Gr., Brighton, S5	..	1948
Lawrence, C. R., BSc, 3 Wright St, Bentleigh, SE14	..	1958
Learmonth, A. P., BSc, 12 Cornwall Rd, Sunshine, W20	..	1955
Learmonth, J. C., Flat 4, 117 Caroline St, S. Yarra, SE1	..	1959
Lord, E. E., G.P.O. Box 5278, Melbourne, C1	..	1950
McLennan, Assoc. Prof. Ethel, DSc, Botany Dept, University, Parkville, N2	..	1915
Marsden, M. A. H., 17 Oak St, Beaumaris, S10	..	1952
Matthaei, Mrs G., 146 Gatehouse St, Parkville, N2	..	1959
Mitchell, S. R., 22 Grosvenor St, Abbotsford, N9	..	1945
Moir, Mrs Marion M., MA DipEd, 434 Elgar Rd, Box Hill, E11	..	1960
Moore, B. R., BSc, Peter St, Eltham	..	1957
Morris, P. F., 6 Mandeville Cr., Toorak, SE2	..	1921
Murray, J. S., BScFor, DipFor *Cres.*, AMIFA, 11 Ocean St, Hampton, S7	..	1960
Neales, T. F., PhD, Botany Dept, University, Parkville, N2	..	1957
Neilson, J. L., 1 Fordham Av., Camberwell, E6	..	1952
Nicholas, T., Bureau of Mineral Resources, Canberra, A.C.T.	..	1958
Passioura, J. B., Agriculture Dept, University, Parkville, N2	..	1961
Philip, Mrs G. M., BSc, Sedgwick Museum, Cambridge, England	..	1957
Pinches, Mrs M., 140 Churchill Highway, Braybrook, W19	..	1943
Pretty, R. B., MSc, Private Bag, Cobargo, N.S.W.	..	1922
Rash, K. E., 75 Humffray St, S. Ballarat	..	1960
Rawlins, R. J., BSc, Elphinstone	..	1957
Reed, K. J., 5 Premier Av., Mitcham	..	1958
Rimington, K. N., BSc, 15 Yuille St, Brighton, S5	..	1948
Shaw, H., 18 Normanby Rd, E. Bentleigh, SE15	..	1956
Sherrard, Mrs H. M., MSc, 43 Robertson Rd, Centennial Park, N.S.W.	..	1918
Simpson, B., 3 Knutford St, Balwyn, E8	..	1959
Singleton, O. P., MSc PhD, Geology Dept, University, Parkville, N2	..	1943
Sinnott, P. J., C.S.I.R.O. Mineragraphic Investigations, University, Parkville, N2	..	1959
Stewart, A. J., BSc, Geology Dept, University, Parkville, N2	..	1961
Stubbs, D., 2 Coleridge St, Elwood, S3	..	1960
Talent, J. A., MSc PhD, Mines Dept, E. Melbourne, C2	..	1955
Vasey, G. H., BCE, University, Parkville, N2	..	1936
Walker, A. L., 1 East St, Northcote, N16	..	1961
Watts, H. A., 15 Tower Hill Rd, Glen Iris, SE6	..	1954
White, O. L., BSc, Dept of Civil Engineering, University of Waterloo, Waterloo, Ontario, Canada	..	1955
Whitehead, Mrs R., 45 Whitehead St, Whyalla, S.A.	..	1942
Wilkins, R. W. T., BSc, Geology Dept, University, Parkville, N2	..	1961
Wymond, A. P., MSc, C.S.I.R.O. Division of Forest Products, P.O. Box 18, S. Melbourne, SC4	..	1951

Royal Society of Victoria

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1960

The President and Council present to members of the Society the Annual Report and Financial Statement for the year 1960.

The following meetings of the Society were held:

March 10—Annual Meeting. The following office-bearers were elected: *President,* Associate Professor G. W. Leeper; *Vice-Presidents,* Mr R. T. M. Pescott, Dr R. R. Garran; *Honorary Treasurer,* Mr L. Adams; *Honorary Secretary,* Mr E. D. Gill; *Members of Council,* Mr J. H. Chinner, Dr C. M. Focken, Professor E. S. Hills, Dr F. L. Stillwell, Dr D. E. Thomas and Mr A. G. Willis.

The following *Members of Council* continued in office: Mr V. G. Anderson, Mr W. Baragwanath, Mr D. A. Casey, Captain J. K. Davis, Professor J. S. Turner and Professor Sir Samuel Wadham.

The Annual Report and Financial Statement for 1959 was received and adopted. At the close of the Annual Meeting an Ordinary Meeting was held. Research Papers (previously read by title): 'Archaeological Excavations at Fromm's Landing on the Lower Murray' by Mr D. J. Mulvaney; 'On the West Australian Kodja Axe' by Mr A. Massola; 'The Tawonga Fault' by Mr F. C. Beavis; and 'The Lismore Meteoritic Iron' by Dr A. B. Edwards.

April 14—Lecture: 'Bridging the Gap Between Race and Species' by Professor Theodosius Dobzhansky.

