BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Record 1980/67

The Cainozoic Evolution of Continental Southeast Australia

Abstracts of papers presented at a symposium held in Canberra, November 1980

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Sponsored by the Geological Society of Australia (Commonwealth Territories Division) and the Bureau of Mineral Resources, Geology and Geophysics.

Compiled

by

E.M. Truswell and R.S. Abell

PREFACE

The abstracts in this volume are those of papers presented at the symposium on the Cainozoic Evolution of Continental Southeast Australia (CECSEA), held at the Canberra College of Advanced Education from 26 to 28 November 1980. The symposium was sponsored by the Commonwealth Territories Division of the Geological Society of Australia, and the Bureau of Mineral Resources.

The record of geological evolution in the southeast during the Cainozoic is preserved in highland landforms, in basalt flows, in scattered lacustrine sediments, and in soil and weathering profiles. It is fair to say that until relatively recently the emphasis of research into these different facets of the record has been uneven; there is for instance a relatively long history of study of basalts in the highland areas, but this has not been matched by studies of sediments, nor of the broad tectonic picture. The spectrum of papers abstracted in this volume, however, provides clear evidence that this imbalance is now being redressed: in addition to studies of geophysics, sedimentation, volcanism, biological and climatic evolution, and soil development, there are included here a number of papers which attempt to synthesise all aspects of the history of this region, and to set events in the continental region against those reflected in adjacent marine basins.

The general upsurge of interest in the Cainozoic of the southeast is almost certainly part of a wider interest now evident in the Cainozoic as a whole, an interest that is in no small measure due to an increasing appreciation of the economic importance of this time interval. The association of alluvial gold deposits with Tertiary deep leads has long been known, as has the Tertiary age of important brown coal deposits. It is rather more recently that the effect of Tertiary climatic fluctuations in bauxite formation has been recognised, and the potential influence of these same fluctuations in accumulations of sedimentary uranium. The economic interest in these Cainozoic sequences is reflected herein in papers describing multifarious aspects of coal basins, placer tin and other heavy mineral deposits, diatomites, industrial extractive minerals such as clays, silcrete and limestone, and groundwater sources.

The initial stimulus for this conference arose in part from the results of investigations into Cainozoic sedimentation at Lake George: at a seminar at the Department of Biogeography and Geomorphology, Australian National University in 1978 Dr J. Bowler reported that palaeomagnetic measurements on drill core suggested an age extending well back into the Tertiary. Concurrently, research in the geology department at the Canberra College of Advanced Education was beginning to demonstrate that the Cainozoic geomorphic history of the Shoalhaven area involved a significant Tertiary component. Efforts made to co-ordinate these studies, and those being undertaken by BMR in the Canberra region, made it apparent that there were enough people interested in the Cainozoic, and especially the Tertiary, history of this small region to make worthwhile the calling together of people with research interests in the southeast as a whole. Response to a preliminary circular confirmed the extent of interest in Cainozoic history, and covered such a broad range of disciplines that it was felt necessary to provide informal discipline workshops in addition to formal presentation sessions. The extent of the interest that has been expressed makes us hopeful that the aim of the meeting, which is to provide an overview of research in the Cainozoic history of the region, will be met. The almost overwhelming response makes us hopeful that this will be achieved, and that in addition new directions for future research may emerge.

The abstracts reproduced here are as they were submitted by authors: only in a few cases have they been retyped to meet the needs and standards required for camera-ready production. The organising committee wishes to thank the speakers, workshop conveners, and field excursion leaders. The use of facilities at CCAE is acknowledged; we are grateful for the logistic support provided by BMR and the financial support of the Geological Society of Australia.

G. Taylor (CCAE) Convener

K.A.W. Crook (ANU)
B.J. Pillans (ANU)
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R.S. Abell (BMR)

CECSEA Organising Committee, 1980

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THE USE OF CHLORINE-36 TO STUDY VERY OLD GROUNDWATER

by

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Chlorine-36 is a β-emitting (E_{max} 0.71 MeV) cosmogenic isotope with a half life of 308 000 y. In principle it can therefore be used, to study the dynamics of groundwater movement throughout much of the Pleistocene epoch.

1. Generation of chlorine-36 in nature

1.1 *Cosmic-ray induced spallation of atmospheric argon.* Oeschger et al[1] have postulated that ^{36}Cl is generated at an average rate of 2.8×10^8 atoms m^{-2} y^{-1}. The specific activity of the isotope will be determined by the average rate of addition of marine salt (which is 'dead' to chlorine-36) either dissolved in rainfall or as dry fall out. Neglecting the latter and assuming an average annual precipitation of 50 cm with a chloride content of 2 mg L^{-1}, the specific activity of chlorine-36 would be 2.8×10^9 atoms ^{36}Cl/g Cl.

1.2 *Cosmic-ray induced spallation of the components of exposed limestone, granite and basalt.* This mode of production has not previously been discussed as a source of chlorine-36 potential importance in hydrological studies. However Yokoyama et al[2] have shown that on the Aguille du Midi (altitude 3080m, latitude 47.4°N) the rate of production of chlorine-36 is 0.84, 0.21 and 0.19 atoms/min^{-1} per kg rock respectively. Surface erosion will lead to a mobilisation of the isotope.

1.3 *The activation of surface chloride by cosmic-ray neutrons.* This source is not considered important because of the short residence time of surface chloride compared with the half life of the isotope.

1.4 *Sub-surface sources of chlorine-36.* The isotope is generated by the activation of chloride by neutrons by spontaneous fission of U-235 and by various (α,n) reactions. The source is likely to be significant only when the groundwater ages exceed 10^6 y.

1.5 *Atmospheric thermonuclear testing.* This source is unlikely to be generally significant because of the low ^{36}Cl yield. The potential interference will be present only in groundwater containing appreciable tritium.

2. Measurement of chlorine-36 at natural levels

2.1 *Liquid scintillation counting.* A number of procedures for counting chlorine-36 at low levels have been used. A method based on the liquid scintillation counting of $SiCl_4$/toluene/butyl-PBD has been adopted by the AAEC. A rapid technique for the conversion of the groundwater field precipitate with silver nitrate to $SiCl_4$ has been developed.

2.2 *Electrostatic accelerator techniques.* The advantage of the accelerator method is that small samples can be measured with high precision and with relatively high throughput. Great care must be taken to avoid interference with sulphur-36 which has the same mass. The disadvantage is, of course, the high capital cost of the equipment.

3. Results

Sufficient reliable measurements have now been published to ensure that chlorine-36 will be useful in hydrological studies. The specific activity in groundwater samples from Lake Ontario, N.Y. have varied from 0.015 to 0.030 dpm g^{-1} Cl. The activites in arid zones are sometimes appreciably greater. For instance, a groundwater sample from near the ephemeral Rillito River, Arizona measured 0.145 dpm g^{-1}. In this work it was shown that samples from the Dalhousie Spring area, the East Lagoon and Lake Eyre varied from 0 to 0.25 dpm g^{-1}. Although some contamination from thermonuclear testing would be expected, the high levels observed in these arid zones could be caused by the relatively small inputs of recycled marine salt. The chlorine-36 method may be particularly useful in studying not only the isotope hydrology of very old basins, but also the evolution of chloride in low rainfall areas. Applications to the investigation of groundwater salinity problems are also foreseen.

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DAUGHTER PRODUCT DISEQUILIBRIA AND THE TRANSLOCATION OF URANIUM OVER THE 10^5 YEAR TIME SCALE

by

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Uranium daughter product disequilibria have been widely observed in nature. Systematic measurements of $^{230}Th/^{234}U$ have been used to date coral, to study the rate of accumulation of sediments and to obtain information on the rate of accretion of micro-manganese nodules. The AAEC, the techniques have been used to contribute to the understanding of the evolution of sedimentary uranium deposits, and to assess the rate of migration of the daughter products in natural environments over the 10^5 year time scale. Although the specific examples will be taken from investigations of the sedimentary uranium accumulation at Yeelirrie, Western Australia, and of the uranium anomaly associated with the Narbarleck deposit in the Northern Territory, the principles are general and can be applied equally to settings elsewhere in Australia.

Yeelirrie is located in the Murchison region of Western Australia about 700 km north east of Perth. The uranium occurs as the mineral carnotite dispersed on calcrete and associated sediments. Samples from above the modern water table were obtained by the Western Mining Corporation and supplied to the AAEC for study of the $^{234}U/^{238}U$ and $^{230}Th/^{234}U$ ratios. The weighted mean values of the ratios were 1.38 ± 0.1 and 0.88 ± 0.26 respectively. The relatively larger variability in the latter ratio is taken as evidence for the translocation of uranium after deposition. Separation of the isotopes is caused by the different mobilities of the thorium and uranium species.

Attempts have been made to use observed disequilibria to "date" sedimentary deposits, and many of these have used over-simplified mathematical treatments. As part of this project, a mathematical formulation was developed which allowed for variations in the initial conditions and for the subsequent linear build-up or removal of uranium. This approach leads to a number of self-consistent alternative hypotheses for the development of the Yeelirrie deposit.

In general, we conclude that uranium daughter product disequilibria cannot be used to determine, unequivocally, the dynamics of the evolution of the uranium deposit. However they can be used to provide quantitative evidence for or against hypotheses based on geological and climatic factors.

Another class of applications is the study of the migration of uranium daughter products through sediments over the 10^5 year time scale. These investigations are of scientific interest because they can be used to study concurrent processes of sediment build-up and erosion, and also to relate laboratory data to field observations. In addition, they are potentially useful in predicting the ultimate fate of some of the waste products of uranium mining and milling, and, in so far as appropriate analogies can be drawn, in assessing the migration of transuranic elements over a long period.

With this in mind, systematic observations were made of the disequilibria in the uranium anomaly in the clays and weathered schists surrounding the Nabarlek deposit. The results are interpreted on the assumption that a fraction of the authogenic uranium-234 has been immobilised by recoil induced transport into that part of the clay structure which is effectively out of the influence of the transporting groundwater.

THE SIGNIFICANCE OF THE CAINOZOIC AS A SOURCE OF INDUSTRIAL MINERALS

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The Cainozoic rocks of continental south-east Australia provide a wide variety of economic minerals for use in a diverse range of modern industrial applications, however, only three industrial minerals, namely ball clay, silcrete, and amorphous limestone are commercially prized because of certain intrinsic properties which are not found in pre-Cainozoic rocks.

Ball clays are highly plastic, fine-grained, mainly kaolinitic sedimentary clays which are associated with sequences of sands and lignites of non-marine origin and Cainozoic age. This origin and age relationship applies to ball clay deposits throughout the world. Ball clays are commercially valued because they increase dry (green) strengths of various ceramic bodies and have white firing characteristics. Usage is mainly in the manufacture of whiteware pottery including sanitaryware, kitchenware, tableware, electrical porcelain and artware. Fine particle size and consequently large surface area is essential for high plasticity and better quality ball clays not only deflocculate readily but also contain 70 per cent or more of particles less than 2μm e.s.d. These critical features are absent from pre-Cainozoic clays due to lithification.

Silcrete is an indurated and brittle rock composed of quartz clasts in a matrix of well-crystallised quartz, "cryptocrystalline" quartz or amorphous (opaline) silica. Silcretes of Cainozoic age provide the most useful raw material for the manufacture of silica refractory bricks for roof linings in open-hearth steel furnaces and in glass-melting tanks. The suitability of silcrete in these applications is due partly to its purity (>99% SiO_2) but mainly to its crushed-grain characteristics which feature a platykurtic particle size distribution and angular particle shape. These characteristics result in a dense, low-porosity brick which resists attack by volatile and molten materials and withstands high load pressures at elevated temperatures. Although pre-Cainozoic quartzites of suitable chemical composition are exceedingly common, the crushed-grain attributes provided by Cainozoic silcretes are invariably absent.

Amorphous Limestone is of special significance in the production of filler-grade whitings and provides powder particles of milky-white colour and rounded shape as well as a positively skewed particle size distribution. The milky-white colour is utilised in paint manufacture to produce paints with greater covering or hiding power. In the manufacture of extruded plastic products such as drain-pipes and electrical cables, rounded particle shape reduces abrasion and wear to costly extrusion dies. A combination of rounded particle shape and positively skewed particle size distribution provides a useful packing density which is exploited by the rubber industry to achieve higher filler loadings in products such as motor car tyres, carpet underlay and conveyor-belts. These useful properties are not found in older, recrystallised limestones because pulverised calcite crystals typically provide transparent and angular particles which form an even particle size distribution.

These examples illustrate the way in which the intrinsic properties of Cainozoic minerals can be used to advantage in modern industrial applications and it is hoped that workers in the Cainozoic become more aware of the economic significance of the features of the rocks they study.

Tertiary drainage on the Southern Tablelands of N.S.W.

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Mapping of Eocene, late Oligocene and early Miocene lavas on the southern tablelands of N.S.W., west of Goulburn, indicates that the main features of the present headwater drainage of two major east Australian rivers, the Lachlan and the Wollondilly, were very well-established at least by the late Oligocene/early Miocene and probably much earlier (Young and Bishop, 1980).

West of the present divide, the north northwesterly gradient of the base of the valley-fill basalt which parallels the present upper Lachlan for about 30 km between Dalton and "Narrawa' trig., and paleocurrent data from sub-basaltic current-bedded sands and gravles indicate that the early Miocene Lachlan flowed in the same direction as the present Lachlan. By the early Miocene, therefore, the Lachlan valley had been excavated to within about 100 m. of its present depth, this 100 m. of post-basalt down-cutting by the Lachlan having taken place since the early Miocene. Lava apparently flowed westward from the area of the present divide, down the eastern side of the Lachlan valley, probably in a tributary to the early Miocene Lachlan River. Other tributaries to the Lachlan were also infilled with lava at this stage.

These valley-fill vasalts were extruded from several, probably many, sources, at least one of which formed part of the bed of the Miocene Lachlan, and some of which are located at the eastern end of the tributary basalt, in the region of the present divide, itself marked by the east-facing 80-100 m. "Lake George Fault" scarp.

East of this scarp, 12 km south of Crookwell, the headwater of Kialla Creek (a tributary of the upper Wollondilly) flow over and have incised through a 5 km long tongue of early Miocene basalt which consists of several superimposed flows filling a valley in the phyllite country rock to a depth of about 50 m. A small patch of probable sub-basaltic sediment outcrops at the base of the series of flows and the paleocurrent data indicate that an east southeasterly current deposited the sediment. The modern Kialla Ck. is in the process of re-excavating a valley which was almost certainly filled with east-flowing lavas in the earliest Miocene.

One vent has been identified within the flows and other sources must lie westwards to the vicinity of the present divide.

A late Oligocene basalt marks a former upper Wollondilly channel 80 m. above the present Wollondilly River, 12-20 km west of Goulburn (Young and Bishop, 1980), thus recording an easterly equivalent of the pattern found in the upper Lachlan.

An undated, higher level basalt in the Lachlan valley, northeast of and with a similar plan to the lower basalts already described from the Lachlan, could well represent a westerly-flowing, pre-Miocene channel of the Lachlan. It is reasonable to suggest that its age should lie in the range from early Eocene to early Miocene. Given this, some rates of erosion and a scheme of drainage evolution, both in the upper Lachlan can be suggested.

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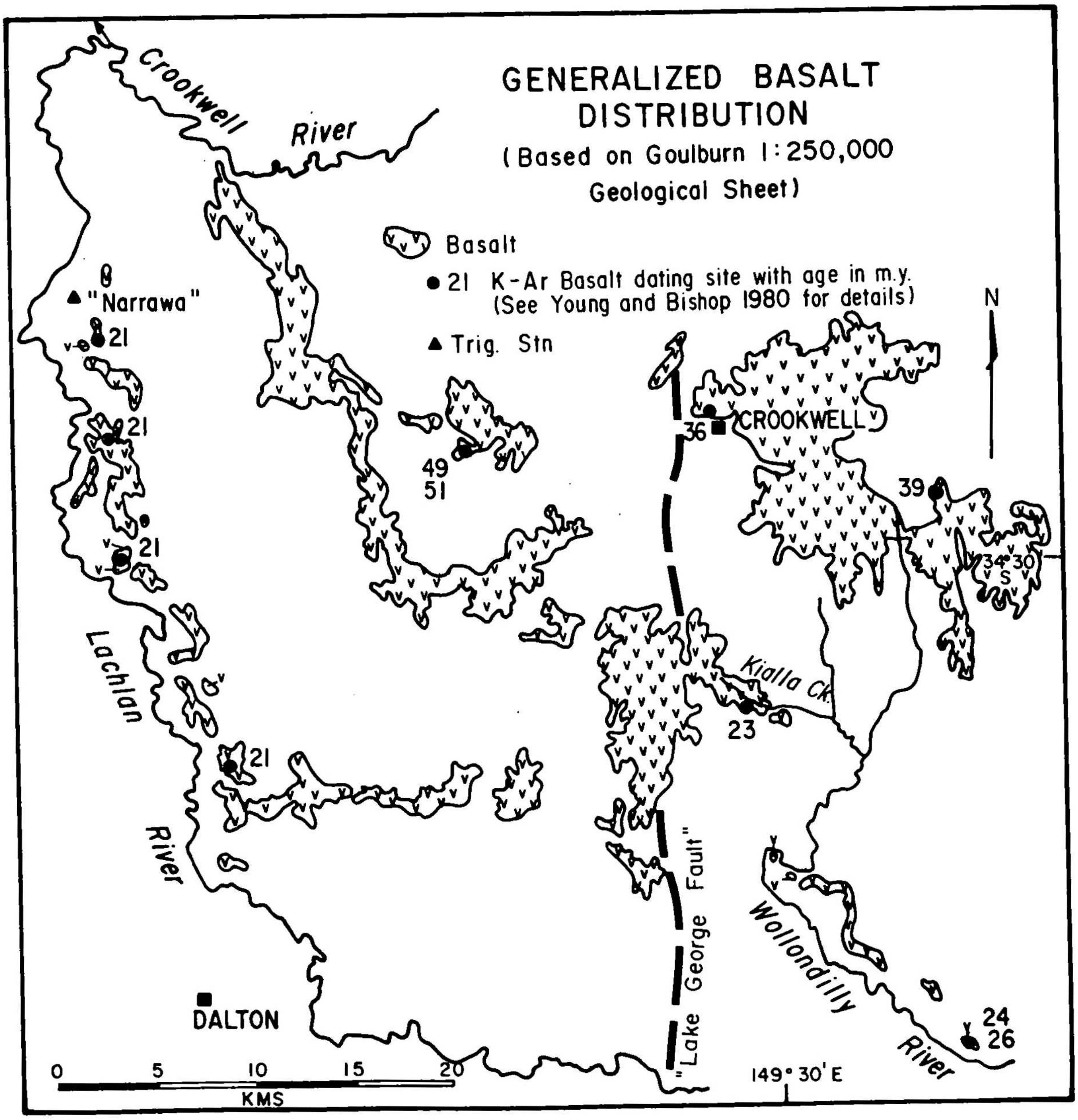

FLORISTIC, ENVIRONMENTAL AND LITHOTYPIC CORRELATIONS IN THE YALLOURN FORMATION, VICTORIA.

