CHAPTER 9

NEW SOUTH WALES GEOLOGY — ITS ORIGINS AND GROWTH

T. G. Vallance

and

D. F. Branagan

". . . every settler is under the necessity of becoming a geologist; . . ."

T. L. MITCHELL (1838).

"The stone of this country is of three sorts; freestone, which appears equal to Portland stone; a bad firestone; and a stone that appears to contain a large proportion of iron. We have good clay for bricks, but no chalk or limestone has yet been found." Thus Governor Phillip summarized in May, 1788, what he had learned of the rocks about the town of Sydney, founded a few months earlier. But search of the surrounding country for useful materials was a slow business limited by the few skilled people available. Watkin Tench, one of the abler residents, admitted in 1793 he had tested "with fire, and chemical preparations . . . all the different sorts of stone to be picked up" in a fruitless and evidently rather indiscriminate search for limestone. With more technical matters the governor had to rely on the help of Sir Joseph Banks in London. It was in material from Sydney Cove sent for testing as pottery clay that Josiah Wedgwood claimed to have found a new chemical element. Called Sydneia or Terra Australis, Wedgwood's "element" attracted attention until it was shown in 1798 that he had been misled by his reagents. There was, in fact, little exceptional about the clay.

During 1797, coal was discovered accidentally on the Illawarra coast and at the mouth of the Hunter River. It had been reported as occurring north of Sydney by convicts escaping in 1791. "Fresh water coal" (carbonaceous shale?) had been noted earlier (1790) in the Hawkesbury River near Windsor. Study of the distribution of coal begins with George Bass, sent by Governor Hunter to inspect the southern coal in August, 1797. Bass traced what he believed to be a single seam six feet thick for some eight miles along the coast. In fact, faulting had there brought several coal seams close to sea level. The Illawarra coal was found, however, to be rather inaccessible and a convict miner, J. H. Platt, received instructions to bore for coal in the upper reaches of George's River. Though unsuccessful, the scheme suggests some awareness of the idea of a coal basin. Attention then turned to the more distant Hunter River. As early as 1799 a shipload of coal had been raised for export to Bengal though organized production did not begin until 1801. The search for limestone continued but none was found in quantity until 1815, by which time a way had been found across the Blue Mountains.

Some awareness of the need for more organized search for useful materials may be seen in the appointment in 1803 of A. W. H. Humphrey (1782?-1829) as His Majesty's Mineralogist in the colony, though one should not be misled by the grand title. A man of little science, Humphrey had some success as a prospector, chiefly in Tasmania. The post lapsed on his retirement in 1812 and was not revived for some years, although W. Parr, "mineralogist" to Oxley's expedition of 1817, made a number of official prospecting surveys before 1820. In 1823, John Busby (1765-1857) became Civil Engineer and Mineral Surveyor—an appointment he held till 1837. Busby is now chiefly remembered for his work on the Sydney water supply.

These government appointees were practical men, expected to be useful rather than concerned with advancing scientific knowledge. At that time, cultivation of science may have been regarded in Britain as an acceptable preoccupation for gentlemen; it was hardly a profession. And doubtless few gentlemen wished to visit, let alone reside in, a remote penal colony. Contemporary French attitudes were rather different. Scientific education in France had developed rapidly since the Revolution, and by the turn of the 19th century institutions such as the Museum d'Histoire Naturelle and the Ecole des Mines were producing a small stream of graduates. We can see the contrast between French and British recognition of science in the arrangements made for the expeditions led by Baudin and Flinders between 1800 and 1804. Baudin had a large scientific staff, including two mineralogists, one of them (Louis Depuch) a student of the great R. J. Haüy. Flinders' scientific staff was, in effect, one naturalist—though that one was the incomparable Robert Brown. A practical miner accompanied the expedition but geological work was just an added responsibility for Brown.