May 12—Forum: 'Science and the Humanities'. Speakers: Dr A. L. Matheson, Professor R. M. Crawford, Mr R. W. T. Cowan, and Professor R. D. Brown.

June 9—Symposium: 'Science and Raw Materials'. Speakers: Dr H. G. Raggatt, Mr J. Richards, and Dr R. R. Garran.

July 14—Research Papers:

- 'Modification of Subantarctic Flora on Macquarie Island by Sea Birds and Sea Elephants' by Dr Mary Gillham.
- 'Plants and Seabirds of Granite Islands in South East Victoria' by Dr Mary Gillham.
- 'Old and New Storm Petrel Rookeries in South East Victoria' by Dr Mary Gillham and Mr J. A. Thomson.
- 'A Technique for Sandison-Clark Ear Chambers: Manufacture, Assembly and Photomicrography' by Dr I. K. Buckley.
- 'New Rototaria (Rotifers) from Victoria' by Mr B. Berzius.
- 'Upper Cretaceous Microplankton from Belfast No. 4 Bore SW Victoria' by Dr Isabel C. Cookson and Professor A. Eisenack.
- 'A Complete Oval Australite' and 'Opal Phytoliths in Residue from Rain' by Dr G. Baker.
- 'Mylonites from the Upper Kiewa Valley' by Mr F. C. Beavis.
- 'Diagenesis of the Wahgi Valley Sequence, New Guinea' by Dr K. A. W. Crook.

August 11—Lecture: 'The Burke and Wills Expedition and the Royal Society of Victoria' by Associate Professor K. Fitzpatrick.

August 20—Ceremony at statue of Burke and Wills.

September 8—Lecture: 'Current Research Problems in Forestry' by Mr J. H. Chinner.

October 13—Presidential Address: 'Arguments about Classification, with Some Reference to Soils' by Associate Professor G. W. Leeper.

November 10—Burke and Wills Centenary Soirée. Reception and exhibits of historical interest. Mr C. W. Brazenor and Mr J. H. Willis described the fauna and flora which were encountered or collected by the expedition; Mr F. J. Kendall gave an account of the instruments and weapons used by the explorers.

December 8—Lecture: 'Archaeological Excavation in Australia' by Mr D. J. Mulvaney.

During December 1959 and January 1960 a Darwin Centenary Exhibition was held in the Palmer Hall, Public Library of Victoria, in co-operation with the University of Melbourne, the Public Library of Victoria, the National Museum of Victoria, the Museum of Applied Science, and the National Herbarium.

The Society wishes to record its thanks to the Specialty Press for the excellent coloured frontispiece to volume 73 of the *Proceedings*, which was a special number containing a history of the Society and other papers having reference to its centenary.

The number of members at 31 December 1960 was: Honorary Members 2, Life Members 16, Members 253, Country Members 28, Associate Members 78, making a total of 377. During the year 2,663 volumes and parts were added to the library.

Attendances at Council meetings were: Adams 3, Anderson 9, Baragwanath 9, Chinner 6, Davis 2, Focken 7, Garran 8, Gill 6, Hills 1, Leeper 4, Pescott 6, Stillwell 9, Tattam 9, Thomas 3, Turner 1, Willis 2. For the first eight months of 1960, in the absence of the President overseas, Mr R. T. M. Pescott was Acting President. During the illness of the Honorary Secretary Dr J. D. Morrison was Acting Honorary Secretary.

The Society deeply regrets the loss during the year of four members:

CHARLES ERNEST WILLIAM BRYANT was born at North Fitzroy, Victoria, and died on 27 October 1960, aged 56 years. In business life he was a partner in the legal firm of Moule, Hamilton and Derham, Melbourne, having been admitted to the Victorian bar in 1929. He achieved historical distinction in Australian ornithology by serving as Honorary Editor of *The Emu*, the journal of the Royal Australasian Ornithologists Union, for an unbroken period of thirty-one years. He contributed a large number of ornithological papers and notes to *The Emu, The Victorian Naturalist* and other publications. He was a member of the Checklist Committee (R.A.O.U.), had served the Union as President, and gave it distinguished service in legal and other capacities. He was also an Honorary Associate in Ornithology at the National Museum of Victoria, a Corresponding Fellow of the American Ornithologists Union, a Corresponding Member of the British Ornithologists Union and a Trustee of the M. A. Ingram Trust. He was elected a member in 1958.

JOHN THOMAS JUTSON, LLB DSc, was born in Melbourne in 1874. While a clerk in a legal firm, he studied geology at the Working Men's College, presenting his first paper to the Society in 1908. In 1909-10 he was a Research Scholar in

Geology at the University of Melbourne, and from 1911-18 was with the Geological Survey of Western Australia. He reported on mining centres in the North Coolgardie goldfield. In his scanty leisure he prepared the first edition of his *Physiography of Western Australia*, published in 1916. He graduated BSc in 1920 at the University of W.A. With no prospect of employment as a geologist, he returned to Melbourne and to the legal profession. He obtained his law degree at the University of Melbourne in 1925, and remained in legal practice until his retirement in 1952. Retaining his interest in geology, he revised the *Physiography of W.A.* (1934), and prepared a series of papers mostly on shore platforms. In 1937 he was awarded the Clarke Memorial Medal of the Royal Society of N.S.W., and gained his DSc at the University of W.A. in 1942. He contributed 24 papers to the *Proceedings* of this Society. He was elected as Associate in 1902, a Member in 1921, and a Life Member in 1958. He died on 14 November 1959.

