Cenozoic vertebrate palaeontology of northern South Australia

Geological
field excursion guide

SOUTH AUSTRALIA

Government of South Australia
Department of State Development

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AUSTRALASIAN PALAEONTOLOGISTS

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Cover
View to Warburton River from clifftop at Toolapinna Waterhole.

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Geological Field Excursion Guide

Cenozoic vertebrate palaeontology of northern South Australia

AB Camens and RT Wells

July 2016

Flinders University

Flinders University, Adelaide SA, Australia

Contents

Excursion itinerary – Leaders: Aaron Camens and Rod Wells

Day 1 – Saturday 16 July
Leave Adelaide at 7 am, approximately 8 hours' drive to Marree, camping at Marree Caravan Park. Dinner at Marree Hotel at 7:30 pm

Day 2 – Sunday 17 July
9 am- drive up to Kalamurina Station, lunch at Mungerannie Hotel at 12:00 noon, camping at Wetlands Campground (3 hrs Marree to Mungerannie and ~4 hrs from Mungerannie to Kalamurina Wetlands Campsite).

Day 3 – Monday 18 July
Visit to Lookout Locality (Late Pleistocene) and Toolapinna Waterhole (sites spanning the last 4 million years) on the Warburton River. Camp at Wetlands camp site.

Day 4 – Tuesday 19 July
7 am break camp and drive down to Lake Palankarinna (~ 6 hrs driving): one of the Lake Eyre Basin's most important Neogene localities. Spend afternoon prospecting around Lake Palankarinna. Camp near Lake Palankarinna.

Day 5 – Wednesday 20 July
Drive up to Cooper Creek where numerous fossils from the Middle Pleistocene Kutjitara Fm and Late Pleistocene Katipiri Sands have been found, camping near Lake Palankarinna.

Day 6 – Thursday 21 July
Pack up camp, leaving by 9 am, and drive down to Brachina Gorge (~7 hrs driving, camp in Brachina Gorge).

Day 7 – Friday 22 July
Pack up camp by 8 am and drive Brachina Gorge geological trail. Then drive south to Burra (stay in Paxton Cottages overnight). Dinner at Burra Hotel 7 pm.

Day 8 – 23 July
Visit Late Pleistocene megafaunal sites in Redbanks Conservation Park. Arrive back at Adelaide mid-afternoon.

Excursion requirements and insurance

Please make sure you bring sturdy boots, a hat, drink bottle, sleeping bag, pillow, torch and appropriate clothing for cold nights and warm days. A small backpack and camera is recommended. There are likely to be lots of flies, so you may also wish to bring a fly net.

Tents, swags (enclosed canvas bedrolls) and camp stools can be provided as needed, please inform us of your requirements.

There are several camping shops along Rundle St in the city (eastern end of Rundle Mall) where equipment can be purchased if needed.

We respectfully ask that you do not return to any of the non-tourist sites visited without appropriate permission, and that you do not record GPS coordinates.

Trip participants are advised that if an injury is sustained on the trip, with no responsibility or negligence on part of Flinders University, he/she will not be covered by the University's insurance policy. Participants are advised to obtain their own travel insurance for the trip.

Trip leaders will be equipped with UHF radios at all times and a comprehensive remote area first aid kit and satellite phone will be brought in case of emergency.

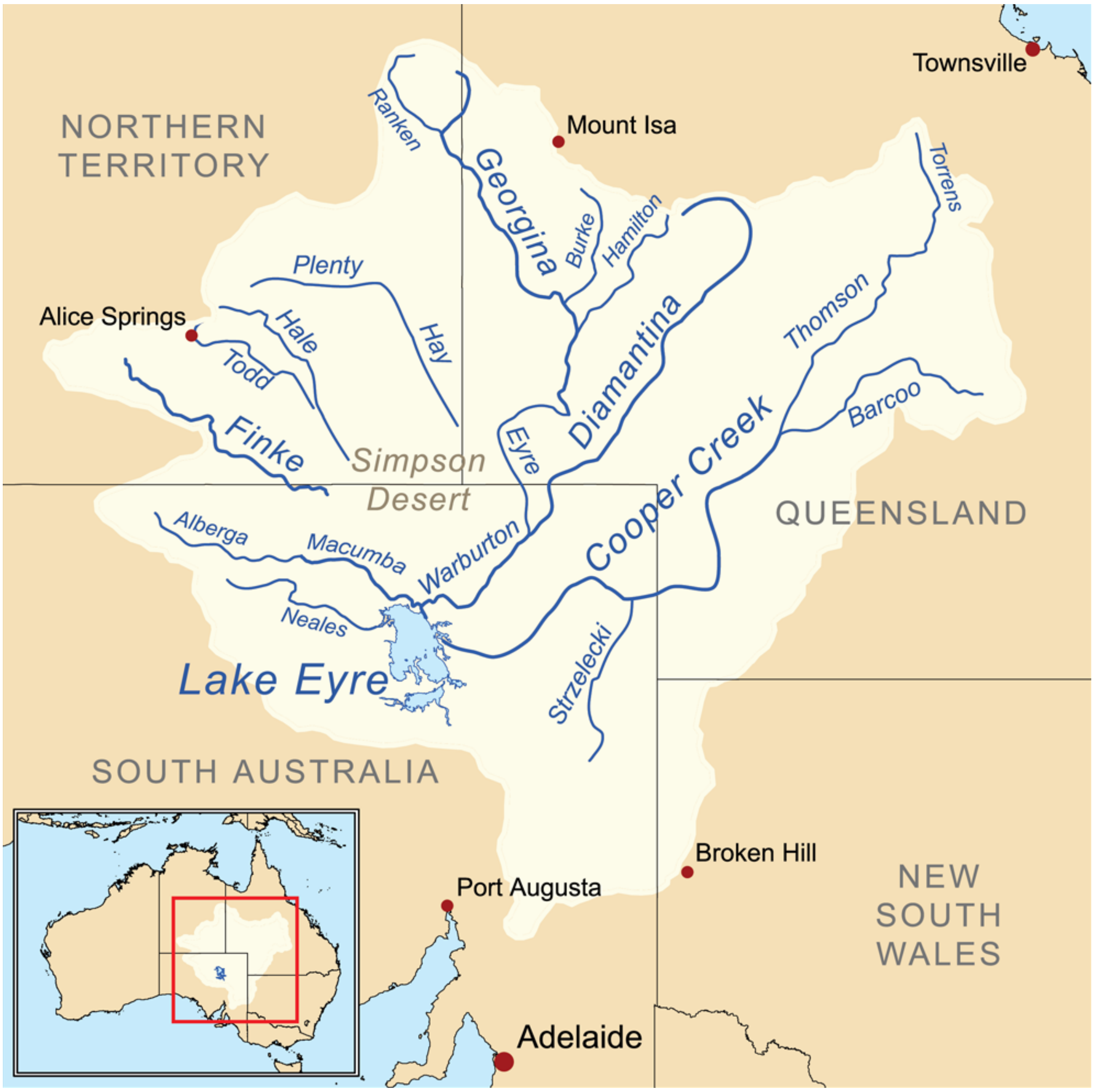


Figure 1 *Catchment area of Lake Eyre Basin. Note that Warburton River and Cooper Creek catchments extend over much of southwestern Queensland. (Image courtesy K Musser)*

Chapter 1

Introduction to Lake Eyre Basin

The modern Warburton River is a continuation of the Diamantina River and the Cooper Creek is fed by both the Thomson and Barcoo Rivers. Together the two rivers have a catchment area that extends across much of NE South Australia and the SW half of Queensland. The Warburton currently cuts down through the southern Simpson Desert and northern Tirari Desert, eventually emptying into the northern end of Kati Thanda-Lake Eyre, while the Cooper flows through the Tirari Desert and feeds into the eastern side of Lake Eyre North (Fig. 1).

The landscape of the region is dominated by red sand dunes and claypans in the swales, interspersed with areas of gibber plain. These vast dunefields remobilised during the last glacial period and the majority of dune building activity is restricted to four distinct periods 73-66, 35-32, 22-18 and 14-10 ka (Fitzsimmons *et al.* 2007). Their consistent north-south alignment is a result of the wind regime that has dominated the weather patterns in the area for much of the more arid part of the Late Pleistocene (Brookfield 1970, Wasson 1983). The area encompassing the northern Tirari and southern Simpson Deserts is also the driest area on the continent at present, with an annual rainfall of <120 mm/yr (Gentilli 1986). It is the vast catchment area in southwestern Queensland that brings the majority of the water to the Tirari Desert. In wetter years a floodplain several kilometres wide can be seen winding towards Kati-Thanda-Lake Eyre (Fig. 2) and as the flood waters recede a surge in plant growth is shortly followed by explosions in animal populations. In recent years the Warburton River has experienced significant flows and the region received much higher than average rainfall in the first half of 2016. We will be privileged to see the area at its most verdant, the removal of stock and the recent rains resulting in much denser vegetation than is usual.

Kalamurina Station has been the property of the Australian Wildlife Conservancy since 2007. It covers 667,065 ha and joins the Kati Thanda - Lake Eyre National Park and the Simpson Desert Regional Reserve resulting in a conservation strip extending from the southern end of Lake Eyre, up its eastern shore and all the way north to the South Australia-Northern Territory border (Fig. 3).

Figure 2 *Warburton River on Kalamurina station after floods in early 2015 (photo Trevor Wright).*

Figure 3 *Kalamurina station links Kati Thanda-Lake Eyre National Park to the Simpson Regional Reserve.*

Lake Eyre is the largest lake in Australia and the fifth largest terminal lake in the world, lying at the end of a northern-monsoon-driven lake system. In the Late Pleistocene it was a critically important source of fresh water, supporting a diverse range of large vertebrates. The Warburton River and Cooper Creek provide the majority of water entering Kati Thanda – Lake Eyre with over 65% of the water passing through Kalamurina. The station preserves a variety of environmentally important riparian, dune, floodplain and claypan habitats. Thirty seven species of threatened vertebrates occur on the station, including iconic taxa (Fig. 4) such as the Ampurta or Crest-tailed Mulgara (*Dasycercus cristicaudata)*, the Night Parrot (*Pezoporus occidentalis*) and the Dusky Hopping Mouse (*Notomys fuscus*). It is also home to regionally endemic species such as the Lake Eyre Dragon (*Ctenophorus maculosus*).

Kati Thanda-Lake Eyre has a geological history extending from the present through the last glacial cycle to the penultimate (MIS Stage 7) and possibly the antepenultimate (MIS Stage 9; 300 ka) cycle. The Pleistocene lakes filling the basin were centred in the areas of deepest deflation during the respective glacial maxima. Today, Kati Thanda-Lake Eyre contains the lowest points on the Australian mainland at ~15 m below sea level (De Vogel *et al*. 2004). Modelling of water levels around the northern end of the Adelaide Geosyncline has revealed that the terminal lakes on the region (Kati-Thanda-Lake Eyre, Lake Gregory, Lake Blanche, Lake Callabonna and Lake Frome) may have once formed a giant horseshoe lake that has retreated with the drying climate (Fig. 5; Alley 1998, De Vogel *et al.* 2004).

Figure 4 Iconic taxa present on Kalamurina station. ***Left:*** *Crest-tailed Mulgara* (Dasycercus cristicaudata) *[image australianwildlife.org];* ***Right:*** *Lake Eyre Dragon* (Ctenophorus maculosus)*; and* ***Bottom:*** *Dusky Hopping Mouse* (Notomys fuscus).

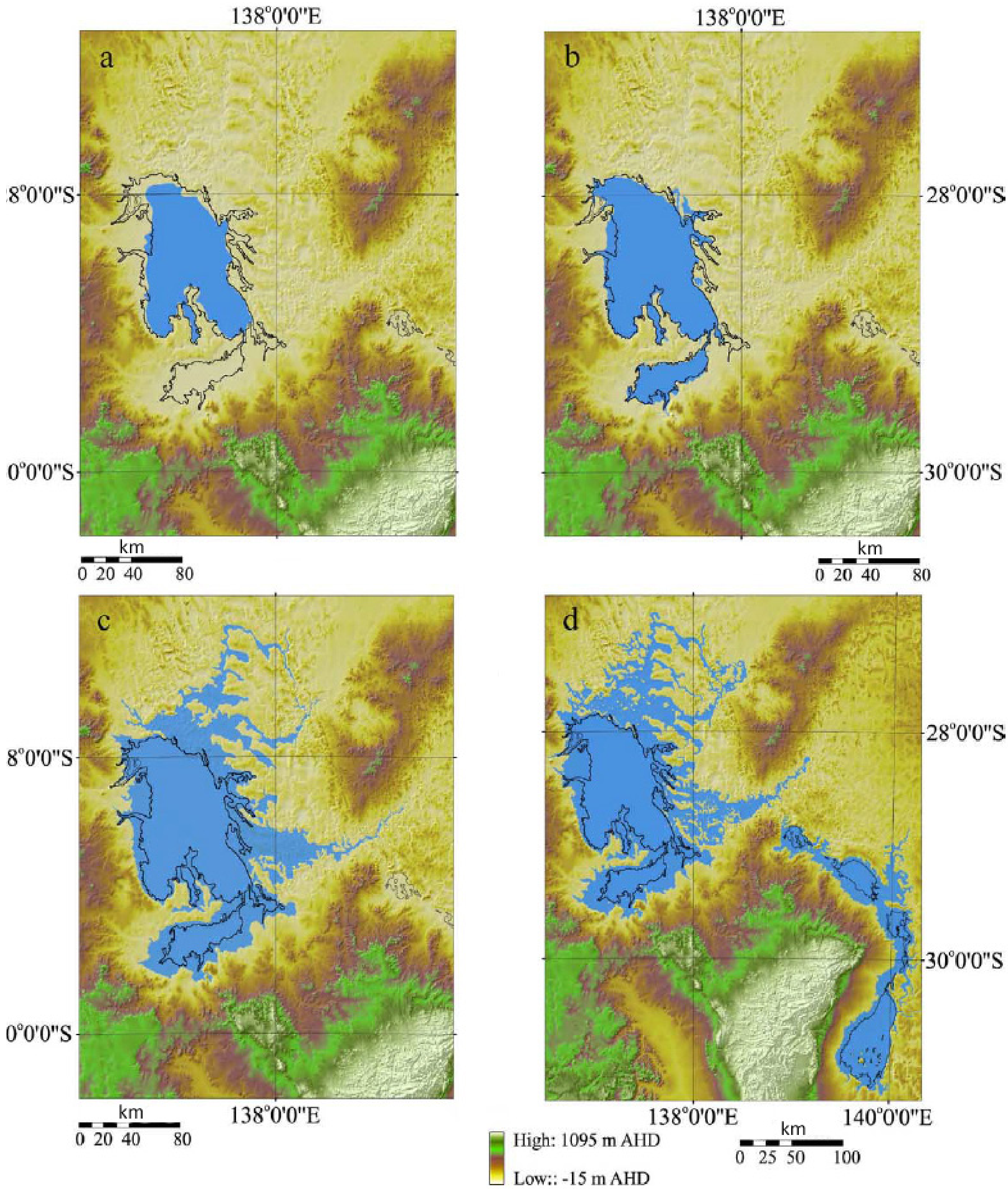


Figure 5 *Maps depicting outline of Lake Eyre at known palaeolevels. Modern playas outlined in black, with palaeolake shown in blue.* ***(a)*** *This map depicts the 40 ka (-10 m AHD) lake filling. The state of the Frome-Gregory system is unknown at this time. Lake Eyre covered roughly 6740 km^2 and contained 20 km^3 of water.* ***(b)*** *This lake (65 ka) rose to -3.5 m AHD. State of Frome-Gregory system unknown at this time. Lake Eyre covered 9920 km^2 and contained 74 km^3 of water.* ***(c)*** *The 80-ka lake full event for Lake Eyre catchment is displayed in this map. At +5 m AHD, 19 590 km^2 of land was blanketed under 216 km^3 of water.* ***(d)*** *Stage 5e Lake Eyre. This is the first coherent image of the lake as it would have looked at its peak highstand, roughly 125 ka. Lake Eyre filled to +10 m AHD and Frome-Gregory system rose to +18 m AHD. Together they covered >34 000 km^2 and held >430 km^3 of water (De Vogel et al. 2004).*

Chapter 2

Palaeontological background: Cenozoic vertebrate fossil exploration in South Australia

Australia's marsupial fauna has fascinated natural historians since the beginning of the 19th century. European exploration and settlement of the continent led to the discovery of many Pleistocene fossil vertebrates that raised questions about the origins and radiation of the Australian marsupial fauna. The HYL Brown expeditions to the Warburton River in 1892 and to the Warburton River and Cooper Creek in 1901 (Brown 1901) and the Gregory Expedition to Cooper Creek in 1901-02 resulted in significant collections of Late Pleistocene fossils from the region and provided the first glimpse into the faunas that inhabited the area prior to human arrival on the continent (Tedford and Wells 1990).

