JULIAN TENISON WOODS, F.L.S, F.G.S. &c. &c. (1832 - 1889)

Vice-President of the Linnean Society, New South Wales

Author of "A History of the Discovery and Exploration of Australia,"

"Geological Observations in South Australia,"

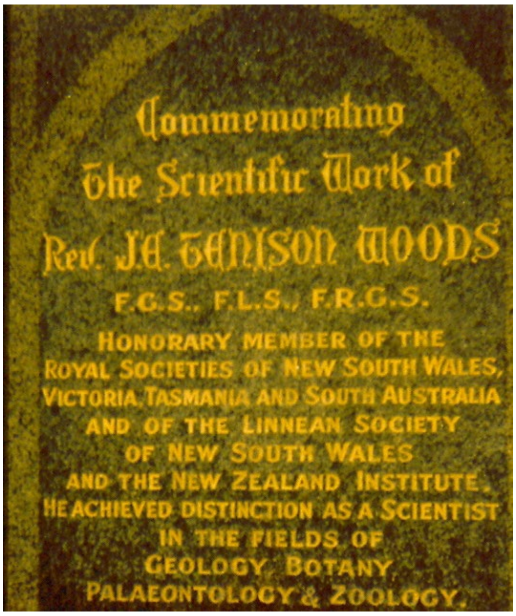
"North Australia,"

Natural History of New South Wales."

&c., &c.

BUSH SCIENTIST: GEOLOGIST

Paper presented as part of a symposium on the life of Julian Tenison Woods, priest and scientist, during the 1989 celebrations in Brisbane of the centenary of his death.



Peter K. Anderson
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Introduction

Naturalists were early attracted to Australia's unique plant and animal life, the majority of it long extinct in other parts of the world but preserved because of Australia's isolation from other land masses. The Australian continent separated from South America and Antarctica some 60 million years ago. Australia contains the most primitive mammals occurring on earth, the platypus and the Echidna (ant-eater). Like reptiles, they lay eggs, but suckle their young as mammals do. They retain in their structure and mode of reproduction some of the features that are characteristic of the oldest known fossil mammals. Early naturalists collected, classified and described native marsupials such as kangaroos, koalas, possums and wombats, the hundreds of different species of native parrots and cockatoos and many of the 1100 species of eucalyptus and wattles. Geology was another colonial interest, because of the rich mineral deposits and also because of an extensive debate on the age of the continent.

The Heroic Age of Geology

During the period 1790 - 1820 the fundamental principles of geology were discovered. Geology developed into a science during the Industrial Revolution stimulated by prospecting for coal and metal ores and also as part of the Romantic Movement. This movement greatly influenced art and music and saw divinity in nature. It pictured nature as creative, spontaneous, and growing, permeated by beauty and an underlying spiritual reality.

Thus, the first European visitors to Australia included men with geological knowledge. Most of our early explorers made observations on the landform, rocks and minerals and recorded their observations. Australia was also in the unique position of being the only continent to be explored since the growth of the new science of geology.

Early Geologists

The two famous British explorers in the 1830's and 1840's, Sir Thomas Mitchell and Charles Sturt, were keen, competent geological observers. Sturt made geological observations and listed rocks and minerals collected in his journal of the expedition to the centre of Australia (1844-1846)

The Clerical Involvement

Ministers of religion were notable among the educated group of 19th century Australians and it was proper for educated people to be well read in what was called natural history. Also at that time a closer relationship was perceived between science and religion than would be understood today. Then there was a search for harmony in all that is. Science was part of the understanding of creation (a term used here not in any fundamentalist sense); the development of science was all part of missionary work. This zeal may not be unrelated to the early 19th century Romantic Movement noted above.

Rev. Adam Sedgewick, an Anglican minister, spent more than fifty years as Professor of Geology at Cambridge and during that period worked hard to establish the subject on a sound scientific basis. One of his students who was also a minister of religion, the 41-year-old Rev. W.B. Clarke (1798-1878) arrived in Sydney in 1839, having applied for a position as chaplain. Almost immediately after settling into his ministry Clarke started on geological work. Initially he studied the coal measures and associated sediments both of freshwater and marine origin in the Sydney Basin. He collected fossils wherever possible and sent them to Sedgewick at Cambridge where they were described by the young Frederick McCoy who was later to become Professor of Geology at the University of Melbourne. Clarke is known as the father of Australian geology and was an esteemed colleague of Woods, the subject of this paper.

Julian Tenison-Woods scientist

Sources of his enormous erudition

As a young theological student Woods spent a period of some weeks holidaying in the Auvergne region of central France where his interest in geology was greatly stimulated. His observations of the volcanic formations there enabled him to interpret the geology of the south east of South Australia where he first combined his pastoral work as a minister of religion with his serious geological and scientific observations. There are some notable similarities between the two regions, as both contain the remains of glaciation and tertiary volcanic eruptions.

Of his time in the Auvergne, he records:

> "There I formed the acquaintance of a young priest, the son of a proprietor in Auvergne. He invited me to come and spend a few weeks in that district and ... I made a most delightful tour of the volcanic district of central France. I was able to indulge my taste for geology" (Memoirs p.173)
>
> "On my return from the Auvergne I made a short expedition to the coal mines of St. Etienne and the country around."

Shortly afterwards he spent a period teaching and studying at a Marist College in Toulon, France. He recalled:

> "I was at liberty to follow any other classes that I wished so that I immediately enrolled myself in the classes for drawing, chemistry, natural philosophy and natural history. The chemical and natural philosophy classes gave me the use of the laboratory and scientific instruments. The professor of natural history ... was an enthusiastic botanist as well. He took a great interest in me and constantly took me with him on excursions. ... The happy hours we spent in collecting and wondering through the mountains were times of unmixed delight for me." (Memoirs, p 191)

In South Australia in 1856, again as a theological student at the Jesuit mission at Sevenhills 90 miles north of Adelaide, he furthered his scientific and mathematical knowledge.

> "He went through a thorough course of geology and mineralogy, for which he had great opportunities in the unexplored mountainous country around the college, and which was so rich in mines and minerals. He took much pleasure in these things and worked a good deal in the analysis of minerals, with the blow pipe, with chemicals, and with a very clumsy microscope".

Here he remained nearly six months and during this stay he undertook " a horse journey... about 100 miles to the north or say 200 miles north of Adelaide. the whole journey was for the sake of making geological observations on this little known region". This journey through what is now known as the Flinders Ranges would have taken him to near present day Gawler and through presently exposed ancient rocks up to 1000 million years old which provide some of Australia's most spectacular arid scenery.

These rock formations are also of special geological interest because here is one of the few places in the world where rock strata carry information regarding the geological history of the world in the latter part of the Precambrian Period. He also observed noted evidence of past glacial action on some of these rocks: "It seemed to me as far as a cursory examination would guide me, that there were distinct marks of snow and the action of glaciers."

Woods' education continued during his ten years at Penola as he engaged in correspondence with distinguished scientific figures in England and Australia.

The British Connection

Scientists at Oxford and Cambridge encouraged interested and educated people throughout the world and especially throughout the British Empire to be alert to the possibility of finding interesting rocks and fossils. Networks involving correspondence and sample exchange and identification were setup with mutual benefit. Colonists became agents for the British scientists. Thus Woods' found contacts who were interested in fostering his scientific interests.