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The Upper Miocene Yallourn Formation in the Latrobe Valley, Victoria contains a diverse megafossil flora including ferns, conifers and angiosperms. Sampling, at one metre intervals, of vertical sections through 70 metres of coal exposed in the Yallourn open cut coal mine, demonstrated floristic successions in the depositional basin. Characteristic assemblages of plant megafossils have been found repeatedly through the formation and can be related to specific coal lithotypes. Low inorganic content of the coals (less than 2%) indicates ombrotrophic peat formation in a closed basin and autocthonous fossil assemblages. These assemblages have specific environmental determinants, in particular ground water levels. Changes in the water table during the depositional period were most probably driven by fluctuations in basin subsidence rates, rather than long term rainfall variation. This resulted in periodic inundation and emergence of the sediment surface and profoundly influenced local plant cover.

Periods of low water table were marked by sedimentation at an exposed peat surface and the deposition of dark coals dominated by roots and aerial remains of *Gleichenia, Dacrydium, Casuarina, Banksieaephyllum* and reedy monocotyledons. Intermediate water levels, with the sediment surface at least seasonally inundated, supported an open woodland with trees of Araucariaceae, Podocarpaceae and Oleaceae with little herbaceous cover. Such conditions produced medium light coloured coals. High water levels resulted in long term inundation and produced the open water deposition of fine grained light coals, consisting mostly of extensively macerated material with rare dispersed cuticles. Later lowering of water level allowed the regrowth of woodlands and the intrusion of the light coals by roots from above. The dispersed cuticles from the light coals are mostly angiospermous and apparently derived from vegetation surrounding the open water sites. Individual lithotypes are usually laterally discontinuous over a scale of about one kilometre, indicating an undulating sediment surface which supported a number of depositional environments at any one time.

The significant contribution, to the formation as a whole, of taxa with xeromorphic features, the presence of proteoid roots and conifer root nodules and the nature of the epiphyllous fungal assemblages, indicate that the floras grew under relatively dry, low nutrient conditions with rainfall in the region of 130 cm. per year. This suggests an equivalence with wet to dry sclerophyll rather than the subtropical rainforest proposed by earlier workers.

THE STRATIGRAPHY AND STRUCTURAL SETTING OF THE CAINOZOIC COALS OF VICTORIA

Roger Blake, Geological Survey of Victoria.

The stratigraphy and structural setting of the Cainozoic Coals of Victoria are reviewed. The age relationships of the coals and the question of Oligocene-Miocene onlap versus marine "Barriers" for the Latrobe Valley coals is discussed. The early structural development of the Otway and Gippsland Basins was similar and is attributed to right lateral wrenching acting through the northern margins of both basins throughout the Late Mesozoic. Renewed wrenching in the Eocene initiated uplift of the en échelon anticlines of the South Gippsland Highlands and the Otway Ranges. The unique coal deposits of the Latrobe Valley are attributed to several factors possibly the most important of which was the rising South Gippsland Highlands which formed a physical barrier to north-south drainage from the Palaeozoic Highlands. Fluviatile sand-shale deposition was more predominant in the physiographic lows and thick coal deposition was confined to the flanks of highs such as the rising Narracan and Balook Anticlines in the Gippsland Basin and the Otway Anticline in the Otway Basin.

LATE CAINOZOIC SEDIMENTS IN THE LATROBE VALLEY, VICTORIA

By P. BOLGER, Geological Survey of Victoria

Deposits forming the overburden to brown coals in the Yallourn-Morwell area of the Latrobe Valley, Victoria, are composed of two stratigraphic units which are well exposed in open cut mines. The older unit is locally developed, comprises structureless indurated siltstone and sandstone and is associated with a number of fireholes in which macropod remains have been found. The overlying unit comprises 1) a widespread facies containing trough cross-bedded coarse sand to find gravel with thin clay and silt lenses 2) a planar laminated find sand-silt facies and 3) a facies of massive kaolinitic clays with subordinate interbedded sand and gravel.

The upper unit overlies the indurated unit in the Morwell Open Cut and overlies Yallourn Seam Coal in the Yallourn Open Cut where the unconformity shows strong dissection of the coal surface. It forms high level alluvial terraces marginal to the Latrobe and Morwell Rivers and Traralgon Creek.

The overburden deposits have been referred to the Haunted Hill Gravels, a term originally introduced to include all beds overlying Older Basalts in the Haunted Hills, and thus by definition include part of the Latrobe Valley Group. The uppermost beds in the Haunted Hills exposed in road cuttings along the Princes Highway are lithologically similar to and continuous with facies 1 & 3 of the overburden at Yallourn.

In the Yallourn and Morwell open cuts, the overburden is 20 m thick, and thickens to the east where lithologically similar deposits intersected in deep bores near Traralgon are up to 120 m thick. Some of these beds have been referred to non-marine facies of the Boisdale Formation, although there appear to be no meaningful criteria for distinction. The term Boisdale Formation should thus be restricted to distinct, thin, coaly and fine sandy and clayey units in bores near Sale.

TERTIARY COAL IN THE MURRAY BASIN

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Groundwater investigations over the past several decades have indicated the presence of poorly known but extensive deposits of Tertiary brown coal within late Eocene to mid-Miocene sediments of the Cainozoic Murray Basin sequence.

The coals occur as intercalated, discontinuous lenses within fine-grained paludal, paralic and fluvio-lacustrine sediments of the late Eocene to early Oligocene Upper Renmark Beds (South Australia; Harris, 1966) and their synonymous equivalents, the late Eocene to mid-Miocene Olney Formation of the Renmark Group (Victoria and New South Wales; Lawrence, 1975, and Woolley and Williams, 1978).

The stratigraphy of the Cainozoic sequence of the Murray Basin may be correlated with global cycles of relative change of sea level which resulted in regional disconformities and laterally extensive and complex migrations of facies boundaries. Deposition of the brown coal deposits appears to coincide with periods of relative rise in sea-level when subsidence and compaction rates were favourably balanced with rates of sedimentation to allow prolonged periods of accumulation of vegetative matter in local marginal depressions and over extensive areas of paludal swamp and marsh environments. In the west, the Upper Renmark Beds/Olney Formation sediments are up to 150 m thick and are overlain by up to 300 m of late Oligocene to mid-Miocene shallow marine carbonates and late Miocene to Pliocene marginal marine and non-marine clastics. In the east, deposition of the Olney Formation continued into the mid-Miocene and the formation is up to 200 m thick and is overlain by up to 130 m of late Miocene to Recent fluviatile and lacustrine sediments.

Borehole evidence indicates that the coal seams are generally thin, discontinuous and grade laterally and vertically into carbonaceous clays and sands. Structure contours on the top of the Renmark Beds indicate that the coals are generally too deep for exploitation although thicker, shallower deposits occur within fault bounded depressions around the basin margins. The coals are of low rank, ranging from peat through soft brown coal to dull black lignite. Analyses indicate they have a low calorific value and high moisture, ash and sulphur contents. In New South Wales and Victoria, comparisons with alternative sources of high grade coals suggest that the Murray Basin deposits are too discontinuous, too thin and too deep and are thus currently thought to have no economic significance. The discovery of the Moorlands, Anna and Bower coalfields, around the margins of the basin in South Australia, has encouraged further investigations (Johns, 1975). However, despite continuing exploration no economic deposits have as yet been located. The recent discovery by Western Mining Co. Ltd of a large deposit of up to 970 million tonnes of brown coal in contiguous sediments of the Gambier Embayment of the adjacent Otway Basin suggests that similar, shallow deposits may yet remain to be discovered elsewhere around the margins of the Murray Basin (Anon., 1980).

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AGE OF SOME SILCRETES IN SOUTH AUSTRALIA AND THEIR RELEVANCE TO CAINOZOIC ENVIRONMENTS

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ABSTRACT

The most extensive and best developed silcretes in the Tarkarooloo Basin of eastern South Australia were formed during late Tertiary to early Pleistocene times. They include massive grey microcrystalline quartz types ("grey billy"), chalcedonic-opaline and quartz-overgrowth varieties. There is limited evidence of "grey billy" silcrete forming in pre-Medial Miocene times - probably during the late Eocene to Early Miocene. This silcrete is more restricted in extent.

In the Simpson Desert (northern South Australia) and the Garford palaeochannel in the Great Victoria Desert (western South Australia) there is evidence of silcrete deposition during Late Eocene to Early Miocene times. Evidence for Mesozoic (pre Palaeocene) silcrete is scanty.

Quartz overgrowth silcretes probably form very early during silica diagenesis. Nodular silcretes are analogous to some calcretes, and may form by similar means. Silica type varies according to the material being cemented - chalcedony and opal are commoner in finer grained less porous materials.

MIOCENE - PLIOCENE PALAEOCEANOGRAPHY AND DEPOSITION IN EAST GIPPSLAND

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The early Miocene was a time of transgression in southern Australia, sea temperature reaching a maximum shortly before the beginning of the middle Miocene, as evidenced by the presence of larger foraminifera. In east Gippsland, the transgression continued in the middle Miocene, the Bairnsdale Limestone onlapping earlier Formations.

The Bairnsdale Limestone is succeeded by the Tambo River Formation; never silty, initially argillaceous, later argillaceous and glauconitic. At Lake Tyers there is evidence of a shallowing environment at the top, suggesting regression. The presence of left-handed "Globigerina" pachyderma suggests lower sea temperatures than previously.

The succeeding Long Point Formation is argillaceous, silty and sparsely glauconitic, except near its top. Present at Lake Tyers, its absence in outcrop west of Lakes Entrance suggests a downslope wedge of sediment formed during a generally regressive regime. Foraminiferal facies suggest two shallowing cycles in this Formation. The foraminiferal fauna contains the morphotypes of the Globorotalia sphericomiozea plexus which occur in the late Miocene in New Zealand. This phase ends with a phosphatic nodule bed; phosphorite nodules encrusted by bryozoans in it suggest a depositional hiatus. The nodule bed has not been reported west of Lakes Entrance.

Channelling of late Miocene age has been reported off-shore. Channel cutting in the Tambo River Formation and all older outcropping Tertiary formations in the Mitchell Valley west of Bairnsdale is apparently contemporaneous.

The Jemmys Point Formation, transgressive and onlapping, overlies the phosphatic nodule bed. Some evidence suggests the existence of downslope wedges of this Formation, older than its outcropping portions. Stratigraphically upwards there is evidence of shallowing facies and increasing sandiness. The Pliocene index species, Globorotalia puncticulata (morphotype with four chambers in the last whorl) occurs in the lower outcropping part of the Jemmys Point Formation.

The depositional environment changes from marine to saline-lagoonal to non-marine. The top of the Formation can be reliably correlated from Nungurner to the eastern side of Lake Tyers, a distance of about 20 km.

Above the Jemmys Point Formation at Lake Tyers, a complex of beach and dune deposits interdigitates northwards (inland) with lacustrine deposits whose distinctive lithology of brown, micaceous, argillaceous, fine sand is traceable from Newmerella to Glenaladale (Mitchell Valley, west of Bairnsdale) at least. Certain facies of this phase have been named the Nyerimalang Formation, but Howitt's name Moitun Creek Formation is the valid name of the lacustrine deposits. The Nyerimalang Formation constitutes a remnant of a Pliocene sand barrier coastline, most of which has been destroyed during subsequent fluctuations of sea level, but whose extent is deduced from the lithological character and thickness (of the order of 50m) of non-marine deposits occurring close to the present shoreline. The transgressive and onlapping nature of the non-marine deposits in the Mitchell Valley combined with their thickness (50m) and occurrence on or virtually on the present coast (Red Bluff and Jemmys Point) is evidence of eustatically rising sea level in the late Pliocene.

TERTIARY MEGAFOSSIL FLORAS OF SOUTH EAST AUSTRALIA

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Biostratigraphic studies of South eastern Australia have been well documented palynologically. Until recently those studies have suggested the existence of a reasonably uniform, *Nothofagus* rich flora.

The megafossil record, in contrast, has shown that particularly during the Eocene, communities existed with high diversity and few if any dominants. It is now clear that not only does this diversity exist within those floras, but also between them. Mid and Upper Eocene floras under study from South Australia, New South Wales and Victoria show a less than 1% common element at the species level.

Comparisons between the pollen and megafossil records for the same localities highlight under-representation of certain taxa from the megafossil record. These include the absence of *Nothofagus* and myrtaceous leaves and a strong under-representation of proteaceous leaves. Studies of the leaf litter accumulations and comparisons with surrounding vegetation recently completed for a rainforest community in Dorrigo National Park suggest that riverine litter deposits provide a reasonably accurate picture of the surrounding vegetation. Extrapolating this to the fossil record increases the significance of those taxa absent from the leaf floras.

Therefore the picture which continues to emerge from the Eocene leaf deposits shows a highly diverse southern Australian flora with little correlation with the associated pollen record and very few taxonomic similarities to the extant flora.

GEOLOGICAL SIGNIFICANCE OF KANGAROO ISLAND THROUGH THE CAINOZOIC

BY

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Kangaroo Island, in South Australia, occupied a position separating three dominantly marine provinces throughout the Cainozoic. The island constituted a marine buffer to the St Vincent Basin to the north whilst forming the extreme western margin of the Murray Basin. The Southern Ocean has flanked the southern and western edges of the island since the separation of Australia and Antarctica in the Early Eocene.

A period of tectonism in the Early to Middle Eocene initiated the development of the St Vincent Basin, and the seas flooded into the basin through the Kartan Passage, which corresponds to the lowland area separating Dudley Peninsula from the remainder of Kangaroo Island. Movement along the E-W trending Cygnet Fault produced a fault-angle depression on the northern side of the island at this time, thus forming the Kingscote-Cygnet Embayment of the St Vincent Basin. Bioclastic carbonates were the predominant deposits in the Kangaroo Island region; they are relatively thin in the Kartan Passage, but moderately thick in the Kingscote-Cygnet Embayment.

No sediments of Late Eocene to Late Oligocene age have yet been recognised on Kangaroo Island. However, the presence of important deposits of this age further north in the St Vincent Basin implies that the island was land during this time, and that the sea had gained access to the main part of the basin by an alternate route, either through Investigator Strait or across Yorke Peninsula..

During the Late Oligocene and Early Miocene, limestones were deposited in the Porky Flat depression on Dudley Peninsula. They record deposition on the extreme western edge of the Murray Basin. Possible Oligo-Miocene limestones near Smith Bay on the north coast could mark the southern margin of the St Vincent Basin.

Late Pliocene to Early Pleistocene limestones and calcareous sands are widespread on Kangaroo Island, and their existence is interpreted as evidence of inundation of the greater part of the island, with Dudley Peninsula, the western plateau and the Gap Hills possibly remaining the only land. Flooding of the Kartan Passage and the Kingscote-Cygnet Embayment provided access to the St Vincent Basin, while shoreline deposition on the eastern end of the island at Cape Willoughby probably occurred at the margin of the Murray Basin. On the other hand, the shelly limestones at Point Ellen and poorly exposed carbonate sediments further inland probably reflect the transgression of the Southern Ocean.

The Quaternary history of the island is significant for the deposition of extensive calcareous dune aeolanites, referred to the Bridgewater Formation, along the southern and western coasts, and for gradual tectonic uplift along the reactivated bounding faults of the Mount Lofty Ranges. However, eustatic uplift has also caused recognisable sea-level changes.

Contemporary stresses in the crust of southeast Australia: evidence from earthquakes and in situ stress measurements.

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Earthquakes in eastern Australia are mostly caused by compressive stresses acting in the crust. The larger earthquakes occur in the upper 20 km of the crust and are associated with steeply dipping faults.

Sometimes the faulting is predominantly strike-slip, as for the 1977 Bowning earthquakes and the Dalton/Gunning Seismic Zone; sometimes the faulting is high-angle thrust faulting as for the 1961 Robertson and the 1973 Picton earthquakes.

