PRESIDENTIAL ADDRESS

By A. B. Walkom, D.Sc.

Delivered to the Royal Society of New South Wales, April 5, 1944.

Part I. THE PAST YEAR.

In the fifth year of the second World War within the memory of most of us, our scientific societies are still able to carry on their activities. In this we are fortunate, for in many countries academic life and scientific research have been partly or completely disrupted. We should therefore take advantage of our favoured position not only to continue our normal activities as far as conditions permit, but to prepare ourselves to take part in post-war restoration in our own country and to assist in the rehabilitation of scientific activities in countries which have not been so fortunate.

Owing to the fact that more and more scientific workers are becoming absorbed in war-time activities, the number of research papers presented is smaller than usual, namely eighteen ; the number of members of the Society shows a slight decrease and now stands at two hundred and eighty-seven.

The presentation of papers at monthly meetings during the year was supplemented by several talks and exhibits, some on recent scientific discoveries. The talks were :

" Penicillin and Gramicidin ", by Dr. F. Lions.
" Biotin ", by Professor H. Priestley.
" Reflection of Light from Film-covered Glass ", by Mr. J. Bannon.
" Evaporated Metal Films ", by Mr. F. P. J. Dwyer.
" The Future of the Native People of the South-west Pacific ", by Professor A. P. Elkin.

The Fluorescent Lamp—a new source of light—was the subject of an exhibit by Mr. D. P. Mellor.

As the lighting restrictions were relaxed during 1943, the Popular Science Lectures were resumed and on the whole were well attended.

Dr. H. G. Raggatt, formerly of the Geological Survey of New South Wales, and now Director of the Commonwealth Mineral Resources Survey, was invited to deliver the Clarke Memorial Lecture for 1943, and chose as his subject " Australia's Mineral Industry in the Present War ".

Dr. W. L. Waterhouse was awarded the Clarke Memorial Medal for 1943 for his work in plant pathology and especially for his studies on varieties of wheat resistant to disease. For 1944, your Council has decided to award the Clarke Memorial Medal to Professor W. E. Agar, of the University of Melbourne.

The Society's Medal was awarded to Mr. Edwin Cheel for his work on Australian botany and his contributions to the advancement of science.

Important events commemorated at meetings of the Society included the bi-centenary of the birth of Sir Joseph Banks, and the 400th anniversary of the publication by Copernicus of his work " De Revolutionibus Orbium Coelestium ", and the publication in the same year by Vesalius of " De Humani Corporis Fabrica ".

Our sister society the Royal Society of Tasmania celebrated its centenary in October, 1943, and a message of congratulation was sent by the Royal Society of New South Wales on this historic occasion.

We again acknowledge with thanks the grant from the Government of New South Wales of £400, which goes towards the publication of the Journal and Proceedings.

Consideration was given during the year to the further encouragement of research by the provision of research grants, and the Council decided to set aside a portion of our funds as a research fund, the interest on which may be used for this purpose.

Mr. Henry F. Halloran, who has been a member of the Society for more than fifty years, offered to donate funds for the institution of two medals, an offer which the Council gratefully accepted. One medal, to be known as the James Cook Medal, is to be awarded for scientific work in the southern hemisphere ; the other, the Edgeworth David Medal, is for the encouragement of the younger members of the Society and will be awarded for outstanding research by members who have not attained the age of thirty-five years.

During the year, as your President, I attended several meetings of the Board of Visitors of the Sydney Observatory, and one meeting of the Donovan Trust. One of the meetings of the Board of Visitors was called specially to discuss the position of Government Astronomer, and I am pleased to be able to report that the recommendation made by the Board, that Mr. H. W. Wood, who had been Acting Government Astronomer, be appointed to the position, was followed in due course by the announcement that Mr. Wood had been so appointed. We offer him our congratulations and best wishes in his work.

As the Honorary Treasurer has told you, the financial position of the Society is satisfactory, in spite of the difficult times through which we are passing.

On your behalf, as well as on my own, I take this opportunity of thanking the Honorary Officers for their continued work on behalf of the Society. It is largely owing to the efforts of the Honorary Secretaries, Professor A. P. Elkin and Mr. D. P. Mellor, and the Honorary Treasurer, Mr. A. Clunies Ross, that the work of the Society proceeds so smoothly and so satisfactorily. We also express our appreciation of the work done by the Honorary Librarians, Mr. W. H. Maze and Dr. A. Bolliger, and Mr. H. W. Wood who was appointed Honorary Librarian on the resignation of Mr. Maze.

I regret to record the deaths of the following members during the year ending March 31st, 1944 : John Job Crew Bradfield, Frederick Chapman, Archibald Howie and James Edward Mills.