His first book on Australian geology contains in the frontispiece a quotation from a pioneering French geologist Baron Georges Cuvier (1769-1832) and it was Cuvier who provided the theoretical framework upon which Woods based his geological work. Cuvier had a particular interest in fossil remains and used them to try to explain the place of fossil organisms in the history of life on earth. He found that the older the fossils, the more they differed from present day life forms, being simpler in structure the earlier they had occurred in the earth's history.

Thus, he made one of the first attempts at correlation by fossils, correctly recognising that the geological history of the earth could be plotted on the basis of a succession of fossil fauna. The fossil record could thus be used for age dating of rock strata. Woods' particular talent seems to have been a prodigious memory for plant, animal and fossil classification. This enabled him to collect and classify flora and fossils during his pastoral work which involved long journeys on horseback.

Work on Tertiary Geology

Tertiary Era

The Tertiary system was an interesting field of study for many reasons, particularly in Australia for it was at the beginning of this period, about 65 million years ago that the continent formed by Australia and Antarctica separated from the more ancient continent of Gondwanaland. At that time of separation, for yet unknown reasons the dinosaurs, became extinct leaving the land and its various habitats available for the development of marsupials and mammals in a way independent of their development in Asia and Europe. This isolation enabled marsupials to evolve in Australia in a manner different from those on other continents. The ammonites, a large group of squid-like molluscs that flourished in Jurassic and Cretaceous seas, had also disappeared. So had the belemnites, a group of molluscs very closely related to today's octopuses. The new masters of the world were the mammals and birds. The mammals particularly, increased in variety and became adapted to a wide variety of habitats. Of course in was that development from which human life arose in a most mysterious manner.

There is still much research going on in this area today. The unknown pre-Miocene Tertiary record for Australian marsupials and bats is a present area of research. The recent discovery of Eocene marsupials from Seymour Island in Antarctica strongly suggests that we will one day find a most extraordinary collection of mammals in the early tertiary record of Australia, the time crucial to an understanding of the first radiation of Australia's mammals.

Also increasing in number and variety were the molluscan snails and bivalves. The fossils of many forms still living today are preserved in Tertiary sediments, and these provide a method of dividing the tertiary into smaller units Eocene, Oligocene, Miocene and Pliocene. Throughout most of tertiary time the climate was warm. Luxuriant forests covered much of Australia while in the seas warm water creatures flourished. The temperatures only began to drop in the following Quaternary period.

Woods' interest in the Tertiary era may have begun with studies on the Tertiary London Basin or from his early geological observation s in the Auvergne or simply from his passion to study all that was available in the south east of South Australia.

Tertiary Molluscs

One of Woods' main interests in science concerned the age and succession of the tertiary deposits of Australia. One reason for this may well have been the ready availability of deposits from this era in the south east of South Australia. His early adviser in this area of study was the famous English geologist, Sir Charles Lyell who was an authority on the Tertiary era. Lyell's theory was that the way to date Tertiary rocks is to compare fossil deposits with present day fauna. Although he did not admit of any evolutionary trend, Lyell proposed that the greater the percentage of present day fauna present as fossil material, the younger the rock. Faunal types just came in and out of existence and did not develop. In 1859 Lyell advised Woods to examine the present day marine fauna as well as the fossil deposits and to compare the two. "By this means", Lyell assured him, "you will soon be in a position to tell more of the age of your tertiary beds than the most learned palaeontologists in Europe could tell you" (Player, 1989). Lyell himself did much work in the Tertiary system, which in 1829 he had sub-divided into the Eocene, Miocene and Pliocene.

A convenient set of fauna to work on were the invertebrate molluscs and bivalves frequenting fresh water and seashore environments. Because of their hard shells, they were readily preserved as fossils. Thus. Woods began the enormous task of identifying and describing molluscs, particularly during the time he spent in Tasmania (1874-1876), when he published thirty-four papers. This vast project was all part of the task of unravelling tertiary geology in Australia. In his own time, his contribution to science was probably seen in marine biology. In 1888, he published among his last works, a paper titled "On the anatomy and life history of Mollusca peculiar to Australia". This lengthy paper was collected from notes made over many years and for it, he was awarded by the Royal Society of New South Wales, the W.B. Clarke Medal (he outlived W.B. Clarke) and purse.

He also wrote extensively on Tertiary invertebrate fossils. Dr Neil Archbold, a palaeontologist at The University of Melbourne, who has been involved in recent research on Wood's work, writes:

"In all his papers on fossils he figured, described or discussed some 240 species of gastropods, bivalve molluscs, corals and bryozoans as well as a few brachiopods and echinoids. These were primarily from the tertiary limestones of S.E. South Australia, Table Cape on the north coast of Tasmania and Muddy Creek just west of Hamilton in Victoria. There is no reason to think that many of the species he named are no longer valid. Many of this coral species have never been revised as few people have worked on the tertiary corals since Tenison Woods. He was ahead of his time in the way he always measured his specimens in `French millimetres.' "

https://southaustralia.com/products/limestone-coast/attraction/blue-lake

"Looking at the walls from any side, four distinct kinds of rock are visible. There is, first, the larger ash, decomposed into soft black surface soil, covered with grasses and trees, and varying in thickness from forty to seventy feet."

Mount Gambier –
Woods' first paper was on Mount Gambier geology. The light coloured layers down near the lake water are formed from Mount Gambier limestone.

Some Tertiary invertebrate items Woods described:

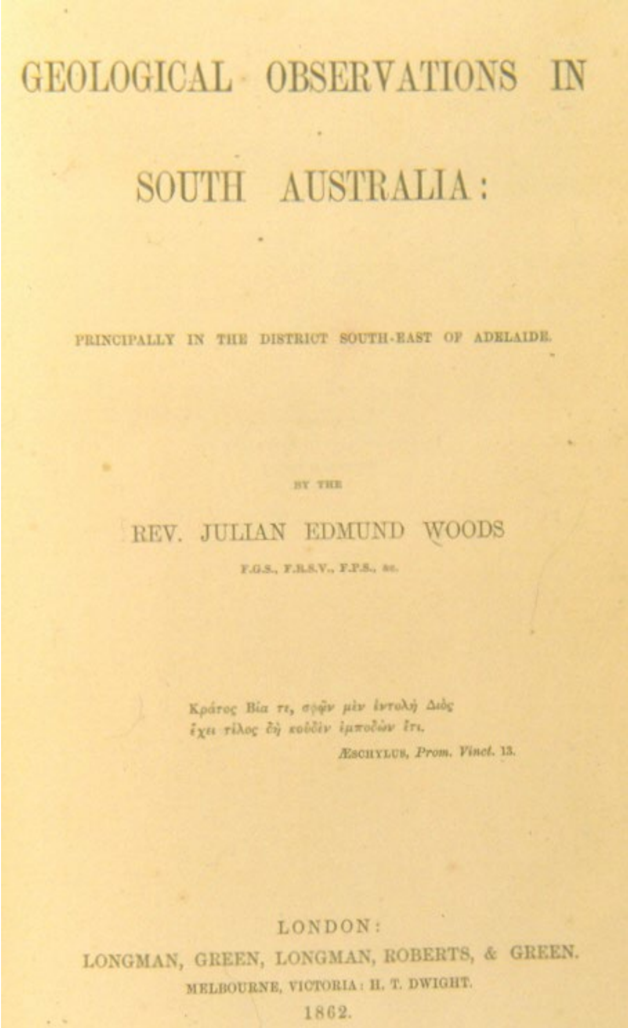
The sea urchin *Hemiaster archeri* from Mount Gambier limestone - about 1.5 inches in size/described 1865.