Although the directions of the pressure axes of all the earthquakes do not form a parallel set, the predominant direction tends to be east-west. The scatter is probably due to pre-existing crustal faults or zones of weakness which are associated with the earthquakes and control the faulting processes. These faults and zones of weakness are not necessarily associated with the current stress regime.

In situ stress measurements have not been made near the epicentral areas of the larger recent earthquakes because of the absence of competent near-surface rocks coupled to the crust. However, in the western part of the Lachlan Fold Belt the *in situ* stress results indicate that the maximum pressure axis is close to east-west. It would not be unreasonable to assume that this direction continues throughout most of the southeast of Australia.

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Fish, Amphibians and Reptiles from the Etadunna Formation, Miocene of South Australia

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In spite of intensive field work by numerous parties, the lower vertebrate fossil record from Cenozoic Australia remains sparse. In particular, microfossil material of lizards and frogs would be of great interest in helping to determine the time of emplacement, past diversity and zoogeographic affinities of these groups in Australia.

So far, the richest sample yet obtained is from the type section of the (Upper?) Miocene Etadunna Formation near Lake Palankarinna, South Australia. Localities RV-7230 and 7247 have produced the material discussed here. These localities are among those that have produced the Ngapakaldi Fauna (Stirton, Tedford and Miller 1961), and occur in green argillaceous sandstone in the upper half of the Etadunna Formation. The fossils were recovered by washing and screening techniques by Michael Woodburne and party; the repository is the South Australian Museum and the University of California, Berkeley (Museum of Paleontology).

The lower vertebrates include lungfish teeth (close to _Epiceratodus_), abundant teleost remains including catfishes (Ariidae) and percoids (Percichthyidae), lizard and frog elements and small crocodilian teeth. Most of the lizard material is referable to the family Scincidae and includes dentaries, maxillae, vertebrae, a few parietals and fragments of appendicular elements. The parietals show parietal scales completely separated by interparietals while the dentaries have columnar teeth and a closed and fused Meckel's groove. The latter is a derived character, and the skinks in Australia today that possess it are referable to the _Egernia_ and _Eugongylus_ groups (Greer 1979). The _Egernia_ group is in addition the only Australian skink group to retain the primitive arrangement of parietal scales separated by interparietal; this and close similarity of the fossil jaw elements to those of Holocene _Egernia_ permit reference to _Egernia_ sp. The Holocene genus has many species and is widespread throughout Australia, with one species extending into New Guinea and west through the Sunda Islands to Sumatra. Habitat preferences of the genus are diverse. The other genera of the _Egernia_ group are _Tiliqua_ and _Corucia_; both differ strongly from _Egernia_ in having enlarged, molariform teeth. Stirton et al (1961) cited the presence of a varanid lizard in the Etadunna Formation. I have not verified the identification.

Identification of the frog material is more difficult. The fossils are few and fragmentary, and include maxillae, vertebrae, humeri, an ilium and incomplete limb and girdle elements. No more than one group appears to be represented, based on humerus, ilium, tibiofibula and sacrum morphology. The humeri resemble those of higher frogs in general, but can be referred tentatively to the Hylidae on the basis of general shape of epicondylar crests and condylar ball, and lack of an extensive or protuberant olecranon scar. The ilium also resembles that of hylids in having a low, laterally-directed dorsal protuberance and a generally triangular acetabular region (the large, truncated subacetabular expansion of leptodactylid frogs is not developed). Although it is not possible to identify these fossils below family level, comparison with the other Holocene Australian frogs, i.e. leptodactylids, microhylids and ranids, gives no reason to suspect that these families are represented. Hylids are common today in Australia and the presence of Miocene fossils of the group is not surprising. Some authors (e.g. Savage 1973) regard Australian hylids as a separate leptodactyloid derivative, the Pelodryadidae, although the bones here cannot be separated from those of non-Australian hylids.

DEEP SEISMIC STRUCTURE OF SOUTHEASTERN AUSTRALIA AND THE CAINOZOIC LITHOSPHERE

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The major crustal structures of southeastern Australia were formed during Palaeozoic and early Mesozoic orogenic episodes. The Cainozoic geological evolution of this continental crust cannot be treated separately from the lithospheric processes which rifted and deformed the earlier crust. That these processes are still active is evident in current earthquake activity and stress and strain observations.

The lithospheric processes affecting Cainozoic evolution are: 1) the stresses associated with the plate tectonic driving mechanism separating Australia from Antarctica, 2) the thermal stresses associated with the opening of the Tasman sea (80-60 m.y. ago) and the Southern Ocean (60 m.y. ago), 3) the stresses associated with crustal thickness differences at rifted continental margins and consequent lateral density differences, and 4) stresses resulting from the translation of the Australian lithospheric plate over a non-spherical earth.

Deep seismic sounding experiments have contributed to our knowledge of variations in the regional crustal structure. In the Lachlan Fold Belt, P-wave velocities in the basement rocks of the upper crust generally increase from about 5.6 km/s near the surface to about 6.3 km/s at depths of 10-15 km, and velocity decreases and inhomogeneities are evident. Within the Sydney Basin sediments, velocities range from 3.6-3.9 km/s at the surface to 4.35-4.8 km/s at 2 km depth and greater. The basement velocity beneath the sediments is 5.75-5.9 km/s, increasing to about 6.36-6.5 km/s at about 15-17 km depth. These velocities are consistent with the idea that Lachlan Fold Belt rocks underlie the Basin.

In the middle and lower crust, the P-wave velocity increases from about 6.3-6.5 km/s to greater than 7 km/s, and there is evidence for velocity decreases within the middle crust. The Moho is characterised by a velocity transition zone rather than a sharp velocity discontinuity. The upper mantle velocity is in the range 7.95 to 8.12 km/s and there is evidence that the lithosphere beneath the crust does not have a simple velocity/depth distribution. The depth at which upper mantle velocities are reached varies from over 50 km under the highest topography to 41-44 km under the northern Lachlan Fold Belt and Sydney Basin.

Similar continental velocity/depth models elsewhere in the world are taken to indicate a heterogeneous crust with only a crude layering depending on metamorphic grade. The layering is likely to be grossly distorted by granitic and mafic intrusions. Large velocity gradients, both positive and negative, are potentially zones of weakness in which large-scale shearing can take place.

In southeastern Australia, earthquake activity is largely confined to the upper 20 km of crust, in which seismic velocities are generally less than 6.5 km/s. Joints, fractures and faults in the upper crust result in brittle-elastic rock characteristics at confining pressures of 5 kbar and less. At greater depths the continental lithosphere behaves as an elastic-plastic medium, responding elastically to seismic waves and plastically to long term stress.

Non-axial breaching of the Tasman Sea rift system has resulted in the transition zone from continental Australia to Tasman Sea oceanic crust being only about 50 km wide. This gives rise to a lateral stress system which could have caused lateral creep within the lower crust; in turn, this can produce differential vertical movements which contribute to the Cainozoic tectonic evolution in southeastern Australia.

The Evolution of Australian Palaeosols

by
Jon B. Firman

Ancient structural features in crystalline basement and resurgent tectonic structures post-dating the Ordovician Delamerian Orogeny controlled the nature and magnitude of younger structural events. These events initiated Upper Palaeozoic, Mesozoic and Cainozoic sedimentation.

During the Permian, marine, fluvioglacial and lacustrine sediments were deposited in structurally controlled valleys and troughs. Triassic and Jurassic sediments were deposited above the Permian sequence, the Jurassic sediments representing an extensive terrestrial freshwater cycle, which may have continued into the early Cretaceous in some places. There was a major transgression of the sea in the early Cretaceous. An increase in sand and the presence of coal beds in widespread deposits records a regression of this sea at the end of the Cretaceous.

During the early Cainozoic, sedimentary basins and embayments were formed along the southern continental margin. Paralic sediments of Paleocene-Eocene age are overlain by marine carbonates with marls, sands (glauconitic in places) and clays of Oligocene-Miocene age. The marine beds are overlain in places by sands, marls and calcareous sandstones - some marine others non-marine - of Pliocene age.

The Cainozoic inland was a time of lacustrine and fluviatile sedimentation. Sands and gravels were laid down during the early Cainozoic in erosional disconformity with the underlying Cretaceous beds. Dolomites, mudstones and sandstones were deposited during the middle Cainozoic. During the late Cainozoic the sediments deposited were clays and sands. Aeolian sands of the great deserts and gypsiferous dunes on lake margins recorded the onset of aridity towards the end of the Pleistocene.

In the provenance areas uplift was followed by erosion, then accumulation of thin clastic mantles on the interfluves and later by weathering and soil formation. In the depositional areas subsidence was followed by sedimentation and the later development of non-conformities during weathering in the upland areas.

There was a "cyclic" repetition of diastrophism, sedimentation, weathering and soil formation during the development of the regolith.

Processes controlled by the position of the continent and the interaction of the prevailing climate upon parent materials produced particular paleosols with distinctive and characteristic features recognisable throughout the landscape.

Stratigraphically bracketed paleosols, which were formed below ancient ground surfaces - mainly during pauses in erosion and sedimentation - range in age from pre-Permian to Holocene (Recent). Older weathering zones and bleached rocks were features of successive landscapes after the early Palaeozoic; ferruginous and siliceous pans in fossil soils after the early Cainozoic; characteristic horizons in great soil groups and calcretes after the Pliocene; younger clay paleosols and carbonate horizons after the medial Pleistocene; and horizons of the modern solum after the beginning of the Holocene. These features were produced by profound changes in climate and groundwater composition.

The record of tectonics, sedimentation, weathering and soil formation, together with changes in flora and fauna can be combined to prepare a climatic curve covering the time of formation of paleosols in Australia following the Delamerian Orogeny.

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The late Pleistocene Spring Creek Site of Western Victoria, a young megafaunal site

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The Spring Creek swamp facies, from near Minhamite, southwestern Victoria, preserves an abundant plant and animal record, probably dating from about 19,000ybp. Both pollen and macro plant analysis from the site is underway, and preliminary identifications (B. Gott, C. Paton, pers. comm.) indicate a predominantly treeless terrain, with perhaps a wet heath community in the immediate vicinity of the swamp. Pollen analysis of the bone bearing sediments show a predominance of Compositeae and Poaceae, with some Cyperaceae and *Casuarina*.

Fauna from the site consists mainly of large mammal species: *Macropus giganteus*, *Prionotemnus agilis siva*, *Osphranter rufus*, cf. *Lagorchestes*, *Protemnodon* cf. *brehus*, *Protemnodon* cf. *anak*, *Sthenurus gilli*, *Sthenurus* sp., *Zygomaturus trilobus*, *Diprotodon* sp., *Palorchestes azeal*, *Thylacoleo carnifex*, cf. *Sarcophilus*, a murid rodent and a small bird. The presence of *O. rufus* tends to indicate that conditions were drier in the area at 19,000ybp than at present.

Macropus giganteus makes up 45% of the minimum number of individuals present at the site. Analysis of the age structure of the *M. gigantus* sample shows it to be similar to a sample reported from Lancefield (Gillespie et al. 1978) and could be interpreted as representing a population under stress (i.e. in drought conditions, where breeding has stopped for several years), or that only mature animals from a normal population were dying. 3.8% of the total number of bones/scraps from the site display opposite, paired cuts, which are interpreted as having been made by *Thylacoleo*. The count is much higher on more complete bones where paired cuts are more readily recognizable.

The Spring Creek site is important to considerations of Pleistocene extinctions and reconstructions of Pleistocene climate as it represents a late surviving, diverse, and dominantly extinct large mammal fauna living under what appears to be drier conditions than dominate the area at present.

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CAINOZOIC ALLUVIATION AND HYDROGEOLOGY OF THE NAMOI RIVER BASIN, N.S.W.

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ABSTRACT

The Namoi River Basin, in northern New South Wales, occupies an area of 43,000 km^2 of which 19,000 km^2 is underlain by Cainozoic sediments. Pre Middle Miocene erosion carved a wide valley into the soft Permian, Jurassic and Cretaceous sediments that occur on the western (downthrow) side of the Hunter-Mooki Thrust system. The last episode of erosion cut a narrow north-west trending palaeochannel into the base of the valley. This narrow valley-in-valley palaeochannel can be traced throughout most of the basin. Alluviation of the valley has taken place since the Middle to Late Miocene. The sediments consist of interbedded sequences of unconsolidated clay, silt, sand and gravel to a maximum known thickness of 140 m.

The Cainozoic sediments in the Namoi Basin are divided into two Formations, which are proposed to be named as follows:-

(1) the Gunnedah Formation contains large channel deposit sequences of sand and gravel interbedded with clay. Palynological evidence suggests a Mid to Late Miocene to Pliocene age of deposition. The thickness ranges from 40 m to 130 m. This Formation has the largest groundwater potential in the Basin.

(2) the Narrabri Formation conformably overlies the Gunnedah Formation and consists of dominant brown clay with minor sand and gravel lenses. This Formation is Pleistocene to Recent in age and ranges in thickness from 10 m to 65 m. The Narrabri Formation acts as an aquitard and restricts the vertical movement of groundwater in many parts of the Basin.

The alluviation of the valley reflects the tectonic history and climate during the Cainozoic era. Late Mesozoic - Early Cainozoic uplift of the New England region by thrust faulting together with extrusion of basaltic lavas created highlands in the north, east and south-east part of the basin providing the source for the detrital valley fill. A change to a drier climate at the end of the Pliocene is considered responsible for

the waning discharge that altered deposition from braided river type for the Gunnedah Formation to predominantly meandering type deposition for the Narrabri Formation. Minor uplift of the New England Plateau during the Late Pliocene or Early Pleistocene is responsible for a return to braided river type deposition for a short time. A continuous sand and gravel bed can be recognised in the Narrabri Formation in many areas and is thought to be related to this uplift.

Potentiometric levels show that groundwater is moving slowly down the valley under semi-confined conditions. Total volume of groundwater in these unconsolidated sediments is estimated at 40×10^6 ML. Yields vary from area to area depending on the thickness, lateral extent and interconnection of aquifer zones. Recharge is slow due to the confining nature of the clays throughout the sequence.

Hydrochemical data indicate that there are two principle hydrochemical facies; (1) sodium chloride type waters, and (2) bicarbonate waters - either calcium plus magnesium or sodium dominant. Zones of mixing between the two facies are common.

PALAEOENVIRONMENTAL INFORMATION FROM A TASMANIAN STALAGMITE

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A 197 cm tall, constant diameter stalagmite from a limestone cave near Mole Creek, Northern Tasmania, was found to have formed under conditions of isotopic equilibrium. It was then sampled at regular intervals for isotopic analysis and $^{18}O/^{16}O$ and $^{13}C/^{12}C$ ratios determined. Ratios are given in the δ notation as per mil differences from the PDB standard. Parallel samples were also drilled from the same stratigraphic positions and the relative intensity of the free radical line measured on an electron spin resonance (ESR) mass spectrometer.

The upper half of the stalagmite was dated by means of four $^{230}Th/^{234}U$ dates and was found to have grown at a constant rate of 5.41 cm/1000 years between 95,000 and 78,000 years BP.

The $\delta^{18}O$ profile indicates that prior to 95,000 years BP mean annual temperatures in Tasmania were significantly higher than they were today. It will not be possible to say how much higher until fluid inclusion work has been completed. After 95,000 years BP temperatures were only marginally higher than today.

The $\delta^{13}C$ profile shows a number of significant fluctuations which do not correlate with the $\delta^{18}O$ record. This agrees with other studies. $\delta^{13}C$ profiles of stalagmites have never been interpreted with confidence because of the number of possible climatic and biological factors that may influence the $^{13}C/^{12}C$ ratio. In the present study we have shown by means of ESR analysis that the uranium content varies from 0.6 to 1.8 ppm along the axis of the stalagmite and that these variations correlate closely with changes in $\delta^{13}C$ values.

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The explanation we put forward is that variations in plant activity cause changes in the partial pressure of CO_2 in the soil and that this in turn has a marked effect on pH. Changes in pH control the degree of isotopic fractionation of carbon during the solution process as well as the mobility of uranium held either in organic compounds in the soil or as uranyl carbonate in the limestone bedrock.

The positive excursion of $\delta^{13}C$ values between approximately 100,000 and 96,000 years BP is tentatively attributed to a sudden cold spell documented elsewhere in the geological record. The event is particularly well shown in the $\delta^{18}O$ profile of the Camp Century Ice Core in Greenland.

The fact that the $\delta^{18}O$ profile of the stalagmite does not indicate a temperature decrease until 5000 years after the onset of the event can be explained by the fact that the change in $\delta^{18}O$ values in stalagmites is controlled by three factors one of which operates in a direction opposed to the other two. During rapid climatic change the lag times with which these factors affect the isotopic composition become an important consideration. One of the two factors causing a change towards less negative $\delta^{18}O$ values during climatic cooling is the change in O-isotope composition of the oceans which can be expected to have a lag time of thousands of years due to the slow build-up of the global ice volume.

It is concluded that $\delta^{18}O$ profiles of stalagmites cannot be used as indicators of palaeotemperatures at times of rapid climatic cooling or warming. In our stalagmite temporal fluctuations in the $\delta^{13}C$ values can be interpreted as predominantly due to changes in plant activity. The lack of correlation between the $\delta^{18}O$ and $\delta^{13}C$ values indicates that plant activity is largely controlled by factors other than mean annual temperature.

Isotope profiles derived from dated Tasmanian stalagmites are expected to contribute to understanding and dating of geomorphic events as well as the interpretation of pollen profiles and archaeological evidence.