Depuch and his fellow mineralogist, Charles Bailly, must have been the first geologically-trained observers to visit the country. Their remarks are both interesting and valuable. Before reaching Sydney, for instance, they had examined beds raised well above present sea level along the Western Australian coast. These beds contained fossil molluscs which they identified as akin to living species. Their observations gained wide currency when Cuvier quoted them in support of his theory of catastrophic revolutions in geological history—a theory invoked, incidentally, by another French scientist, R. P. Lesson, in 1824 to account for the Blue Mountains valleys. During their stay in Sydney in 1802, Depuch and Bailly described shales containing fossil "ferns" at Parramatta as younger than the sandstones of Sydney and predicted that coal would be found at depth. The nature of pebbles in the bed of the Hawkesbury River provided them with clues regarding the likely geological picture within and, perhaps, beyond the Blue Mountains, then uncrossed. Later French expeditions to Australia were no less distinguished but limitations of space prevent our dealing with them here.

The trained scientists attached to maritime expeditions had to confine themselves to the coastal regions. Turning to inland exploration, a different pattern emerges. Responsibility for this work passed to resident surveyors and military officers almost entirely unsupported by scientific staff. Apart from T. L. Mitchell (1792-1855) and, perhaps, Charles Sturt (1795-1869) few of our early explorers had more geological expertise than a rudimentary knowledge of lithology, though their contributions to physical geography are well known. Mitchell, in fact, has the distinction of preparing the first published (1838) Australian geological map—that of the Wellington Valley. But by taking samples for subsequent detailed study, most of the explorers helped, in their way, to enlarge geological knowledge. The interest generated by increasing awareness of the Australian fauna and flora and the discovery, for example, of living forms closely related to European fossils, ensured a ready scientific welcome to any collections from the antipodes. When J. Lhotsky of Vienna announced in 1829 his intention of visiting New Holland to collect specimens—including minerals, "petrifications" and fossil animals—for subscribers, he found no lack of sponsors. Several European institutions profited from his labours during the six eventful years spent in Australia. Lhotsky was one of the first of our independent scientific explorers, a tradition to which P. E. Strzelecki (1797-1873) and L. Leichhardt (1813-1848) also belong. All three had extensive geological experience and did valuable work here.

The study of Australian collections in Europe has important links with the rise of local stratigraphy. As early as 1810, Leopold von Buch had tried, without notable success, to find evidence of order among the material gathered by Depuch and Bailly. Ten years later, William Buckland of Oxford recognized "transition limestone" (Palaeozoic) in Oxley's collection. Evidence of a Tertiary age for the marine succession, discovered by Sturt in 1830 along the lower reaches of the Murray River, was established by James Sowerby from a study of

Sturt's material. The discovery of fossil bones in the Wellington Caves, at a time (*ca.* 1829) when Buckland's researches were renewing interest in the Noachian deluge, prompted Richard Owen's lifelong association with the study of Australian fossil vertebrates. The record of European collaboration in Australian geology was only beginning.

As in Europe, our early stratigraphical essays tended to be based in part, at least, on lithological characters and the coal measures offered a convenient reference. Acceptance of William Smith's method, utilizing organic remains, came gradually. W. H. Fitton, in his review of Australian geology in 1826, based on collections made by Flinders and P. P. King and published literature, concluded that a sequence ranging upwards from mountain limestone (Carboniferous limestone of England) to coal, New Red Sandstone, oolite (Jurassic), recent calcareous breccia and alluvium rested on a primitive basement. Recognition of New Red Sandstone, for instance, was based on the occurrence of salt in Tasmania, recorded by Humphrey and Archdeacon T. H. Scott. Both Sturt and Mitchell referred to red sandstones in the interior of New South Wales as Old Red.

But development of a meaningful stratigraphy depends on a combination of careful field study and palaeontological data. A break in the stratigraphical succession of the South Coast was clearly recognized by Alexander Berry (1781-1873) in 1822. Going southwards to Bateman's Bay, Berry found vertical beds beneath the gently dipping sandstones associated with the coal. Granitic rocks underlying sandstone in the Blue Mountains were already known. Then, in 1828, the fossil plants *Glossopteris browniana* and *Phyllotheca australis* were recognized by Adolphe Brongniart in coal samples from New South Wales. The former plant occurred also in some Indian coals; neither was known in Europe. Brongniart, however, continued to accept the common view that Australian coal must be equivalent stratigraphically to that of Europe and North America. Salutary warnings, such as those of H. T. de la Beche in the 1830's, that lithology offered no rational basis for correlation of Australian with European formations, passed without much notice.