The small gastropod *Trivia minima* from the Miocene of Muddy Creek near Hamilton, Victoria. (The scale bar is 1mm in length.)

Fossils from Mount Gambier (1862).

Fossil bryozoans from Mount Gambier (paper read 1861 - Royal Society of Victoria).

Geological Observations in South Australia (1862)



GEOLOGICAL OBSERVATIONS IN SOUTH AUSTRALIA:

PRINCIPALLY IN THE DISTRICT SOUTH-EAST OF ADELAIDE.

BY THE

REV. JULIAN EDMUND WOODS

F.G.S., F.R.S.V., F.P.S., &c.

Κράτος Βία τε, σφῷν μὲν ἐντολὴ Διὸς
ἔχει τέλος δὴ κοὐδὲν ἐμποδὼν ἔτι.

ÆSCHYLUS, *Prom. Vinct.* 13.

LONDON:
LONGMAN, GREEN, LONGMAN, ROBERTS, & GREEN.
MELBOURNE, VICTORIA: H. T. DWIGHT.
1862.

This was his first major work, largely on the tertiary geology of the south coast of South Australia. Though written by one who was very much an outsider in scientific circles and one from the "back-blocks of the antipodes", it received favourable reviews in overseas periodicals. It was also the first systematic examination of the geology of South Australia. It covered land formations, Tertiary fossils, volcanic remains at Mount Gambier and Mount Shark and limestone caves and would have made fascinating popular reading.

Some of Woods' descriptions of the scenes provided in "Geological Observations":

> "Mount Gambier is a chain of craters extending nearly, but not quite, east west; the wall on the west side being by much the most elevated. There are three lakes - that on the east end the Blue Lake with banks of 200 to 300 ft. high and so steep that descent to the water’s edge is quite impossible except in one or two places. The sides are thickly wooded with Melaleuca except where rocks stand out in perpendicular escarpments. These crags sometimes hang over the water, whose already deep blue tint is rendered still more gloomy by the reflection of their black and stony fronts. The whole appearance of the lake is wild and sombre in the extreme."

"The third lake differs much from the other two. It is larger than the Blue Lake crater and of almost circular form, but the bottom is only partially covered with water, very deep at the east end, but shallow on the west. The water is at each end, and the ground in the middle, but by far the largest lake is on the eastern side. In the dry part, there are three ponds, which being circular, appear at a distance like wells sunk side by side."

"Looking at the walls from any side, four distinct kinds of rock are visible. There is, first, the larger ash, decomposed into soft black surface soil, covered with grasses and trees, and varying in thickness from forty to seventy feet."

"The highest wall of the Valley Lake crater is formed of successive layers of an ash conglomerate, composed of scoriae, fragments of obsidian."

"There is on the northern side an isolated hill or hummock forming part of the wall. Between this and the higher wall the sides slope down into a kind of half-basin. This half basin, with its isolated ash cone, forms somewhat of an inlet from the general form of the lake. Evidently it has been a crater; probably oldest and first of all. From this crater it would appear the lava has been derived which lies about the limestone in the Valley and Blue Lakes, flowing away in the direction of the Blue Lake in a highly liquefied state."

12 apostles - Limestone rock of similar age to that at Penola and first described by Capt Sturt and Flinders (p 117 of Geological Observations).

Source: https://www.visitmelbourne.com/regions/great-ocean-road/see-and-do/nature-and-wildlife/beaches-and-coastlines/12-apostles

Murray Cliffs

> "When Captain Sturt first traced down the Murray from the Murrumbidgee in 1829, he came suddenly to a part of the river bounded on each side by huge limestone cliffs." (He then goes on to list the fossils described by Sturt.)

Source:. http://www.aussietowns.com.au/town/red-cliffs-vic

Interdune corridor -

> "The swamps are continually run through with spurs of land which are as thickly covered with scrub and lofty trees as they can be."

Avenue dune -

> "The next kind of country is that containing sandy ridges. They are generally timbered elevations. They seem to cover everywhere and run in all directions."

Mosquito Ck. structure –

> "Towards the south nothing but immense swamps to be seen."

Source: https://www.epa.sa.gov.au/reports_water/c0177-ecosystem-2010

Solution cavities - Light Bros.

> "All the rocks of the district belong to one formation: this is a tertiary limestone, containing amid portions of coral, etc. considerable quantities of silica. It is quite white, resembling chalk being easily cut with a saw and though rather soft, answers excellently for building purposes."

> "About 25 miles North of Penola a series of caves are found. It is like an immense gothic cathedral. Not the least beautiful being that it is tinted by almost every variety of colour."

Source: https://www.mountgambierpoint.com.au/attractions/naracoorte-caves/

Fish and Fisheries of NSW

This work was commissioned by the NSW Government as a contribution to the 1882 International Fisheries Exhibition held in London. For this contribution the author received a gold medal from King William III of the Netherlands for the most distinguished and original scientific work of the year. It combines scientific accuracy and thoroughness, evidences his enormous erudition, and shows his desire to make his work accessible to all.

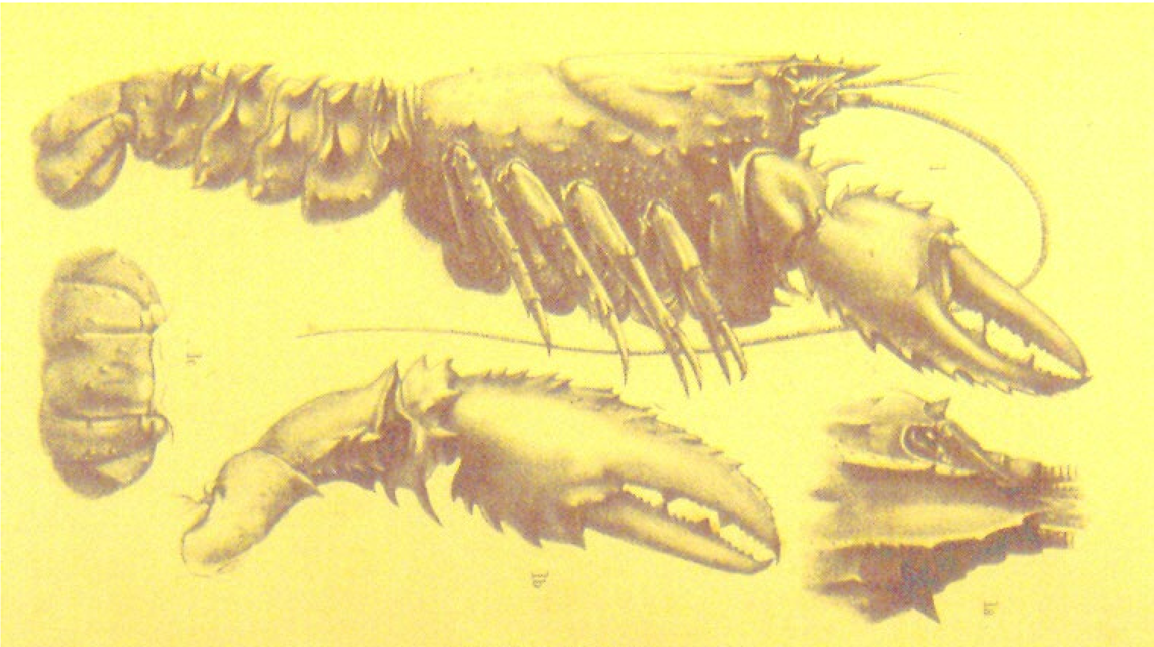
> "By this means every fisherman of ordinary education will be able to get the scientific name of any species he may find... all that science has recorded about the fish, its uses, habits, structure, anatomy, and its place in nature. Such information will be added as to the habits and mode of capture as will. be useful either to the professional fisherman or the sportsman".