THE TERTIARY WEATHERED MANTLE AND SOIL SALINITY IN SOUTH-EAST AUSTRALIA

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Abstract

Owing to high relief and steep slopes, Tertiary deep weathering in the south-east region was not as extensive as in the northern two-thirds and south-west of Australia. Scattered residuals of the weathered mantle do, however, occur on divides and lower slopes, generally in undulating to rolling terrain, where they have been preserved from stripping. Chemical alteration affected a wide range of rocks of which the most extensive were folded Palaeozoic sediments, largely of marine origin, and granitic and volcanic rocks. The kaolinitic, weathered profiles consist of ferruginous, mottled and pallid zones and silcrete layers are sometimes present. As in similar profiles which developed elsewhere, the mottled and pallid zones commonly contain appreciable stores of soluble salts, dominantly sodium chloride. In areas where weathered residuals occur, extensive land clearing since European settlement has increased accessions to groundwater and has led to soil salinization on lower slopes and valley floors. It is suggested that systematic mapping of weathered landscapes would assist in the prediction of salinity hazards.

EOCENE EUSTACY AND THE DEPOSITION OF LIGNITES IN SOUTH AUSTRALIA

by

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The deposition of lignites and highly carbonaceous siliciclastic sediments was widespread in all of the major South Australian Basins bordering the proto-Southern Ocean during the Eocene and extended onto more stable cratonic areas. Four phases of sedimentation are recognised from palynological evidence which correspond to proposed world-wide eustatic cycles. Lignite development is associated with these cycles both in marginal marine and in continental environments but the best developments are those bordering ancient coasts. The transgressions associated with the eustatic changes reach a maximum in the latest Eocene (the youngest of the cycles) and the most significant lignites in the Eucla, St Vincent and Murray Basins are closely related to this cycle. In the St Vincent Basin the maximum development of lignites was high on the delta plain but depositional models for other basins are less well founded. Suffice it to say that those lignite occurrences bordering the Eucla Basin do have indications of "marineness" and those of the Murray Basin at Moorelands and Anna are overlain by marine sediments.

The second important lignite occurrences are in the Middle Eocene and are related to the second cycle. Lignites at this time were well developed in the Polda, Pirie-Torrens, St Vincent, Otway and central Murray Basins.

Continental sequence and their non-depositional episodes match very closely those in coastal margins and periods of rapid deposition correspond with times of elevated sea levels.

Climatic data would indicate high annual precipitation probably in excess of 1000 mm with a temperature trend showing a decline from high values during the Early Eocene to relatively cooler conditions at about the Eocene/Oligocene boundary. Notwithstanding this trend there were however significant fluctuations. This climate was therefore amenable to a sub-tropical, if not tropical, rainforest vegetation over much of southern Australia.

A Tectonic Origin for Southeast Australian Streams

By Chris Herbert

A convincing explanation of the origin of the characteristic eastern Australian drainage pattern of long, low-gradient, westerly flowing streams and has to date not been forthcoming. Also, the idea of rejuvenation of topography by the process of uplift in a tectonically "quiet" area such as southeastern Australia is not convincing. However, the theory of plate tectonics now offers a broad explanation of geomorphological events over long periods of time.

During the Jurassic and Cretaceous a rift valley probably existed in a position immediately east of the present edge of the continental shelf. This rift developed between the Australian continent and the Lord Howe Rise continental fragment which at that time were part of one continuous continental mass. Thermal doming had elevated the topography immediately west of the rift valley so that a Jurassic-Cretaceous dividing range probably existed in the vicinity of the present continental shelf (figure 1a). Long, westerly and north-westerly flowing streams probably eroded this old divide carrying sediment into the southern part of the Great Australian Basin until the early Late Cretaceous. Short, easterly flowing streams probably emptied into the narrow rift valley, or by Late Cretaceous time, into a shallow sea formed by the rift and the submerged Lord Howe Rise (Late Cretaceous marine sediments have been found in drill core from the rise, Ringis 1972) (figure 1b). According to Falvey (1974), widening of a rift valley takes place before actual continental breakup by a process of collapse by block faulting. During this process the position of maximum elevation, along the margin of south-eastern Australia, would have migrated westwards. Thus, the Jurassic-Cretaceous dividing range would also have moved westwards (figure 1c).

After continental breakup and the commencement of sea-floor spreading to eventually create the Tasman Sea floor (80 to 60 m.y. BP), thermal contraction would have caused progressive subsidence of the continental margin involving block faulting (figure 1d). Therefore, the southeastern margin of Australia probably experienced uplift from Jurassic to Late Cretaceous time (80 m.y. BP) and nett subsidence thereafter. Thus, during the Tertiary, and probably continuing to the present, a dividing range has been pushed gradually and spasmodically westwards by progressive collapse of more easterly blocks (figure 1e). Westward migration of the dividing range has resulted in complex, largescale stream capture. Short, steep coastal rivers have, since the beginning of the Tertiary, been sucessively capturing the headwaters of westerly flowing streams. Griffith Taylor (1923a and 1958) has previously speculated on the possibility of a similar westerly moving dividing range which he referred to as an "earth wave".

Throughout the Tertiary, streams west of the divide were probably providing sediment to the Murray basin. Successive capture of their headwaters by easterly flowing streams indicates that the Murray Basin has been provided with a steadily diminishing sediment supply.

GEOMORPHIC EVOLUTION OF THE EASTERN MARGIN OF N.S.W. (MESOZOIC TO CAINOZOIC)

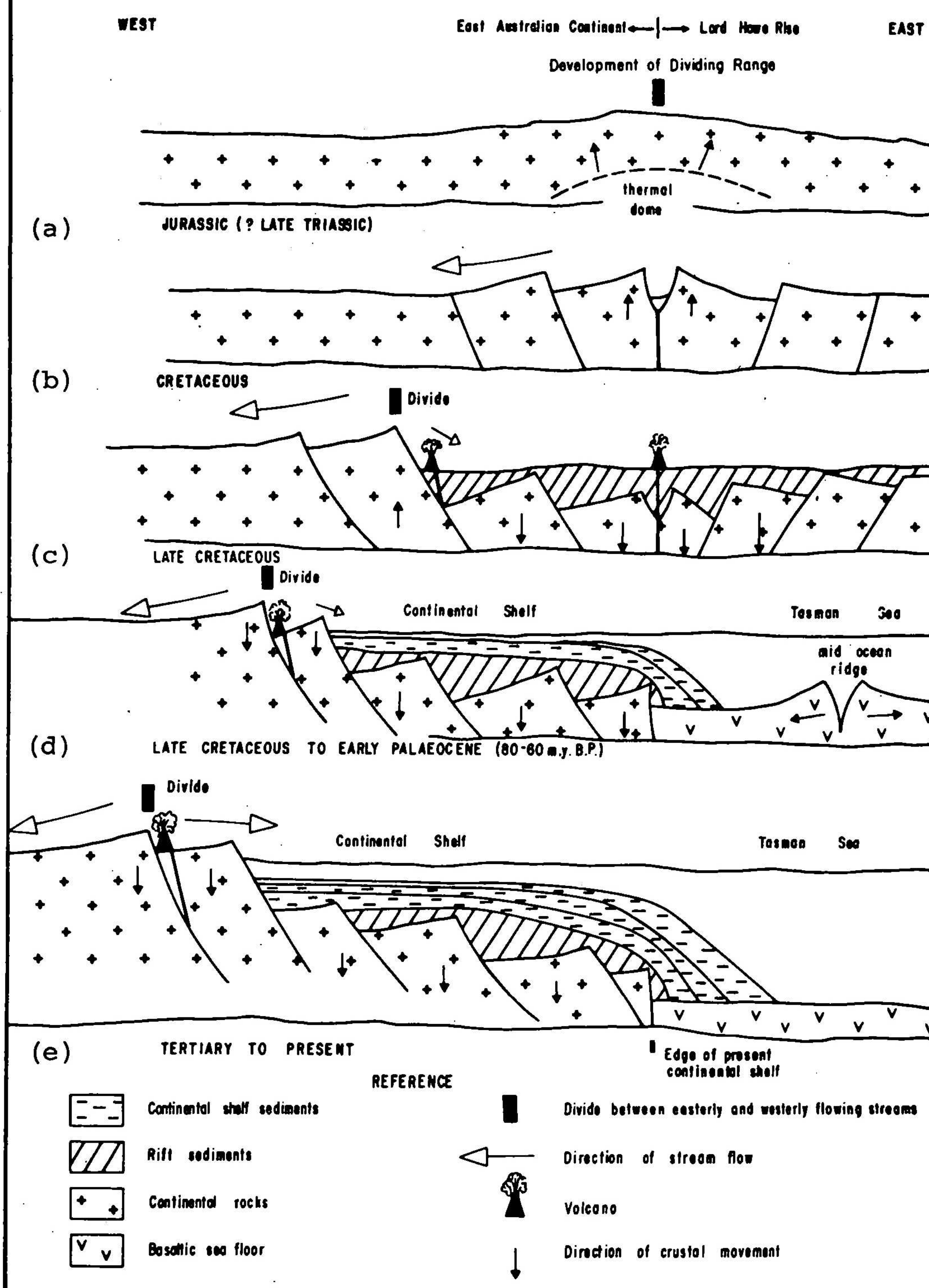

FIGURE 1

After Herbert (in prep)

10379

LOWER CRUST COMPONENTS OF XENOLITHIC ASSEMBLAGES IN CAINOZOIC BASALTS OF SOUTH-EASTERN AUSTRALIA

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Lower crustal rocks form a widespread minority group amongst xenolith assemblages in S.E. Australian Cainozoic basalts. Detailed studies of material from localities such as Table Cape, Scottsdale and Andover (Tas.) and from Mt Franklin, Lake Bullenmerri and The Anakies (Vic.) show some common characteristics.

Compared with upper mantle xenoliths, those from the lower crust are less magnesian and richer in Ti. Most lack the strong partial melting and complex exsolution textures that characterise mantle metaperidotites and metapyroxenites. Amphiboles are kaersutitic, garnets are pyrope-almandines (Mg_{50}), plagioclase is abundant and pyroxene pairs plotted for Ca-Mg-Fe mostly fall on the Fe-side of an approximate tie between Opx=Mg_{70} and Cpx=Mg_{40}.

Amongst layered pyroxenites (and peridotites), developed from upper mantle melts, there are diapiric cumulates (Lake Bullenmerri). In Victoria these are locally metasomatised by hydrous, dioritic intrusives which have generated kaersutitic amphiboles and pyrope-almandine. Layered feldspathic granulites and gabbros are most widespread and include restites (The Anakies). This and the absence of dioritic intrusives indicates that such xenoliths came from a zone above the layered pyroxenites.

Preliminary reconstructions of the lower crust in Victoria, based on the xenoliths, indicate a feldspar-poor, layered pyroxenite zone at or near the base of the crust. This is overlain by feldspathic granulites and gabbros. The situation has been complicated by the local penetration of melts generated in the upper mantle.

The Tasmanian lower crust consists of pyroxenites, granulites and gabbros, but relative relationships are as yet unclear. Crustal material includes sanidinites (Scottsdale) and nephelinitic cumulates (Lake Sorell).

Alluvial zircon and corundum is widespread in S.E. Australia, apparently derived from the Cainozoic volcanics. These minerals are probably crustal xenocrysts, although no xenoliths containing them have yet been found. Indications are that there has been considerable modification of the lower crust by metasomatism and addition of intrusive materials.

A CLASSIFICATION OF LOWER CRUSTAL XENOLITHS FROM S.E. AUSTRALIA:

PERIDOTITE - PYROXENITE GROUP

1. GRANULAR SUITE -
   Websterite & clinopyroxenite; olivine clinopyroxenite & olivine websterite; kaersutite pyroxenites.

2. POIKILITIC SUITE -
   Amphibole peridotite; clinopyroxene peridotite; amphibole clinopyroxenite; anorthoclase pyroxenite.

3. METASOMATISED SUITE -
   Complex pyroxenite - diorite hybrids; pyroxene garnetite.

HORNBLENDITE - DIORITE GROUP

1. LHERZITE SUITE -
   Hornblendite; kaersutite phlogopitite (glimmerite).

2. DIORITE SUITE -
   Meladiorite & diorite; garnet diorite porphyry; apatite andesinite to leucodiorite.

3. MICRODIORITE SUITE -
   Granophyric microdiorite; porphyritic garnet microdiorite.

GABBRO - GRANULITE GROUP

1. ACCIDENTAL SUITE -
   Hornblende & biotite gabbro; pyroxene gabbro & granulite; sillimanite & garnet granulite; charnokitic granulite.

2. MAGMATIC SUITE -
   Alkali gabbro; pegmatitic alkali gabbro; sanidinite; nephelinitic cumulates.

QUATERNARY FAUNAL STUDIES IN AUSTRALIA'S SOUTHEAST

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This survey summarises the state of research into Quaternary vertebrate assemblages in N.S.W., Victoria and Tasmania. The region contains several famous cave deposits, but there are also many important fluviatile, lacustrine and aeolian sites. Each type of depositional situation has its own bias, and reconstructions of past faunas need data from all sources.

Caves are naturally located in the limestone areas, along the main range in eastern N.S.W., in east Gippsland and the lower Glenelg regions in Victoria and in north and central Tasmania. Given appropriate conditions bone can also be preserved in caves and rockshelters in other rock types; important faunal sequences occur in granite and shale caves in Tasmania. Fluvial and lacustrine sites are concentrated along the upper tributaries of the Darling River in northern N.S.W., at the Murray-Darling junction and in central and western Victoria. Fossil assemblages have also been recovered from lakeside dunes in western N.S.W. and Victoria. Fossiliferous peat deposits such as Mowbray and Pulbeena Swamps in northwestern Tasmania are rarer.

Many fossil sites in southeastern Australia have been known since early last century, although the original studies were restricted to the description of new taxa, particularly the spectacular extinct forms. More recently two strands of research have interwoven: the search for causes of the Pleistocene extinctions and palaeoecological studies of smaller extant vertebrates.

Initially both these aspects involved mainly climate-related models, but the development of research into Aboriginal prehistory over the last 20 years has had a major impact, both in terms of theory and technique. Caves with relatively sparse archaeological remains have nonetheless been excavated with great care, providing well-dated and controlled sequences of small vertebrate faunas. This has led to detailed faunal analyses at Devils Lair, W.A., Seton, S.A., and my unpublished studies on Cave Bay Cave and Erith I., Tas., and Cloggs Cave, Vic. Other sites, such as Lancefield, Vic., have been reinvestigated when it seemed possible that they might document an association between Aborigines and the extinct Pleistocene taxa.

Active research tends to be site oriented, with Wellington Caves (L. Dawson), Tambar Springs (A. Ritchie and R.V.S. Wright), McEacherns Cave

(J. Hope), Spring Creek (T. Flannery) and Bacchus Marsh (T. Rich) among those investigated over the last 2-3 years but not yet published. One major regional project, on the prehistory and palaeontology of the lower Darling Lake systems in western N.S.W. (J. Hope), is under way.

Relatively neglected areas are the numerous fluviatile, lacustrine and cave sites in northern N.S.W., and the lake systems in western Victoria. With the exception of Texas and Wellington Caves, McEacherns Cave, and the Montague and Florentine Valley caves in Tasmania, there have been no recent studies of the many non-archaeological cave deposits known. This is a reflection of the small number of palaeontologists working in the Quaternary, most of whom already have a considerable backlog of unanalysed material.

While archaeological considerations will continue to be a major impetus for the study of late Pleistocene and Holocene faunal sequences, it is to be hoped that more Quaternary faunal assemblages will be studied in their own right, particularly in terms of palaeoecological and biogeographic theory. The large samples available from many sites lend themselves to more sophisticated analyses than are possible for most Tertiary faunas.

Earlier Pleistocene faunas continue to be elusive, though I suspect that we already have several (such as the older sequence from McEachers Cave) which are not yet recognised as such, because of the lack of research on those sites and the difficulties of dating beyond the range of radiocarbon.

A Palaeomagnetic Study of Chemical Remagnetization in the Hawkesbury Sandstone, and its Implications.

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The Triassic Hawkesbury Sandstone of the Sydney Basin contains abundant hematite-rich iron concentrations, the hematite occurring most commonly as a pore filling within the grain-supported quartz sand fabrics of the sandstone. A palaeomagnetic investigation of the iron-rich sediments was undertaken with a view to placing time constraints on the introduction of the iron into the sandstone.

Over 400 individually oriented samples were collected from 53 sites spread geographically and stratigraphically throughout the Hawkesbury Sandstone. Both thermal and chemical demagnetization techniques were employed in an attempt to isolate the stable magnetic components. Most sites provided stable directions with relatively small error circles. A significant feature of many sites was the presence of both normal and reversed directions, suggesting that deposition of hematite within the sandstone had taken place over a time period sufficient to average out secular variation. Hence each site can be interpreted as giving an independent age of introduction of hematite.

Site means, plotted as pole positions, show a linear distribution northwards along the 130^{o} meridian of longitude, from the present geocentric south pole to about 80^{o}S latitude. Statistical analysis indicates significant differences between site means at the extremes of the distribution. This suggests that localized hematite deposition has been an active process for many millions of years, and is possibly still occurring.

The distribution of poles from the Hawkesbury Sandstone is displaced significantly to the east of the Australian Apparent Polar Wander Path (APWP - McElhinny et al., 1974). This, and other evidence, suggests that there may be inaccuracies in that APWP, and therefore it is not possible to place a definite older age limit on the introduction of hematite. It may be, however, as old as 20 million years.