John Job Crew Bradfield, D.Sc. (Eng.), was born at Sandgate, Queensland, in 1867, and was educated at Ipswich. He gained an Exhibition to the University of Sydney. In 1889 he graduated Bachelor of Engineering with first-class honours and the University Medal, and in 1896 he took the degree of M.E. On graduation in 1889 he was appointed draughtsman under Colonel Stanley, Chief Engineer for Railways, Brisbane. In 1891 he joined the Public Works Department, N.S.W., and was engaged on the design and construction of all classes of engineering works. He was sent abroad by the Government of N.S.W. in 1914 to visit the underground railways and long span bridges in Europe and America, and made a special study of traffic and train operation, and also made passenger traffic surveys of large underground stations throughout the world. In 1912 Dr. Bradfield was appointed Chief Engineer for Sydney Harbour Bridge and City Transit, and his scheme for Sydney's system of underground railways and the Harbour Bridge was adopted by Parliament. The City Railway construction cost more than seven million pounds sterling. In 1922 after preparing plans and specifications for the Sydney Harbour Bridge Dr. Bradfield was sent abroad again, to give information to prospective tenderers.

Dr. Bradfield was for a number of years a Member of the University Senate, also of the Town Planning Institution, of the Australian National Research Council, the Royal Society of N.S.W., the Commonwealth Engineering Standards Advisory Committee, and the Institution of Engineers, Australia. With Professor Warren and Mr. A. E. Cutler he established the Aviation School at Richmond, N.S.W., for the training of pilots during the war of 1914-1918. After the completion of the Sydney Harbour Bridge, on which he was engaged for seven years, Dr. Bradfield spent much of his time in Brisbane, having been appointed Consulting Engineer to the Queensland Bureau of Industry for the design, fabrication and construction of the Story Bridge, which spans the river at Brisbane, and has a total length of 1,463 feet as compared with the Sydney Harbour Bridge of 1,650 feet. He was also intimately concerned with the planning and design of the new University of Queensland. He investigated and strongly advocated a scheme to provide for an inland lake, and so make available enormous areas of otherwise desert country in the centre of Australia, his intention being to divert the flow of certain rivers from the sea to inland areas.

Frederick Chapman, an Honorary Member of the Royal Society of N.S.W. since 1939, was born in London in 1864, and died on December 13th, 1943. He began his scientific career as an assistant to Professor Judd at the Royal College of Science, London. During the period of twenty years that he occupied this post he became an authority on the foraminifera, on which he published a text-book. He was appointed palæontologist to the National Museum, Melbourne, in 1902, and began his long study of the fossils of Australasia. He identified and arranged the palæontological collections of the Museum, and described and figured many rare specimens in papers published in scientific journals. He also published papers on palæobotany. He was appointed palæontologist to the Geological Survey of Victoria and was also part-time lecturer in palæontology at the University of Melbourne. He reported on the foraminifera of the Nimrod, Discovery and Funafuti expeditions. In 1927 he retired from the National Museum, and was engaged by the Commonwealth Government to report on specimens submitted in the search for oil. He retired from this work seven years later.

Chapman held office as president of the Royal Society of Victoria, of the Field Naturalists' Club of Victoria, and of the Microscopical Society of Victoria. He was member for Australia of the International Commission for Zoological Nomenclature. Among honours received by him were the Lyell Medal of the Geological Society of London, the Clarke Memorial Medal, the Australian Natural History Medallion, and the David Syme Prize. He was a tireless worker, and was always ready to help others and to give freely of his knowledge. In 1914 he published the first text-book on Australasian Fossils, and also wrote two popular volumes, "Open-Air Studies in Australia" and "The Book of Fossils". In all he published more than 500 papers on palæontological subjects and many on other subjects, in addition to many popular scientific articles.

Archibald Howie, a prominent Sydney business man, became a member of the Royal Society in 1936. He was Chairman of Directors of Howie, Moffatt and Co., and had held many important offices. He was an alderman of the City of Sydney, and was Lord Mayor in 1936 and 1937. He was president of the Royal Agricultural Society, also of the Sydney Chamber of Commerce, and for five years was president of the Jersey Herd Society, being himself a noted breeder of stock. He was elected to the Legislative Council in 1934, and served until his death. He was appointed Chairman of the Advisory Panel for Defence Works in July, 1939. He became a member of the Senate of the University of Sydney in the same year. Sir Archibald Howie was knighted in 1938.

James Edward Mills, who died very suddenly on May 11th, 1943, was born at Roma, Queensland, in 1905. He received his university education at the University of Queensland, and on completing his course there was awarded an 1851 Exhibition, and went to University College, London, where he took his Ph.D. degree. He returned to Australia, and was appointed to the Chemistry Department in the University of Sydney, retaining this post until his death.

Dr. Mills was particularly interested in spectroscopic research and in gas analysis, and analysed a number of specimens of oil and gas from Queensland bores, which had been put down to find one or other of these products. His spectroscopic work covered both emission and absorption spectra, and he taught the technique of absorption spectra measurement to graduates of Sydney and other Australian universities. During the years which have followed the outbreak of war Dr. Mills worked at the high pressure necessitated by shortage of staff and extra work imposed by the exigencies of war: it has been said of him by one of his colleagues that the idea in his mind was "to do the job, regardless of the consequences", and probably this continuous high pressure activity was in part responsible for his death while still in his prime.