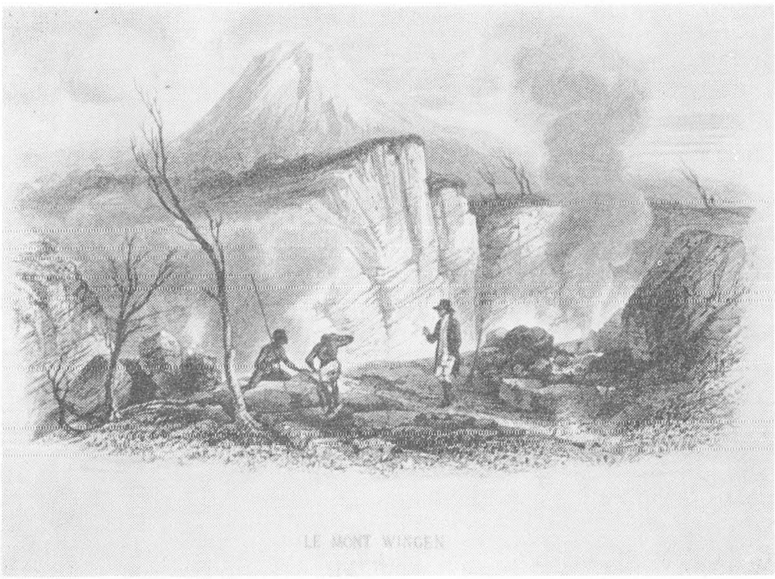
Little progress, in fact, could be made until an acceptable order of succession among Palaeozoic rocks had been established, an achievement which stands largely to the credit of A. Sedgwick and R. Murchison in Europe. Apart from the special case of the Ordovician, the Palaeozoic column, as known today, had been completed by 1841 when Murchison erected his Permian system. As early as 1838 and aware of Murchison's work, Mitchell attributed a Silurian age to rocks at Limestone Plains (Canberra). Two years later, E. de Verneuil announced identification of a fossil collection from eastern Australia containing types ranging from Silurian to Jurassic in age. Strzelecki's *"Physical Description of New South Wales and Van Diemen's Land"* (1845) provided many more data on Palaeozoic rocks and fossils as well as a geological map showing areas representative of four "epochs". The oldest fossiliferous rocks were ascribed to his Second Epoch (Silurian) above which was a succession of Carboniferous age and including both coal and marine beds. Loose sands, gravels, raised beach deposits and cave breccias constituted the materials of Strzelecki's Fourth Epoch. Then, in 1846, L. de Koninck (1809-1887) of Liège remarked that fossils from the marine strata associated with the Australian coal bore a close resemblance to forms in the European Permian. A Permian age for the coal succession was also proposed in 1849 by J. D. Dana (1813-1895), on the basis of ganoid fish remains. He amended this view later in the belief that plant fossils from the coal indicated a Triassic age. Such apparent conflict in the palaeontological evidence, in fact, was to be a source of argument for many years.

During his stay in Sydney as a member of the U.S. Exploring Expedition (1839-1840), Dana made the acquaintance of a man, himself a newcomer, who was destined for fame as Australia's first great resident field geologist. The Rev. W. B. Clarke (1798-1878) became, in fact, the dominating geological authority of his time in this State. Clarke had arrived in 1839 and quickly resumed geological activity which he combined with clerical duties, as he had in England. He early visited the Illawarra district and Newcastle, where his fellow-chaplain, the Rev. C. P. N. Wilton, had been geologizing for some years. It was Wilton who attracted notice overseas with his descriptions of the "burning mountain" at Wingen in 1829; he was also the first person to describe the pseudomorphs, later called glendonites, at Glendon Brook. During his visit of 1842, Clarke discovered a fossil "forest" on the shores of Lake Macquarie and began to devote much attention to the problem of the age of the Hunter Valley coal. Clarke argued for a Carboniferous age, claiming to have found *Lepidodendron* and *Calamites* associated with the coal, but in 1847 the coal fossils he had sent to Sedgwick at Cambridge were pronounced to be Jurassic by Frederick M'Coy (1817-1899). The ensuing wrangle between Clarke and M'Coy increased in warmth after the latter was appointed (1854) Professor of Natural Sciences in the new University of Melbourne and became more involved with the problems of Australian palaeontology.