In this work also there are examples of his sense of humour and a colourful style of writing designed to capture the popular imagination.

> "But of all the curious fishes that were ever seen Phyllopteryx is the most extraordinary. It is the ghost of a sea horse, with its winding-sheet all in ribbons around it; and even as a ghost it seems in the very last stages of emaciation, literally all skin and grief. The process of development by which this fish attained to such a state must be the most miserable chapter in the history of "natural selection". If the be "survival of the fittest", it is easy to understand what has become of the rest. ... Never did the famishing spectres of the ancient mariner's experience provide such painful spectacles. If these creatures be horses, they must be lineal descendants of those which were trained to live on nothing, but unfortunately perished ere the experiment was quite concluded. The odd thing about these strange fishes is that their tattered cerements are like in shape and colour to the sea-weed they frequent, so that they hide and feed with safety. Thus the long ends of ribs which seem to poke through the skin to excite our compassion are really "protective resemblances", and serve to allure the prey more effectually within reach of these awful ghouls. The Phyllopteryx is therefore, in spite of his rags of emaciation, an impostor, and like many a sturdy human beggar puts on the aspect of misery to ply his trade. Just as the leaf-insect is imitative of a leaf, and the staff insect of a twig, so here is a fish like a bunch of sea-weed. If this is development, it stopped here just in time; one more step and it would have been a bunch of kelp" (P.29).

Note also here his humorous attempts to cope with Darwin's theory of evolution, a challenge to Christian thinkers at that time.

The book also contains an excellent example of his artistic skill. In the preface Woods thanks "Prof. M'Coy F.R.S., for permission to use some of his plates". However, the freshwater crayfish p 116. is referred to as "our plate XLIV"



Astacopsis serratus.—SHAW.

FRESHWATER CRAY-FISH.

1—Animal slightly reduced in size. 1a—Head. 1b—Claw. 1c—Tail. All natural size.

Of another species, he writes of knowledge gained from his early years in South Australia and Victoria:

> "They used to be prized as food by the aborigines; and near the swamps and rivers of Victoria heaps of their remains may be seen in the old middens of the natives. Some white people like them too, but their flavour is decidedly muddy. I have reason to be grateful to them. in 1856, in doing a long overland journey between Victoria and south Australia, I must have suffered great exhaustion but for the food these cray-fishes afforded me" (p 127).

The Sandstone Papers

Of all the rock types which came within the range of his observations and his ability to classify, the well-known sandstone, the stone of many of the early colonial buildings, seems to have attracted his attention most, being the subject of two substantial papers, one on the Hawkesbury sandstone and a second on what was then known as the Desert Sandstone.

The Hawkesbury Sandstone

The 1882 paper on "The Hawkesbury sandstone" deals with the flat-lying Triassic quartz sandstone which dominates the Sydney landscape and is particularly well exposed in the coastal cliffs to the north and south of Sydney harbour, as well as in the Blue Mountains west of Sydney.

The paper discusses the origin of this sandstone which has been an object of interest and study since Charles Darwin speculated about it on his visit to Sydney in 1844. The purpose of Woods' paper was to establish the origin of the Hawkesbury sandstone as aeolian (formation from wind transport and deposition in dune structures). He concluded "that the Hawkesbury sandstone is a wind-blown formation interspersed with lagoons and morasses, with impure peat" (p.87).

The work is a masterpiece of scientific methodology, reasoning and theoretical development. Woods gathered evidence of the shape of the deposit, the lithology or quartz grain characteristics, the sedimentary structures and fossil remains. He carried out small scale experiments on the behaviour of wind blown over sand and drew upon his knowledge of sand formations at Wide Bay, the Burdekin River and at Low Island inside the Great Barrier Reef. Using a fundamental geological principle that the "present is the key to the past", he argued cogently and coherently for an aeolian or wind blown origin for the Hawkesbury sandstone."

That current thinking favours a fluvial or river deposited origin for this sandstone does not detract from the value of his work, but merely illustrates the necessary progress of science in which he played a significant.

The Desert Sandstone (Roy. Soc. NSW, 1888, 290-335)

This second major paper on sandstone relates to the sandstone of Tertiary age named Desert sandstone on Richard Daintree's first geological map of Queensland (Australian Handbook, 1872). It is of interest to note here the extra detail added by Woods (Australian Handbook, 1883), and to compare Woods' map with the present map, (Day et al., 1982). (Slides of maps shown)

The paper on "The Desert Sandstone" was written after Wood's returned from Asia. Also worth noting here is the magnitude and quality of his scientific output after he has just returned seriously ill from his Asian travels and now within a year of his death.

The paper follows from his Asian experiences with volcanic terrain and dark volcanic beaches. He combines this with his knowledge of recent volcanic activity along the whole of the east coast of Australia to propose a volcanic origin for the sand which subsequently formed the desert sandstone. Here, as well, he calls upon an enormous store of geological data of central and northern Australia and a study of the sand grains forming the desert sandstone to support his conclusions. He compared the microscopic appearance of the sand grains with volcanic sands collected in Asia:

> "After having examined a considerable number of specimens of the desert sandstone taken from different places, I incline to the conclusion that they are all volcanic sands" (p315).

> "There is not a grain of sand cast forth from the bosom of the earth that is not stamped with marks innumerable to show the nature of its origin. As truly as every coin bears a stamp to mark the place of coinage, so each tiny grain of dust bears its impress unmistakably. It is almost proverbial to say that grains of sand are as like one another as things will be. But direct the tube of the microscope upon them and what a number of differences are revealed. The volcanic grain with its freshly molten certificate of character, its glassy inclusions, its gas cavities, and its optical properties has entirely peculiar qualities of its own which no other grain of sand in the world can pretend to" (p311).

Scientific Instruments

The use of scientific instruments was another aspect of his work upon which we might reflect because we have with us here today, probably shown for the first time for public display, parts of microscopes, believed to have been used and owned by Woods.