Dr. Mills was Honorary Treasurer of the Australian Chemical Institute, and was a member of the Chemistry Man-power Committee for New South Wales. He also belonged to the Volunteer Defence Corps, and was a past president of the Sydney University Chemical Society and of the Sydney University Science Association.

Part II. THE SUCCESSION OF CARBONIFEROUS AND PERMIAN FLORAS IN AUSTRALIA.

In choosing as the subject of my address "The Succession of Carboniferous and Permian Floras in Australia", I have been prompted by a desire to add some small contribution to a subject which during the past fifteen or twenty years has received much attention from Australian geologists. I have been interested in the Carboniferous-Permian problem for more than thirty years, my first geological fieldwork having been carried out, in collaboration with Dr. W. R. Browne, on rocks of this age in the Pokolbin district. The results of that work were published in this Society's Journal in 1911. In spite of all that has been done, our knowledge of what Mr. E. C. Andrews referred to as the Permian problem in his recent Clarke Memorial Lecture is still far from complete. Until we are able to make a satisfactory correlation of the occurrences of Carboniferous and Permian strata in various parts of the Australian continent, it does not seem possible to determine just how the Australian succession fits in with the accepted succession in other parts of the world. Much remains to be done in the study of the faunas and floras preserved in these rocks, and once these are moderately well known, it remains to explain what may appear to be contradictory conclusions as to age arising from the study of different groups of animals and plants. On the whole, more satisfactory work seems to have been done with the faunas than with the floras. This is perhaps due to the fact that collecting of the faunas has made available more material for study and, perhaps as a consequence, there have been more palæontological workers on the faunas. Collection of the floras has been less concentrated—there has been comparatively little systematic collecting from specific horizons and consequently it is difficult, if not impossible, yet to recognize distinct horizons by the study of the contained fossil plants.

I have therefore chosen to speak in a more general way of the three distinct fossil floras in our Carboniferous-Permian succession, to indicate some of the relations of the elements in these floras with those of other continents, especially the southern continents, and to suggest some of the difficulties still to be surmounted in the exact correlation of the occurrences within Australia.

The three floras mentioned have been referred to respectively as (1) *Lepidodendron Veltheimianum* flora, (2) *Rhacopteris* flora, and (3) *Glossopteris* flora. The *Lepidodendron Veltheimianum* flora and the *Rhacopteris* flora are held to be of Carboniferous age ; the *Glossopteris* flora is generally regarded to be of Permian age though a number of palæobotanists have suggested that it had its beginnings in the later part of the Carboniferous. This group of palæobotanists included the late Sir Albert Seward, Professor B. Sahni and Dr. A. L. du Toit, but I do not think I am alone in believing that a convincing case has not been made out for placing the appearance of the *Glossopteris* flora before the beginning of the Permian.

Professor Sahni, indeed (1926, Chart III) went so far as to place the Lower Marine Series, Lower Coal Measures, and Upper Marine Series of New South Wales all in the Carboniferous, though he placed both Lower Bowen and Upper Bowen Series of Queensland in the Permian.

(1) The Lepidodendron Veltheimianum Flora.

The *Lepidodendron Veltheimianum* flora, the oldest of the three floras, includes the following plants :

Asterocalamites scrobiculatus (Schloth.)
Lepidodendron Veltheimianum Sternberg
Volkmannianum Sternberg
Osbornei Walkom
sp. (Cf. *L. brevifolium*)
sp. (Cf. *L. dichotomum*)
Ulodendron minus Lindley & Hutton
Stigmaria ficoides Brongniart
Clepsydropsis australis Sahni
Aneimites austrina Etheridge
? *Rhacopteris* sp.
Pitys Sussmilchi Walkom

These plants occur in the Upper Burindi and Lower Kuttung Series and their equivalents. They present a complete change from the flora of the Upper Devonian in which the most abundant plant was *Lepidodendron australe*, a species which does not persist into the Carboniferous and which is very distinct from the types of *Lepidodendron* known from the Carboniferous. *Lepidodendron Osbornei* is a type similar to *L. spetsbergense* which is known only from Lower Carboniferous of the northern hemisphere. *Pitys* too is known only from Lower Carboniferous rocks.

Recent examination by S. W. Carey and W. R. Browne (1938) of the relation between the marine Burindi Series and the freshwater Kuttung Series has resulted in the suggestion by these authors that the Lower Kuttung Series is of the same age as the Upper Burindi Series, and they place the age of these two series as Viséan, the upper of the two divisions of the Dinantian, the lowest division of the Carboniferous.