M'Coy, using fossil evidence unrelated to field observations, claimed the coal must be much younger than the beds immediately below which, he agreed, contained Palaeozoic remains. Clarke, however, could demonstrate in the field a conformable sequence upwards from marine beds into the coal. No less an authority than J. B. Jukes (1811-

The "fossil forest" at Lake Macquarie, N.S.W., discovered by the Rev. W. B. Clarke in 1842. From a pencil sketch by Clarke now in the Fisher Library, University of Sydney.

1869), who had visited Sydney in H.M.S. *Fly* during 1842, was content to accept Clarke's field evidence, though he and the palaeontologist E. Forbes showed much less enthusiasm for the identification of *Lepidodendron* in the coal measures. With the advantage of hindsight, we can see that Clarke, at times, confused true Carboniferous rocks containing *Lepidodendron* with members of the more important Permian coal-bearing succession. The mistake is hardly surprising, for Clarke's clerical duties can have left him with little time to devote



The "burning mountain" near Wingen, N.S.W., from an engraving in Dumont d'Urville's "Voyage autour du Monde".

According to the Neptunian theory, developed by A. G. Werner of Freiberg, rocks now regarded as igneous were taken to be aqueous precipitates. Volcanic phenomena were attributed to such local features as burning coal seams. Although by the time (*ca.* 1829) the Rev. C. P. N. Wilton brought Mount Wingen to scientific notice support for Neptunian ideas was rapidly waning, this splendid example of a burning seam became widely known overseas as a volcano or pseudo-volcano. The author of this sketch has taken the liberty of treating the distant hill as if it were a volcanic cone; in fact, it consists of a Tertiary basalt cap resting on Triassic and Permian sediments.

to detailed mapping. Yet there is no denying his achievement. It was Clarke who brought order to what Strzelecki had called the Newcastle Basin by establishing the sequence (lower) marine beds, coal, marine beds, (upper) coal in the Hunter Valley followed southwards by Hawkesbury beds, the base of which he took to be reddish shales. Wianamatta beds occupied the top of Clarke's succession in the Sydney district. At first, Clarke included the post-coal rocks with the Palaeozoic but, towards the end of his life, admitted the possibility of their being early Mesozoic and even that the uppermost coal might be Permian.

For a time in the 1850's, Clarke's attention was effectively diverted from coal problems to those of the older Palaeozoic rocks and, in particular, the occurrence of gold. Both he and Strzelecki had already discovered gold during their separate journeyings among the older rocks as had the surveyor M'Brien as early as 1823. Unaware of these finds which had been kept secret, Murchison in 1844 started to hint publicly in Britain at the likelihood of valuable gold resources being found in eastern Australia, basing his opinion on supposed analogies with the auriferous Ural Mountains. Thus prompted, local authorities began to show more interest in the possibility of mineral wealth. During the year before Hargraves' loud proclamation of his discovery at Summer Hill Creek, which marked the start of the gold-rushes, the New South Wales Government appointed Samuel Stutchbury (1797-1859) of Bristol to undertake a mineralogical and geological survey, a task he pursued unobtrusively until 1855 when he returned to England. Stutchbury's arrival caught the government so ill-prepared that he was able to pay a short visit to Newcastle late in 1850 while his detailed instructions were being arranged. It would be quite untrue to say that Clarke welcomed Stutchbury's appointment but, in the event, both became involved in geological surveys having official sponsorship. Their paths diverged from the outset, Stutchbury setting off in 1851 to examine the country about Carcoar and Wellington, working thence into what is now Queensland. Clarke went south to the Shoalhaven River and eventually into north-eastern Victoria. His southern tour completed, Clarke turned to the New England region, while Stutchbury was still moving north. Clarke ensured recognition of his contribution by re-issuing his reports as "Researches in the Southern Gold Fields . . ." (1860); Stutchbury's work remains buried, quite undeservedly, in parliamentary papers.