By the middle of the 20th century, remains of only one Tertiary mammal, *Wynyardia bassiana* from Table Cape in Tasmania, had been recognised. The apparent absence of Tertiary vertebrate fossils from the mainland was puzzling. The advent of the American Fulbright Scholarships following World War 2 led US vertebrate palaeontologists to turn their attention to Australia as the new frontier. Professor Ruben A Stirton (Fig. 6) from the University of California, together with his graduate student, Richard H Tedford (Fig. 7), led the charge. Success came in 1953 at the end of nine months prospecting Cenozoic sediments across three states with discovery of Tertiary marsupial fossils at Lake Palankarinna in South Australia. The importance of this discovery was recognised in 1954 with its establishment as Australia's second fossil reserve.

How old were these finds? The uniqueness of Australia's faunas precluded correlation with faunas elsewhere in the world. Placing the fossil record in Lyellian timeframes was problematic. Some success came from coastal margins where marine sequences containing global marker fossils intertongued with terrestrial sediments containing vertebrate remains. Accordingly, it became Stirton's aim to establish a biochronology based on the Diprotodontidae, the large quadrupedal marsupial herbivores that inhabited Australia and New Guinea until their extinction in the Late Pleistocene (Stirton *et al.* 1967). In the absence of absolute dating, Stirton applied stage-of-evolution criteria similar to that used for US mammals to estimate the ages of Australian fossil faunas. As yet, none of the three areas in Australia where terrestrial vertebrate fossil sites from the Late Oligocene-Early Miocene period occur (Northern Lakes- Lake Eyre Basin, Lake Frome Basin and Riversleigh) has been radiometrically dated. Norrish and Pickering (1983) published a Rb-Sr age of 25 Ma from an illite from the Etadunna Formation approximately 50 km southwest of Lake Palankarinna but it could not be stratigraphically correlated to any of the fossil bearing localities. Lindsay also suggested a Late Oligocene date for the Etadunna Formation based on the presence of a particular foraminiferan also known from dated Late Oligocene deposits from New Zealand. Further evidence for this age was provided through palaeomagnetic dating carried out by Woodburne *et al.* (1994). As such a Late Oligocene- Early Miocene age is now accepted for the fossil deposits of the Etadunna Formation in the Lake Palankarinna area and, through biocorrelation, the fossil faunas of the Namba Formation in the Lake Frome Basin.

Figure 6 Ruben A Stirton, 1955 (photo www.ucmp.berkeley.edu).

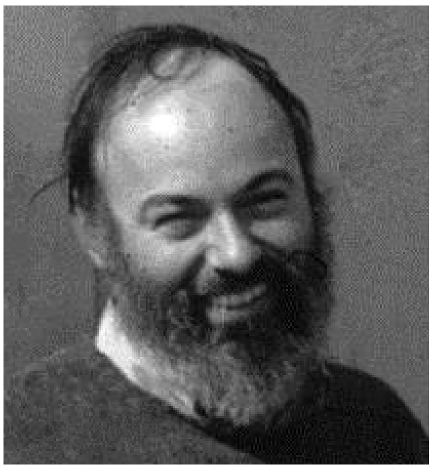


Figure 7 Richard H Tedford, 1973 (Photo R Wells).

Australian land mammal ages. The Cenozoic sedimentary succession of the Lake Eyre Basin, study of which was pioneered by Stirton and colleagues, has played a central role in the establishment of an Australian biochronological framework based on mammals (Fig. 8). Stage-of-evolution biochronology centred on the zygomaturine diprotodontids provided a backbone for the synthesis (Stirton *et al.* 1967). This was later refined and expanded, with the incorporation of other critical taxa and localities from across Australia (Woodburne *et al.* 1985).

This led eventually to an Australian land mammal age scheme (Fig. 8; Megirian *et al.* 2010), in which a preliminary succession of six ages were named for the late Oligocene to present. This system allows the rapidly expanding knowledge of the continent's terrestrial faunal record to be expressed in terms of faunal succession without resort in the first instance to Lyellian chronostratigraphic terms in the absence of radiometric dating and any means of correlating Australia's unique terrestrial faunas with those on other continents.

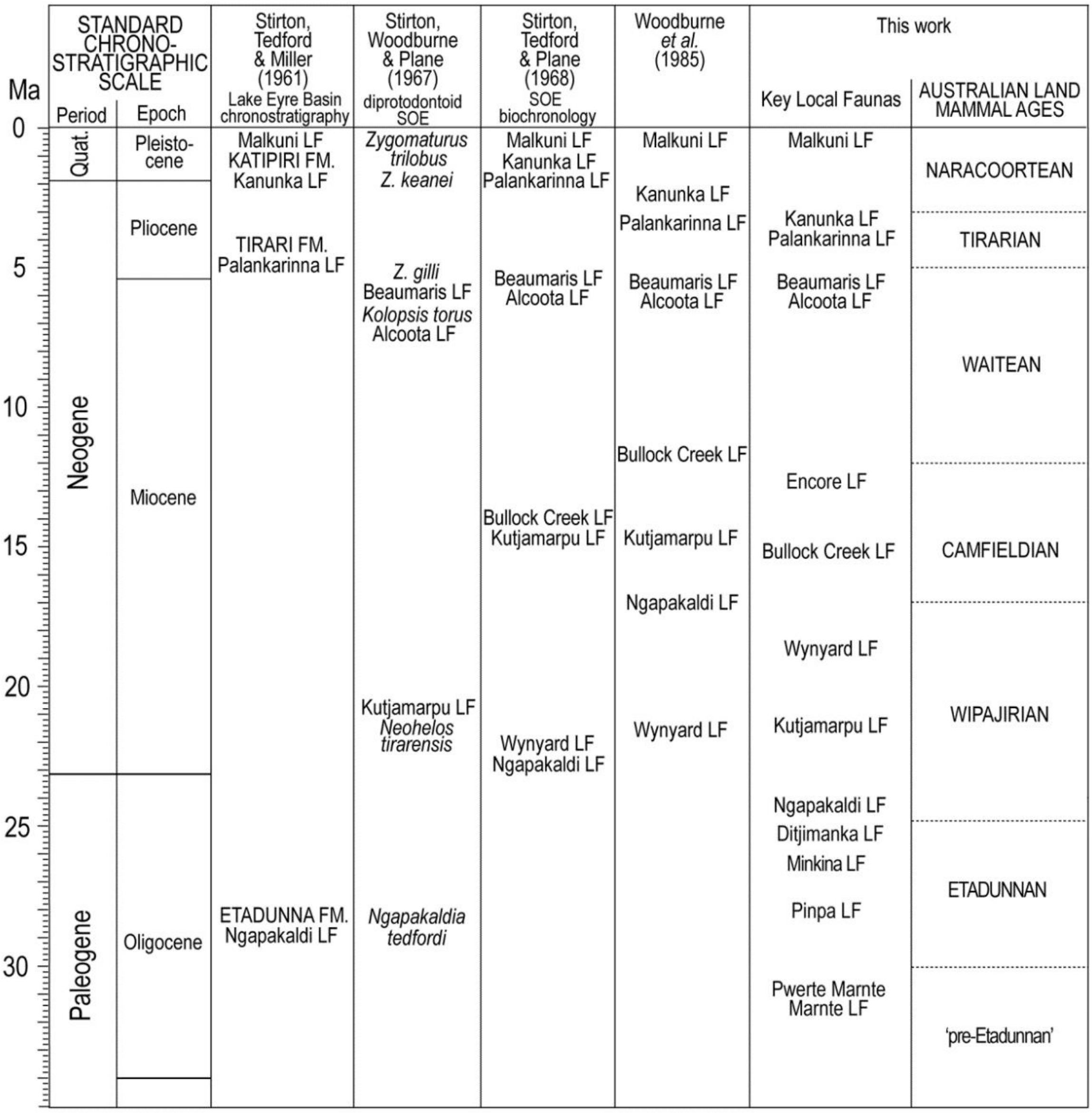


Figure 8 Steps in calibration of Australian land mammal biochronological framework, as represented by key reference local faunas of historical significance. This encapsulates developments over the past three decades with regard to grounds for recalibrating the scheme based on correlative datasets, refinements to Lake Eyre Basin palaeontology, stratigraphy and geochronology, and elaboration of zygomaturine stage-of-evolution biochronology. From Megirian et al. (2010).

Chapter 3

Excursion overview

We will begin this field trip by visiting the area where HYL Brown made his first collections of Late Pleistocene megafaunal fossils on the Warburton River. We will then revisit the site of Stirton's ground-breaking discoveries at Lake Palankarinna and discuss developments since 1953. After leaving Lake Palankarinna we move on to sites along the Cooper Creek, where some of the first Quaternary vertebrate fossils from central Australia were found at the close of the 19th century (see. Fig. 9 for full trip route).

The first substantial collection of fossils from this region was made by Gregory on his 1901-02 expedition. He published an account of this expedition famously entitled *The Dead Heart of Australia* in 1906. Gregory's stated objectives have guided all subsequent palaeontological research in this area: 'the objects of the expedition to Lake Eyre were to secure a collection of fossils of that area, to determine with greater precision the age of the giant marsupials that once lived there, to gain further information as to the geological history of Central Australia; and to see what light geology could throw on the legends and original home of the Aboriginals.' We return via the spectacular Flinders Ranges and will visit the area famous for the remarkable Ediacaran animals. We will conclude the trip with a visit to the megafaunal deposits at Redbanks Conservation Park where Late Pleistocene fossils from the alluvial fans on the eastern flanks of the Flinders and Mount Lofty Ranges are providing valuable information about megafaunal distribution and palaeoenvironment immediately prior to human arrival on the continent.

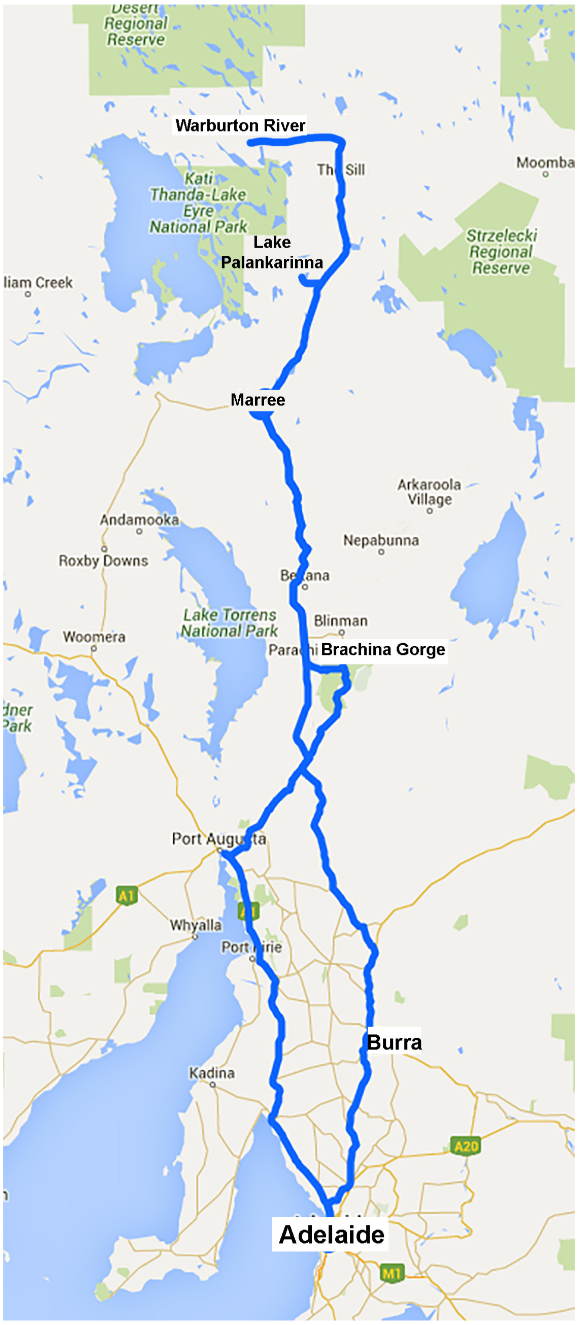


Figure 9 *Excursion route.*

Northern Lakes

Geology of the Lake Eyre Basin fossil localities

The fossil vertebrate deposits of the southern Lake Eyre Basin, and particularly those at Lake Palankarinna and nearby Lakes Kanunka, Pitikanta and Ngapakaldi (collectively known as the Northern Lakes), are central to our understanding of marsupial evolution in Australia. Notwithstanding the superb preservation of fossil material from other sites, it is only in this region of Australia that we have sediments and faunas in demonstrable stratigraphic superposition. Sediments outcropping at Lake Palankarinna range from the Late Cretaceous Winton Formation through the Palaeocene–Eocene Eyre Formation, late Oligocene Etadunna Formation, early Pliocene Tirari Formation to Pleistocene Kutjitara and Katipiri Formations (Fig. 10). With the exception of the Winton Formation, these sediments are exposed in the bluffs along the western margin of Lake Palankarinna, oldest to the south, youngest to the north.