This study also provides a way of placing an age constraint on folding in the Hawkesbury Sandstone along the Lapstone Monocline, west of Sydney. Sites were collected on and adjacent to the Monocline, sampling the full range of dips present in the Hawkesbury Sandstone. Field directions from the variously dipping rocks were not displaced by the folding and it can be concluded that the age of folding pre dates even the earliest introduction of the hematite.

Once again, problems with the Australian APWP preclude certainty, but it is likely that the fold is older than 20 m.y.

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SOUTH AUSTRALIAN STRANDED BEACH RIDGES AND THE MILANKOVITCH THEORY OF ICE AGES

M. Idnurm[1] P.J. Cook[2]

South Australia contains a major sequence of stranded beach ridges that extends across almost its entire southeastern corner. The ridges have been generally considered to mark the high stands of past oceans and to have become stranded by a gradual uplift of the region. Their significance for Pleistocene ice ages and for the ice age theories was recognised long ago, but those concepts were only partly developed because the ridge chronology remained elusive.

Recently a series of remanence measurements has been carried out on the sequence between Robe on the coast and Naracoorte 100 km inland, in a systematic search for the first reversely magnetised ridge. The reversed magnetisation, which records the most recent reversal of the geomagnetic field 720 000 yrs ago, was located at Naracoorte, and provided the first time constraint for the sequence. This time constraint and the ridge spacings are found to be consistent with the climatic periodicities of approximately 20 000, 40 000 and 100 000 yrs as predicted by the Milankovitch Theory of ice ages, adding to the growing evidence in favour of the theory. Discrepancies however occur between the ridge evidence and the predicted phase and magnitude of the 100 000 yr cycle.

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CHEMICAL WEATHERING IN SE QUEENSLAND AND THE TERTIARY CLIMATIC DECLINE

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Palaeomagnetic methods have been used to date chemically weathered profiles in SE Queensland in a 20 000 km^2 region between Millmerran and Surat. Weathering imprints are prevalent in that region but, because of strong erosion, only few residuals of the complete profiles remain. Samples collected from the residuals and from ferruginous parts of truncated profiles indicate that the weathering in SE Queensland was multicyclic, with three distinct episodes occurring approximately 60, 30 and 15 m.y. ago. The two oldest episodes, at 60 and 30 m.y., have been encountered previously in SW Queensland, and there is increasing evidence from other parts of Australia for a widespread episode at 15 m.y.

The ages obtained in SE Queensland are compared with laterite ages from other continents and with other kinds of palaeoclimatic indicators. This evidence is examined for the cause of the Tertiary climatic decline that commenced with warm and equable conditions and ended with the ice ages.

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HISTORY OF THE SOUTHEAST AUSTRALIAN HIGHLANDS

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Correlation of the stratigraphy of the Murray Basin with the Cainozoic basalt chronology of the Southeast Australian Highlands gives grounds for the hypothesis that periods of more intense volcanism have also been periods of uplift in the Highlands and subsidence of flanking basins, while periods of less intense volcanism have been periods of settling of the Highlands and shallowing of the flank basins with a concomitant reduction of gross relief. Time constraints on cycles of transgression/regression in the Gippsland, Bass, and Otway Basins are compatible with this hypothesis.
We conclude that the Highlands assumed their present gross character early in the Cainozoic, as the latest manifestation of the gradual settling of ancestral late Mesozoic highlands of much greater extent and relief.
In the Cainozoic, recurrent periods of volcanism/tectonism have retarded but not reversed this gross subsidence of the southeast margin of the continent.

Late Cainozoic volcanism in southeastern Australia; age, distribution and tectonic setting.

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The period of activity which produced the Newer Volcanics of Victoria and southeastern South Australia began about 5 m.y. ago and continued into the mid-Holocene. Some four hundred points of eruption have been catalogued but only about thirty K/Ar dates are available and perhaps a similar number of radiocarbon dates. Moreover the dates generally refer to lava flows or ash deposits and the sources may not be readily identifiable.

In 1975 I attempted to find a relationship between the distribution of volcanism in the province and its tectonic setting. Other authors have also considered this problem (Gunn 1975, Sutherland 1978; Ollier 1979). The hypothesis of one of more hots spots beneath the moving Australian plate has helped explain volcanism earlier in the Tertiary in Eastern Australia (Wellman and McDougall 1974) but is not relevant to the Newer Volcanic province.

A major problem in relating volcanism to its setting in southeastern Australia has been the lack of knowledge of how activity varied with time. Is there a consistent pattern of movement or were eruptions randomly distributed in time and space?

Land systems of a representative part of the volcanic province in far western Victoria were delineated by Gibbons and Gill (1964). By inserting into their scheme absolute dates now available, the age of the land surfaces can be obtained and then the points of eruption identified and dated. The scheme has now been extended across Victoria using first a land systems mapping approach, then incorporating available dates, and finally producing a general scheme of dated volcanic deposits and points of eruption.

We are now in a position to look at the relationship of activity to its tectonic setting, through time. Relevant factors will include :

uplift of the Victorian Highlands: subsidence of the Cainozoic Otway Basin of Western Victoria;

structural trends related to folding and faulting as revealed by geological and geophysical studies, or by Landsat interpretation;

changes in rate and direction of movement of the Australian plate.

Other factors to consider include depth to basement or other sub-surface discontinuity, altitude of the ground surface at the eruption point, local uplift or fault activity around the point of eruption, and possibly Late Cainozoic sea level fluctuations and presence of ground water aquifers beneath the maar volcanoes.

Developing such a scheme of distribution of volcanic activity with time can also show if cycles of activity exist within the period of activity. It should be possible to see how eruption type, volume, and composition have varied with time. It should also become apparent which areas need additional absolute dating.

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CAINOZOIC STRATIGRAPHY OF THREE BASINS AT "LANYON" STATION, A.C.T.

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Maps and photographs are presented of a sequence of pedoderms on three basins at "Lanyon" station in the southern Tuggeranong valley of the A.C.T. The north and south basins have a mean elevation of 600 m with bajadas extending to 670 m; the perched basin is preserved on a higher land-surface of mean elevation 840 m with a pediment, modified by Quaternary cryogenic processes, extending to 870 m.

Within each basin there are five easily recognizable geomorphic surfaces - pediment, bajada and 3 basin fill levels which possess a unique modal sequence of pedoderms indicating that landscape modifications were contemporaneous with, and a surface expression of, Cainozoic soil development.

Prior braided stream deposits of the Rob Roy pedoderm are preserved only in the central and western areas of the north basin which was downthrown by about 20 m during Cainozoic jostling on the nearby Murrumbidgee Fault suggested by the direction of rotation of joint sets in the Silurian volcanic rocks around the basin. The arenites are soft and friable with unstrained quartz grains (35-60%), feldspars (15-25%) and undeformed rock fragments (5-25%).

The Murrumbidgee pedoderm represents an extensive period of fan building on the bajada and fluviatile deposition from braided streams in the basins. Pseudogley patterns unique to this pedoderm are considered to be sufficient proof that the unit was subjected to prolonged subaerial weathering and pedalogic aggregation before burial.

The Tuggeranong pedoderm indicates a return to active fan building and scour and fill of the Murrumbidgee pedoderm in the basins, followed by dust accession and pedogenesis under conditions of moderate aridity. Indicators of the aeolian provenance of the upper facies of this pedoderm include the wide-spread occurrence of thick blankets of a dense, highly-plastic clay (Tuggeranong clay) at high elevations, minimal textural differentiation down profiles, abundant calcareous material in the B2 horizons and subsola and a clay mineral assemblage dominated by montmorillonite, unlikely to be produced by weathering of rhyolitic rocks.

The Lanyon pedoderm was deposited during a period of vigorous planation in the basins with only small-scale hillslope denudation. The pedogenetic environment was characterized by a greatly increased leaching capacity from highly seasonal rainfalls which produced friable kaolinitic clays on the hillslopes grading to latosols rich in hematite, goethite and gibbsite on the lower slopes and mixed layer montmorillonite-illite hydromorphic clays in the basins. Exposed hillslope sections of the Tuggeranong clay were extensively desilicated and deposition of mangans and development of slickensides in the Tuggeranong clay occurred during prolonged periods of wetting and drying.

Yellow podzolic soils of the Big Monk pedoderm developed on high terraces and slopewash sheets which locally modified the bajada to a greater degree than the preceeding Lanyon pedoderm. Development of the hydromorphic equivalent soil in the basins followed a period of secondary planation of the Lanyon pedoderm. On the perched basin, erosion of the regolith and re-deposition of detritus to form the Big Monk pedoderm occurred mainly by slopewash and to a lesser degree by solifluction. The eastern pediment was modified into incipient cryoplanation terraces; the dominant processes were severe frost shattering during dry winters and sheetwash erosion during heavy spring rains.

The Gigerline pedoderm was initiated during the succeeding periglacial maximum which was characterized in part by strong westerly winds. Boulder trains of this age on south-westerly slopes indicate dry winters with effective frost wedging at the free face followed by spring or summer rains of high enough intensity to induce large mud flows over the slip plane of Tuggeranong clay. Duration of pedogenesis was comparatively short but leaching was effective producing earths with low soluble salts. The podzolics of the Big Monk pedoderm may well have undergone secondary partial saturation in the B horizon and significant A horizon interflow to evolve to their present morphology during the stable phase of the Gigerline pedoderm.

The Riverside pedoderm, a minimal prairie soil restricted to low alluvial terraces, hardly affected the basin surfaces but extensive slopewash sheets were deposited in the perched basin.

The Taphonomy of the Bacchus Marsh Diprotodon Site

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The Bacchus Marsh Diprotodon site has yielded a fauna comprising at least 22 Diprotodons, 10 macropods, 3 rats and a lizard. The entombing sediments indicate the proximal part of a low flow regime ephemeral run off system with intercalated erosional screes representing times of non hydraulic influence. Bone orientations are related to channel morphology with bone distribution showing sorting into 'Voorhies groups'. Surface textures and fracture patterns of bones indicate periods of subaerial prediagenetic exposure. Several episodes of bone deposition distinguish generic concentrations, the main event involving a biassed selection of young adult Diprotodons. All this data along with other evidence suggests aridity as the cause of death.

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A POLLEN ATLAS OF PROTEACEAE AND ITS USES.

The "Pollen Atlas of Proteaceae" is a study of the pollen morphology of all extant genera of Proteaceae throughout the world. It comprises approximately 90 plates. Genera are represented in rough proportion to their size and importance. Species are depicted in polar and equatorial view and the majority of figures have insets showing LO analysis of the exine. SEM pictures of selected representatives of each genus are included. The text gives a general introduction to the Family, its history and importance, a glossary of terms, generic and species descriptions and Tables giving parameters such as mean size and ratios of length to breadth, for a total of about 450 species. Other information includes comments on possible taxonomic relationships and comparisons with Cainozoic fossil forms with related morphology.

The Atlas, in its present manuscript form, is exhibited for comments and suggestions as to possible improvements. The value of the addition of sections dealing with morphology of palynomorphs of supposed fossil representatives of the Family and the use of computerised data is canvassed.

The use of the Atlas in the study of some Australian fossil pollen types is illustrated.

STRATIGRAPHIC PALYNOLOGY IN NEW SOUTH WALES

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The palynology of the river valleys down the western slopes and onto the riverine plain is displayed on the poster.

For the northern rivers, viz., the Gwydir, Namoi and Castlereagh, Tertiary deposition started in mid-late Miocene time. In the Namoi, the Miocene is only found west of Narrabri. Tertiary deposition upstream of Narrabri is Pliocene and younger. In the Castlereagh, both Miocene and Pliocene is found round Gilgandra.

To the south, Tertiary deposition started in the mid-late Eocene in the Murray Basin and continues through the Miocene, with rare occurrences of the Pliocene and Pleistocene. The Miocene is found as far east as the head of the valleys, viz., Jemalong Gap on the Lachlan and Narrandera on the Murrumbidgee. Further upstream, all deposition is Pliocene and younger.

Where relevant, the ages of the basement is displayed.

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THE USE OF QUANTITATIVE RELATIONSHIPS IN STRATIGRAPHIC PALYNOLOGY

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In the area between Hillston, Hay and Narrandera, there are thick sections of the *Proteacidites tuberculatus* zone (Stover and Partridge, 1973) which is early Oligocene to mid Miocene. There is little to subdivide this zone if reliance is placed on diagnostic species. Some quantitative relationships are hopeful as reliable stratigraphic markers.

The "high *Phyllocladidites mawsonii* ratio" probably approximates the Upper *Nothogagidites asperus* zone (Stover and Partridge 1973), of late Eocene into early Oligocene. In this area, this zone cannot be distinguished on diagnostic species alone.

There are two "high *Nothofagus flemingii* ratio" layers, one low down in the *P. tuberculatus* zone, the other high up in this zone. These layers are particularly useful as stratigraphic markers.

It is thought that "high *Ph. mawsonii* and high *N. flemingii*" represent different environments. The palaeoecological implications are discussed.

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LATERITE IN SOUTH AUSTRALIA

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Lateritic deep weathering profiles and the palaeosurfaces to which they relate are conspicuous elements of both the landscape and the stratigraphic column in many parts of South Australia. The prominent summit surface in the Mount Lofty Ranges and adjacent upland areas of Kangaroo Island exhibit a well developed laterite including a ferruginous duricrust which commonly displays evidence of reworking, and associated mottled and pallid kaolinitic zones. Laterite profiles are commonly 10-15m thick, but weathering has been recorded to depths in excess of 50m. Laterite also crops out on highland surfaces on Eyre Peninsula. However, on Eyre Peninsula and in the Mount Lofty Ranges, and elsewhere in South Australia for example along the northern margins of the Flinders Ranges, variously preserved remnants of deep weathering profiles occur at low levels in the landscape, either on erosion surfaces in lowland valleys, or beneath a sediment cover ranging in age from Jurassic to Pleistocene. It is with the geological relationships between the deep weathering zones and this sediment cover, and the consequent assessment of the age of lateritisation, that this paper is concerned.

THE GEOLOGY OF CAINOZOIC PLACER DEPOSITS, RINGAROOMA VALLEY, NORTH-EAST TASMANIA

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Three main styles of placer tin deposits are recognized.

1) Deposits of coarse black cassiterite in poorly-sorted, boulder-rich sediments at relatively elevated sites.

2) Deeply buried deposits of relatively fine-grained black and brown cassiterite, with abundant ilmenite and monazite, in a sedimentary sequence dominated by stratified gravels, trough cross-bedded gravels, planar cross-bedded sands, and peat units. This type occurs at a major break in basement slope.

3) Shallow surficial deposits of red, yellow and black cassiterite, plus accessory spinel and gold, in a fining-up sequence of pebbles, sands and clays. This type is restricted to the present Ringarooma river and preserved remnants of elongated zones which run essentially parallel to the river.

The maximum age for sedimentation is inferred as Late Oligocene - Early Miocene by pollen dating. A regional basalt age of 16 m.y. (Brown, 1977) temporally separates Type 2 and Type 3 deposits.

Sedimentological and palaeobotanical evidence is consistent with a depositional model involving a pre-basalt series of braided fluvial fans flowing into, and being transgressed by, a body of fresh water.

DRAINAGE DEVELOPMENT IN THE BERRIDALE AREA, N.S.W.

BURTON MURRELL
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ABSTRACT

The palaeoalluvials on Stony Creek near Berridale, N.S.W., represent drainage from the present Lake Eucumbene catchment which was captured by the Eucumbene River about 36MA ago.

The majority of the drainage pattern seen east of the Eucumbene River is a superposed pattern which developed on successive floods of basalts from the Monaro Ranges and Murlingbung centres from 50MA to 36MA B.P.

The Upper Murrumbidgee River was part of the Snowy River system until diverted into the Umaralla River by the eruptions of 36MA B.P. This implies a small shift of the divide at this time from one catchment to the next but affects neither the shape nor gross position of the Dividing Range.

EVOLUTIONARY GEOMORPHOLOGY: A MODEL FOR S.E. AUSTRALIA

C. D. OLLIER

A recent British textbook, Timescales in Geomorphology (Cullingford et al. 1980) concerned itslef with short time scales (10^1 to 10^2 years), medium time scales (10^3 to 10^4 years) and long time scales (10^4 to 10^5 years and longer), but in typical northern hemisphere style it implies that anything over a million years is getting beyond geomorphology. We know that in Australia our time scales are very much longer, and we can perhaps trace our landscape evolution bak to the Permian, say 2.5 x 10^8 years. We might regard this as an extra-long timescale. Geomorphology in Australia is thus on the same timescale as continental drift, plate tectonics and biological evolution, and it would be surprising if new geomorphic concepts were not needed.

Geomorphology on a Pangean supercontinent would have been very different from that of today. Great changes would come with continental splitting, drift and collision, features not considered in older models of landscape evolution. I have suggested (1979) the term "evolutionary geomorphology" as a name for the geomorphology associated with this extra-long timescale, and dominated by unique events rather than cyclic ones.

Many Australian geomorphologists now agree on the long timescale, but there is disagreement on several major issues including:

1. The timing, manner and cause of uplift of the eastern Highlands
2. The age, origin and significance of surficial deposits such as silcrete, ferricrete and gravels.
3. The nature of basalt eruption and its subsequent erosion
4. Models of landscape evolution. Is it cyclic or not?