Much new information on Upper Silurian (known since separation of the Ordovician, as Silurian) and Devonian rocks in New South Wales came from the goldfields work. Agreement on the Devonian was, however, no simple matter. Both Clarke and Stutchbury claimed to have found Devonian strata during their surveys but, at the time, there seems to have been a marked reluctance, especially among overseas geologists, to attribute a Devonian age to any part of the Australian succession. Australian strata containing fossils strikingly similar to Devonian forms in Europe were regarded as either lowermost Carboniferous or uppermost Silurian. As late as 1861, M'Coy was claiming Devonian rocks did not exist in this country. By this time Stutchbury was dead, but it is evident that Clarke was rather overwhelmed by the concerted opposition. For a while he became decidedly diffident about his Devonian, but the publication of de Koninck's *"Recherches sur les Fossiles paléozoiques de la Nouvelle Galles du Sud"* (1876-1877), based on Clarke's own collections, finally placed the existence of Devonian strata in New South Wales beyond reasonable doubt.

In the early study of lower Palaeozoic stratigraphy, New South Wales geologists played a less important part than their colleagues in Victoria. The infant colony of Victoria provided the rest of Australia with a model in its first geological survey, established in 1852. A. R. C. Selwyn (1824-1902), fresh from work on older Palaeozoic regions in Wales, was selected to lead the survey and gathered about him a remarkably able group of assistants. During the 16 years of its existence, Selwyn's survey had no equal in this country, and few abroad, for excellence in exposition of structural and stratigraphical principles. Its disbanding at the end of 1868 on the grounds of economy led to other States gaining trained geologists, but Selwyn, himself, was lost to Canada. New South Wales was fortunate in securing the services of C. S. Wilkinson (1843-1891) to found its geological survey in 1874. The foundations set by Selwyn's survey were gradually built on by other Victorian workers. Years before Lower Silurian (Ordovician) rocks had been recognized in New South Wales, extensive graptolite faunas were known in Victoria. It is hardly surprising that many of the stratigraphical terms for units of the lower Palaeozoic in eastern Australia have Victorian names.

Between the conclusion of the goldfields survey with Stutchbury's departure in 1855 and the establishment of the New South Wales Geological Survey, official geological work in this State was confined largely to studies of the coal areas by men such as W. Keene and J. Mackenzie, who bore the title Examiner of Coal Fields. Clarke had returned to his parish in 1853 but continued his own private researches.

Some improvement through regular geological studies might have been expected when the University of Sydney appointed A. M. Thomson (1841-1871) in 1866 as Reader in Geology, promoting him to a chair in 1870. Thomson's early death dashed these hopes. He had shown a keen interest in field studies. His last work, in company with the naturalist G. Krefft of the Australian Museum, was an examination of the Wellington Caves and its Pleistocene vertebrate remains, undertaken at the behest of Sir Richard Owen. The interests of Thomson's successor, A. Liversidge (1847-1927), lay in chemical mineralogy—of which he was practically the Australian founder. By this time, however, the geological survey was beginning its work.

The early annual reports of the geological survey contain an amazing record of geological reconnaissance completed by Wilkinson with very little official assistance. At Rydal, in his study of Upper Devonian rocks, Wilkinson had the help of the elderly W. B. Clarke. Clarke's then unpublished geological map of the State provided Wilkinson with a starting point for his regional surveys and the rate of geological progress became more rapid. We can see this exemplified in the study of Mesozoic successions. Cretaceous rocks, first recognized in Queensland, were soon traced into New South Wales and the discovery in 1878, following Wilkinson's prediction, of artesian water at Kallara station, in the north-west of the State, provided the impetus for much deep drilling from which data on the Great Artesian Basin were derived. In the North Coast region, the coal-bearing succession of the Clarence basin had long been a puzzle. Clarke had thought it equivalent to the coal measures of the Hunter Valley, but the fossil floras seemed to be different. The Clarence coal flora lacked *Glossopteris* and had closer affinities with Mesozoic types. Here and in the wider field of late Palaeozoic and Mesozoic floras in Australia, notable contributions were made by O. Feistmantel of Calcutta, whose studies of Clarke's collections were published by the New South Wales Geological Survey. The liaison originally established between Clarke in Sydney and Oldham and Feistmantel in Calcutta and the early attempts at stratigraphical correlation between Australia and India foreshadow the Gondwana concept of a unified southern continent in earlier geological times.