The microscope shown here has been in the possession of the Woods family for a long time and is believed to be owned by Woods. In his letters to Archer he speaks of selling a monocular instrument and replacing it with one that is binocular. He appears to have bought the binocular instrument, but the sale of the other fell through. In this case there are parts of three instruments a monocular, two eyepieces from a binocular and an eyepiece from a third instrument. This microscope was characteristic of its time with other brands having similar design. It is a travelling microscope and was probably strapped to the saddle during journeys on horseback. Notice the vertical fine adjustment as distinct from the side adjustment of today. Also, the coarse adjustment is achieved by drawing out the tube. There is an inclination joint and the aperture is formed by rotating a multi-holed plate into position rather than by an adjustable diaphragm. The mirror swings so as to make use of prevailing light.

He makes constant reference to heights during the ascent of mountains, heights recorded by means of a barometer which he carried. When climbing Geelong Babun in Pirah, he mentions carrying "a few instruments such as a prismatic compass, a pocket sextant, thermometers, Aneroids etc". At one point in the ascent he mentions boiling water to determine the height since the greater the height the lower the atmosphere pressure and then the lower the temperature at which water boils. On top of the mountain he records also the use of telescopes and theodolites. Sextants and theodolites allowed mapping from the top of the mountain in preparation for his geological work.

Woods the Botanist

Despite his ready facility in naming observed plant species down to species level, Woods left the work of naming new species to others. Whilst in Malaya, he was instrumental in having Fr Scortechini, another catholic priest, from Nerang in Brisbane commissioned to perform the plant classification of Perak. His own botanical work was to be on a grander scale as he grappled with the need to compare vegetation on an international scale and to develop a conceptual framework within which this could be done.

His comparative work was of a very high standard. He showed a knowledge of vegetation over such a range of latitudes as was unique for his time , and probably not equalled today. This knowledge extended from Tasmania, the southern and eastern coasts of Australia, the top corner of the Northern Territory and on through Java, Malaya, coastal Borneo, the Philippines, Hong Kong and even a little bit of Japan and Vietnam, an astonishing cross-section of the botany of the East Asian - Australian region.

Development of his thinking on Ecology

Towards the end of his life he began to develop the fundamental concepts of plant ecology. Plant ecology is the study of vegetation rather than species and looks at the complex of inter-relations which exist between plants themselves and between plants and environmental factors such as climate, topography and soil. In this he was way ahead of his time, as ecological studies are usually thought to have begun only in the early part of this century with Tansley's (1911) pioneering manual on the ecological approach to the description of vegetation.

At a time when botanists were busily identifying new species, Woods was developing more comprehensive concepts. He appears to have been stimulated by Sir Joseph Hooker's Introductory Essay to the "*Flora Tasmania*" (1860). Hooker stressed the need to identify the various "geographic elements" in the make up of a flora (sum total of the component species of plants in a region), as a key to its history. Component species in a locality give rise to a vegetation type or a "geographic element". We are familiar with the terms "rainforest" or "brigalow scrub" or heath or dune vegetation, terms unheard of in the 1870's and 1880's. Ecology is the study of the network of interdependent relationships which produce, and exist within a particular vegetation type such as one of the forest types. As noted above, The study of ecology is normally thought to have begun with Tansley's (1911) pioneering manual. However, a careful study of Wood's botanical works shows that he was developing these concepts in the last 10 years of his life.

Contribution to Plant Ecology

Woods had a number of significant papers on both fossil and modern botany and these are discussed here using material supplied by Dr Peter Martin, a research botanist from Sydney (Appendix 2).

Relations of the Brisbane Flora (1879)

In this paper, Woods follows the advice of Sir Joseph Hookers' Introductory essay to the "*Flora Tasmaniae*" (1860). Hooker stressed the need to identify the various "geographic elements" in the make up of a flora as the key to its history.

He identified the various geographic elements/vegetation types in the make-up of a flora. He also noted that the relevant numbers of individuals within a species are more important than the existence of a very rare species in characterising a vegetation type. For the systematic botanist the rare species might be the distinguishing mark.

Flora of Tropical Queensland, Part V (1882)

This is a comparative study of vegetation types leads to recognition that vegetation types are characterised by a particular structure rather than a particular species. "No one genus or even species gives its character to the forest." These were entirely new concepts in the 1880's as botanists struggled to describe vegetation in other than species - list fashion. He expressed frustration on lack of terminology to describe vegetation types.

Tasmanian Forests: Their Botany and Economic Value (1978)

> Here a particular vegetation (Tall or wet sclerophyll forest) is studied in these locations: Eastern Tasmania, Gippsland Victoria and the south coast of New South Wales. Here he recognised that there is a constancy of structure through the changing localities, but that different species are seen to replace one another in the particular role they play in the workings of the vegetation formation.

On the Vegetation of Malaysia (1889)

> Despite its preparation during a period of severe illness and in this last year of his life this work shows the most advanced thinking ecologically. He jdentified subdivisions of flora arising from position, soil, climate etc. (This approach is as good as anything found in Tansby (1911)). He divided vegetation into a set of types and sub-types. Noted the same set of species can produce decidedly different vegetations due to effects of soil and climate as found on mountain slopes or plains.

From this it can be argued that Tenison Woods was distinctly ahead of his time with his well-developed ecological approach to vegetation, which was stimulated by the enormous range of vegetation types with which he was familiar and the need he felt to develop some generalising concepts to assist in classification and comparison on a scale that went far beyond national boundaries.

Palaeobotany

As well as providing official government reports on the Queensland coalfields and finding new coal deposits in Borneo for use by the British Admiralty in servicing merchant and naval steam ships, Woods had an interest in the fossil plants, the carbonaceous remains of which make up the coal deposits. Fossil remains are normally obliterated in the coal formation process, but they can sometimes be found in associated shale or sandstone deposits.

The following analysis on Woods' work on palaeobotany is derived from a presentation by Dr. Peter Martin at a recent symposium on Woods at the Australian Museum in Sydney.

> Fossil botany is a difficult subject even today, but in the 1870's and 80's the relevant literature was in German or French to the disadvantage of English speaking workers. For those in the colonies, there was the added difficulty that type specimens were almost all held in museums in Europe. Given these difficulties Woods' paper "On the Coal Flora of Australia" (1883) is most remarkable. It is a masterly synthesis of all the relevant literature (regardless of language or country of publication) and a complete descriptive listing of all plant fossils known from the Australian coal formations up to that time, including a large number of new forms, he had discovered during his investigations in Queensland. This is no mere museum study, but a piece of literary research backed up by extensive field experience with coal-measure fossils.

Throughout the paper he displays finely balanced judgement, a cautious approach towards the erection of new species and frequently looks to living forms for assistance in interpreting the fossil structures. This large (130 pages) and comprehensive paper is of international quality and for a long time after its publication served as a convenient guide to the fossil botany of the Australian coal measures for overseas specialists.

Other Studies in Geology

Geology of South Australia

Tertiary Rocks

Geology of Tasmania

Marine Shells.