Are we dealing with peneplanation, pediplanation, etchplanation, or some other processes? I shall present one model of landscape evolution which may serve as an Aunt Sally for further discussion.

The Eastern Highlands Model

An undulating plain rises from Central Australia to the Great Divide, which is generally remarkably flat, and then descends towards the east coast. It does not reach the coast, for it stops abruptly at a great escarpment. This scarp can be traced for long distances in Queensland, New South Wales and Victoria, and is a major break between two geomorphic provinces with quite different geomorphic systems. I shall call these two provinces the "tablelands" and the "coastal ranges". On the tablelands relief, though significant, is low; rates of geomorphic processes are slow; total available relief and inversion of relief are limited: preservation of palaeoforms is common. East of the scarp in the "coastal ranges" geomorphic processes are fast; relief is great; and palaeoforms are rare. The shape of the scarp in plan, with deep embayments along valleys and peninsulas along interfluves suggests that the scarp is moving backwards by fluvial erosion and irregular scarp retreat, presumably from an original position near the coast. I suggest that this massive landscape feature started when chasmic faults created a new continental edge and a new base level for erosion. In a sense it is like the initiation of a new cycle of erosion, but as there was only one such event in recorded geomorphic history of the region it cannot be regarded as cyclic at all.

On the tablelands various minor "cycles" or "sequences" of local landscape development have progressed by peneplanation, pediplanation, etchplanation or some other mechanism. I want to suggest two particular features of the tablelands that differ from earlier cyclic explanations.

Firstly, some surfaces in the tablelands are being created (or exhumed) by stripping of basalt cover. These are not post-basaltic erosion surfaces, but exhumed pre-basalt surfaces (though the stripping may be to a level slightly below the original pre-basalt surfaces).

Secondly, some of the granites that reach elevations above the surrounding plain may have been intruded to levels above the surrounding plain and exposed by erosion of a fairly thin cover of superincumbent rocks. If the granites were intruded as surficial domes, we cannot in working out our geomorphic history cast imaginary peneplains over the granites to reconstruct our earliest "surface". The general tableland level existed at the time of intrusion, and it has kept roughly the same relative level ever since.

Other models are needed in certain parts of S.W. Australia, as in places bordering sedimentary basins, and in Western Victoria where the great escarpment is absent.

This symposium will highlight, if not resolve, the major issues in the geomorphology of S.E. Australia. Many new techniques will be used, and more importantly many new ideas will be generated. Geomorphology will never be the same again!

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A new Miocene Vertebrate Faunal Assemblage from the Lake Eyre Basin: Preliminary Account

Neville S. Pledge, South Australian Museum

A new fossil locality at Mammelon Hill, Lake Palankarinna occurs in Etadunna-like sediments of younger age than elsewhere, preserved in a small downfaulted block. Pollen analysis of carbonaceous sapropelic shales below the fossil horizon suggests the age is somewhere between Mid-Miocene to Mid-Pliocene i.e. younger than previous Etadunna determination. Closer definition is not possible because of the paucity of the pollen flora, and the paucity of comparative pollen stratigraphy for this time period.

Fossil vertebrate evidence indicates an age between that of the "Ngapakaldi Fauna" and the Kutjamarpu Fauna. Vertebrate fossils include bones of lungfish, teleosts, turtles and crocodiles, a small lizard jaw, several bird bones, and some mammal bones and teeth. The most complete specimen is the jaw of a new species of *Ektopodon*, which seems to be less specialized than the type *E. serratus* from the Wipajiri Formation, but more evolved than ektopodontids found in typical Etadunna Formation sediments.

The mammal assemblage includes

- *Ektopodon* n.sp.
- a petaurid, like *Pseudocheirus*
- a phalangerid (?)
- a potoroid
- a macropodid (?)
- and a zygomaturine diprotodontid

The pseudocheirine is represented by a well preserved right M^4 and left P^3 only slightly smaller than and different from *Pseudocheirus peregrinus*. Evidence for the phalangerid is an incomplete and very worn upper molar. The potoroid is represented by the fragments of premolar, one of which is the posterior half of an upper tooth rather similar to *Aepyprymnus*. A small, diamond/spatulate tooth may be an upper canine referable to this taxon, as may a small "folded" left upper incisor (I^3?). Some small associated ankle bones (left cuboid and astragalus, and right calcaneum) and a phalanx may also be potoroid, or may be referable to the same taxon as a small brachydont, bunodont macropodid (?) lower molar. On the evidence at hand so far, this molar could as easily be associated with the premolars.

Slightly better represented are diprotodontids, by an upper first molar, a partial molar loph, two different incisors, and two identical but partial right humeri, preserving the distal ends. A deciduous molar (M1) has also been found. Plane (pers comm.) has suggested the species is 25% smaller than *Neohelos*, a late Miocene taxon.

Species (apart from *Ektopodon*) are not yet well enough known to compare with other local faunas, but the fossils suggest a riparian assemblage in keeping with the slightly earlier pollen flora, and close in age to the Kutjamarpu Fauna.

Neogene and Pleistocene Avian Assemblages of Australia

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Since Rich (1975a, b; 1976) reviewed the fossil avifaunas of Australia, a considerable number of additional bird fossils have been collected and several papers have appeared, both reviewing older literature (particularly that of DeVis), and reporting on new material. Reviews of older literature and reexamination of fossils found during and prior to the first half of the 20th century have demonstrated that many of the unique species and genera thought restricted to the Pleistocene of Australia are actually conspecific or congeneric with living Australian forms (Olson, 1975, 1977; Patterson, 1980; Rich and van Tets, 1980a, b; van Tets, 1974; van Tets and Rich, 1980). Although a few new species of megapodes (van Tets, 1974) and pelicans (Rich and van Tets, 1980) have emerged upon reanalysis, overall, Pleistocene avian diversity as evidenced by the fossil record, is considerably less than suggested by older reports. On the other hand, geographic ranges of certain species, such as that of the flightless Tribonyx mortierii, were at times during the Pleistocene much greater. T. mortierii, presently restricted to Tasmania, was known as far north as Queensland in the Pleistocene.

New material described or currently under study includes fossils of the diverse, endemic, and now extinct Dromornithidae, which was known only from Genyornis and one bone of Dromornis in 1975, all of Pleistocene age. The group was quite diverse and widespread during the mid-Tertiary when 4 genera existed (Rich, 1979), and this high diversity suggests a decidedly longer history than is currently recorded. Additional material includes a nearly complete skeleton of an aegothelid (owlet-nightjar) of early to mid Miocene age (Quipollornis koniberi) that clearly is primitive within its family, yet still a member of a modern family. Other bird fossils recovered in recent years from locales in northern South Australia, also of mid-Tertiary age, do not clearly belong within any of modern avian family. Currently being described, these forms may represent remnants of the earlier Tertiary fauna of Australia, much as Wynyardia is such a remnant of a more primitive marsupial fauna on this continent. Members of the Passeriformes and Columbidae are now known from the mid-Tertiary as well, and restudy of contemporary flamingo fossils, mainly from northern South Australia indicate endemism at the generic level within this group, especially during the Miocene.

In summary, the Australian fossil record of birds, at the time when the first diverse assemblages appear in the early Miocene, shows a mixture of modern and extinct families, with modern families predominant. Broad evolutionary trends can be seen in some groups (e.g. Dromornithidae, Casuariidae, Aegothelidae), but at present the record is still very spotty with major gaps in the Paleogene and Pleistocene. Only when those voids are filled will a good picture of avifaunal evolution in Australia begin to emerge.

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The Early Pliocene Hamilton Fauna

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Through a combination of dogged determination and good luck, Edmund Gill discovered the early Pliocene Hamilton fauna in 1952. Subsequent work at this site by Turnbull and Lundelius resulted in the recognition of the presence of eighteen mammalian taxa, nine of which could be identified at the generic or specific level. This work was based on the recovery of approximately 150 isolated teeth and tooth fragments and was summarised in their paper of 1970 (Fieldiana: Geology, volume 19).

The locality is particularly important because the fossiliferous unit is overlain by a basalt which has been radiometrically dated at 4.35 ± 0.1 mybp and underlain by an assemblage of Kalimnan marine invertebrates in the Grange Burn Formation. Thus it provides an important benchmark in the biochronologic scheme based on fossil terrestrial mammals gradually being built up in Australia.

Beginning in 1977, the National Museum of Victoria began a new phase of excavation at the site and in the second year of that effort, located a much richer concentration of fossils than was available to Turnbull and Lundelius. Excavation of this new area has resulted in the recovery of approximately 1,000 isolated teeth together with about thirty jaws and maxillae plus a single, extremely fragmentary skull.

The following is a preliminary analysis of the fauna based both on the earlier published work of Turbull and Lundelius plus the new material subsequently recovered by the National Museum of Victoria. Material collected and currently under study by Turnbull and Lundelius and not reported on in their 1970 paper is not considered here.

Faunal List

Dasyuridae:
- Antechinus sp.
- Genus & Species indet.

Peramelidae:
- **Peramelidae? new genus & species

Phalangeridae:
- Phalanger cf. orientalis
- Phalanger cf. vestitus

Burramyidae:
- *Burramys n. sp.

Petauridae:
- **Pseudokoala erlita
- *"Pseudocheirus" marshalli
- *Petaurus sp.

Potoroidae:
- cf. Aepyprymnus
- cf. Hypsiprymnodon
- **Propleopus sp.

Macropodidae:
- cf. Dorcopsis sp.
- **Sthenurus sp.
- **Troposodon sp.
- **Protemnodon sp.
- Thylogale sp.

Palorchestidae:
- **Palorchestes n. sp.

Diprotodontidae:
- New genus & species

Ektopodontidae:
- New genus & species

Vombatidae:
- Genus & species indet.

Microchiroptera:
- Genus & species indet.

* Species extinct
** Genus extinct

Except for Burramys, all the extant genera represented in the Hamilton fauna occur today in the moist, tropical regions of northern Australia and (or) New Guinea. It is possible that the present range of Burramys parvus in the mountainous area of Victoria is a relict distribution of a once more widely spread form. This is suggested by its occurrence in Pleistocene sites outside the present range. Nothing in the fauna would suggest that the onset of the more xeric conditions characteristic of the latest Cainozoic had occurred in western Victoria by the early Pliocene. Rather, a continuation of a warm, moist regime from the Miocene as indicated by the mammalian assemblages of that age in South Australia is suggested.

Preponderantly, the collection of the Hamilton fauna consists of the remains of isolated teeth of small mammals. Bones are rare as are the remains of larger mammals. The absence of bone may be owing to their chemical destruction by the action of sulfides in the basalt which immediately overlies the fossiliferous unit. In part, this may explain the almost total non-occurrence of other vertebrate classes. Of the non-mammalian vertebrates, only a few limb bones of frogs have been recognised. All except two of the mammalian groups that reasonably may be expected at the locality have been found there. Exceptions are the rodents and phascolarctids. Given their size being in the range most frequently encountered, the absence of rodents is probably owing to their actual absence from the area and consistent with the idea that they had not entered Australia until after 4.35 mybp. Phascolarctid teeth, on the other hand, are large enough that the bias in the sample against teeth of their size may be safely invoked as the cause of their absence.

The Ektopodontidae are a group of aberrant phalangerids or phascolarctids previously known only in the medial Miocene of the Etadunna and Namba Formations of South Australia. The form identified as Peramelidae? new genus and species is congeneric, if not conspecific, with an as yet undescribed taxon known from the Etadunna Formation. Except for Pseudokoala and the new genus and species of Diprotodontidae, all the remaining genera are well known in Quaternary deposits and several are extant. However, none of the few species that have been recognised thus far is known in the Quaternary or Recent.

The Geology of the Upper Shoalhaven Plain

by B.P. Ruxton* & Graham Taylor*

In the middle course of the Shoalhaven valley early Tertiary sediment, basalt, and duricrust extend from Larbert to Bungonia.

The area studied has a bedrock of lower Palaeozoic sediments and volcanics and lies in a tray-like depression. This depression is bounded on the west by a north-south fault passing through Tarago (Mulwaree Fault) and on the east by a high scarp of resistant Permian sandstones. The Permian sandstones formerly extended further to the west and there is evidence that their dip flattened out in this direction. Some or all of the "Shoalhaven Plain" of Craft could have been exhumed from beneath the Permian cover.

The sub-basaltic, sub-alluvial surface is an undulating plain cutting across the Palaeozoic structures. It appears to be semi-continuous with a duricrust mantled plain and the whole would be equivalent with the Shoalhaven Plain of Craft. In general it lies between 610 m and 670 m with protruding hill groups (e.g. Sunset Mountain 730 m) and incised river valleys (down to 550 m). In places close to the Shoalhaven River it appears to be a flat valley floor at about 625 m and is some 3 to 5 km wide.

This dissected plain is younger than the Permian sediments and older than the early Tertiary sediments, probably late Mesozoic. The plain was a partial peneplain developed on the soft Ordovician greywacke. The permian sandstone scarp may have been present at this time.

Early Tertiary sediments are pre-, post-, and inter-basaltic and include rare colluvial breccias, fan sediment, coarse alluvium, paludal and lacustrine deposits. They are up to 90 m in thickness and partially blanket a strip along the Shoalhaven valley some 12 km wide. Near Mayfield their base is at 665 m. North of Windellama they are frequently cemented by iron hydroxides or manganiferous cement. They directly underlie basalt in at least four localities.

Tertiary plant fossils and wood are very common at several localities and the Cinnamonum flora has been recognized at Bungonia. At Titringo Creek near Nerriga a special study of the microflora of siltstones indicated a lower Eocene assemblage. More recently palaeo-botanists have favoured an early to middle Eocene age.

Bores by the Metropolitan Water Sewerage and Drainage Board indicate ? early Eocene beds of gravel, sand and clay, as lenticular beds, with some carbonaceous muds. There are rapid lateral facies changes and in the Spring Creek area regular beds of sand, silt and clay suggest a quiet lake.

Near Larbert on the Shoalhaven River alluvium is over 46 m in thickness and its base is below the rock bed of the present Shoalhaven River suggesting a buried prior channel. The lower part of the alluvium is weathered and is here considered to be part of the early Tertiary sediments. The younger gold-bearing alluvium may be much later (N.S.W. M.W.S. & D.B. report on Welcome Reef Dam Site, 1978).

Prior early Eocene Shoalhaven River courses have been mapped out by Gray, and a gorge about one kilometer wide occurs within a wider valley near Charleyong.

The cause of such deep alluviation is not known but Gray has suggested damming back by basalt flows, though this would only explain post-basaltic sedimentation. Tilting is also possible perhaps due to a transverse upwarp across the course of the Shoalhaven valley. This would represent an earlier phase of movement than the Norwood or equivalent warps which have been put forward to explain Lake George, Lake Bathurst, and the diversion of Boro and Reedy Creeks.

Scattered basalt occurrences over a wide area between Bungonia and the Endrick River have been dated as late Eocene and volcanic activity probably occurred in the period 46 to 44 m.y. ago. Two more occurrences have been dated in this study from Hedly homestead and Windellama creek and they both belong to the Nerriga Province (McDougall pers. comm.).

Many of the basalt outcrops have been weathered to bauxite. The distribution of basalt and bauxite is predominantly as cappings on the top of flat summits at between 640 m and 716 m. Basalt has also infilled some incised valleys, up to 30 m deep in Windellama

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creek and up to 107 m deep in the Endrick River (Titringo Creek). The former extent of the basalt cover is unknown but the scattered occurrences today are clearly relics of a much more extensive mantle.

The basalt may rest directly on ferruginized or silicified Palaeozoic bedrock or onto soils and even red loams. In many places it rests on colluvium or early Tertiary sediments.

The duricrusts of the Shoalhaven area are of two types; those associated with basalts and those produced by the weathering of bedrock and alluvial cover. The palaeomagnetic evidence (M. Idnurm pers. comm.) shows that both types of duricrusts are of similar age - Miocene.

Bauxites cap the highest ridges (620 to 700 m). Manganacrete occurs just below the bauxite with silcretes lower still (< 620 m). The bauxites have strong profile development grading from pisolitic bauxite at the top, down through massive and vermicular bauxite and ironstone, to a kaolinite/sesquioxide mottled zone, to weathered basalt and fresh basalt. In some cases no trace of basalt, fresh or weathered, remains and the bauxite profile has been lowered onto the Ordovician metasediment bedrock. The manganacrete is a cobalt rich manganese oxide cemented talus breccia and alluvium which flanks the high bauxite ridges.

The silcretes are microquartz and overgrowth cemented quartz rich alluvium. These drape the hillslopes from below the manganacrete and bauxite to the valley bottoms in some cases.

The bedrock and alluvium type duricrusts are typified by lateritic profiles, extensive silcretes at all topographic levels and remnants of deep weathering profiles. The lateritic and deep weathering profiles are, for the most part, developed on Ordovician bedrock, sometimes with thin, now ferruginised, alluvial cap. The silcretes occur at various levels in the quartzose alluvium of the old Shoalhaven Plain. At many localities the silcretes rim extensive alluvium topped plains.

At Tomboy intra-basaltic leads of quartzose sediments are silcreted and at Larbert sub-basaltic leads are silcreted. These silcretes are probably not related to the bedrock silcretes.

In both types of duricrust the presence of the duricrusts has resulted in a topographic inversion. What were valley fill materials, basalt or alluvium, are now topographically high, duricrusted residuals.

As with the alluviation the sequence of terraces is complex and of uncertain age. For example, we do not know when the new Shoalhaven river course was commenced, nor when it was entrenched into bedrock beneath the alluvium (? and basalt), or when the gorge incision occurred. However, both old and new channels are adjacent and crossing indicating the persistence of the same topographic low from its inception to the present day.