It is perhaps desirable at this point to make some reference to the confusion that may arise from the use of the terms Lower, Middle and Upper Carboniferous, in view of different meanings attached to these terms. The late R. Kidston, in his memoir on the Carboniferous flora of Great Britain, used only the terms Lower and Upper Carboniferous, making the line of division between the two at a floral break in the Millstone Grit.

This is the usual practice in Great Britain, as indicated by Seward (1941, p. 161), from whose table on page 261 it is seen that the European terms Westphalian and Stephanian correspond with the lower and upper portions of the Upper Carboniferous of Britain.

At a congress on Carboniferous Stratigraphy held at Heerlen in 1927 (Congrès pour l'avancement des Etudes de stratigraphie Carbonifère) a fourfold division of the Carboniferous was agreed upon, the system being divided into Dinantien, Namurien, Westphalien and Stephanien. (Heerlen, 1927, p. xliv.)

The Dinantien includes the two divisions Tournaisian and Viséan. Both Dinantien and Namurien would be included in the term Lower Carboniferous as used by Kidston and Seward. It is in this sense that I have used the term in referring to floras as Lower Carboniferous in age.

(2) The Rhacopteris Flora.

More species are known in the *Rhacopteris* flora than in the *Lepidodendron Veltheimianum* flora, but we are still dealing with a flora of the lower part of the Carboniferous and quite distinct from the Upper Carboniferous flora of the northern hemisphere. In these Carboniferous floras we are able to make some more or less direct correlation with the northern floras whereas, later, when we come to the Permian, there are distinct floral provinces with little in common between northern and southern floras.

The *Rhacopteris* flora contains the following species :

Asterocalamites scrobiculatus (Schloth.)
Lepidodendron Veltheimianum Sternberg
Stigmaria ficoides Brongniart
Cyclostigma australis Brongniart
Rhacopteris ovata (McCoy)
  septentrionalis Feistmantel
  Wilkinsoni (Feistmantel)
  Römeri Feistmantel
  intermedia Feistmantel
Cardiopteris cf. *polymorpha* Goeppert
  cf. *frondosa* Goeppert
? Sphenopteridium cuneatum Walkom
Adiantites ? robustus Walkom
? Noeggerathia sp.
Sphenopteris Clarkei Dun
Clepsydropsis australis Sahni
Rhacophyllum diversiforme Etheridge
Trigonocarpus (*?*) *ovoideus* Walkom
  (*?*) *ellipticus* Walkom
Samaropsis (*?*) *ovalis* Walkom
  cf. *barcellosa* White
  Milleri Feistmantel
Carpolithes striatus Walkom
Cordaicarpus (*?*) *ovatus* Walkom
  prolatus Walkom

The predominance of *Rhacopteris* species, associated with *Asterocalamites*, *Lepidodendron*, *Stigmaria* and *Cardiopteris* at once marks this flora as a Lower Carboniferous assemblage of plants.

It contains none of the large group of species belonging to such genera as *Alethopteris*, *Neuropteris* and *Pecopteris* which appeared in the northern hemisphere in the Upper Carboniferous (Westphalian and Stephanian).

The appearance in abundance of a new group of genera including *Rhacopteris*, *Cardiopteris*, *Sphenopteridium*, *Adiantites* and *Noeggerathia* indicates a distinct break between the rocks containing the earlier *Lepidodendron Veltheimianum* flora and those containing the *Rhacopteris* flora.

Of the genera included in this flora *Clepsydropsis*, *Rhacopteris* and *Cardiopteris* do not, according to Seward (1941, pp. 267-269) extend beyond the Lower Carboniferous. Kidston, however, records that one or two species of *Rhacopteris* are represented in the Upper Carboniferous, but in each case only by a single specimen.

(3) The Glossopteris Flora.

The *Glossopteris* flora occurs in abundance throughout Gondwanaland and in Australia the following long list of species is known :

Reinschia australis Bertrand and Renault
Pila australis C. Bertrand
Schizoneura gondwanensis Feistmantel
Phyllotheca australis Brongniart
  robusta Feistmantel
Phyllotheca deliquescens (Goeppert)
  Etheridgei Arber
Annularia australis Feistmantel
  cf. *stellata* Schl. (*? =Lobatannularia sinensis* Halle)
  Ivini Walkom

Sphenophyllum speciosum (Royle)
emarginatum Brong.
Glossopteris Browniana Brongniart
indica Schimper
ampla Dana
angustifolia Brongniart
angustifolia var. *tænio-pteroides* Seward
? orbicularis Feistmantel
tortuosa Zeiller
Jonesi Walkom
decipiens Feistmantel
spathulo-cordata Feistmantel
conspicua Feistmantel
? Mitchelli Walkom
sp. (scale leaves)
Vertebraria indica Royle
Gangamopteris cyclopteroides Feistmantel
angustifolia McCoy
Sphenopteris polymorpha Feistmantel
Sphenopteris lobifolia Morris
alata Lindley & Hutton
Gondwanidium validum (Feistmantel)
Cladophlebis Roylei Arber
Noeggerathiopsis Hislopi (Bunbury)
Dadoxylon Arberi Seward
farleyense Walkom
? Psygmophyllum cf. *flabellatum* Lindley & Hutton
Walkomia australis (*Brachyphyllum australe*) (Feistmantel)
Samaropsis Dawsoni (Shirley)
Etheridgei Walkom
Pincombei Walkom
moravica (Helmhacher)
Nummulospermum bowenense Walkom
Carpolithes circularis Walkom
Carpolithus belmontensis Walkom
Cornucarpus striatus Walkom
Cordaicarpus emarginata Walkom
? Pityolepis sp.
Dictyopteridium sporiferum Feistmantel