Geology of Queensland

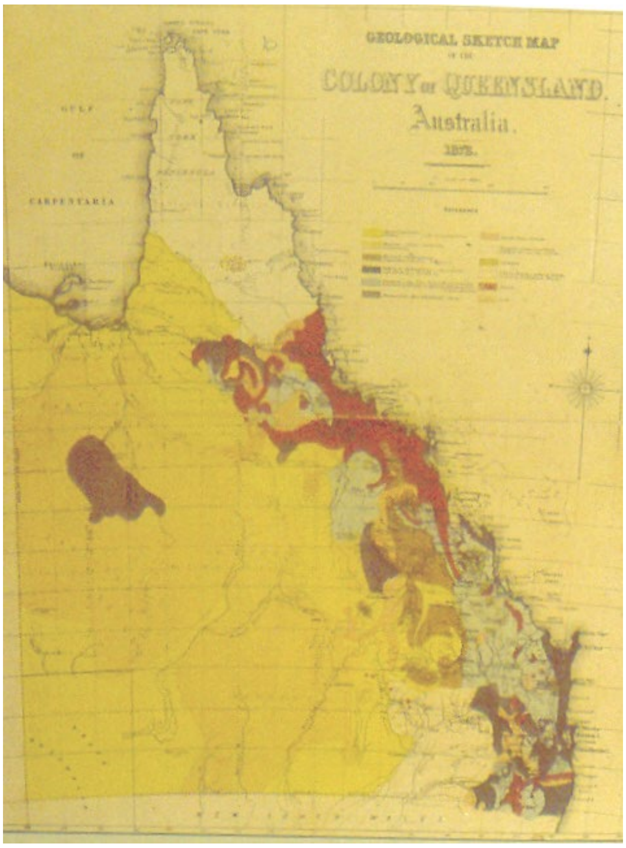
Northern Queensland

Coal Deposits

Herberton Tin Mines (1881)

Hodgekinson Gold Field (1881)

Coral reef



1878 Sketch map of Geology of Queensland by Julian

Woods, J.T., (1883), Geological Sketch Map, with lines by Rev. J.T. Woods, Published with the Australian Handbook. Woods, J.T., (1882), Geology and Natural History of New South Wales

Geology and Mineralogy of the Northern Territory

Geology

Mineralogy

Arnhem's Land

Victoria River

The Geology of Malaysia

On the invitation of Sir Frederick Weld, formerly Governor of Tasmania, Woods accepted the task of assessing the economic potential of tin mining in the Perak area of Malaysia. Here he was asked by the British resident in Perak to recommend a botanist to work on an official census of plants in Perak and his recommendation was a Fr. Scortechini who was then parish priest of Nerang in Brisbane. Bishop Dunne allowed Scortechini a year to complete these botanical studies. However, Scortechni died before being able to return to Brisbane. He and Woods worked together, notably in their combined ascent of Gulong Papu, a 6500 ft. mountain in Perak. Here Scortechini described and collected flora and Woods, among other things, was able to obtain bearings for his mapping work, on features in the valleys below which contained the valuable tin deposits. After this event Woods and Scortechnini went on with their separate tasks.

In Sumatra, Woods observed what is now known as a volcanic arc formed above subducting oceanic crust as shown in the following diagram. He was present in that region during the explosive eruption of Krakatoa where gases released by a cooling magma blew the sealed "lid" off the magma chamber removing most of the island, setting up vast tidal waves and causing enormous loss of life and property.

Behind this chain lies an older volcanic chain, Peninsula Malaya. Here erosion had exposed solidified magma intrusions revealing zones of contact with ancient limestone reefs where chemical interaction between the hot magma and the limestone had caused the formation of tin and tungsten deposits. It was Woods' task to assess the economic potential of these deposits with a view to restructuring the tin mining industry in Malaya. His assessment appears to have been correct as even today the area provides nearly 30% of the world's tin requirements.

Woods was given a second task, after reporting on the Tin, and that was to assess the coal deposits of the region for the British Admiralty which needed coal for its ships. Coal, at that time, had to be transported from England. He was provided with a ship to complete this task

Oceania

New Guinea

Fiji

Malaysia

Japan

Java

In 1883 a volcano on the island of Krakatoa, in the islands of the East Indies as they were then called, erupted. In a series of violent explosions half the island was blown away. Some 36000 people died and every trace of plant and animal life in the island perished. As stated above, Woods' was present in the region and provided an eye witness account of this event

Borneo

Perak

Tin deposits

Summary

The scientific work of Tenison-Woods is characterised by many qualities incompletely summarised as follows:

(i) his enormous erudition including extensive knowledge of contemporary scientific literature in at least English, French and German;

(ii) his acute powers of observation and recognition of natural phenomena, including ready identification to species level of animal and plant life, as well as, accurate identification of common rocks and minerals in the field or in hand specimen;

(iii) the extent of his journeying in Tasmania, the southern, eastern, and northern coasts of Australia, and then South-East Asia as far as Vietnam and Japan;

(iv) his astonishing capacity for handling large quantities of data enabling him to make comparative observations on even a world-wide basis with ease;

(v) his ability to readily marshal the vast information of his experience to develop coherent and persuasive theoretical models to explain his data. Although not all of these models would be acceptable today, this is the way science proceeds;

(vi) the integrity of various scientific methodologies, proper to the areas in which he worked, which he was able to employ;

(vii) his ability to do original thinking and develop new concepts well ahead of his time;

(viii) his desire to make his scientific observations available to the general public, by means of many series of articles to newspapers in Sydney and Brisbane, which paralleled his formal scientific writing. He also made use of the art of public speaking, of which he was an acknowledged master.

(ix) the relationship of mutual esteem, respect and even affection which he enjoyed with pioneering scientific workers at Oxford and Cambridge Universities, the University of Melbourne and later the University of Sydney; His relationship with ministers of religions of other Christian traditions who shared his scientific interests, were similar, and perhaps unusual for the time.

(x) the pioneering nature of his own scientific work in Australia and South-east Asia;

(xi) the assignments he received from the governments of NSW, Queensland, and the Northern Territory, as well as the British Admiralty to make reports of mineral and other resources beneficial for their respective economies;

(xii) the part-time and secondary role of much of his scientific work, which ran parallel to that of a minister of religion, a ministry characterised by mystical insights into the unity of all that is, and a passionate desire to share this with all;

(xiv) the early recognition from the scientific community (he was an esteemed member of learned societies in Australia and Asia), by national and international awards;

(xv) the prolific nature of his scientific writing, presently numbered as at least 175 publications, including books and many substantial journal papers, which appeared right up to the year of his death.

Conclusion

I believe that the examples I have given in this talk of the variety, extent and integrity of Wood's scientific work have gone some way towards supporting the claims I made in the introduction to his paper. In particular, they support his acute powers of observation, his enormous erudition, his capacity to develop an argument and to think ahead of his contemporaries as well as his concern for ordinary people and the economies of nations.

I thank the organisers of this symposium for the opportunity I have been given to share in this centenary communication. I consider it a great honour to have had my name associated in any way with today's proceedings, honouring an Australian of the stature of Julian Tenison-Woods, priest and scientist.

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Appendix 1

Comments on Tenison Woods' Botanical Work,

(especially in relation to the suggestions contained in the last two paragraphs of my Australian Museum Abstract (14/09/89))

Dr Peter Martin (Personal Communication, Oct 1989)

Tenison Woods had a significant output of papers on both fossil and modern botany. Of his total list of about thirty botanical contributions, I consider the following to be the most significant scientifically:

On the Coral Flora of Australia, Proc. Linnaean Society N.S.W., 1883, pp. 37-167.