The oldest gravel covered terrace of this topographic low is at 610 m to 625 m forming flat-topped hills. It has been considered to be the highest terrace of the New Shoalhaven River and of ?Pliocene age. We think it possible that it is much older and it may even belong to the prior Shoalhaven River course thus pre-dating the early Eocene events.

Lower terraces of the present Shoalhaven and its tributaries up to 595 m have local silcrete with polymict pebbles often only 9 m above the streams (e.g. Nadgigomar creek east of Eden Park).

From the evidence at the Endrick River and Windellama it is evident that the Shoalhaven and its tributaries have re-occupied the pre-basalt valleys and incised to relative levels similar to those that existed pre-basalt.

A major problem is whether duricrusting occurred direct on the landscape created by the basaltic activity or whether there was post-basalt erosional topography and then duricrusting or both. The presence of silcrete drapes suggests that duricrusting occurred after a post-basalt topography developed or that these silcretes developed at or near the base of large sand valley fills below or adjacent to the basalts.

STRATIGRAPHIC, ENVIRONMENTAL AND VEGETATIONAL RELATIONSHIPS OF POLLEN FLORAS FROM LATROBE VALLEY BROWN COAL SEAMS

By I. R. Sluiter and A. P. Kershaw
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Pollen analytical studies are being undertaken to elucidate the vegetation communities, climatic conditions and depositional environments responsible for the production of peat deposits which were the precursers of present brown coal seams in the Latrobe Valley. Of central interest is the explanation of the origins and nature of individual lithotypes and how these vary in relation to one another and also through the whole thickness of coal seams.

To date two sequences have been completed on the Yallourn Seam. The range of pollen recorded in all samples was very similar suggesting that there had been little change in the kinds of vegetation present within the region. With the assistance of numerical methods and the application of information on the ecology and pollen production and dispersal characteristics of extant taxa, a partial picture of the vegetation within the catchment area has been constructed. Dryland vegetation was composed of a variety of temperate and subtropical closed forest communities with Casuarina on drier sites or as a secondary plant associated with closed forest. In contrast, vegetation within the coal-forming basin was dominated by taxa such as Epacridaceae, Restionaceae, Banksia and Myrtaceae which now characterise sclerophyll vegetation, and Coniferae which now have very restricted distributions in Australia.

Variations in abundance of taxa growing within the basin suggests major changes in the distribution and extent of local vegetation communities. These changes can be explained largely as responses to water level fluctuations, probably resulting from differential basin subsidence rather than climatic change. From numerical analyses of pollen spectra, four main assemblages were identified which appear to form a series from unvegetated open water to raised bog. These correspond well with lithotypic variations based on quantitatively determined colour values with assemblages from open water to raised bog falling along the colour gradient from pale to dark.

The significance of conclusions from these initial studies are being tested presently by construction of complete seam sequences from both the Yallourn and Morwell seams.

THE NATURE AND SIGNIFICANCE OF LACUSTRINE DEPOSITS NEAR BUNYAN, N.S.W.

by Graham Taylor[1], P.H.Walker[2], N.O. Jones[1] & J. Hutka[2]

Freshwater diatomite deposits have been reported along the banks of Middle Flat Creek near Cooma since the 1880's but little information on the associated sediments is available.

Drilling and coring during the present research program have shown the diatomites to be the upper part of a 50 m section of clays, coal and diatomite. These deposits extend for about 5.5 km north of the diatomites and are up to 3 km wide east/west. The nature and distribution of these sediments indicate they were deposited in a lake.

The lacustrine sediments lie unconformably on deeply weathered Silurian volcanics. The weathering profiles at some localities have iron oxide mottles and are capped by a ferruginous hard-pan.

Well laminated to massive clays make up the bulk of the deposit. The clays are dominantly well crystallised fine ($\sim$ 0.2 μm) kaolinite with lesser amounts of montmorillonite, illite and locally metahalloysite. This mineralogy suggests the clays probably originated from the Monaro basalts which must have been deeply weathered during the Oligocene - early Miocene. The main body of clays vary in colour from grey to black, red, pink and yellow and are frequently mottled by sesquioxides and jarosite. Gypsum occurs as crystal aggregates, nodules and fracture coatings in certain stratigraphic intervals above the coal. Scattered throughout the clays are quartz grains (up to 7 mm) and fine dark grains (?) ilmenite. In the lower parts of the sequence the clays contain carbonised and pyritised wood fragments. The basal clays are typically blue and contain minor gravel; at marginal localities the clays immediately above the weathering profile are themselves red and in places contain large (up to 1 m) sesquioxide nodules or beds.

Lignite seams up to 0.75 m thick occur interbedded with clays between 15 m and 28 m above the base of the deposit. The lignites contain abundant macroflora and pollen and are pyritic.

At the southern end of the deposit the top 15 m of the sequence is composed of well laminated to massive diatomite. The diatomite has clay partings between many laminae and zones of brecciation in association with concentration of

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organic residues (? palaeosols). Small diatomite lenses occur in the underlying clays and in places contain well preserved megafloral impressions. Murray Cod fossils have been recorded from the diatomite.

The lake deposits overlie weathering profiles which are dated palaeomagnetically as late Tertiary (P. Schmidt pers. comm.) and contain pollen (Nothofagus, grass, and bullrushes) dated as Miocene (E. Truswell pers. comm.). R. Gould and D. Thomas (pers. comm.) report the diatoms are also probable Miocene age and D. Christophel (pers. comm.) identified megafloral impressions as Miocene.

The nature of the sediments, their distribution, flora and fauna indicate that during the Miocene there was a substantial lake which was probably fairly shallow. During the early part of the lake's existence it was surrounded by relatively lush vegetation (pollen and coal) and probably did not dry up until after the coal was deposited but was intermittently dry after that period. Drying caused the deposition of gypsum and jarosite (since redistributed), oxidation of the clays (red zones ? palaeosols) and the desiccation features in the diatomite. This change in the character of the lake deposits probably reflects a change in climate in the late Miocene.

There are minor clay deposits overlying weathering profiles of Miocene age at Cosgrove Hill south of Bredbo and at Chakola, suggesting the lake may have extended as far north as Bredbo, making it possibly 25 km long and 6-7 km wide during the mid to late Miocene. The location of the dam responsible for the lake is uncertain. The simplest possibility is that movement on the Murrumbidgee Fault may have blocked the Murrumbidgee River just north of Bredbo.

LIGNITE DEPOSITS OF THE WESTERN GIPPSLAND BASIN

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17 October 1980

The accumulation of thick lignite deposits along the western margins of the Gippsland Basin accompanied a marine ingression that lasted from the late Oligocene to the middle Miocene in this area.

Within the Lake Wellington Depression, the interface between the carbonaceous rich sediments of the Latrobe Valley Coal Measures and their calcareous equivalents, the Seaspray Group to the east, is represented by a thick but laterally narrow sandy sequence just to the east of Rosedale. This facies, called the Balook Formation, is interpreted as representing a delta-front facies formed by drainage systems developing a delta within a narrow fault-controlled graben. The barrier-complex has a thickness of 400 metres but is less than seven kilometres wide, which is taken to indicate a rapid rate of marine transgression accompanied by a rapid rate of sedimentation and basin subsidence.

Two main coal bodies accumulated behind the barrier-complex during this period - the Morwell and Yallourn Formation coals. It is proposed that the lignites developed around local structural "highs" during two main periods of rising sea-levels, as indicated by facies variations exhibited by the barrier sands. A similar sequence is being investigated to the south of the Balook Block where coals of equivalent age have accumulated around the Gelliondale Block. The barrier-complex, so far not fully delineated, occupies a north-south zone to the east of Yarram.

A regressive sequence overlies both the lignites and the marine sequence but the occurrence of thin beds of coal within it may have been formed in response to the brief Pliocene marine transgression that resulted in the deposition of the Jemmys Point Formation in the eastern part of the basin.

An older, Eocene, sequence of lignites disconformably underlie much of the onshore Gippsland basin and extend across the offshore area as well, where they form part of the Latrobe Group. Within the Lake Wellington Depression thick lignites of this age, known as the Traralgon Formation, occur at shallow depths or beneath the younger coals, around the Loy Yang Dome, the Baragwanath Anticline and across the Stradbroke Block. Coals of this age also occur beneath the younger series in the Gelliondale Coalfield area.

THE SIGNIFICANCE OF THE RECOGNITION OF PSEUDOGLEY IN SOIL STRATIGRAPHIC INTERPRETATIONS

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The recognition of pseudogley in soil profiles and distinguishing pseudogley from gley are of critical importance in soil stratigraphic and geomorphic interpretations.

Gley and pseudogley are related to fundamentally different environmental conditions. Gley develops in a zone above a permanent, or at least seasonally prolonged, groundwater accumulation and is a general feature of low-lying or extensive flat, poorly drained land. Pseudogley is related to relatively rapidly alternating wet and dry conditions of a surficial water regime. This water regime is governed by accession from precipitation and seepages, and by depletion due to evapotranspiration and drainage. Pseudogley is characteristically an upland development. Thus controlling factors in gley are more related to landscape figuration, and in pseudogley more to climate.

Pseudogley was originally mainly known from shallow occurrences in the sola of soil profiles related to present environmental conditions. The present study is concerned with deep-seated developments in palaeosols.

It has been established in the first instance that palaeosols can be characterized by specific subsolum pseudogley patterns in certain slope situations, and that this also provides a basis for palaeoclimatic interpretations (van Dijk 1969). An important application is in the interpretation of thick hydromorphic clay mantles which all seem to represent a rather similar, common type of gley-clay related to the present environment. It has now been found that large sections of these clay mantles are characterized by intensive pseudogleying which developed to unusual extent on slopes (= long hydromorphic reach) indicating relationship to past climatic conditions greatly different from the present.

Secondly, the recognition of pseudogley is critical in the interpretation of layered profiles in which horizons resembling buried A- or B-horizons may in fact be related to pseudogleying. The latter may be induced by depositional bedding or associated with split-subsoils.

Thirdly, recent studies of lateritic mottled zone materials in SE Qld. have led to the conclusion that extensive occurrences of these materials, previously regarded as part of a gley profile of very considerable depth, seem to represent surficial pseudogley developed in relatively shallow profiles. This is also of considerable consequence for geomorphic reconstructions.

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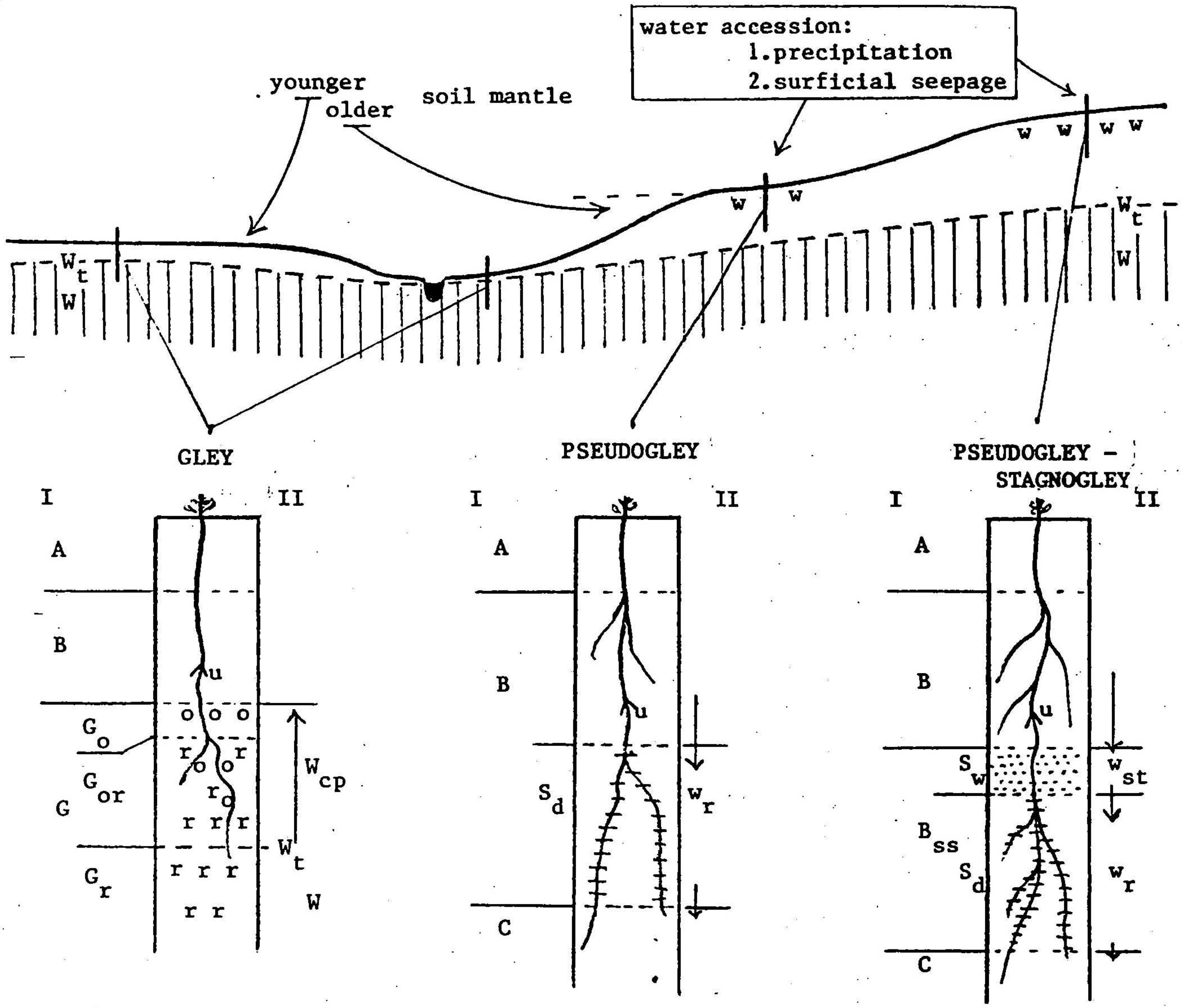

I SOIL HORIZON SYMBOLS

A = surface soil } solum
B = subsoil
B_{ss}= subsolum } (split subsoil development)
C = substratum

G = gley horizon
G_o = oxidation (o) horizon (brown, grey and rusty mottling)
G_r = reduction (r) horizon (grey-greenblue coloured)
G_{or} = transitional between G_o and G_r (grey, yellow and rusty mottling)

S = pseudogley horizon
S_d = pseudogley in rootzone (yellow and grey vein patterns)
S_w = pseudogley-stagnogley (light grey (bleached) horizon with sesquioxidic concretions)

II SOIL WATER CONDITIONS

W = permanent free groundwater accumulation
W_t = water table
W_{cp} = capillary rise
u = water uptake by plants

w = temporary soil wetness within the soil profile due to impeded internal drainage
w_r = moderately retarded internal drainage
w_{st} = strongly stagnating conditions

PERIODIC SOIL DEVELOPMENT IN THE EASTERN HIGHLANDS

(poster presentation)

D.C. van Dijk, CSIRO Division of Soils, Brisbane, Qld.

Illustrations are presented of a soil stratigraphic sequence and related landform developments identified in the Murray Valley at Albury-Wodonga (van Dijk and Rowe 1980).

In establishing the soil differences between the stratigraphic units, intensive use was made of deep-seated pedogenetic features. It was found firstly that specific pedological patterns in the subsola of the older soils provide particularly useful diagnostic characteristics for separating the stratigraphic units, and secondly that deep-seated pedologic differentiations may be the cause of confusing stratigraphic situations. A particularly important, widely occurring example of the latter is split-subsoil development within a single stratigraphic unit which may be, and indeed often has been, mistaken as representing superposition of two soil layers of different age.

Investigations of relationships between periodic soil development and landscape, as illustrated in the lower half of the poster, were a major part of the study because the principal aim was to develop an understanding of soil layering on upland slopes. Principal attention was paid to the gentle, undulating to rolling, topographies which are the more important for land use.

The landscape studies in the first instance have provided detailed landform criteria in addition to the soil characteristics for the recognition of the soil stratigraphic units.

At the same time these studies led to the conclusion that very considerable alterations of the landscape relief accompanied the soil stratigraphic evolution. A succession of specific landscape developments (relief generations) was identified.

Systematic study of the landscape developments in relation to valley physiography led to the recognition of the following main types of general valley development.

Early development was characterized by the formation of broad (in general 3-10km wide) trough-shaped valleys; subsequent trunk stream incisions were first accompanied by the formation of broad tributary valley basins (resulting in typical "pediplain-basin" morphology), followed by detailed slope sculpture leading to dell-like landforms. Final landscape developments showed as their main manifestation only terracing along the major drainage lines.

The recognition of these major trends in stratigraphic-geomorphic valley development provide a systematic basis for broad scale soil landscape subdivisions (= soil strato-landscapes, defined as: landscape units with specific soil stratigraphic assemblages, comprising the remnants of certain ranges of sedentary and depositional palaeosol layers and relict weathering zones, and displaying certain surface morphologies (van Dijk 1979).

The considerable differences in character of soil profile developments, particularly at depth, and in type of landforms indicate the influence of significantly varying climatic conditions.