The discovery of an extensive Tertiary flora came chiefly through the exploitation of gold- or tin-bearing stream and lake beds, often covered with flows of basalt and known as "deep leads". M'Coy and F. von Mueller in Melbourne and C. von Ettingshausen of Vienna all added to our knowledge of Tertiary plant remains which led to the establishment of a local Tertiary chronology complementing the work of the Rev. J. E. Tenison Woods on Tertiary marine successions.

Clarke's work of supplying outside palaeontologists with local material was continued by the Survey until 1887 when it attracted Robert Etheridge, Jun., back to Australia. Etheridge had served with Selwyn in Victoria and, since, had gained an enviable reputation as a palaeontologist at the British Museum. In Sydney, he was to hold the dual post of palaeontologist to both the Survey and Australian Museum until 1895 when he became director of the museum. The first trained palaeontologist to take up his profession in this State, Etheridge was able to make an immediate and important contribution to our geological knowledge. The range of his work here in systematic palaeontology has probably never been surpassed. Although his main work may have been of a specialized nature his influence on stratigraphy was considerable. The term Permo-Carboniferous, which had currency in New South Wales and Queensland for many years, was introduced by Etheridge as a way round the thorny problems of late Palaeozoic classification. Publication of the Records of the Geological Survey and of the Australian Museum, both valuable sources of scientific information, began at his instigation.

Five years before Etheridge's return, T. W. Edgeworth David (1858-1934) joined the New South Wales service as assistant geological surveyor, replacing a man who had disappeared in mysterious circumstances while engaged in field work on the South Coast. No unhappy accident was ever turned to better account.

David's early years with the Geological Survey provided him with no lack of variety. Completing his first major study, that of the Vegetable Creek tin field, which appeared as the first of a distinguished series of Survey Memoirs in 1887, David's attention was directed to the strata of the Sydney-Newcastle region. Clarke had demonstrated the broad stratigraphical pattern here but there still remained scope for debate. Only a few years before, Tenison Woods had argued for the abolition of Clarke's Wianamatta beds on the mistaken grounds that the shales of this unit were simply intercalations within the Hawkesbury sandstone and formed part of it. The lower part of the succession interested David at this time, and in 1887, he advanced convincing reasons for recognizing the separate existence of Clarke's "passage beds" between the upper coal measures and the Hawkesbury sandstone and gave them the name Narrabeen shales. By this time, David had moved on to detailed mapping of the Hunter Valley coalfield, a work which, incidentally, led to the discovery and tracing of the Greta coal seam. His memoir, not published until 1907, is one of the classics of Australian geology.

Recognizing David's unusual ability, the University of Sydney secured his services as co-examiner with Professor W. J. Stephens, who had assumed charge of non-mineralogical geology from Liversidge in 1882. On Stephens' death, David was appointed Professor of Geology, a post he held for some 33 years until his retirement in 1924. Geological knowledge in New South Wales has increased greatly since 1891 and a measure of David's achievement lies in the fact that so much of the advance came directly from the work and inspiration of this one man and his students. Moving to the university with a broad experience of survey work, David enriched the whole of his science. Geology, for him, knew neither specialist compartments nor geographical limits. His masterly leadership of the 1897 expedition to the Pacific atoll of Funafuti, organized to test Darwin's theory of the growth of coral reefs, brought him an international reputation.