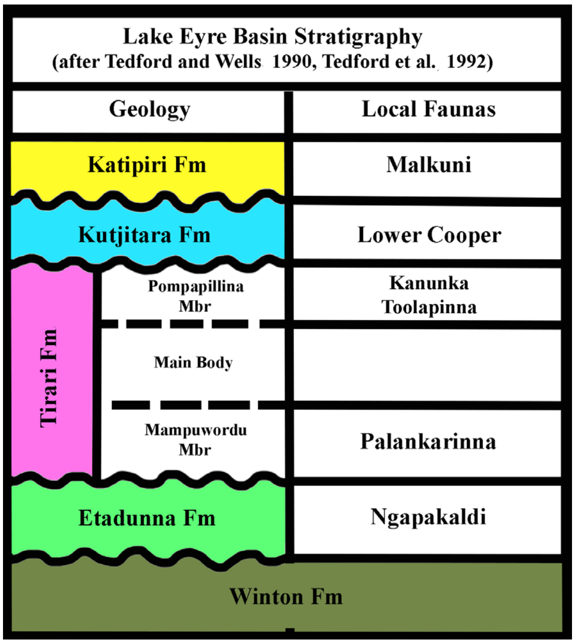


Figure 10 Lithostratigraphic units of Lake Eyre Basin and associated faunas (modified from Tedford et al. 1992).

Winton Formation. A small outcrop of the Cenomanian Winton Formation consisting of carbonaceous claystones, siltstones and fine sandstones outcrops near Ditjimingka Cave southeast of the lake.

Eyre Formation. The Palaeocene to Eocene Eyre Formation consists of fine to gravelly carbonaceous sandstones laid down in a complex of sandy channels and braided streams under a relatively warm, high-rainfall climate (Wopfner 1974). Silicified plant fossils and gastropods are common in these sediments but to date no vertebrate remains have been found (Greenwood *et al.* 1990, Christophel *et al.* 1992). These sediments outcrop at the southern end of the lake, the pattern of silicified sediments delineating the ancient channels.

Etadunna Formation. Disconformably overlying the Eyre Formation are the lacustrine green and grey claystones and dolomitic mudstones of the Etadunna Formation. These sediments are gently folded into a broad syncline along an eastwest axis and are cut by at least two normal faults at the northern end of the lake. Stirton *et al*. (1961) divided the Etadunna into nine members (Fig. 11). The Mampuwordu Sand is regarded by some as a channel facies of the Etadunna Formation (e.g. Callen *et al.* 1995), however the fossils derived from this member at Lake Palankarinna clearly indicate that it is a basal member of the Tirari Formation (Tedford, Wells and Barghoorn 1992).

Tirari Formation. In their pioneering study of the Cenozoic deposits of the Lake Eyre Basin, Stirton *et al.* (1961) gave the name Tirari Formation to the 'flat-lying brick-red, argillaceous sandstones and arenaceous claystones' that lie with angular unconformity upon the Etadunna Formation. The stratigraphic provenance of a fossiliferous channel at the base of the Tirari Formation, the Mampuwordu Sand remained uncertain for some time (see above). It is now recognised as the Mampuwordu Member of the Tirari Formation and yields the Palankarinna Local Fauna (Tedford *et al.* 1992). A bed of white, very fine to medium quartz sand with intraformational clay clasts and lenses occurs about 1 m above the base of the unit and is easily traceable along the bluffs (Fig. 12). The upper portion of the Tirari Formation consists of fine- to medium-grained, festoon cross-bedded quartz sands that pass upwards into redbrown mudstones. Intense gypsum cementation marks the upper 2 m, forming a plateau upon which rests the Quaternary dunefield. The Tirari Formation has now been traced to outcrops along the lower Cooper Creek at Cuttapirra (=Katipiri) Waterhole and northwards to the Warburton River. Magnetostratigraphy places the upper portion of the Tirari in the interval 3.9–3.6 Ma, and the lower portion around 4.5 Ma (Tedford *et al.* 1992) although recent studies suggest that the Palankarinna Fauna from the base of the Tirari Formation may be around 3.9 Ma (Fig. 13).

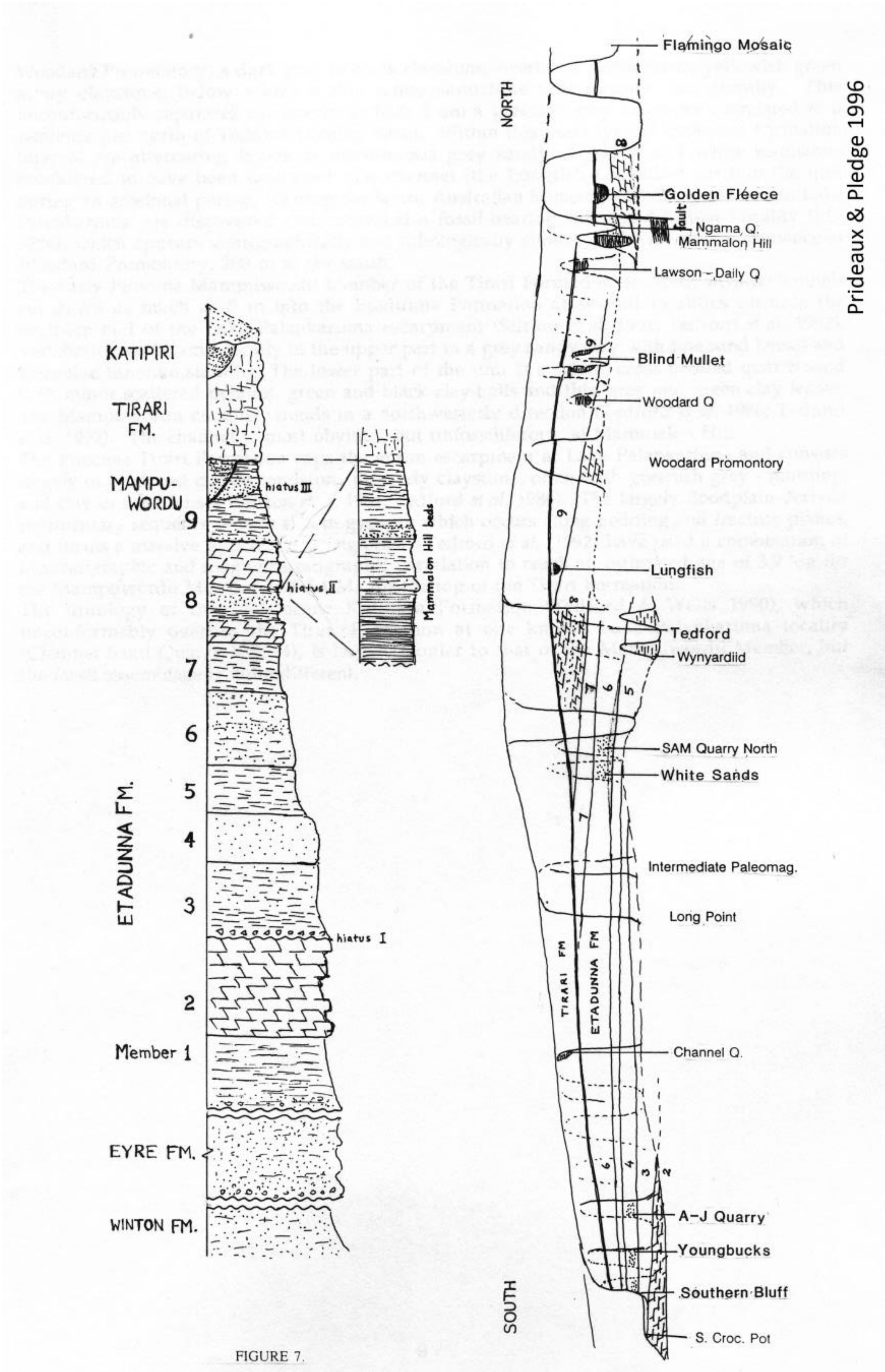


Figure 11 *Lithostratigraphy and site locations at Lake Palankarinna (from Prideaux & Pledge 1996), showing the nine units of Stirton et al. (1961)*

Figure 12 *Tirari outcrops at Lake Palankarinna. Note gypsum crust capping outcrop and white sands towards base. (Photo Rod Wells).*

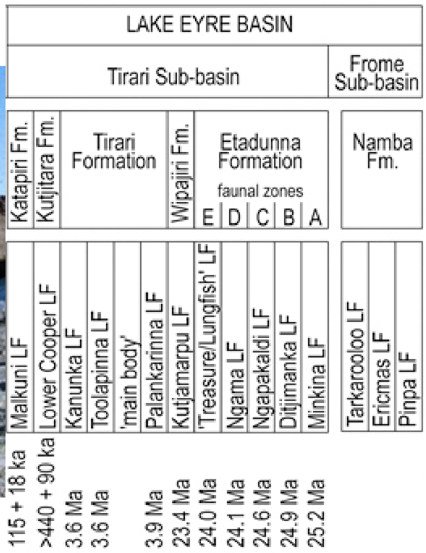


Figure 13 *Lake Eyre Basin localities where fossil assemblages occur in chronostratigraphic succession. From Megirian et al. (2010).*

Faunas of the Lake Eyre Basin fossil localities

Ngapakaldi fauna

Etadunna Formation. Teleost fish spines and vertebrae, lungfish tooth plates (*Neoceratodus*), turtle carapace fragments and crocodile osteoderms and teeth (e.g. *Australosuchus clarkae*) are common elements in many sites of this region. A range of water birds including the short-legged flamingo *Palaelodus* are known from the deposits (e.g. Stirton *et al.* 1961, Williams 1976, Prideaux and Pledge 1996).

The platypus *Obdurodon insignis* provides an important mid-Tertiary insight into the evolution of monotremes in central Australia and was first described from a single molar found at Tedford Locality at Lake Palankarinna (Woodburne and Tedford 1975).

Fossils from the Etadunna Formation also provide some of the earliest glimpses of many of our modern families of marsupials. At Lake Palankarinna specimens of the extinct koala genera *Litokoala, Perikoala* and *Madakoala* have been found at a number of sites (Stirton *et al.* 1967, Woodburne *et al.* 1994, Prideaux and Pledge 1996). Representatives of other modern marsupial families found in the fossil deposits include wombats, dasyurids, bandicoots, kangaroos, potoroos and possums. A host of extinct marsupial families are also represented including the Oligocene oddities the ?wynyardiids (*Muramura, Namilamadeta*) and ilariids (*Ilaria, Kuterintja*), the strange possum-like ektopodontids (*Chunia, Ektopodon*), as well as the more familiar diprotodontids (*Neohelos, Raemeotherium, Ngapakaldia, Pitikantia*) and thylacoleonids (*Priscileo, Wakaleo*) (Rich 1991, Woodburne *et al.* 1994).

Articulated, near-complete skeletons of the plesiomorphic diprotodontid *Ngapakaldia* (Fig. 14) have been found in abundance at Lake Ngapakaldi 50 km to the north. These skeletons provide important information about the origins of the diprotodontid family and the palaeobiology of one of its earliest known members. However, other tantalising glimpses of rarer diprotodontid taxa including *Raemeotherium* and *Pitikantia* indicate significant diversity amongst diprotodontids, even at this early point in their fossil record.

Figure 14 *The holotype of* Ngapakaldia tedfordi, *an early diprotodontid known from the Northern Lakes that may have climbed trees (Photo AB Camens).*

Several invertebrate taxa are also known from sections of the Etadunna Formation. Two species of land snails, *Bothriembryon praecursor* and *Cupedora lloydi*, which are related to snails that typically inhabit the more arid parts of South Australia, have been found in the lower dolomitic mudstone (member 2; Stirton *et al.* 1961, McMichael 1968, Ludbrook 1980, Prideaux and Pledge 1996). A number of ostracods have been found in member 4 of the Etadunna Formation, including *Bulliminoides chattonensis*, a foraminifer associated with saltwater. This taxon represents a biostratigraphic marker that can be tied to morphologically similar species from Late Oligocene sediments from elsewhere in Australia, New Zealand and Germany (Lindsay 1987, Prideaux and Pledge 1996).

Palankarinna, Kanunka and Toolapinna faunas

Tirari Formation. Faunas from the Tirari Formation are dominated by extinct taxa including diprotodontid and macropodid genera not found in Pleistocene or Recent assemblages. The Mampuwordu Member and the contained Palankarinna Local Fauna have yielded abundant fish, turtle and crocodile remains. No waterbirds are yet known from this fauna but the bones of ratites (*Dromaius*) and dromornithids (cf. *Genyornis*) have been found. Among mammals smaller forms are rare; the only taxon so far identified being the bilby *Ischnodon australis* (Stirton 1955). Among larger mammals the remains of the diprotodontids *Meniscolophus mawsoni* and *Zygomaturus keanei* have been found as well as several macropodids and an unidentified phascolarctid (Stirton 1955, 1967, Stirton *et al.* 1961, Prideaux and Pledge 1996).

Lower Cooper and Malkuni faunas

Kutjitara and Katipiri Formations. Stream channels incised into the Tirari Formation at Lake Palankarinna likely represent the Katipiri Formation (see Warburton River section) and preserve vertebrate taxa similar to those known from other Pleistocene deposits in the region (Williams 1976). These formations can be traced northwards to outcrops along the Warburton River and Kallakoopah Creek.

Warburton River

Drilling and outcrop studies carried out by Tedford and Wells (1990) revealed a stratigraphic history for events in the Kati Thanda – Lake Eyre region that predated the later Pleistocene lakes. The latter can still be seen curving around the northern end of the Flinders Ranges in modern times.

The most widespread evidence for the evolution of this landscape is contained in a Pliocene unit, the Tirari Formation, first recognised from isolated units cropping out towards the southern end of the Lake Eyre Basin at Lake Palankarinna (Tedford *et al*. 1992). These sediments have a depositional centre to the north beneath the Simpson Desert where up to 100 m of gypsiferous red clays and gypsum sand indicate the presence of a shallow saline lake. The sediments include fossil mammal remains and correlations with the geomagnetic polarity time scale indicate a span exceeding that of the Pleistocene lakes (Fig. 15).