The magnitude in both soil profile and landform developments suggest that considerable periods of time were involved. Indeed a late to mid Miocene age for the oldest stratigraphic unit is indicated by recent palaeomagnetic studies (Idnurm, van Dijk and Senior, CECSEA '80). This evidence points at mid to early Pleistocene and Pliocene ages for appreciable portions of the more important sections (for land use) of the present soil mantle, since it was found that the older stratigraphic units established during this study are extensively represented in the gentle topographies of the valleys.

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Mechanism of uplift of the eastern highlands, from K-Ar dating, regional gravity, and repeat geodetic measurements

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Models of the timing of uplift in the eastern highlands can be divided into three types: intermittent uplift, uplift at a constant rate, and early uplift. The models partly reflect the inferred, or assumed, speed of horizontal and vertical erosion. If valley widening is thought to have been fast, then smooth horizontal landscape 'surfaces' can be interpreted as due to periods of no uplift, and slopes between the 'surfaces' as due to periods of uplift; this leads to models of intermittent uplift. With slow valley widening the 'surfaces' can be interpreted as due to variations in erosional resistance. If the potential rate of downcutting of major rivers is thought to have been faster than the uplift rate, then the change in level of the river bed with time can be used to infer the change in level of the highland relative to the base level of the adjacent lowland; this leads to models of uplift at a constant rate. If the rate of down-cutting of the major rivers is thought to have been slower than the uplift rate, then changes in the level of the river bed with time reflect mainly the relative resistance of the rocks to erosion, leading to models where the uplift was early.

The preferred model for the southeast highlands has both uplift and the rate of extrusion of volcanic material occurring at a constant rate during the Cainozoic. Both processes are inferred to be driven by constant-rate plate tectonics. The measured gravity field shows that at present, $0.5^{\circ} \times 0.5^{\circ}$ areas of the highland are very close to being in isostatic equilibrium; this equilibrium almost certainly applied in the past. To maintain isostatic equilibrium during uplift the crust must be thickened, either by shortening or by addition of material within it or at its base. The most satisfactory model is for crustal thickening by underplating of dense material on the base of the crust. Underplating is consistent with recent seismic refraction models, in which the upper 30 km of the crust has a normal 'continental' velocity distribution and is underlain by over 20 km of high-velocity crust. Underplating is also consistent with the measured heat flows, the mean of which is 1.7 times the world average; this is not sufficiently high to allow the crustal thickening by intrusion into the upper crust, but allows underplating, or intrusion into the lower crust. Crustal underplating is suggested by Ewart on independent petrological grounds.

Evidence for recent tectonic activity in the highlands consists of widely-scattered, small earthquakes occuring over the width of the highlands, a few areas where granite is thrust over late Cainozoic gravels, and local faulting and warping which have caused late Cainozoic river aggradation and lakes. The present rate of horizontal movement has been measured in the Canberra area by comparing geodetic surveys carried out about 100 years apart. The comparison shows that the shear component of crustal motion is about 20 parts in 10^9 per year, with a north to northwest principal axis of compression. The movement is thought to produce stored elastic strain, later to be released by movements on existing faults accompanied by earthquakes. This shear rate is equivalent to horizontal deformation of 4 mm per year across the 200 km wide highland. It is much higher than the possible average rate for the Cainozoic deformation of the highlands, but is consistent with the present earthquake frequency. This present-day upper crustal shear deformation is not thought to indicate significant crustal shortening, but rather to be minor deformation accommodating the uplift of the crust and high surface stress.

Fossil Vertebrate Deposits of Victoria-Fossil Cave Naracoorte South Australia

R.T. Wells and K. Moriarty
Flinders University, South Australia

Abstract

Victoria-Fossil Cave is one of the larger vertebrate fossil sites recorded in Australia. A late Pleistocene age is suggested for most of the cave fills and fossils. Evidence is advanced to support a Tertiary age for some of the karst and cave fill. Horizontal cave development is controlled by joint pattern with vertical development controlled by bedding planes in the limestone. Stripping of the overlying Pleistocene dunes and beach deposits exposed the entrances to the caverns. Entrances acted as traps for sediments and animals. Sediments within the cave reflect the pedogenic processes existing outside and hence shifts in climate. An analysis of the fauna correlates with the inferred climatic shifts. The cave was sealed approx. 17,000 years BP. Preliminary uranium series dates suggest maximum ages of fossils in excess of 150,000 yrs BP.

TITLE: Late Quaternary fluviatile deposits in eastern South Australia.

By D.L.G. Williams

ABSTRACT

G.E. Williams (1973) recognised a period of cold, arid conditions, beginning before 38,000BP and ending by 30,000BP, which was responsible for the deposition of alluvial fans in the Flinders Ranges. Similar deposits of the same age occur near Adelaide.

New studies have been made in the Burra area, 160km north of Adelaide.

The coelesced fans on the eastern margin of the North Mt Lofty Ranges have occasionally yielded vertebrate fossils in the past. These originate in gravelly alluvium of the fans, which also fills intermontane valleys.

Prior to 40,000BP the climate was uniform and stable. The basal silty unit which occurs throughout the region reflects a moist, low-energy environment, with permanent fresh waterholes in the creeks. Elsewhere the unit displays a prominent nodular carbonate horizon which indicates a period of temperate-climate weathering. No vertebrate fossils are known from this unit.

Radiocarbon dates in the range >40-34,000BP date the fossil-bearing gravelly alluvium which erosively overlies the basal silt. The nature of the sediments suggests a strongly seasonal climate, with intense flooding in the streams and erosion from the surrounding hills. The fossil assemblage includes species of *Diprotodon*, *Sthenurus*, *Protemnoden*, *Bettongia*, *Macropus*, *Osphranter*, *Lasiorhinus*, and *Thylacoleo carnifex*, as well as *Onychogalea*.

Subsequent events include a period of soil formation, development of playa lakes, and stream incision on the surface of the fans. These probably form a sequence which extends into the Holocene.

REFERENCE:

Williams, G.E. (1973) Late Quaternary piedmont sedimentation, soil formation and paleoclimates in arid South Australia. Z. GEOMORPH.17, 102-125.

CAINOZOIC SEDIMENTATION OF THE EASTERN MURRAY BASIN, N.S.W.

R.M. Williams and L.W. Drury
(Water Resources Commission of New South Wales)

Contours on the pre-Tertiary surface of the eastern Murray Basin show a palaeodrainage system quite discordant with the present drainage system although suggesting that a drainage system ancestral to the present Murray-Murrumbidgee was in existence in Eocene times. The fluviatile provinces were established in the Early Tertiary and have not changed markedly since that time except near Corowa where the Murray River enters the Basin.

During the period from Middle Eocene to Early Miocene the only co-ordinated drainage system for which evidence is available is in the Narrandera area, where a large fan developed in association with the palaeo-Murrumbidgee. Extensive swampy conditions occurred further to the south and west. Sedimentation in them formed the Olney Formation which shows a marine influence west of Wakool.

The Late Miocene regression resulted in considerable erosion of the existing sediments and formation of the Mologa Surface west of Deniliquin. Aggradation of the fluviatile Calivil Formation is attributed to rising base levels associated with the Late Tertiary marine transgression. The large fan associated with the palaeo-Murrumbidgee was formed during this period, but in the Murray valley, concurrent and/or younger faulting and the consequent erosion of the sediments has resulted in an incomplete stratigraphic record. It is assumed that the main drainage was from the eastern highlands along the Murray valley and from the south along the Ovens graben. There is a marked lacustrine character to the sediments on down faulted blocks near the faults. Deposition continued into the Pliocene, and the unit is a partial time equivalent of the Lachlan Formation of the alluviated valleys.

Changing climate in the Late Pliocene and Pleistocene caused a change in river regime and resulted in contraction of the Murrumbidgee fan towards Narrandera. The course of the Murray River at this time was well north of Corowa and re-entered what is now Victoria near Yarrawonga, with the Ovens River joining it north of the present confluence. Sediments deposited during this period are part of the Shepparton Formation and are characterised by variegated clays with thin sands. Defined leveed stream traces which have an expression at the present land surface characterise the top of the Shepparton Formation. They show that during this period the Murray flowed from Corowa to Berrigan whilst distributaries of the Murrumbidgee fanned out from Narrandera.

GEOLOGY OF THE EASTERN MURRAY BASIN IN N.S.W.

D.R. WOOLLEY (WATER RESOURCES COMMISSION OF N.S.W.)

The most important economic aspect of the Tertiary sediments in the eastern part of the Murray Basin is the occurrence of a major aquifer system within them. Investigation of its groundwater resources has been carried out by the Water Resources Commission over the past 10 years and has included refraction seismic traverses and resistivity soundings, test drilling, and collation of data from private water bores and from oil and mineral drilling. This has led, among other things, to a better understanding of the Cainozoic stratigraphy of this part of the Basin, and the structure and configuration of its basement.

The Basin was initiated by movement along major lineaments during Early Permian and Jurassic - Early Cretaceous time and active sedimentation took place as subsidence continued during the Cainozoic. The pre-Tertiary basement consists of Permian, Triassic and Cretaceous sediments, and Palaeozoic granite and metamorphics. The shape of the unconformity on which the Tertiary deposits rest is very strongly influenced by the structural framework, in which north and north-west trending lineaments are prominent. Structure contours on this surface give an indication of a paleo-drainage system quite discordant with the present river system.

East of Balranald, sedimentation commenced in the Early Eocene, and was entirely non-marine. The stratigraphic nomenclature used by Lawrence (1975) has been followed for the non-marine and generally unconsolidated sequence in the N.S.W. part of the Basin. The basal Warina Sand, and the Olney Formation (sand, grey and black clay, and peat) of the Renmark Group were extensively deposited. The Olney Formation ranges up to Early Miocene age in the eastern part of the Basin, where the younger part of the sequence is a time equivalent of marine units west of Balranald. Following a period of non-deposition during the Middle Miocene, deposition of the Calivil Formation took place. This unit is characterised by white kaolinitic clay and, particularly in the alluvial fan whose apex is at Narrandera, by coarse white quartz sand and gravel. Deposition continued through the Pliocene, and the unit appears to be at least partly a time equivalent of the Lachlan Formation which is a quartz gravel unit within the valley tract of the Lachlan, Murrumbidgee and Murray Rivers. Changing climate in Pleistocene time caused a change in river regine and erosional mode, and resulted in deposition of the Shepparton Formation, characterised by variegated clay and thin polymict sands. The latter include the shoestring sands of the prior stream system which still have a surface expression visible on air photos.

Total thickness of the unconsolidated sedimentary sequence in this part of the basin is about 350m.

LAWRENCE, C.R. 1975 Geology, hydrodynamics and hydrochemistry of the Southern Murray Basin. Geol. Surv. Vict. Mem. 30

HEAVY MINERAL STUDIES OF STANNIFEROUS DEEPLEADS, NORTH-EAST TASMANIA

YIM, W.W.-S. Department of Geology, University of Tasmania, GPO Box 252C, Hobart, Tasmania 7001.

The main objective in this study is to obtain a better understanding of stanniferous sediments, in particular the deepleads, by investigating heavy mineral distribution and using sedimentologic methods relating to palaeo-environments, provenance and palaeocurrents. From this work, it should be possible to construct pre-depositional geomorphology, and successive deposition stages and thus identify criteria useful in the exploration of tin placers. An account is given here of the preliminary findings on provenance and distribution of heavy minerals in Cainozoic sediments of the Ringarooma River system.

In the field, palaeocurrent directions were determined by measuring imbricate structures and cross-beddings. Sediment samples from pit expoosures and drill-holes were panned down to minimise sub-sampling errors carefully to avoid the loss of heavy minerals. This is followed by heavy liquid separations at specific gravities 2.96, 3.32 and 4.2; and the plus-4.2 fraction was further separated using a Boxmag hand magnet into four fractions varying in magnetic intensity from strongly magnetic, moderately magnetic, weakly magnetic to nonmagnetic. Mineralogical examinations were then carried out on the mineral fractions.

The specific gravity and provenance of heavy mineral species identified is summarised in Table 1. Three heavy mineral associations are found.

(1) A cassiterite/almandine/pleonaste(rare)/corundum/topaz/zircon(both types) association, occurring at depth below the Tertiary basalts. Localities include Briseis, Pioneer and Endurance. At least 16 Ma in age, probably much older.

(2) A cassiterite/topaz/zircon(fine grain euhedral type) association, occurring both north and south of Mount Cameron, for example at Clifton and Sextus Creek respectively. No Tertiary basalts are known at these localities, but they occur at elevations close to or just below that of the nearest basalt and/or ferricrete duricrust outcrop. About 16 Ma or slightly older.

(3) A cassiterite/gold/pleonaste/corundum/topaz/zircon(both types) association, mainly restricted to the present day floodplains of the Ringarooma River. Localities include Riverside and numerous shallow workings on the Great Northern Plains. Younger than 16 Ma.

GEOMORPHOLOGY AND TECTONIC INTERPRETATIONS OF PART OF THE HIGHLAND CREST, N.S.W.

R. W. YOUNG

University of Wollongong

Because of the scarcity of deformed post-Mesozoic sediments reconstructions of the Cainozoic tectonic history of much of the highland of southeastern Australia have relied heavily on geomorphological interpretations of erosional forms. These interpretations have been almost exclusively cyclical in nature, being based on the Davisian tenets introduced to Australia at the turn of the century by Andrews. Recent K-Ar dating has thrown much new light on the age of many erosional features, thereby revising traditional views of the timing of postulated tectonic events, but estimates of the number and magnitude of earth movements are still based mainly on long-held beliefs concerning stream grade and cyclical planation.

Little thought has apparently been given to the implications for such tectonic schemes of the repeated assaults on cyclical analysis that have been so prominent in developments in geomorphological theory over the last two decades.

This paper presents an assessment of evidence of sequential planation and uplift during the Cainozoic in that portion of the Lachlan Fold Belt drained by the upper Lachlan, Abercombie and Wollondilly Rivers. Cainozoic chronological control is provided by 15 K-Ar determinations. The main conclusions are:

1) The major planation of the fold belt strata was associated with Permo-Triassic sedimentation in the adjacent Sydney Basin.

2) Eocene basalts on the higher parts of the terrain show that little modification of the Mesozoic surface had occurred by the Early Tertiary.

3) Distribution of Miocene basalts from virtually the highest parts of the terrain down to within 80 m of some of the main valley flows indicate that the area had reached its present elevation by middle to late tertiary times. The great altitudinal range of the Miocene basalts lends little support to the concept of sequential cyclical planation.

4) A model combining high level stripping with the slow headward retreat of valleys is proposed as an alternative to the traditional one of relatively rapid adjustment to new base levels following periodic uplifts. The reconstruction of tectonic history from erosional forms may be a far more uncertain exercise than many accounts have suggested.

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VERTEBRATE PALAEONTOLOGY

WORKSHOP

CECSEA- CANBERRA

28 November 1980

077797

MORNING SESSION (Chairman: M. Plane)

9.00 - 9.30	A new Miocene faunal assemblage from the Lake Eyre Basin: Preliminary Account. N.S. Pledge*; M. Plane.
9.30 - 10.00	The Bow local fauna: a Pliocene vertebrate assemblage from northern New South Wales. M. Archer, J. Mahoney.
10.00 - 10.30	The Early Pliocene Hamilton Fauna. T.H. Rich
10.30 - 11.00	Neogene avian assemblages of Australia. P.V. Rich, G.F. Van Tets.
11.00 - 11.30	An Overview of Australian Neogene Terrestrial Vertebrate Assemblages. T.H. Rich, M. Archer.
11.30 - 12.00	General Discussion.

LUNCH

AFTERNOON SESSION (Chairman: R. Wells)

1.00 - 1.30	Quaternary faunal studies in Australia's southeast. J. Hope.
1.30 - 2.00	Quaternary avian assemblage from Australia. G.F. Van Tets.
2.00 - 2.30	Quaternary stratigraphy and Vertebrate Palaeontology of the Lake Eyre Basin - Preliminary Report Only. R.A. Tedford R. Wells, D.L.G. Williams.
2.30 - 3.00	Late Quaternary fluviatile deposits in eastern South Australia. D.L.G. Williams.
3.00 - 3.30	Fossil deposits of Victoria Fossil Cave, Narracoorte, South Australia. R. Wells, K. Moriarty.
3.30 - 4.00	The late Pleistocene Spring Creek site of Western Victoria, a young megafaunal site. T.F. Flannery.
4.00 - 4.30	The taphonomy of the Bacchus Marsh *Diprotodon* site. J.A. Long.
4.30 - 5.00	General Discussion.
Please Note:	Each speaker will have 20 minutes for presentation, 10 minutes for discussion.

*underlining indicates speaker.

THE BOW LOCAL FAUNA: A PLIOCENE VERTEBRATE ASSEMBLAGE FROM NORTHERN NEW SOUTH WALES

M. Archer & J. Mahoney

The vertebrate fauna from an unnamed fluviatile deposit exposed at Bow, New South Wales, is described. Taxa so far recognised include: birds; fish; lizards; turtles; *Ornithorhynchus* sp.; *Dasyurus dunmalli*; two unnamed peramelid bandicoots, one of which resembles *Microperoryctes; Thylacoleo crassidentatus; T.* sp. cf *T. hilli; Protemnodon chinchillaensis; P.* sp.; *Macropus (Osphranter)* spp.; *Troposodon minor; T.* sp.; *Sthenurus* sp.; a new genus of macropodid; *Phascolonus* sp.; *Palorchestes parvus;* a nototheriine diprotodontid; a possible zygomaturine diprotodontid; and other as yet undetermined taxa. This fauna is most similar to the Chinchilla and Bluff Downs early Pliocene faunas of Queensland.