Various members of this flora occur in what we know in New South Wales as the Lower (Greta) Coal Measures and the Upper (Newcastle) Coal Measures. For the purposes of this address, in which I am dealing rather with the floras as a whole, I have not attempted to divide the flora according to the species present in the Lower and the Upper Coal Measures. Indeed, I am not quite certain that it would be possible to do so with any great degree of accuracy. The division of the Series containing this flora into Lower and Upper divisions in the occurrences scattered widely over Australia and their correlation with one another is still far from completely determined. In addition, too little attention has been given to detailed collecting to enable one to make accurate lists of the species which have been found at individual horizons.

However, the flora as a whole is completely different from the *Rhacopteris* flora. The only genera so far known to be common to the two floras are *Sphenopteris* and some of the genera of seeds such as *Samaropsis*, *Carpolithes*, *Cordaicarpus*. *Sphenopteris* is of course a form genus and the species recorded from the two floras are different. The seeds, as at present incompletely known, also represent different species in the two floras, and most of them are known only from impressions, few yet having been described with any indication of their structure.

We have, therefore, a flora which has nothing in common with the *Rhacopteris* flora, and one which is characterized by the appearance in notable abundance of a series of plants of quite new type—especially *Glossopteris* and *Gangamopteris*. It is thus reasonable to conclude that there is a considerable time break between the rocks containing the *Rhacopteris* flora and those containing the *Glossopteris* flora. What we have to consider most closely is whether this break may have been long enough to represent the time between Lower Carboniferous and Permian. Our main difficulty arises from the fact that our floras from the lower part of the Carboniferous may be compared directly with the Lower Carboniferous floras of the northern hemisphere, and Europe in particular, whereas the *Glossopteris* flora only bears comparison with similar floras in the various parts of Gondwanaland. The *Glossopteris* flora did indeed reach Russia some time late in the Permian, but this does not help us in determination of the time of appearance of the flora in the southern hemisphere.

One thing that is remarkable in connection with the *Glossopteris* flora is the lack of precise knowledge of the nature of the plants which bore the leaves, *Gangamopteris* and *Glossopteris*. These two genera are extremely abundant in Permian rocks throughout the land areas which formed parts of Gondwanaland. There are a few known specimens which show leaves of *Glossopteris* attached to stems. It is presumed that *Vertebraria* was the rhizome of the *Glossopteris* plant but this has not been proved. From close association in a number of localities it is also believed that seeds referred to *Nummulospermum* were probably borne by the plant of which *Glossopteris* represents the foliage. But here again no definite proof has been produced of the actual connection of the seeds with the plant.

It has been generally agreed that *Gangamopteris* and *Glossopteris* are very closely related, and in restorations of the plants of Permian age, Seward (1941, p. 247) has shown both as represented by shrubs of similar habit to one another. There is some justification for this in the character of the specimens showing leaves attached to stems.

Recently, however, Dr. Teichert (1942) on the basis of a single *Gangamopteris* leaf, which appears to be imperfectly preserved in a marine series, has pictured *Gangamopteris* as a plant of very different habit. If his idea is correct and his determination of the leaf as *Gangamopteris* is also correct, it means some radical change in the view that *Gangamopteris* and *Glossopteris* are closely related plants. It were better, however, to await some further support for his contention, in view of the somewhat insecure foundation on which it is based.

Palæontologists who have worked on the fossil content of the rocks in which the *Glossopteris* flora occurs, as well as of the associated marine series, mostly place them all in the Permian. Raggatt and Fletcher, after a detailed examination of the fauna in Western Australia and comparison with similar faunas in other parts of Gondwanaland, conclude (1937, p. 182): " The similarity in the faunas of the Kashmir, Indian and Australian sequences is so striking that contemporaneity and free communication between these regions may be assumed. We appear to be justified in concluding that beds characterized by the *Eurydesma-Conularia* fauna and the *Gangamopteris-Glossopteris* flora should be assigned to the Permian."

Among the genera of the *Glossopteris* flora there are a number which had already appeared in the European Carboniferous, e.g. *Annularia*, *Sphenophyllum*, *Sphenopteris*, *Psygomphyllum*, but generally there are specific differences between species of these genera from the two provinces. The southern hemisphere stems described as *Dadoxylon* and the leaves known as *Noeggerathiopsis* are also doubtless closely related to the northern genus *Cordaites*.