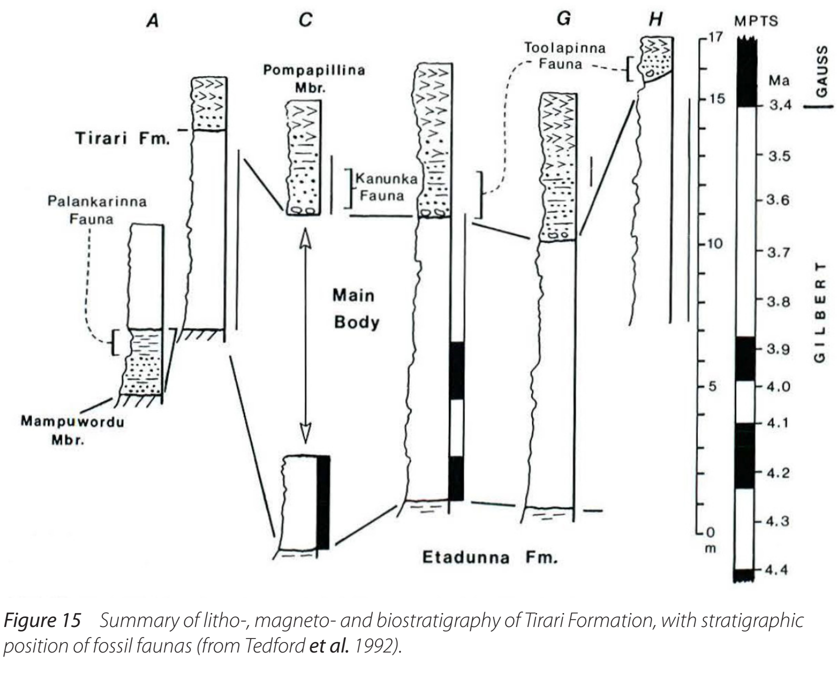


Figure 15 Summary of litho-, magneto- and biostratigraphy of Tirari Formation, with stratigraphic position of fossil faunas (from Tedford **et al.** *1992).*

The source areas for the Tirari sediments would appear to be terrain on the periphery of the Lake Eyre Basin capped by remnants of red palaeosols (ferricrete). The younger portion of the Tirari Fm. includes the Pompapillina Member, a plexus of low sinuosity streams carrying quartz sediments from these sources. Biostratigraphic, lithostratigraphic and magnetostratigraphic data indicate a late Pliocene age of approximately 3.4 Ma for the Pompapillina Member (Tedford *et al.* 1992). Deflation and stream erosion has exposed these palaeochannels so that their courses can be seen trending centripetally north to the Tirari depocentre beneath the Simpson Desert. This drainage pattern is diametrically opposed to the northerly sources of the Pleistocene lakes and indicates a greater influence of southerly storms.

The most complete northwest trending element is exposed in the 30km reach of the Warburton River from Toolapinna to Keekalana waterholes. Here the modern river is contained in a trench cut into the Tirari Formation, and at Toolapinna down into the Etadunna Formation (Fig. 16).

In the southern bank of this Tirari exposure (up to +15 m AHD) is a plexus of shallow channels filled with Katipiri Formation of mid-Pleistocene age (440 ± 90 ka and 320 ± 71 ka; Nanson *et al.* 2008) At Punkrakadarinna waterhole and on the northern bank opposite Toolapinna waterhole, low bluffs show the Tirari sediments overlain by the Katipiri. These outcrops form part of the evidence supporting the hypothesis advanced by Tedford and Wells (1990) that buried channels are responsible for the northwest trend of the playa lakes at the base of the Simpson Desert. Fossils from this part of the sequence are referred to as the Toolapinna Fauna. More recent OSL dates from various fossil localities along this stretch of the Warburton support a Middle Pleistocene age for these channels (Wells unpublished data; Figs 17-19).

Figure 18 displays an updated hypothesis of the relationship between the stratigraphic units exposed along the Warburton River. A full understanding of the actual timespan of the Katipiri Fm. and the length of the hiatus between deposition of the Katipiri and Pompapillina channel sands awaits further OSL and palaeomagnetic dating.

Figure 16 *Typical section exposed along cliffs at Toolapinna Waterhole: at base is Etadunna Formation, conformably overlain by lacustrine clays of Main Body Tirari Formation, in turn incised by fluvial channels of Pompapillina Member and capped by Katipiri Sands. Upper part of section, indurated with gypsum, marks a groundwater highstand (photo AB Camens).*

Figure 17 *Toolapinna Waterhole, Warburton River. Figures on left excavating buried channel containing macropodid fossils. OSL 289 ± 21 ka (MIS 8e) (photo Rod Wells).*

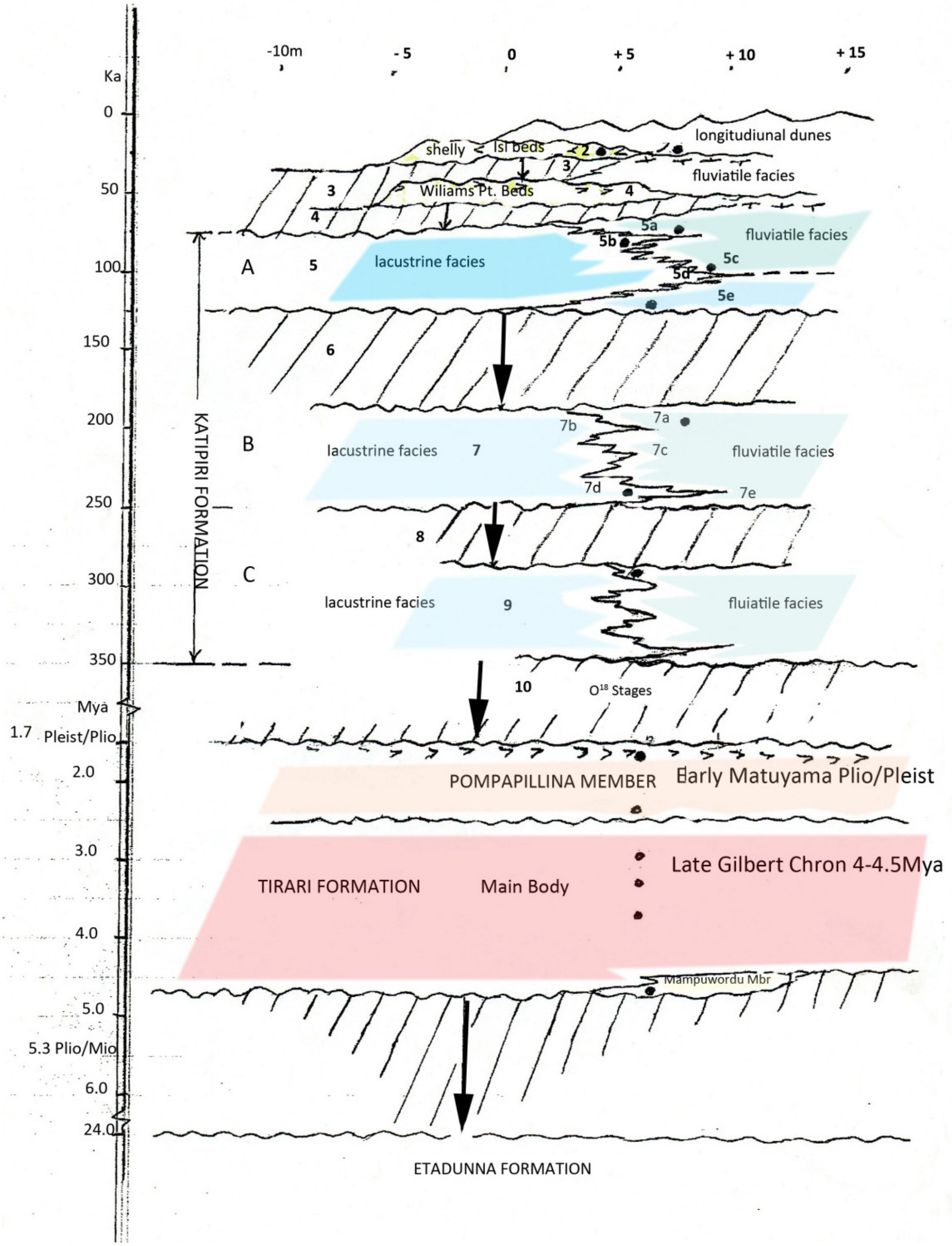


Figure 18 *Composite stratigraphic succession for Lake Eyre Basin sediments (Tedford and Wells unpublished).*

Figure 19 Keekelanna Waterhole, Warburton River: ***Left:*** *channel sands OSL >285 ka (MIS >8e).* ***Right:*** Diprotodontid tibia *in channel sands, Keekalanna East, OSL 194 ± 25 ka (MIS 7b). (Photos Rod Wells).*

Warburton River fossils

Brown collected a number of fossils from the Warburton River and Cooper Creek including 'crocodile, tortoise or turtle, lizard, bird, fish, kangaroo, and *Diprotodon*, and a jaw with teeth of a carnivorous marsupial' (Brown 1901) but it is unclear how many of these came from the Pleistocene units exposed along these water courses and how many, if any, came from the Tirari Formation.

The vast majority of fossils from the Warburton River have been collected on joint expeditions between Flinders University and the American Museum of Natural History (1980-1, 1983, 2000-1 and 2006) led by Rod Wells and Dick Tedford.

Fossils from the Main Body of the Tirari Formation are rare but include the discovery of an articulated diprotodontid hindlimb on the 2001 trip followed by discovery of a partial skull of the Pliocene diprotodontid *Euowenia grata* and trackways potentially belonging to the same taxon on the 2006 trip (Fig. 20; Camens and Wells 2009, 2010).

Fossils from the Pompapillinna Member are particularly intriguing as they demonstrate a transition from the Pliocene faunas (themselves representing in many ways relict Miocene faunas) through to the highly distinctive Late Pleistocene faunas. Taxa represented in the Toolapinna Waterhole deposits include macropodids such as *Troposodon*, *Macropus ferragus* and *Protemnodon*, an undescribed species of thylacinid, dasyurids and diprotodontids.

Fossils are also abundant in the Katipiri Sands along this stretch of the Warburton River but are much more typical of the Late Pleistocene assemblages seen throughout much of southern and eastern Australia (Fig. 21).

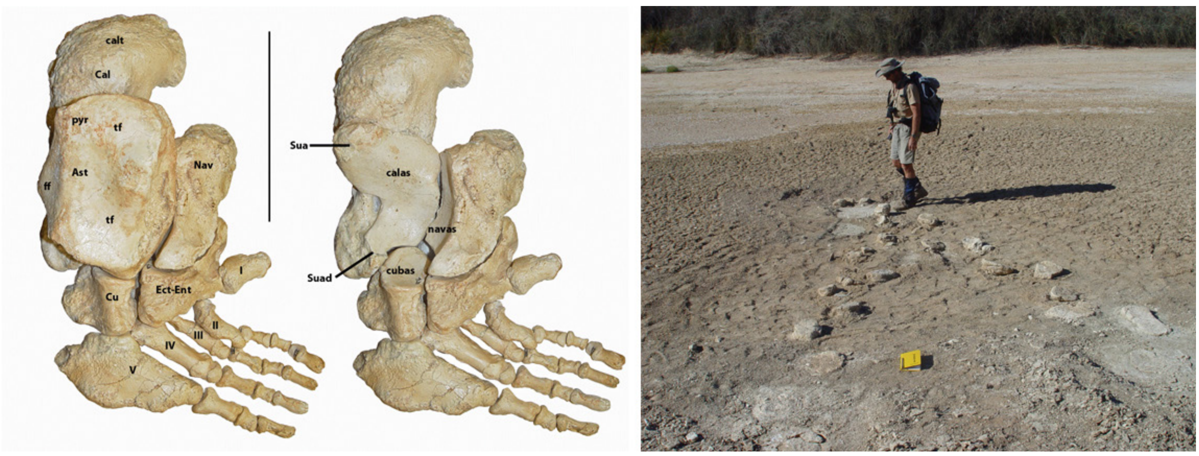


Figure 20 ***Left:*** *Articulated foot of* Euowenia grata *from Camel Swamp Yard on Warburton River (Camens and Wells 2009); and* ***right:*** *preserved footprints of* E. grata *at Keekalanna (photo AB Camens).*

Figure 21 Scene depicting typical extinct megafaunal assemblage from central Australia. Clockwise from top left: Genyornis newtoni, *a giant flightless mihirung bird most closely related to ducks and geese;* Diprotodon optatum, *largest marsupial ever to have lived;* Procoptodon goliah, *largest of the short-faced, browsing kangaroos;* Thylacinus cynocephalus, *Tasmanian 'tiger' or 'wolf';* Thylacoleo carnifex, *'marsupial lion', largest of the marsupial predators; and Megalania* (Varanus priscus), *a giant varanid approximately twice the mass of a Komodo Dragon (artwork by Peter Trusler).*

Mid-North

The modern day mid-north region of South Australia is subject to a Mediterranean climate of cool, wet winters and hot, dry summers. Winter rain-bearing depressions come from the SW such that the eastern side of the ranges are drier than the west, with the plains to the east receiving less than 250 mm annual rainfall. Summer thunderstorms associated with the northern monsoon produce occasional torrential flow. The area drains to the west into Spencers Gulf and Lake Torrens and to the East into the Murray Basin. Burra is a rural hub within the mid-north and the township has embraced its fossil heritage after the discovery of several articulated *Diprotodon* skeletons in the early 2000s (Fig. 22) and have recently refurbished the old train station for use as a natural history museum.

The first Australian megafaunal discoveries were made in the early part of the 19th century but it would be another 50 years before similar discoveries were made in South Australia. In South Australia's Mid-North the majority of megafaunal fossils were found in in the badlands-style topography where modern fluvial processes were cutting down through the older alluvial fans on the flanks of the ranges. Tate (1879) referred to this outwash alluvium and associated fossil material as 'the mammaliferous drift' and went on to correlate these 'drift' deposits with those of the Adelaide plains and the alluvium deposited in the fans and infilling the inter-montane valleys of the Flinders Ranges (Tate 1886).

The earliest collections of vertebrate fossils from the Burra region were made in 1889 at Baldina Creek and Bundey (Zeitz 1890). Baldina Creek yielded a partial skeleton of *Diprotodon optatum*, the most complete in South Australia at the time, and a fragmentary femur of *Genyornis newtoni*. The Bundey dam site yielded *Thylacoleo*, *Sarcophilus*, 'a not yet identified species of kangaroo' and *Diprotodon* remains including parts of the skull

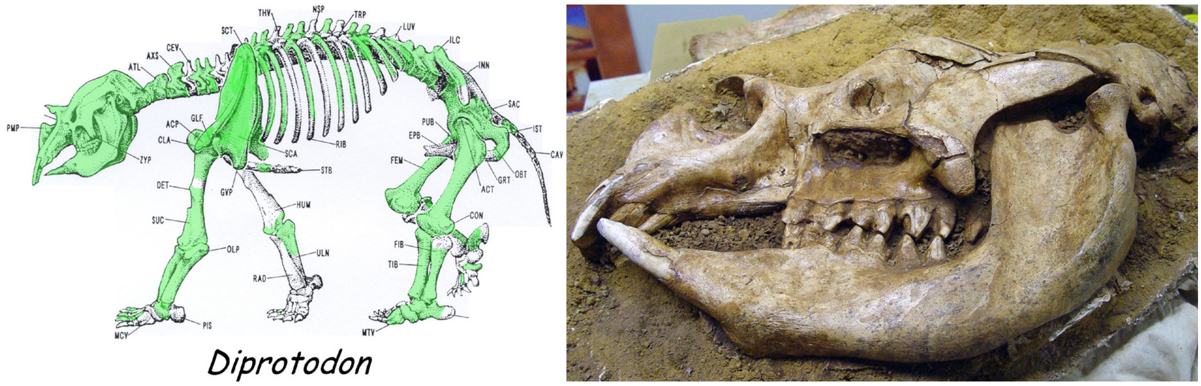


Figure 22 **Left:** Diprotodon *skeleton from Baldina Creek Site 2 (missing elements in white);* **Right:** *skull of Site 2* Diprotodon*, now on display in South Australian Museum (images AB Camens).*

and dentition of a small morph, *D. minor* (Stirling and Zeitz, 1899). These initial discoveries were overshadowed by the discovery of the rich Lake Callabonna deposits in 1893 (Stirling and Zeitz 1899).