David's work on the upper Palaeozoic successions of the Hunter Valley and northern New South Wales continued at the university. Detailed knowledge of Devonian rocks in this region may be said to begin with the study of radiolarian rocks containing *Lepidodendron australe* at Tamworth, undertaken by David and E. F. Pittman of the Geological Survey. Within the succession regarded as truly Carboniferous, the contrast of an upper freshwater facies carrying *Rhacopteris* with a lower marine association had been recognized during David's survey days, but the main stratigraphical contributions were yet to come. One of David's problems here was the relation between upper Carboniferous strata and the Permo-Carboniferous. Glacial characters were noted at Lochinvar in rocks which he took to be basal Permo-Carboniferous. David claimed in 1899 that a marked unconformity existed between erratic-bearing shales and the underlying sequence with *Rhacopteris,* the break involving also a return to marine conditions. Subsequent work, aided by the processes of erosion, has shown that there is, in fact, no angular unconformity here, but the idea persisted for many years and had a strong influence on the study of Carboniferous-Permian problems. It should be remembered that at this time, glacial features had not been recognized in the Carboniferous.

Glacial geology had claimed David's interest in his native South Wales. It was to remain a subject of special concern throughout his life, drawing him, for instance, to face the rigours of Antarctica with Shackleton's expedition of 1907-1909. In New South Wales, the idea of past glaciation had been advanced as early as 1852 by Clarke, in the course of his goldfields work. Clarke believed that the present landscape at Kosciusko owed its character to glacial action but, over the years, there had been active doubters. In David's time, the Rev. J. M. Curran, a teacher of geology at the Sydney Technical College, was a vocal opponent of Kosciusko glaciation. The observations of David, R. Helms and E. F. Pittman, published in 1901, at once vindicated and developed the concept of Australian Pleistocene glaciation. In fact, the whole subject of scientific study of landscape was one in which David played a founder's role in this country. His influence may be seen in the physiographic studies of E. C. Andrews, W. R. Browne, C. A. Süssmilch and Griffith Taylor, who had been members of the Sydney school.

Mention of David's students brings us to the threshold of modern specialist developments in New South Wales geology. Names like W. N. Benson, W. R. Browne, L. A. Cotton, H. I. Jensen, Douglas Mawson, C. A. Süssmilch, Griffith Taylor and W. G. Woolnough, for instance, would have an honoured place in any record of our petrological tradition. In fact, apart from the pioneering efforts of Curran and survey men such as David himself, it is to David's students and, in particular, to Woolnough and Browne, that we must look for the origins of detailed work on the igneous and metamorphic rocks of New South Wales. Browne's later study of the relations between tectonic activity and the characters of batholithic masses is one of the few Australian contributions that can fairly be said to have influenced the course of geological thinking throughout the world.

None of these men was a narrow specialist; each shared his master's breadth and contributed to a variety of fields. Benson's study of the Great Serpentine Belt in northern New South Wales may be taken as a good example. In addition to a wealth of information on the basic and ultrabasic rocks of the belt, Benson supplied the first coherent picture of stratigraphy and structure for the whole region. His mapping extended David and Pittman's work at Tamworth to embrace the upper part of the Devonian sequence in which he established the Baldwin and Barraba units. These were followed by Lower Carboniferous marine sediments, which he termed Burindi mudstones. Benson's stratigraphy, announced in 1913, has been followed by subdivision of Devonian successions elsewhere in the State—notably on the South Coast, and later, at Yass, through the efforts of Ida A. Brown and others.

In 1914, David made the discovery of glacial beds in the freshwater Carboniferous association at Seaham, near Maitland. A great strengthening of interest in Carboniferous rocks resulted, and our present knowledge owes much to the studies of David, Süssmilch, Browne, W. S. Dun, A. B. Walkom and, a little later, G. D. Osborne. The term Kuttung was applied by Süssmilch and David in 1919 to that part of the Carboniferous succession which included the so-called *Rhacopteris* beds and lay above Benson's Burindi mudstones. Subsequent work has shown that this view needs modification. The later Burindi environment existed at the same time as the early Kuttung freshwater and terrestrial conditions, but the essential argument stands. A pattern of stratigraphical subdivision within the Kuttung came with Osborne's study in 1922. Osborne later devoted much attention to structural investigations in the Hunter Valley. His work of defining the great Hunter thrust fault system, by which Carboniferous rocks appear in places over the Permian sequence, continued for many years.