Relations of the Brisbane Flora, Proc. Linnaean Society N.S.W., 1879, p. 117.

Notes on the Flora of Tropical Queensland, Part V, Proc. Linnaean Society N.S.W., 1882, p. 56.

Tasmanian Forests: Their Botany and Economical Value, Proc. Royal Society off N.S.W., Vol 12, pp. 17-28, 1878.

On the Vegetation of Malaysia, Proc. Linnaean Society N.S.W., 1889, p. 9.

I will discuss each of these in turn.

ON THE COAL FLORA OF AUSTRALIA (1883)

Fossil botany is a difficult subject even today, but in the 1870's and 80's, the subject presented enormous problems to workers in England, let alone in the Australian colonies. English speaking workers suffered from the general disadvantage that almost all the relevant literature was in German or French, while those in the colonies had the particular disadvantages of lack of ready access to the literature and virtually no opportunity to consult type specimens because these were almost all held by museums in Europe.

In the light of these difficulties, Tenison-Woods' paper is a major work. It is a masterly synthesis of all the relevant literature (regardless of language or country of publication) and a complete descriptive listing of all plant fossils known from the Australian coral formations up till that time, including a large number of new forms he had discovered during his investigation in Queensland. This is no mere museum study, but a major piece of literary research backed up by extensive field experience with coal-measure fossils.

Throughout the paper, he displays finely balanced judgements, a cautious approach towards the erection of new species and frequently looks to living forms for assistance in interpreting the fossil structures.

This large (130 pages) and comprehensive paper is of international quality and for a long time after its publication, served as a convenient guide to the fossil botany of the Australian coal measures for overseas' specialists.

RELATION OF THE BRISBANE FLORA (1879)

A very competent piece of work in the style and method of Sir Joseph Hooker. It provides an analysis of the Brisbane flora in terms of the probable origins of the elements within it (i.e. geographic elements). The main conclusion is that the Brisbane flora shows an interesting mixture of temperate Australian species, widely distributed species from the warmer regions of the globe and truly tropical species of Indo-Malayan affinities. He notes that the concentration of this latter group is greatest in the river-bank and creek bank "scrubs".

This paper is important in the development of his ecological thinking because of the emphasis placed on numbers of individuals as being more potent in determining the appearance of the vegetation than a very rare species which may, however, from the point of view of the systematic botanist, be the chief distinguishing mark of the flora of that area.

The following quotations from this paper contain a number of interesting statements:

> "Now that the great work of cataloguing our Australian Flora has been concluded, and that the *Flora Australiensis* of Bentham and Mueller is a standard of reference to which recourse can easily be had, the preparation of local floras will be the first care of Australian botanists. Until this is done, the real character of Australian vegetation will hardly be manifest. At present our knowledge does not go much further than a enumeration of species. Their geographical distribution has hardly been touched upon. Information as to the habitat where each specimen has been found is of course given in the "Flora," but the range of the species is not attempted" (p117).

> "In the meantime what is very important is to have a good census made at certain important stations, such as Port Jackson, and at distinct points on the coast, and in the interior, where marked differences might be expected" (p118).

> "The tract is well watered by rivers, and enriched by that dense vegetation known as river scrubs. We thus have considerable tracts of marshy ground both fresh and salt, and though we include no mountain range of any height above a thousand feet, yet there are hills and rises sufficient to give a dry soil with the diversified flora we might expect upon elevated ridges. In the scrubs we have a moisture and deep shade which in this climate is favourable to the growth of any tropical plant, and the range of the temperature and the rainfall are all favourable to the growth of any plant which would flourish in a much warmer latitude.

> It should be borne in mind that a census refers only to orders, genera, and species, and takes no account of the prevalence of individuals. Thus an exceptional plant which is outside the usual features of the order and genus to which it belongs, may be a very rare plant, yet its peculiarities give a name and character to the flora, while a world-wide species which is common everywhere is not taken into account. And thus it is that very distinct botanical provinces may bear no marked peculiarity externally" (p119).

> "And this resemblance points to a remarkable fact that must be taken into account in estimating the Australian flora. We have both in genera and species a certain

> amount of world-wide forms, and these are for the most part species which are richest in individuals as well. If we were, for instance, to take away the grasses, ferns, sedged, and rushes, (Junceae, &c.,) from the Brisbane flora, its connection with the floras of other parts of the world would seem very slight, but in the absence of such members of a flora, the aspect of the country would be a desert indeed. Taking them all-in-all, therefore, our resemblances are greater than our differences, and this must limit our notions of the exclusive peculiarities of the Australian flora.
>
> Many of the plants have a very peculiar habit or physiognomy, giving in some cases a character to the forest scenery" (p120).

FLORA OF TROPICAL QUEENSLAND, PART V (1882)

In one sense, this is a strange paper because much of it is not about tropical Queensland, but rather a careful comparative discussion of what constitutes a "scrub". In this discussion he clearly recognises the concept of vegetative formations as characterised by a particular structure rather than by particular species. For example, on p. 569, referring to what we would now call tropical rain forest, he says "no one genus or even species gives its character to the forest".

In his treatment of the Brigalow scrubs, he clearly recognises that it is dominance by Brigalow, rather than an exclusive tree cover of Brigalow, which determines the nature of the whole formation known as Brigalow scrub. These things may seem obvious the late twentieth century reader, but they were entirely novel concepts in the 1880's as botanists struggled to find some way of describing vegetation in other than economic or species-list fashion.

Other evidence in the paper suggests his increasing frustration at the absence of a proper terminology to describe vegetation - something I am sure he would have contributed to in a significant way at Empire level (because of his extensive powers and comparative powers) had he lived for another 10-15 years.

TASMANIAN FORESTS: THEIR BOTANY AND ECONOMIC VALUE (1878)

The whole paper is interesting, but from my point of view, I have singled out the few pages in which he compares with seemingly effortless ease, and from first-hand experience, the tall Eucalypt forests in Eastern Tasmania, Gippsland (Victoria) and the south coast of New South Wales. Very few people would have had the opportunity to study all three areas in detail at that time, and even fewer would have viewed the scenes in the way that he did, ie., recognising that within a characteristic form of forest (what we would now call high forest or wet sclerophyll forest) in different localities, that one species tends to replace another in terms of a particular role in the workings of the vegetation formation. This is the earliest evidence I have found (1878) of the emergence of his thinking on this aspect of vegetational ecology.

ON THE VEGETATION OF MALAYSIA (1889)

This very lengthy paper (which covers what is today Indonesia, Malaysia, Brunei and parts of Burma) is not as well organised as most of his work, and may reflect the fact that he was very ill when fitting it together. It falls into three sections:

(i) general geographical introductions
(ii) the vegetations
(iii) cultivated plants of the region.

Although somewhat disjointed, the section on vegetation shows a clear advance in his ecological thinking since 1882 - perhaps as a result of his much wider travels and opportunities for botanical reflection in the 1880's. The following quotations will show something of this:

> "The best way to deal with the character of the flora as prepared in this essay will be first to describe generally its features, and then such subdivisions as arise from friction, soil, climate, etc." (p.14).