Some of the southern examples of *Annularia* probably show their closest affinity with species from the Shansi flora of Asia described by T. G. Halle who is of opinion that the beds containing them are of Permian age. *Annularia* cf. *stellata* described from near Dunedoo may be identical with *Lobatannularia inequifolia* Kawasaki or with *L. sinensis* Halle. Other similarities to this flora have been noted by Whitehouse who has recorded, but without description, the genera *Emplectopteris* and *Lobatannularia* from Queensland rocks.

Recent work in India (Palæobotany in India, 1943) has shown the existence of a rich microflora in some of the Gondwanaland rocks containing the *Glossopteris* flora. D. D. Pant has examined some of the Bacchus Marsh tillite and B. Sahni some of the clay shale from the base of the Dwyka tillite from Vereeniging near Johannesburg. This work is being extended and samples from measured horizons of the Dwyka tillite are being examined by Pant. The results will be watched with interest and may yield important data for correlation purposes.

Comparison with the Succession in other Parts of Gondwanaland.

We may now turn to a comparison of the Australian succession with that in other regions. As noted before it is only the Lower Carboniferous floras that bear direct comparison with those in the northern hemisphere. It seems that Carboniferous (Lower Carboniferous especially) floras were cosmopolitan, groups made up of the same or very closely allied species occurring in continental areas of both northern and southern hemispheres. It may be that in the older rocks in which fossil floras are known we yet know insufficient of the plants preserved to enable us to determine the presence of floral provinces. In the Permian, however, there is sufficient evidence that there were distinct botanical provinces of which Seward (1941, p. 251) states that there were at least three. He refers to (1) what he calls the Atlantic-Chinese flora, including the Shansi flora which has affinities with floras of North America and Europe, (2) the Kusnezk flora in Siberia extending from the Dwina River to Vladivostock, (3) the *Glossopteris* flora which is present in all those southern areas constituting what we generally know as Gondwanaland. These Permian floral provinces were the subject of discussion by Schuchert (1932) as well as by Seward (1941, pp. 234-287).

For useful comparisons for the Australian succession, it is therefore apparent that we can look chiefly to the floras of various parts of Gondwanaland.

South America.

The most complete comparison is obtained when we study the succession in western Argentina where, in the pre-cordilleran region, south of the town of San Juan, there is a wealth of fossil plant material. These plants occur in an area where there has been a considerable amount of tectonic disturbance, including much overthrusting. Dr. Harrington, when sending me some fossil plants for examination, said of this region, " The stratigraphical relations of the different fossil bearing horizons are unknown as the beds form part of a highly complicated thrust-structure of Alpine type and magnitude but of Hercynian age ". As a result floras of apparent different ages occur in close geographical association and there has been a good deal of discussion as to their relative stratigraphical positions. Plants of Carboniferous and Permian ages occur at localities not far removed from one another, and these field occurrences have been used in support of the suggestion that the *Glossopteris* flora came into existence before the close of the Carboniferous.

Dr. Du Toit (1927) has given an account of a number of these occurrences (pp. 36-37) involving the presence of Carboniferous types closely associated geographically with typical Permian species. The Carboniferous forms include :

Asterocalamites scrobiculatus (Schlotheim)
Lepidodendron aculeatum Sternberg
cf. *australe* McCoy
selaginoides Sternberg
Veltheimianum Sternberg
Pedroanum (Carruthers)
cf. *nothum* Unger

Botrychiopsis Weissiana Kurtz
Rhacopteris Szajnochai Kurtz
inequilatera var. *ovata* McCoy
Archæopteris argentinæ Kurtz
Cardiopteris polymorpha Goeppert
elegans Kurtz
Adiantites antiquus (Ett.)
Cordaites sp.

The Permian species, indicating the presence of the typical *Glossopteris* flora, include :

Phyllotheca australis Brongniart
deliquescens (Goeppert)

Glossopteris Browniana Brongniart
indica Schimper

Glossopteris retifera Feistmantel
Gangamopteris cyclopteroides Feistmantel
Gondwanidium validum (Feistmantel)
Cordaites (*Noeggerathiopsis*) *Hislopi* (Bunbury)
Noeggerathiopsis Whittiana (Feistmantel)
Rhipidopsis densinervis Feistmantel
ginkgoides Schmalhausen

Du Toit says of these, " Keidel has been to great pains in order to prove that there are actually *two distinct series* resting unconformably upon the older Palæozoics, one with a flora including Lower and Upper Carboniferous forms and hence of Carboniferous age, overlain by the second formed of the glacials and the sediments with the *Glossopteris* flora, belonging to the Gondwana system and of ' Permian ' age ". He refers to the doubts as to the determination of precise horizons from which the different collections were obtained but admits that his limited opportunity for collecting did not enable him to dispel such doubts. He goes on, " In analysing these various collections, we observe further that in one locality or another some typical member of the ' northern flora ' is in apparent association with some member of the ' southern ' and this in so many ways that we have difficulty in escaping from the conclusion that all these various plants must probably have occurred intermingled on horizons intimately associated with the glacial series. It will, however, not be denied that the southern forms might perhaps have come from slightly higher levels within that particular series than those that yielded the northern elements, and it will therefore be conceded that *Gangamopteris*, *Glossopteris*, etc., if not actually accompanying *Rhacopteris*, *Cardiopteris*, etc., must occur shortly above this lowest plant-bearing carbonaceous zone *d*, with its northern Carboniferous flora.