There are now seven major Late Pleistocene fossil deposits known in the Burra region, spanning 85 km from Waupunyah Creek in the north to Witto Creek, Baldina Creek and Burra Creek in the south (Fig. 23). Numerous smaller deposits occur throughout the region. The fossils occur in the valley fill and alluvial fan deposits on the eastern flanks of the ranges and are exposed by modern streams. In the late 1970s and early 1980s Dominic Williams undertook a PhD at Flinders University, part of which involved placing the fossil deposits of the mid-north in a time stratigraphic sequence. The main foci of this study were the Baldina Creek and Burra Creek sites due to the deep sections exposed there and the diversity of the fossil assemblage in the former.

Recent widespread application of OSL dating to these alluvial fans (Quigley *et al*. 2007) has built on the earlier work of Williams and Polach (1971) and Williams (1973) and has refined the ages of the sedimentary sequences seen repeated on both the eastern and western flanks of the ranges. They place the deposition of the Pooraka coarse sedimentary sequences at >*ca* 71 – < *ca* 56 ka and the Pooraka conglomerates at *ca* 32–29 ka. Quigley *et al*. (2007) also addressed the problem of distinguishing tectonic from climatic controls in landscape evolution and subsequent implications for the alluvial fan sequences of the Flinders Ranges. They demonstrated that depositional and erosional events occurred at time intervals independent of discrete tectonic events, while tectonism influenced the volume and morphology of the alluvial fans. They note that deposition of the

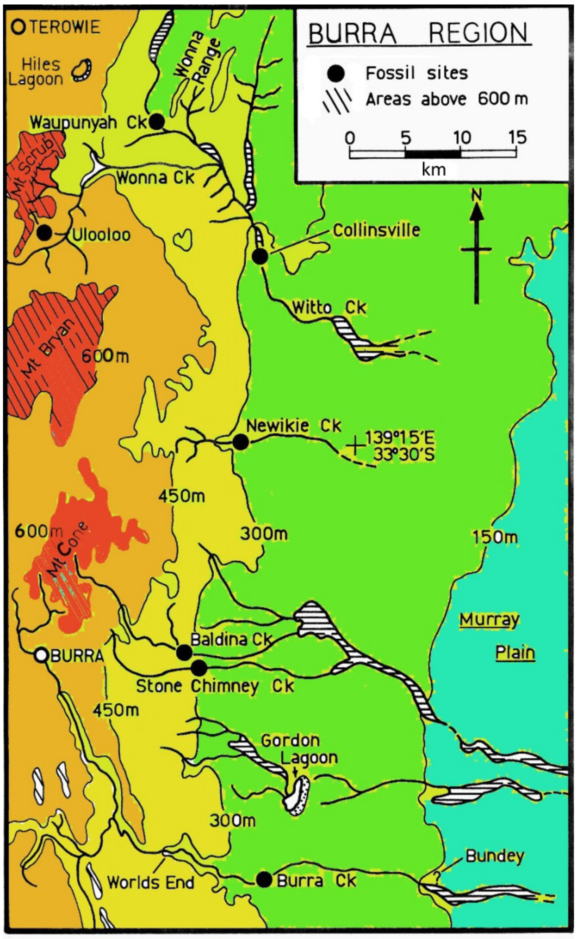


Figure 23 Location of major fossil localities on eastern flank of ranges in Burra region (after Williams 1982).

Pooraka Formation (Tate's 'mammaliferous drift') suggests derivation from a source primarily of fine grained sediment and attribute its deposition to episodic high magnitude flooding of a soil mantled landscape.

Williams (1982) recognised two major units in the alluvial fan at Baldina Creek which he referred to as Unit A and Unit B (Fig. 24). Unit B he divided into two *viz* Member 1 and Member 2. Only the overlying Member 2 is fossiliferous. The base of Member 2 is characterised by a thin sand and gravel layer with local concentrations of calcareous algal tubules and mollusc shells. The contact with the underlying silty Member 1 is traceable for hundreds of metres along Homestead and Baldina Creeks and appears as a slight bench for almost a kilometre on the northern side of Baldina Creek after it exits the gorge beyond the ford. Unit A is thought to be considerably older, shows well developed soil profile(s) with rhizomorphs and is heavily carbonate cemented. It outcrops in only a few places, notably, at the base of the cliff at Redbanks where a heavily cemented and mineralised portion of a kangaroo limb was collected. It is possibly a Hindmarsh Clay equivalent.

The Baldina Creek catchment is relatively small (80 km^2) (Fig. 25) and the accumulated alluvial sequence is accordingly likely to represent only local events such as short periods of very heavy rainfall or perhaps melting of winter snowfall. A shift to a monsoonal summer rainfall pattern following a period of 'glacial' aridity is another possibility.

The uppermost portions of the Baldina Creek valley fill is capped by a powdery carbonate horizon with carbonate encrusted megafaunal fossils suggesting no Holocene deposition of sediments (Williams 1982), Stone artefacts and old fireplaces are scattered over this surface.

More recent excavations by Flinders University palaeontologists (2000-present) in the Burra area have revealed the presence of further articulated megafaunal remains in the red silty clays of the upper Pooraka Formation. The bones are exposed by modern fluvial processes cutting down through the fans and include the usual Late Pleistocene megafaunal assemblage with taxa such as *Diprotodon*, *Zygomaturus*, *Phascolonus*, *Sthenurus* and *Thylacoleo* as well as extant taxa.

Present evidence suggests the loessic deposits of the region were wind deflated from the great surrounding playa lakes of the Torrens, Eyre, Frome and Murray Basins (Haberlah *et al.* 2010), with calcareous rhizomorphs in the uppermost layers indicating periods of relative landscape stability. The *Diprotodon* remains at Baldina Creek Site 2 are associated with a layer of calcareous algal tubules that are characteristic of a low-energy aquatic environment such as an ox-bow lake. ESR dating places this fauna around MIS 4 to early MIS 3, *ca* 42-78 ka (Grün *et al*. 2008). OSL dating is currently being undertaken by Nigel Spooner and Lee Arnold at the University of Adelaide to try and help resolve the age of the megafaunal deposits in the region and the role that climate may have played in the extinction of the megafauna.

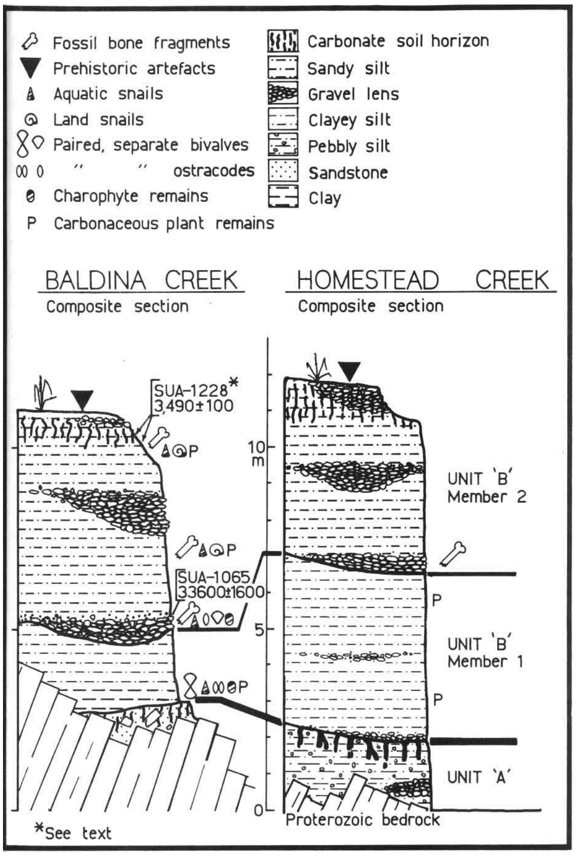


Figure 24   *Stratigraphic section at Baldina Creek where the most complete* Diprotodon *skeleton from the area has been found (from Williams 1982).*

The extinction of the Australian megafauna is still a contentious issue, largely due to the lack of direct evidence for the factors that contributed to their continent wide extinction. The term megafauna is now used to refer to any animal over 40 kg or any animal at least 30% larger than its living relatives. By 40 ka Australia had lost more than 90% of its megafauna (23 of 26 genera), the only surviving megafauna being the grazing kangaroos of the genus *Macropus*, the emu and the estuarine crocodile. The three main factors thought to have possibly contributed to their demise are: modification of vegetation through changes in fire regimes associated with human burning of the landscape; human hunting; and climate change.

Proponents of the overhunting hypothesis, popularised by Tim Flannery in his book *The Future Eaters* (1994), note that the disappearance of the majority of megafaunal species closely coincides with the arrival of humans on the continent (e.g. Roberts *et al*. 2001, Turney *et al*. 2008), in a time of relative climate stability. Studies such as that carried out by Prideaux *et al*. (2010) have been able to demonstrate at least 9 thousand years of megafauna-human overlap with humans arriving in southwestern Western Australia at *ca* 49 ka and the last of the megafauna disappearing from the record *ca* 40 ka. This study (see also Johnson and Prideaux 2004, Prideaux *et al.* 2007, Miller *et al*. 2016) demonstrates that the extinct megafaunal taxa were also able to survive significant climatic fluctuations associated with the glacial/ interglacial cycles preceding human arrival, supporting the hypothesis that it was an anthropogenic factor that caused the extinctions. This contrasts markedly with studies of the Lake Eyre Basin that suggest there was a catastrophic drying phase around 48 ka resulting in the drying up of the 'megalakes' in the region (Cohen *et al*. 2015).

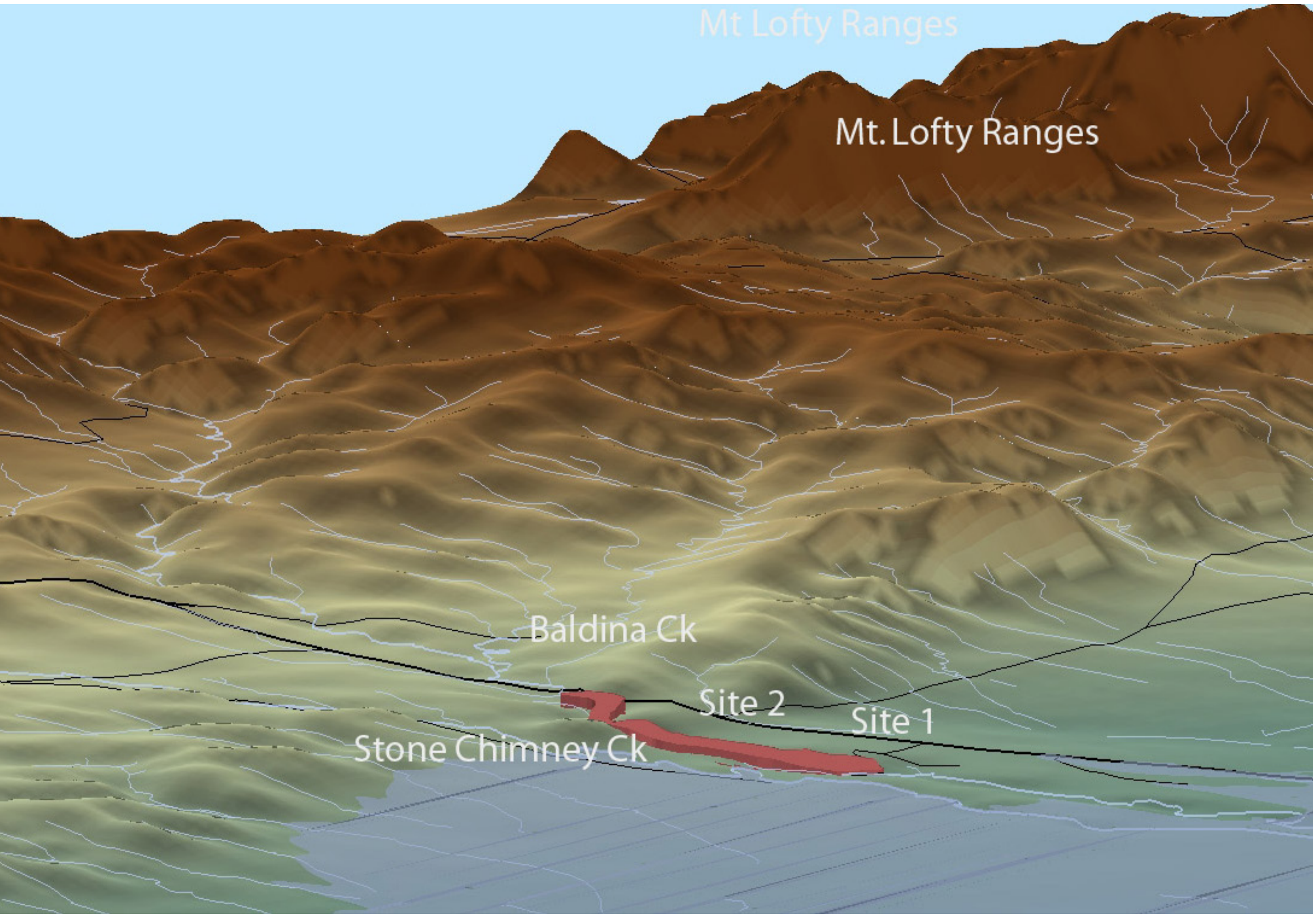


Figure 25 Baldina Creek Catchment. Red strip indicates extent of fossiliferous Badlands; Sites 1 and 2 mark locations where articulated Diprotodon *skeletons have been found (graphic courtesy R Keane).*

Others (e.g. Wroe and Field 2006, Price *et al*. 2011, Wroe *et al.* 2013) have noted that many species of megafauna appear to vanish from the fossil record prior to human arrival on the continent, indicating that climate change was the main factor contributing to their extinction. Evidence for the impact of human firing of the landscape on the giant extinct flightless bird *Genyornis* (or the megapode *Progura* sensu Grellet-Tinner *et al.* 2016) immediately prior to its extinction has been demonstrated by Miller *et al.* (1999, 2005). Many studies have noted an increase in landscape burning around the time that humans first arrived in Australia (e.g. Prideaux *et al*. 2010, Dos Santos *et al.* 2013, Rule *et al.* 2013) but teasing out the cause and effect in this scenario can be difficult. Dos Santos *et al.* (2013) concluded that, in SE Australia, vegetation change (and burning) actually *followed* faunal change, the possible explanation being that removal of large herbivores leads to much greater build-up of fuel load and hence more common and more catastrophic fires.

It can thus be seen that the factors contributing to the extinction of the megafauna can only be teased out through the careful study of sites such as those in the mid-north in order to better inform us of the climatic fluctuations occurring in in various parts of the continent and the way in which megafaunal species were responding to these fluctuations. This will give us a much better idea of the environmental tolerances of both living and extinct Australian animals and help us to better understand what impact anthropogenic factors had, and are likely to have into the future.