This approach is as good as anything found in Tansley's (1911) pioneering manual on the ecological approach to the description of vegetation.

He divided the vegetation into the following types (p23), which are listed together with the sub-types he recognised:

Marine littoral vegetation
Alluvial Plain vegetation
- open ("grasslands")
- forests
- swamps/ponds
- river bank forests

Mountain slope forests
Sub-alpine vegetation of mountain summits.

In relation to the forests of the plains and mountain slopes (lower), he notes (p33) that "There is a decided difference between them", but that this difference is the result of "a more stately and luxuriant growth" on the mountain slopes rather than a change of any significance in botanical composition.

Here we see the converse of some of the situations he had previously described - here the vegetation of the two regions was recognised as decidedly different, but the botanical makeup (ie., species' composition) was the same - it was one of the effects due to soil and climate (see quotation from P. 14 above) that he had recognised throughout his travels in tropical Asia.

In relation to the Dipterocarf forests, he notes (p44) that despite some changes in the species involved "there is only one aspect for the flora between Borneo and Ceylon". Here he is using "aspect" to mean general appearance, a usage he had stabilised as far back as his Brisbane Flora paper of 1879, but the use of "flora" is loose and confusing; the meaning intended here is "vegetation".

CONCLUDING COMMENT

These examples should be sufficient to support my contentions that Tenison-Woods was distinctly ahead of his times with his well-developed ecological approach to vegetation. I feel certain that his thinking in this direction was greatly stimulated by the enormous range of vegetation types with which he was familiar, and the need he felt to develop some generalising concepts to assist in classification and comparison on a scale that went far beyond national boundaries.

This map (Martin, 1989, pers. Com.) shows Areas of Vegetation with which Tenison-Woods had

(a) Detailed knowledge

(b) General familiarity

The map is very rough and should not be used to do anything more than suggest that his great land knowledge of vegetation extended from Tasmania, right up the southern and eastern coasts of Australia, the top corner of the NT and on through Java, Malaysia, coastal Borneo, the Philippines, Hong Kong and even a little bit of Japan and Vietnam - an incredible cross-section of the botany of the East Asian - Australian region.

P Martin, October, 1989

Appendix 2

Rev. Julian Edmund Tenison-Woods: Founder of the Sisters of St. Joseph

Extract from Annual Address of Prof. Liversidge, president Royal Society; New South Wales (May 7th 1890)

> `The Society has sustained a great loss by the death of the Rev. J.E. Tenison-Woods, M.A., F.G.S., F.L.S., Hon. Mem. Royal Soc., Victoria; Hon. Mem., Roy. Soc. Tasmania; Hon. Mem. Adelaide, Phil. Soc.; Hon. Mem. New Zealand Institute; Hon. Mem. Linnean Soc. & C who died in the 7th October last. He was one of our first honorary members elected in 1875, and he almost immediately acknowledged his connection with the Society by presenting contributions to it, the first being entitled "On some Tertiary Australian Polythox" read before our meeting held on Oct. 4th, 1876, followed by others at frequent intervals. The following account of the Rev. J. Tenison-Woods is formed upon various notices which appeared at the time of his death. `The Rev. Julian Edmund Tenison-Woods was born 15 November 1832 at West Square, . New South Wales and made Sydney his head quarters; he now gave up most of his time to the study of natural history and geology, and worked with unflagging energy, as is shown by the bart list of the papers published by him. In 1883 on the invitation of Sir F.A. Weld, K.C.M.G., Governor of the Straits Settlements, he proceeded to Singapore; there he made an exploratory trip through Malacca and reported upon its geology and tin resources. He also visited Java. Borneo, Siam and Philippine Islands, Japan and other places and was at Krakatoa during part of the volcanic eruption. After a lengthened cruise he returned to Hong Kong. From that place he left to ascend the Hoang Ho, the Chinese "river of Sorrows"; but fevers compelled him to return to Hong Kong and finding his health was seriously impaired he determined to make his way back to Sydney. He came by H.M.S. "Flying Fish", surveying vessel, as far as Port Darwin, visiting on his way some islands which had heretofore been unknown.
>
> "Mr Parsons, the Government Resident in the Northern Territory, invited him to visit and report upon the mineral districts of that part of the country which is made the rule of South Australia. His health by no means good at the time he undertook the task, was still from further impaired by the fatigues and privations which were unavoidable on such a journey and after an absence of about four years he returned to Sydney. A short visit to Queensland terminated his wanderings, and his return to New South Wales was a welcome rest to him. The hardships he had undergone began, however, to tell upon him seriously, and partial paralysis of his hands and legs slowly crept over him, and his health slowly but surely gave way. For nearly two years he was confined to his house, and was so debilitated, that he was unable to see any but his intimate acquaintances. He suffered greatly, but he bore his affliction with remarkable fortitude and patience. Although an invalid he still continued to work at his scientific pursuits with a vigour that could be barely expected from a person in his physical state, and published many essays on the natural history of the countries he had visited, one of his latest being "The natural history of the Mollusca of Australia", for which he received our medal and a grant of $25, offered for the best original communication upon that subject.

Mr Woods was at one time President of the Linnean Society of New South Wales and at the time of his decease was one of its vice-presidents. He was the Clarke Medallist of the Royal Society of New South Wales in 1888. He also received the gold medal of His Majesty William III, King of the Netherlands for a work on "Fish and Fisheries of New South Wales" written by him at the request of the Government of New South Wales, at the time of the Fisheries Exhibition held in London. He was an accomplished scholar and excellent linguist, a good musician and an artist of considerable ability; most of the drawings which illustrate his scientific works were the work of his own hand. He was characterised by great simplicity, courtesy and kindness of manner, a quiet, cheerful, pleasant voice and really kindly smile, no small matters in these days of hurry and high pressure. Having been resident in several of the colonies, he was very widely known and laudatory biographical notes appeared in all the leading Australian papers. The full funeral honours of the Roman Catholic Church were paid to our late member (whose remains previous to interment in the Waverley Cemetery were in cast, taken to the Roman Catholic Cathedral) by the Cardinal and other Church dignitaries; amongst those who attended his funeral as a tribute of respect, were your President, the Senior Honorary Secretary and other members of the Council, together with members of the Council of the Linnean Society, many representative citizens and personal friends of the deceased naturalist.

Note - List of papers contributed to different learned societies too numerous to copy:

Royal Society (NSW) -	16
Linnean Society (NSW) - 68 and two in conjunction with F.M. Bailey making total of	70
Philosophical Society (Adelaide) and Royal society (South Australia) -	6
Royal Society (Tasmania) -	23
Philosophical Institute (Vic) -	3
Royal Society (Vic) -	10
Qld Philosophical Soc. -	1
Atrifo Institute (N.Z.) -	1
Wellington Phil. Soc. (N.Z.) -	1
In other publications -	12
Reports, Pamphlets - etc.-	8
Letters to Newspapers -	20

and

"*Geological Observations in South Australia*, 1862, 1 vol, London & Melbourne.

Discovery and Exploration of Australia, History of, 1865

Fish and Fisheries of NSW, 1882, 1 vol, Sydney.