" *Granted that the data have been correctly interpreted* (italics mine), the presence of *Gangamopteris*, *Glossopteris*, *Neuropteridium*, etc., would suggest that the whole of this conformable succession, down to its very base, resting discordantly upon pre-Carboniferous strata, should be regarded as forming part and parcel of the Gondwana System."

In 1926 Sahni had listed the Argentine plants in two groups, one as Lower Carboniferous, containing

Asterocalamites scrobiculatus
Lepidodendron sp. aff. *L. nothum Pedroanum*
Botrychiopsis (*? Rhacopteris*) *Weissiana*
Rhacopteris sp. cf. *Machaneki*
Cordaites sp. cf. *borassifolius*
? Rhabdocarpus

The second group indicated as Carboniferous and Permian (mixed horizons), contained a mixture of what I have called in Australian floras the *Rhacopteris* flora and the *Glossopteris* flora.

I have searched carefully through Du Toit's description and can not find that he put forward any definite proof of the mixing of the two floras.

It is of interest to note that the succession of floras in this pre-cordillera region of western Argentina has a parallel in the succession of the faunas. Dr. H. Harrington has been working on the faunas in recent years and these, he says in a letter written in 1941, " range from Lower Carboniferous to Middle Permian ".

I have dealt at some length with these Argentine floras since they are almost identical with our Australian floras of the same succession, and moreover because the strata containing the *Glossopteris* flora are closely associated with marine strata containing a fauna that shows close resemblances to the fauna of our Permian marine series. In eastern Argentina Dr. Harrington refers to the marine fossils found in association with the *Glossopteris* flora and remarks that the faunule is " truly Australian in character ".

One other feature in which the South American succession resembles the Australian is the complete absence of the northern Upper Carboniferous flora as represented by the *Neuropteris*, *Alethopteris*, *Pecopteris* group of plants. Du Toit does not make any comment on the absence of this group in Argentina.

South Africa.

In South Africa the succession is not represented as completely as in Australia, the Carboniferous elements being absent except for the occurrence of species of *Sigillaria* and *Lepidodendron* associated with the *Glossopteris* flora in the Ecca Series. In the Dwyka Series there is a record of a *Lepidodendron* which has been compared with *L. australe*, a species which in Australia is confined to the Devonian. There is some doubt in my mind as to the identity of the South African specimen with the Australian species—based on an examination I was able to make of the described specimen in South Africa. One interesting feature in South Africa is the occurrence of northern hemisphere Upper Carboniferous species in association with the *Glossopteris* flora in the coal measures at Wankie in southern Rhodesia. This interesting association has been described by Walton (1929), who has identified the following species from the Upper Wankie Sandstones :

Phyllotheca sp.
Sphenophyllum speciosum (Royle)
    cf. *Thonii* Mahr
    Thonii var. *minor* Sterz.
    oblongifolium (Germ.)
cf. *Cyclodendron Leslii* (Sew.)
Chansitheca cf. *Kidstoni* Halle
Pecopteris unita Brong.
    forma *emarginata* (Goepp.)
    arborescens (Schloth.)
    cf. *cyathea* Schloth.

Asterotheca sp. A and B
Cladophlebis sp.
Glossopteris indica Schimper
    Browniana Brong.
    retifera Feist.
    tortuosa Zeiller
    cf. *angustifolia* Brong.
Cordaites Hislopi Feist.

Walton refers to the presence " of a very pronounced northern element in the flora, including plants which are characteristic of the Upper Carboniferous and Lower Permian in western Europe, and some which occur in the Shansi Coal-field in China, and in rocks which are probably of Lower Permian age in Sumatra ". Dr. Walton regarded this flora as indicating the age of the Upper Wankie Sandstones as Lower Permian or older.

India.

As regards the succession of floras, India offers little for comparison since the only typical Carboniferous assemblage consists of three species, viz. cf. *Rhacopteris inequilatera* (Feist.) (=*R. ovata*), cf. *Sphenopteridum furcillatum* (Ludwig) and cf. *Sphenopteris rigida* Ludwig, which occur in the Po Series (early Carboniferous) of Spiti. The Permian flora is of course very abundantly represented in rocks ranging from the Talchir Series to the Raniganj Series, and higher still the *Glossopteris* flora is found associated with the *Thinnfeldia* flora in rocks regarded as Triasso-Rhætic in age.