*Baldina Creek fossil fauna (*taxon extinct)*

- Mammalia
  - Marsupialia
    - Peramelidae
      - *Perameles bougainville* (Western Barred Bandicoot)
      - *Isoodon sp.*
    - Thylacinidae
      - *Thylacinus cynocephalus** (Tasmanian Tiger)
    - Dasyuridae
      - *Dasyurus sp.* (Quoll)
      - *Dasycercus sp.* (Mulgara)
      - *Sarcophilus harrisii* (Tasmanian Devil)
    - Diprotodontidae
      - *Diprotodon optatum** (Marsupial 'rhino')
      - *Zygomaturus trilobus** (Marsupial 'hippo')
    - Vombatidae
      - *Phascolonus sp. cf. gigas** (Giant wombat)
    - Thylacoleonidae
      - *Thylacoleo carnifex** (Marsupial 'lion')
    - Macropodidae
      - Sthenurinae (short-faced browsing kangaroos)
        - *Sthenurus atlas*; S. andersoni*: S. cf. tindalei*; Sthenurus sp.**
        - *Procoptodon cf. browneorum*; Procoptodon sp.**
      - Macropodinae (modern grazing/mixed-feeding kangaroos)
        - *Protemnodon sp.**
        - *Macropus rufus; M. fuliginosus; M. robustus; M. rufogriseus*
        - *Onychogalea cf. fraenata*
      - Potoroinae
        - *Bettongia penicillata* (Brush-tailed Bettong)
  - Placentalia
    - Muridae
      - *Leporillus conditor* (Greater Stick-nest Rat)
      - *Notomys cf. cervinus* (Fawn Hopping Mouse)
- Reptilia
  - Scincidae
    - *Tiliqua rugosa* (Sleepy Lizard/Bobtail/Shingleback)
- Aves
  - Dromornithidae
    - *Genyornis newtoni** (giant flightless bird)
    - *Dromaius sp.* (Emu)

Chapter 4

Excursion stops

Day 1 – Saturday 16 July

Adelaide to Marree

Our route takes us north to Port Augusta across the outwash plains and alluvial fans flanking the western side of the Mount Lofty / Flinders Ranges (Fig. 1). Approaching Port Augusta at the head of Spencer Gulf we turn northeast up through Pichi Richi Pass to Quorn and north across the Willochra Plain to Hawker, Copley, Leigh Creek, Farina and into Maree. Dinner is at the famous Marree Hotel. We camp overnight in the Marree Caravan Park.

The faulted and uplifted Mount Lofty and Flinders Ranges act as an orographic barrier to the south-westerly weather systems sweeping out of the Southern Ocean. The highest rainfall occurs in winter along the Ranges and in the intramontane valleys. Rainfall diminishes to the north and east in the rain shadow of the Ranges. There are few permanent streams. The Torrens, Gawler, Light and Wakefield Rivers drain west to Gulf St Vincent; the Broughton River drains north through the Ranges and onto the Torrens Plain. To the east spring-fed creeks fail to emerge from the plains, but large alluvial fans, debris flows and abandoned channels attest to higher rainfalls in Pleistocene times.

Our journey in many ways follows the settlement pattern of South Australia. Early agricultural settlement spread north through the easily cultivated woodlands and grasslands of the intramontane valleys. The coastal plains to the west were carpeted with mallee eucalypts requiring much labour to clear and were slow to be settled. Areas of chenopod shrublands to the north and east of the ranges were more easily cultivated but poor soils and unreliable rainfall eventually put an end to wheat growing in these areas. The boundary that separates the farmer from the grazier, 'the desert from the sown,' we know today as Goyder's Line, which marks the 250-mm rainfall isohyet. It is the boundary between the arid and the semi-arid regions (Fig. 26).

Heading north we pass a number of ports along Gulf St Vincent and Spencer Gulf. Port Wakefield, first developed to export copper from the mines at Burra and Kapunda; Port Pirie for export of copper, lead and zinc from Broken Hill, Port Augusta for copper from Blinman; and Port Broughton and Port Germein for wheat. All were served by narrow gauge railways.

Approaching Port Augusta we leave Highway 1 at Stirling North and climb into the ranges to Quorn following the route of the narrow-gauge Pichi Richi Railway. In 1802 Matthew Flinders anchored HMS *Investigator* at the head of Spencer Gulf. He was following instructions from Sir Joseph Banks to seek a passage through Australia. A shore party including the ship's botanist, Robert Brown, ascended the mountain to our right which bears his name, Mt Brown (964 m).

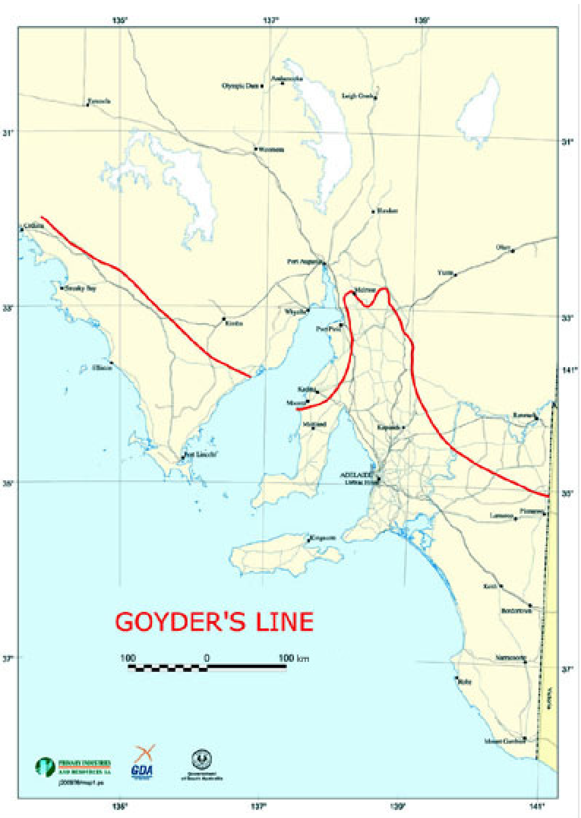


Figure 26 *Goyders Line, which tracks the 250 mm rainfall isohyet (Community History Unit; www.history.sa.gov.au).*

Immediately to the north of Port Augusta is a series of lakes and associated lunette dunes. Deflation pans within these dunes have yielded a variety of megafaunal fossils as well as eggshell from the giant, flightless dromornithid bird *Genyornis* and Aboriginal stone implements (Williams 1982). Recent finds at Dempsey's Lake attest to the longevity of human occupation in the area with optically stimulated luminescence and carbon dates from a hearth suggesting that it was formed 45–40 thousand years ago (Walshe 2012).

Appila Tillite. On the crest of the first major rise east of Stirling North we pass an outcrop of the Appila Tillite (Fig. 27), which formed during the Sturtian glaciation 700 my ago. The alignment of magnetic minerals in these rocks places the Australian continental plate at the equator at the time. This was the first of two global glaciations which mark the Cryogenian Period, the basis of the controversial 'Snowball Earth' hypothesis. The eventual melting of the ice is thought to be linked to volcanic activity resulting in the release of huge quantities of greenhouse gases. The end of the Cryogenian is followed by the Ediacaran and the earliest evidence on Earth of multicellular life.

Figure 27 *Appila Tillite near Stirling North, 700 Ma (photos Rod Wells).*

We have now crossed Goyder's Line, which runs along the 250 mm rainfall isohyet, and see the first evidence of salt-tolerant saltbushes and bluebushes (chenopods), that characterise the arid and semiarid lands.

Remains of giant Pleistocene marsupials, including the rhinoceros-sized *Diprotodon optatum* and giant short-faced kangaroo *Procoptodon goliah*, have been recovered from sand and gravel quarries on the outwash fans at the foot of the range.

As we enter the range near the abandoned township of Saltia we see to our left the anticlinal folds of the Brachina Formation, marine siltstones and fine-grained sandstones deposited in shallow seas 600 my ago (Fig. 28). To our right are the sandstones and siltstones of the Elatina Formation (*ca* 500 Ma), squeezed and buckled against the Gawler Craton in the great Adelaidean Rift Basin. They provide evidence of the second great Cryogenian ice age, the Marinoan.

Figure 28 *Brachina Formation, marine, 600 Ma.*

Figure 29 *Mudcracks in ABC Range Quartzite, 590 Ma (photos Rod Wells).*

On our way through the pass we can see some excellent stone walling built by Chinese labourers recruited from the Victorian goldfields in the 1870s. Mudcracks and ripple marks can be seen in places in the hard 590 Ma ABC Range Quartzite, which forms the crests of the ranges (Fig. 29). The valley floor is dominated by the red-purple shales of the Brachina Formation. To the east, Devils Peak is seen capped by the Rawnsley Quartzite member of the Pound Subgroup, and preserves the Ediacaran Fauna.

Quorn: Comfort stop. During World War 2 Quorn was a major rail junction with trains running north to Alice Springs, west to Perth via Port Augusta, and east to join the Broken Hill and Adelaide lines.

Leaving Quorn we head north across the Willochra Plain. Stone ruins mark abandoned townships and railway buildings, reminders of lost dreams and the folly of trying to grow wheat in a region of unpredictable rainfall. Much of the tilled earth remains bare and scalded. In places bluebush, saltbush and scrubby acacias are returning, in others overgrazing by sheep and rabbits has removed much of the remnant plant cover leading to soil erosion. Vertebrate fossils exposed in erosion gullies on the Willochra Plain and in the Hookina Creek alluvial fan indicate that *ca* 100 ka this area was home to small herds of *Diprotodon* and mobs of kangaroos, some still extant, others now extinct, as well as *Zygomaturus*, small rat-kangaroos, wallabies, Tasmanian Devils, sticknest rats, emus and *Genyornis* (Williams 1982). Indeed, evidence suggests that the late Pleistocene environment was little different from that at the time of European settlement.

Figure 30   Willochra Plain looking west from Police Hill at Hawker (photo Rod Wells).

The Willochra Plain lies within the Willochra Basin, a great north–south faulted depression (Fig. 30). The lacustrine fine-grained carbonaceous sands, silts and clays filling this Tertiary basin are an important source of underground and artesian water. It drains to the northwest into the Lake Torrens Basin. The Plain is mantled by fine-grained loessic sediments, much of it derived from wind deflation of the great playa lakes to the north.

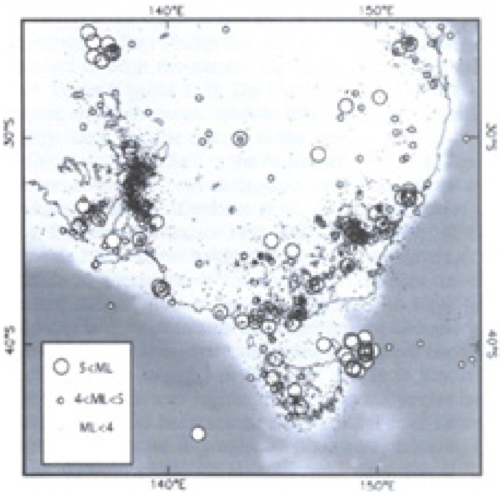


Figure 31 *Earthquake distribution and magnitude in southeastern South Australia.*

Figure 32 *Hawker Seismographin.*

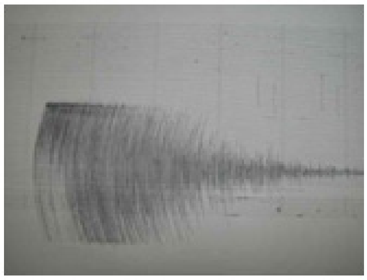


Figure 33 *Magnitude 3.8 on Richter scale, 23 November 2003 (photos Teague family Motors).*

Hawker. We refuel and take a break for lunch at Hawker Motors, owned and operated by the Teague family for three generations. The roadhouse has a small museum and a seismograph. Hawker is at the centre of one of the most seismically active areas of Australia (Figs 31–33), a great shatter belt that stretches north through the continent. The rocks of the Flinders Ranges maybe very old but the faulted and uplifted ranges are relatively young.

On leaving Hawker we see the occasional red Holocene sand dune and areas of hummocky spinifex grasses. Spinifex belongs to the genus *Triodia* of which there are 67 known species. Patches of *Triodia irritans* occur throughout the ranges in rocky areas and on the sand plains on well drained, nutrient-poor soils (Fig. 34). Aboriginal people have long used and traded the sticky spinifex resin.

Aborigines with links to the Flinders Ranges refer to themselves as the Adnyamathanha, or Rock People. Their ancestors were from a number of distinct language groups. As hunter-gatherers the Adnyamathanha lived and foraged in the rocky gorges and were notable for not using spears and spear throwers, preferring instead a range of hunting clubs, snares and game nets (Clarke 2008). Adnyamathanha rock-art sites are found throughout the Ranges (Fig. 35).

Figure 34 *Spinifex hummocks.*

Figure 35 *Rock art at Yourumbulla Caves (images from Clarke 2008).*

Copley and Leigh Creek. Thirty kilometres south of Copley we pass by Ediacara Conservation Reserve, situated halfway between Barndioota Road and Lake Torrens to the west. Reg Sprigg discovered fossils here in 1946 that represent some of the earliest examples of complex organisms. The Ediacara Hills are the locality after which the Ediacaran Period was named. This is the only period of time to be internationally ratified anywhere in the world in over a century (Knoll *et al.* 2006).

Coal was first discovered at Leigh Creek in 1888 during the sinking of a water bore to serve the steam trains. Open-cut mining (Fig. 36) began in the 1940s. Coal was railed to power stations in Adelaide and Port Augusta but today is only railed to the power station at Port Augusta. The coal measures are of Late Triassic age and occur within part of a Late Triassic–Early Jurassic sequence of freshwater sediments that lie within a number of north–south-aligned intramontane basins. The sediments contain fossil ferns (*Thinnfeldia, Dicroidium*), gymnosperms (*Heidiphyllum, Rissikia*, *Rochipteris*), freshwater mussels (*Unio*) and rare fish *Leighiscus* (Fig. 37).

Lyndhurst. Beginning as a railway siding in 1878, Lyndhurst lies at the junction of the Strzelecki Track, which leads east to Innamincka and the NSW border, and the Oodnadatta Track, which leads north to Marree and the Birdsville Track.

Farina. Originally known as Government Gums because of the River Red Gums (*Eucalyptus camaldulensis*) lining the water courses (Fig. 38), local farmers changed the name to Farina to reflect their dream of establishing a great wheat growing area (Latin *farina*, meal or flour). Farina was the station from which the Hurst brothers and Zeitz and Stirling from the South Australian Museum set out on camels to collect Pleistocene skeletons of *Diprotodon* at Lake Callabonna in 1893 (Fig. 39). Looking at Farina today (Fig. 40) it is hard to believe that living specimens of brush-tailed possums (*Trichosurus*) were collected from here in the 19th century. Since 2009 a group of volunteers have been working to restore the ruins, including opening a bakery. We are lucky that the trip coincides with the annual two month period that the bakery is open for business, so we'll have a chance to sample the baked goods from an oven built in the late 1800s and only recently restored.