Austin Burton Edwards, PhD DSc, was born in Melbourne in 1909 and educated at Caulfield Grammar School and the University of Melbourne, where he graduated BSc with first class honours in geology, and the Howitt and Bartlett scholarships. His geological studies in the Healesville and Warburton districts won him an 1851 Exhibition. His work at the Imperial College of Science led to a PhD degree in 1934. Returning to Australia, he joined the Mineragraphic Section of C.S.I.R.O. where he remained for the rest of his life, becoming officer-in-charge in 1953. His studies of Australian ores and ore deposits were supplemented by work on mill and smelter products, and led to the recognition of the oolitic iron ores of the Northern Territory and Constance Range, Queensland. He became an authority on brown coals, and acted as consultant to the State Electricity Commission of Victoria. He also made contributions to sedimentary petrology, geochemistry, geomorphology and meteorites. He was sole or joint author of 128 papers, including 30 contributed to the *Proceedings* of this Society. In 1937 he shared the David Syme Research Prize and in 1942 gained his DSc. His book *Textures of the Ore Minerals* was published in 1947. He edited and contributed to the volume of the geology of Australian ore deposits published for the Fifth Empire Mining and Metallurgical Congress in 1953. In 1960 he was awarded the Clarke Memorial Medal of the Royal Society of N.S.W. During a visit to Europe, he collapsed and died in Rome on 8 October 1960.

George Richard Nicholas was born at Majorca, near Maryborough, Victoria, and died in Melbourne on 20 September 1960, aged 76. He began his career as a pharmaceutical chemist in Melbourne in 1913. In 1915, while conducting a small pharmacy at St. Kilda junction, he began manufacturing aspirin. At that time its manufacture was covered by a German patent, and as a consequence all supplies were cut off from the Allies. Mr Nicholas received the sole manufacturing rights in Australia. On this foundation, he built the large company of Nicholas Pty Ltd, manufacturers of pharmaceutical and veterinary products. He gave generously to religious and educational institutions. He was elected a member in 1934.

FINANCIAL STATEMENT

The balance at the bank was lower at the end of the year than at the beginning of the year, but it could be pointed out that the Centenary Symposium and all expenses connected with it were dealt with during that period. Rents and sales of publications were down considerably, but refunds were higher which offset this to some extent.

The Society expresses its appreciation to the State Government for its Grant of £500, and also to the University of Melbourne for its assistance in the publication of papers.

SUMMARY FOR THE YEAR ENDING 31 DECEMBER 1960

Total Receipts	£3,395	10	6
Balance from 1959	1,200	6	5
	£4,595	16	11
Expenditure	3,987	9	2
Balance at Bank 31/12/60	£608	7	9

INVESTMENTS HELD AS AT 31 DECEMBER 1960

Australian Guarantee Corporation Limited—7% Debenture Stock	£1,000	0	0
Australian Aluminium Company Limited—7% Debenture Stock	800	0	0
	£1,800	0	0

FINANCIAL STATEMENT FOR YEAR ENDING 31 DECEMBER 1960

RECEIPTS

Balance at Bank 1/1/60		£1,200 6 5
Subscriptions		866 19 7
Rents		694 17 0
Sale of Publications		244 10 2
Interest		411 16 1
Grants and Donations—		
The Government of Victoria	£500 0 0	
University of Melbourne	60 0 0	
		560 0 0
Refunds—		
Hallkeeping	£84 10 6	
Electricity	27 4 0	
Telephone	34 15 8	
R.C.O.G.	365 6 7	
Sundries	6 4 0	
		518 0 9
Centenary Charges and Contributions		99 6 11
		£4,595 16 11

EXPENDITURE

Salaries—		
Assistant Editor	£31 10 0	
Assistant Librarian	275 3 8	
Clerical	37 13 2	
Hallkeeping	337 4 1	
		£681 10 11
Printing Proceedings 72 (1-2)		1,128 6 1
Stationery		65 3 2
Telephone		63 5 0
Rates		27 16 3
Electricity		275 17 7
Repairs and Maintenance		1,060 7 6
Sundry Purchases—		
Journals	£36 1 9	
Insurance	57 14 4	
Legal Charges	8 8 0	
Burke and Wills Centenary	48 8 7	
		150 12 8
Postage		71 12 10
Centenary Symposium		462 17 2
Balance at Bank 31/12/60		608 7 9
		£4,595 16 11

LIONEL ADAMS, *Hon. Treasurer*

Audited and found correct.
15 February 1961

T. M. CHERRY } *Hon.*
R. R. GARRAN } *Auditors*

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