Of species common to the Indian and Australian floras it may be of interest to note that *Neuropteridium* (*Gondwanidium*) *validum* is known in India only from the Karharbari Series, and *Glossopteris tortuosa*, *G. conspicua*. *Phyllotheca robusta*, *P. indica* and *Cladophlebis Roylei* only from the Raniganj Series. Some of these species may be helpful in determining the ages of scattered occurrences in Australia.

Correlation of the Permian Succession.

There are still many difficulties to be overcome in correlating the Permian succession in various parts of Australia. A typical area such as the Hunter River Valley presents the simple problem of two marine series and two freshwater series in the order Lower Marine, Lower freshwater, Upper Marine, Upper freshwater. There is much in common between the faunas of the two marine series, as there is also between the floras of the two freshwater series. It is known that the *Glossopteris* flora was in existence as far back as about the middle of the Lower Marine epoch, and that it continued at least till the close of the Upper Coal Measure epoch. Throughout that period of time the *Glossopteris* flora must have existed somewhere on the land surfaces of the continent, for it is inconceivable that it should have died out and appeared again without any notable change in its composition. It could be believed that when the marine seas receded they retreated beyond the limits of the present continent, and therefore that there may be a definite break between the deposition of the strata which we know to contain the Lower Marine and Upper Marine faunas. Whilst this is a possibility, it does not seem a probability, and with increased knowledge of the faunas and their ranges we should be able in time to trace the complete story of marine deposition from the beginning of Lower Marine time onwards. To arrive at a similar knowledge of the continuity of the floras will be much more difficult, for it seems reasonable to suggest that at any time during the life of the *Glossopteris* flora, on the continental area there may have been larger or smaller basins of freshwater deposition where plants could have been preserved. We are prone to think that any deposit of freshwater origin which contains remains of the *Glossopteris* flora should be correlated with either the Lower Coal Measures or the Upper Coal Measures. But there does not seem to be any reason why such isolated occurrences could not have been deposited at the same time as one of the marine series was being laid down. Thus the way to a complete understanding of the Permian problem still seems long and arduous. Much careful field work is necessary—both in tracing the stratigraphical relations of the strata from one district to another, and also in the careful collection of floras and faunas from definite horizons as an aid in determining the possibility of recognizing distinct zones by the contained fossils. One excellent piece of work has been done on the Carboniferous, viz. that of Drs. S. W. Carey and W. R. Browne, who have, as a result of careful field observations, suggested that the freshwater Lower Kuttung Series in New South Wales were deposited at the same time as the marine Upper Burindi Series. There is room for much work of this type on the Permian succession. An excellent basis for such studies should be available when it becomes possible to use the results of the extensive and careful field observations being made in the search for indications of oil in Australia.

Thus I seem to have shown only that, although the Permian problem has been the subject of many studies over a great number of years, there is ample work still to occupy a team of geologists on this one problem for a long period. So in this, as in many another problem, the fascination lies in the fact that with each advance in our knowledge there is opened up an ever-widening field for further investigation.

References.

Carey, S. W., and Browne, W. R., 1938. Review of the Carboniferous Stratigraphy, Tectonics and Palæogeography of New South Wales and Queensland. *J. Roy. Soc. N.S.W.*, **71**, 591-614.

Du Toit, A. L., 1927. A Geological Comparison of South America with South Africa. *Carnegie Inst. Washington, Publn.* 381.

Halle, T. G., 1927. Palæozoic Plants from Central Shansi. *Geol. Surv. China,* Pal. Sinica, Ser. A, Vol. ii, fasc. i.

Heerlen, 1927. Congrès pour l'avancement des Etudes de stratigraphie Carbonifère. Compte rendu, Liége (1928).

Palæobotany in India, 1943. Progress Report for 1942. *J. Indian Bot. Soc.*, **22**, 171-182.

Raggatt, H. G., and Fletcher, H. O., 1937. A Contribution to the Permian-Upper Carboniferous Problem and an Analysis of the Fauna of the Upper Palæozoic (Permian) of North-West Basin, Western Australia. *Rec. Aust. Mus.*, **20**, 150-184.

Sahni, B., 1926. The Southern Fossil Floras : A Study in the Plant-geography of the Past. *Thirteenth Indian Sci. Congress,* 229-254.

Schuchert, C., 1932. Permian Floral Provinces and their Interrelation. *Amer. J. Sci.*, **24**, 405-413.

Seward, A. C., 1941. Plant Life Through the Ages. *Cambridge Univ. Press.*

Teichert, C., 1942. *Gangamopteris* in the Marine Permian of Western Australia. *Geol. Mag. London,* **79**, 321-327.

Walton, J., 1929. The Fossil Flora of the Karroo System in the Wankie District, Southern Rhodesia. *Geol. Surv. Bull. S. Rhodesia,* No. 15, 62-75.