Figure 36 Leigh Creek open cut coal mine.

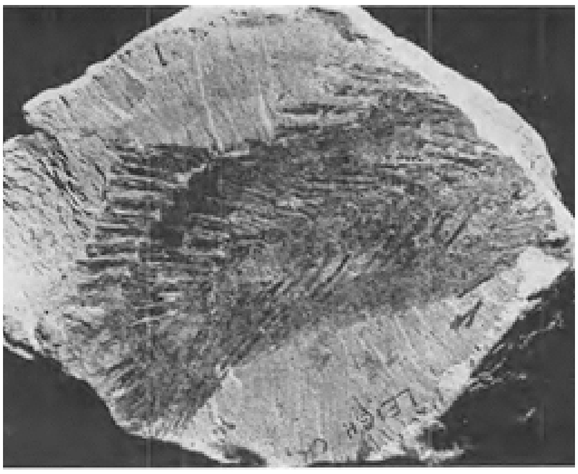


Figure 37 Leighiscus hillsi. *(images from Wade 1953).*

Figure 38 Farina Waterhole 1898 (photo State Library of South Australia).

Figure 39 South Australian Museum expedition to Lake Callabonna, 1893 (photo South Australian Museum).

Figure 40 *Old Bush Hospital at Farina ruins (photo AB Camens).*

Dinner – Saturday 16 July

Tonight we will slake our thirst and dine at the Marree Hotel, built in 1883 (Fig. 42). A two-course dinner is included in the field trip costs (drinks not included).

Dinner 7:30 pm

Marree. After World War 1 Hergott Springs was renamed Marree. It is situated at the junction of the Birdsville and Oodnadatta Tracks. In summer temperatures can reach 49°C and dust storms are common. A line of mound springs stretching northnorthwest from Marree to the Northern Territory border provided a path through this arid country followed by Aborigines, early European explorers, the Overland Telegraph and the railway (Bailey 2007). Marree was once a major railhead for shipment of cattle brought down the Birdsville track from western Queensland (Fig. 41).

The springs are a natural discharge from aquifers in the outcropping Mesozoic sediments of the Great Artesian Basin. The intake beds for the basin are along the western slopes of the Great Dividing Range in Queensland. Bones of Pleistocene megafauna have been found in tufa deposits around these springs.

Afghans and their camels, brought to Australia by Sir Thomas Elder in 1866, played a central role in the early exploration, transport and development of this country because much of it is too harsh for horses. Marree police used camels to patrol the outback until 1949. Australia's first mosque was erected in Marree to serve the local Afghan community.

Figure 41 *Ghan Engine Shed, Marree, 1984.*

Figure 42 *Great Northern Hotel, Marree, 1984 (photos Rod Wells).*

Further reading

The following books are recommended for further information on the history of this region of South Australia.

Bailey J. 2007. *Mr. Stuarts Track*. McMillan. Story of John McDowell Stuart's heroic efforts in finding a route from Adelaide to Darwin.

Farwell G. 1950 (reprinted 1975). *Land of Mirage*. Rigby. A fascinating account of the history and characters along the Birdsville track.

Meinig D. W. 1962 (reprinted 1972). *On The Margins Of The Good Earth. The South Australian Wheat Frontier, 18691884*. Rigby. An account of the early settlement of South Australia, the successes and the failures.

Day 2 – Sunday 17 July

Maree to Kalamurina

Today we join the Birdsville Track and head out into '*The Land of Mirage*' and '*The Plains of Illusion*' (Farwell 1950). Our track takes us northeast, out past the old Government camel breeding station at Lake Harry, on across the Clayton River, past Dulkaninna Station, Blazes Well and Milner Pile. We will be stopping at Mungerannie Pub for lunch (Fig. 43) where an uncapped bore has formed a wetland that is now home to over a hundred different species of birds.

After lunch we will head further up the Birdsville Track and turn west on to Kalamurina Station (Fig. 44), managed by the Australian Wildlife Conservancy. We will make our way across the dunes, swales and claypans typical of the southern Simpson Desert (Fig. 45) on the southern side of the Warburton River, arriving at our campsite late afternoon. We will be camping at the Wetlands Campsite and venturing out to visit fossil localities the following day.

Figure 43 *Artificial wetlands created by an uncapped bore at Mungerannie are now an important watering point for birds in the region (photo AB Camens).*

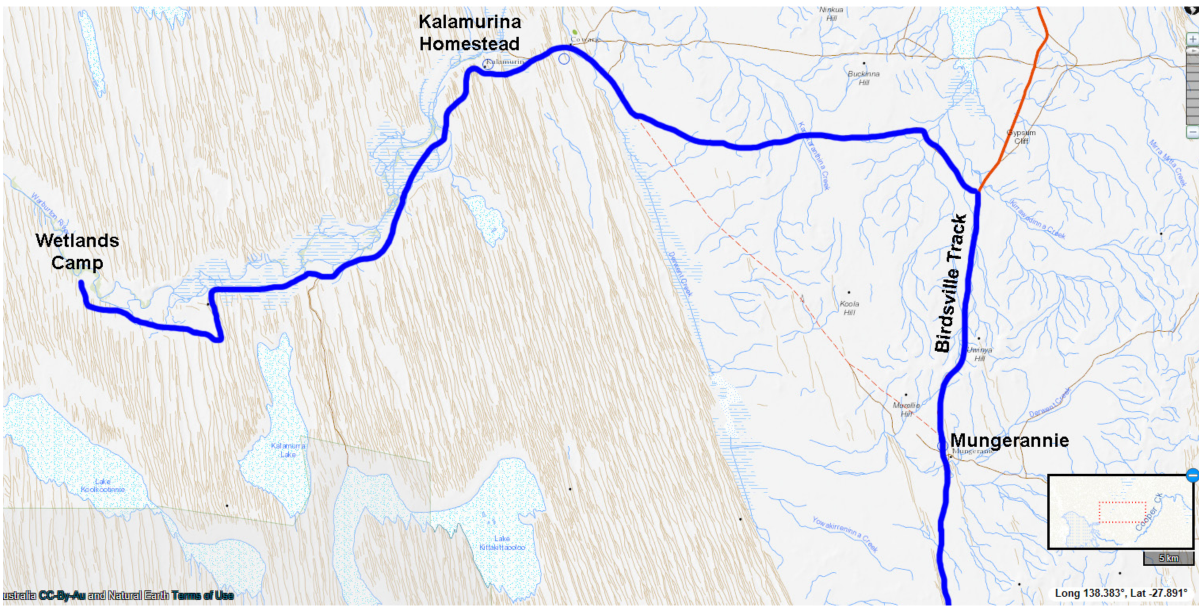


Figure 44 *Route to Wetlands campsite on Kalamurina station.*

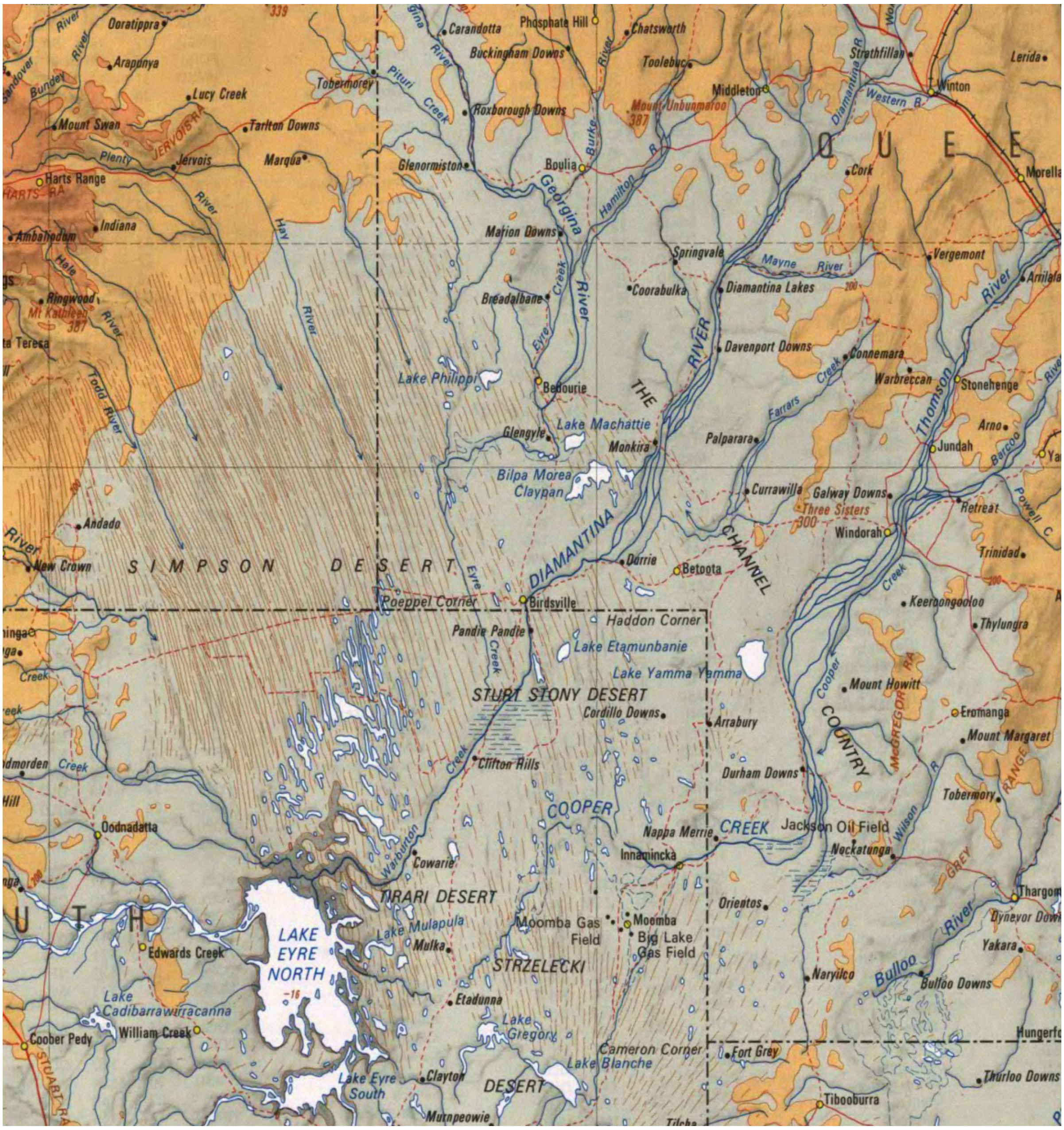


Figure 45 *Main catchment area for Warburton River and Cooper Creek, which drain into Lake Eyre. Note that dunes of Simpson Desert have choked off much of the drainage from the north and that residual playa lakes are indicative of a more northerly-situated depocentre during Pliocene (http://mrsboothsclass.weebly.com/uploads/2/1/6/4/21646298/5631218_orig.jpg). Most of our field trip will be spent in the area along the eastern shore of Lake Eyre North.*

Day 3 – Monday 18 July

Warburton River fossil sites

Today we will start out by visiting the Lookout Locality Late Pleistocene fossil site (Fig. 46) where an extensive exposure of the Katipiri Formation is host to the bones of crocodiles, turtles, fish, birds, *Diprotodon*, Megalania, *Phascolonus* and a variety of extinct kangaroos.

In this stretch of the Warburton there is approximately 3 m of Etadunna Formation at creek level, overlain by a 7 m-thick band of Katipiri Sands, dated to around 95-110 ka, and in turn overlain by modern fluviatile and aeolian sequences. The fossils are found eroding out of the base of the Katipiri Sands, just above the contact with the Etadunna Formation.

We will then prospect other areas of this stretch of river where AWC staff have been finding megafaunal fossils in the last few years. The huge volumes of water that have come down the Warburton River in the last few years have scoured the riverbanks, so there is excellent potential for further fossil material to have eroded out.

In the afternoon we will drive over to Toolapinna Waterhole, a few kilometres downstream of Lookout locality. The cliffs a Toolapinna extend for 3 km and clearly display the main geological formations recognised in the region (Fig. 47).

Figure 46 *Cliffs at Lookout locality. Banded layers at base are Etadunna Formation and are overlain by white laminated sand and red-bedded mudstone of Katipiri Formation (photo Rod Wells).*

Rare fossils have been found from the Etadunna and Main Body Tirari Formations here but fossils from the overlying Pompapillina Member and Katipiri Sands are abundant.

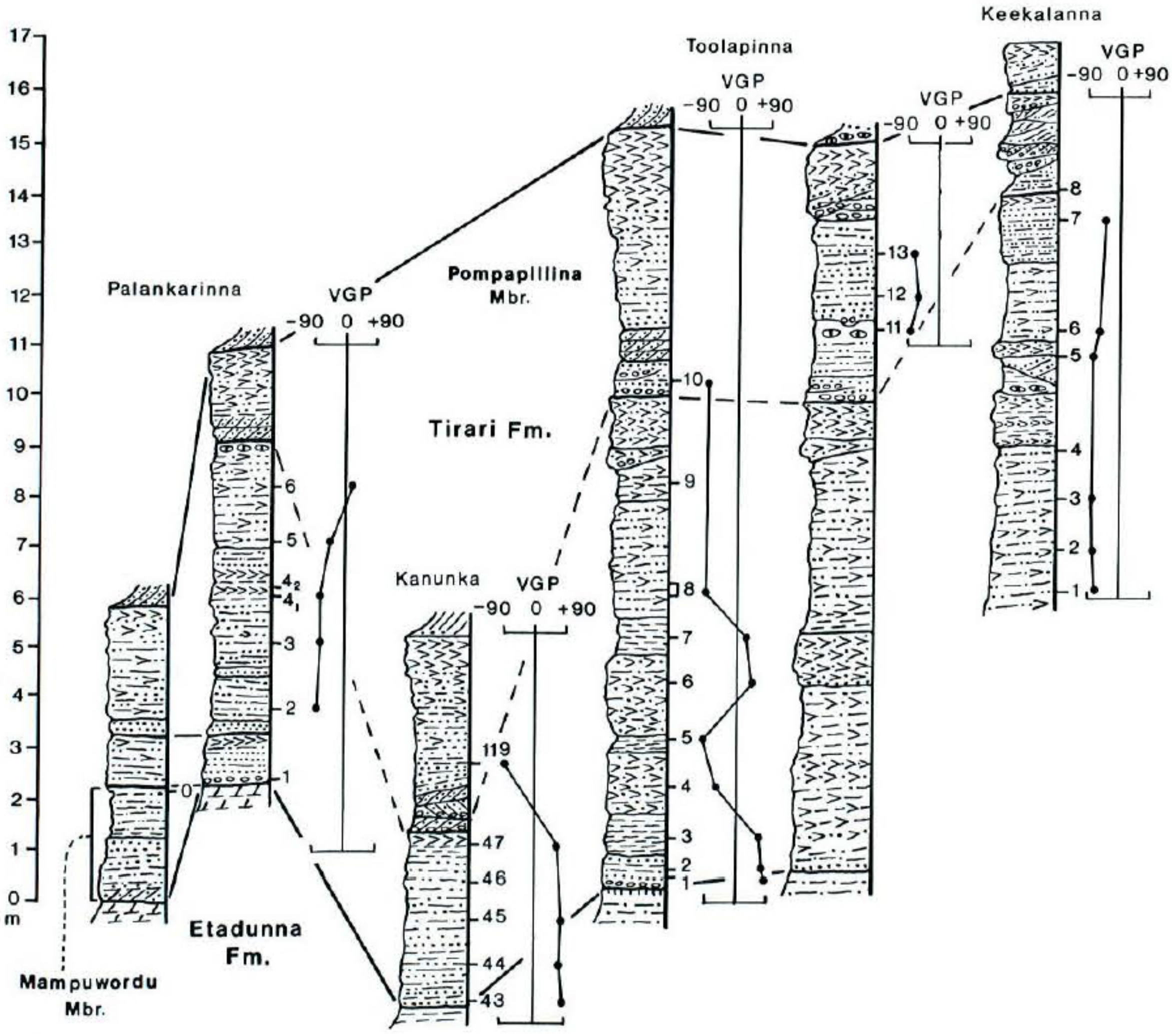


Figure 47 *Stratigraphic columns correlating sediments at Toolapinna Waterhole with those at Lake Palankarinna (Tedford et al. 1992).*

Figure 48 *Rod Wells (foreground), Aaron Camens (left) and Dick Tedford (back) preparing fossils at Toolapinna Waterhole campsite, 2006 (photo Trevor Worthy).*

We finish the day back at the Wetlands campsite and then pack up and head down to Lake Palankarinna tomorrow.