The years of David's occupancy of the Sydney chair were marked by the closest collaboration between his department and the New South Wales Geological Survey. Some members of the survey staff lectured to students (W. S. Dun, for instance, held a part-time lectureship in palaeontology for some 32 years) and university people joined in some of the survey work. C. S. Wilkinson, David's old chief, died in 1891, and leadership of the survey passed to E. F. Pittman, who was succeeded, in turn, by J. E. Carne and E. C. Andrews, the latter retiring in 1931. Each has claims to recognition for his geological work; Andrews, in fact, internationally known for his studies in physical geology, was quite the most distinguished of all our Government geologists.

Too often, those who control Government finance in this State have shown but slight awareness of the fact that the prime function of an official geological survey should be concern with systematic mapping and cognate studies. Throughout its history, the New South Wales Geological Survey has been required to devote much attention to work of prospecting-type in areas with mineral deposits of economic importance—a subject developed elsewhere in this volume. But the accidents of economy are not necessarily unrelated to matters of intrinsic scientific interest, and nowhere is this better illustrated than in the surveys of the New South Wales coalfields. David's work in the Hunter Valley was followed by other splendid stratigraphical studies—those of the western coalfield, led by Carne, and of the southern coalfield by Harper. The records of these investigations show, too, the outstanding support given the field geologists by their laboratory-based colleagues in dealing with analytical, petrographic and palaeontological aspects of the work.

Many of the survey investigations of metalliferous areas were no less distinguished. We need refer only to two important contributions from Andrews to make this clear. In his study of the New England plateau, published in the Survey Records between 1904 and 1907, Andrews demonstrated clearly his versatility and penetration. Topics ranging from genesis of the ore deposits to a general study of the regional physiography all received close attention. The New England study includes the first detailed examination of the field, petrographic and chemical characters of a batholithic mass in this State. Andrews' work at Broken Hill is even better known. Once thought to be Silurian, the metamorphic rocks at Broken Hill, now known collectively as the Willyama Complex, had been recognized as much older, following Mawson's demonstration in 1912 that beds lying unconformably above the Willyama rocks were equivalent to part of the Adelaide system. Andrews was assigned the task, in 1917, of making a thorough investigation, which included mapping the metamorphic complex and the surrounding country. At times, assisted by W. R. Browne and F. L. Stillwell, who gave valuable petrological support, Andrews spent some four years on the work, the results of which appeared in his splendid memoir of 1922. Many have studied the region since, but the fact that their contributions are concerned largely with points of detail and interpretation indicates something of the quality of the survey work.

We draw this review to a close with the 1920's, for it has been our intention to outline the broad pattern of growth of geological information, not to summarize the present view. Furthermore, by this time, geological data here and in neighbouring States had accumulated to the point where attempts to establish detailed relations between tectonic history, sedimentation, palaeogeography and igneous action might be undertaken with some reasonable expectation of intellectual profit. Many had contributed, but there was one above all who could distil the essence. David, in fact, had long been fascinated by the problems of stratigraphical correlation and tectonism, and during the later years of his life, became especially concerned with the preparation of a geological map of the Commonwealth and a major review of Australian geology. The map with a volume of explanatory notes providing an invaluable outline of our geological history, as then understood, appeared in 1932. The major work, however, was left unfinished at David's death two years later, and became the responsibility of W. R. Browne, who found that his was to be no simple task of editing. Delays caused by the intervention of a world war increased the need for extensive revision and addition of new material. Although "The Geology of the Commonwealth of Australia" was not issued until 1950, and includes many data not available in 1934, it stands as a noble memorial to the most influential figure in the whole history of Australian geological endeavour — Professor Sir T. W. Edgeworth David, F.R.S.

Since David's time, geologists in the University of Sydney, the New South Wales Geological Survey, the technical colleges and the Australian Museum have been joined by colleagues in the recently established Universities of New England, New South Wales, with its constituent colleges, and Newcastle, the N.S.W. Institute of Technology and Macquarie University. Government authorities concerned with such matters as water conservation and industrial groups involved in the search for and exploitation of mineral deposits, have also added to our store of information. The number of geologists active in this State has increased greatly since 1945, and the past few decades have witnessed unparalleled growth and diversification. Those readers seeking a statement of current geological knowledge should consult "The Geology of New South Wales", to be issued shortly by the Geological Society of Australia.