Day 4 – Tuesday 19 July

Kalamurina to Lake Palankarinna

Today we break camp and drive back south to Etadunna Station, turning off at Cannuwaukaninna Bore, before heading west into the Tirari Desert to Stirton's Camp in the lee of the Cannuwaukaninna Dune (Fig. 49). In Stirton's day the track was not much more than a couple of wheel ruts across the gibber plains and vanished almost entirely in the dunes.

After setting up camp we cross Cannuwaukaninna Dune and travel out to the northwest tip of Lake Palankarinna. It was from the top of this Dune in 1953 that one of Stirton's party, Paul Lawson of the South Australian Museum, noticed bluffs on the western side of the Lake, which led to the discovery of Tertiary vertebrate fossils. We will spend the afternoon prospecting along these bluffs, the type section for both the Etadunna and Tirari formations (Figs 50-51).

Figure 49 *Stirton Camp, 1971.*

Figure 50 *Lake Palankarinna, 1984 (photos Rod Wells).*

Figure 51 *Mammalon Hill at Lake Palankarinna (photo AB Camens).*

Day 5 - Wednesday 20 July

Cooper Creek and Lake Palankarinna

Cooper Creek. Today we head west past Lake Florence to Georgia Bore to intersect the 82RBF seismic track line and make our way north to intercept Cooper Creek downstream of Cuttapirra Waterhole (Figs 52-54).

Katipiri Formation. Traces of the broad meander belts, marking the former limits of the palaeovalleys cut into the Tirari Formation sediplain, are visible adjacent to the present path of the Cooper Creek (Fig. 54). These ancestral river systems formed a meander belt up to four times as wide as that incised by the modern streams. These are similar to the meanders we saw along the Warburton River further to the north. These channel networks are clearly visible in both Landsat and aerial photos. The fossiliferous ancestral channel fills are exposed in the banks of the modern streams and were named the Katipiri Sands by Stirton *et al.* (1961).

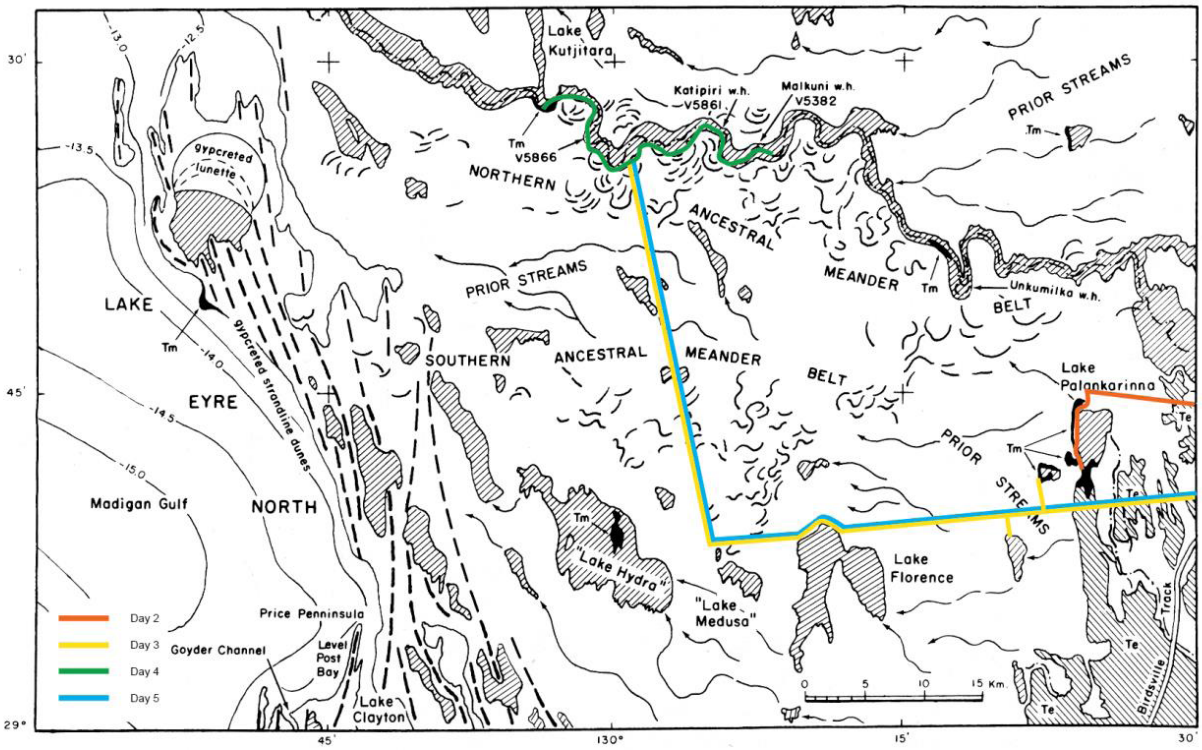


Figure 52 *Map showing Cooper Creek and its ancestral meander belts together with a prior stream drainage (from Tedford and Wells 1990).*

Figure 53 *Cuttapirra Waterhole.*

Figure 54 *Malgoona (Malkuni) Waterhole. Note longitudinal (seif) dunes, ancestral stream traces, sandy bed load and gypsum plateau (photos Rod Wells).*

Figure 55 *Cuttapirra Waterhole, type section for Katipiri Formation in bluff beneath sand dune (photo Rod Wells).*

The Katipiri Formation is seen at both the Cuttapirra Waterhole and Malgoona (= Malkuni) Waterhole localities (Figs 54-55). Fossil sites along this section of the Cooper produce a faunal assemblage (Figs 56-57) similar to those of many other parts of Australia, including several iconic megafaunal taxa such as *Genyornis, Phascolonus, Diprotodon, Protemnodon, Sthenurus, Procoptodon* and *Varanus* (= *Megalania*) (Stirton *et al.* 1961, Williams 1980, Tedford and Wells 1990).

Figure 56 *Crocodile, lungfish, turtle, bird and mammal fossils that had accumulated on point bars in Cooper Creek downstream of Cuttapirra Waterhole.*

Kutjitara Formation. An older distributary network of channels and prior streams is evident in the northwest alignment of the playa lakes (Fig. 52). These prior streams drained to a depositional centre now beneath the Simpson Desert. Tectonic subsidence in the southern part of Lake Eyre led not only to a southward shift in drainage but also to the integration of the Lake Eyre Basin with the catchments of the Diamantina and Cooper systems in Queensland.

As we venture down to the Lower Cooper Creek we also see this channel network exposed. The Lower Cooper Local Fauna from the Kutjitara Formation is similar to the Malkuni Local Fauna from the Katipiri Formation, except that a few Early to Middle Pleistocene taxa are also present such as the macropodid *Troposodon* and a diprotodontid similar in form to *Euryzygoma dunense* (Tedford and Wells 1990).

The gypsum induration of much of Kutjitara Formation is related to past high water levels in a greater Lake Eyre (Magee and Miller 1998). Traces of the last-glacial strandline dunes are evident in Madigan Gulf (Fig. 52).

Figure 57 *Richard H Tedford (American Museum of Natural History) examining specimens from Cuttapirra Waterhole, 1980 (photos Rod Wells).*

Today will also provide the opportunity to systematically prospect for fossils on foot along the Cooper Creek, including an appraisal of the type section of the Katipiri Formation. The country between Cooper Creek and the Warburton River has a rich and colourful history. Upstream of Malgoona Waterhole was Unkamilkina station, operated about 1918 by a couple of French remittance men, 'Count' Charles de Peri and his brother Bill.

Lower Cooper local fauna. The skeletal fragments of fossil reptiles, birds and mammals lie scattered as a lag on the bars in Cooper Creek where they have been weathered from the ancestral Katipiri Formation channel-fills. Occasionally fossilised bones are found *in situ* in the base of these channels where cut by the modern drainage. The most commonly preserved elements include fish vertebrae and spines, lungfish tooth plates, fragments of turtle shell, crocodile teeth and scutes, bird bones, foot, hand and craniodental elements of kangaroos along with jaw and tooth fragments and vertebral centra of *Diprotodon*.

Fossils collected by party members will be assessed by trip leaders at the end of the day. Those of significance will be stabilised where necessary, registered with a field number, wrapped and returned to the Flinders University Palaeontology Laboratory for study before being deposited in the South Australian Museum.

Day 6 – Thursday 21 July

Lake Palankarinna to Brachina Gorge

Today we leave Lake Palankarinna and Cooper Creek behind and start making our way back towards Adelaide. Just south of Parachilna we will turn east and head into Brachina Gorge where we will camp for the night. On the way in keep an eye out for the Yellow Footed Rock Wallaby (*Petrogale xanthopus*).

There are many Yellow-Footed Rock Wallaby colonies within the Flinders Ranges (Fig. 58). In the 1800s and early 1900s these wallabies were hunted for their beautiful coats. Today they face competition for food from feral goats, rabbits and sheep and predation by foxes, wedge-tailed eagles and feral cats. Once widely distributed through the drier mountain and forested areas of South Australia, northwestern New South Wales and southwestern Queensland today they are found in six isolated pockets in these three states. It is one of the few species that have been bred in captivity and successfully reintroduced to the wild (Fig. 59).

Figure 58 Yellow-Footed Rock Wallaby, Petrogale xanthopus *(photo Rod Wells).*

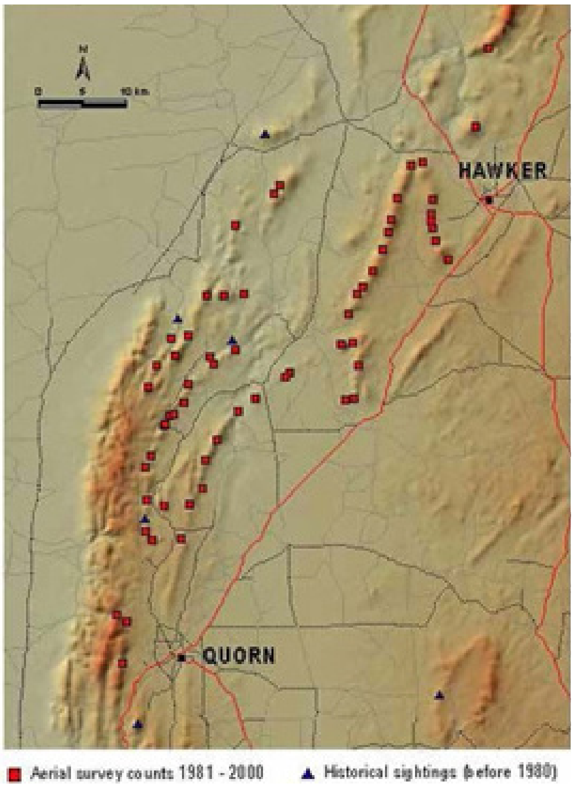


Figure 59 Yellow Footed Rock Wallaby colonies 1981–2000. From http://www.environment.sa.gov.au

Day 7 - Friday 22 July

Brachina Gorge to Burra

The following Brachina Gorge geological trail information is largely taken from Hiern and Krieg (2015) and is available for download as a brochure at sa.gsa.org.au/Brochures/Brachina%20Gorge_final.pdf

We will be starting the trail at the younger (western) end of Brachina Gorge and will wind our way through progressively older rocks as we work our way east.

Regional setting

One of the best records in the world of sedimentary deposition in the period of geological time between about 800 Ma and 500 Ma is exposed in the Flinders Ranges, Mount Lofty Ranges and the Olary region in South Australia. Sandy and silty sediments derived from erosion of older rocks of the Gawler Craton in the hinterland to the west, and island masses of this basement rock rising from an undersea ridge over 200 km to the east, were deposited into an extensive marine basin called the Adelaide Geosyncline in which the seafloor was slowly subsiding along a series of elongated north-south step or graben faults. During the 300 my of continuing but intermittent subsidence of the basin floor, a thick pile of sediment accumulated in the geosyncline. This sequence was then compressed and hardened by deep burial and later folded into a high mountain range by a new regime of earth movements.

Subsequent erosion has reduced these highlands to their present form and deposited huge amounts of sediment to the east into younger sedimentary basins formed by later crustal down warping.

Excellent exposures of rocks deposited in the Adelaide Geosyncline in the interval 650-500 Ma can be seen in Brachina Gorge, particularly on the southern wall (Figs 60-61). Here the sequence dips at moderate angles to the west except at the western end of the trail where the rocks have been buckled by faulting. Much younger flat-lying sediments deposited in the Pleistocene Epoch between about 35 000 and 18 000 years ago can be seen midway along the trail. A plaque describing a site of international geological significance, marking the base of the Ediacaran Period of geological time, was placed in 2005 on the southern bank of Enorama Creek, 500 m east of the Enorama campsite. This records a major change, which began about 635 million years ago, in the evolution from simple single-celled life forms to more complex multicellular organisms.

Evidence of other significant events in the geological history of the rocks in the Brachina Gorge includes:

- depositional structures in the sandy and silty sediments eroded from adjacent hinterlands, such as cross bedding and mud cracks, resulting from varying conditions of water depth and temperature during deposition;
- dumping of glacial till in the melt water of a worldwide period of continental glaciation;
- precipitation of ironstone, limestone and dolomite in the sea by chemical and biological action;
- debris from the impact of a large meteorite which fell near Lake Acraman in the Gawler Ranges about 300 km to the west;
- and some of the very earliest life forms which existed before the world renowned Ediacaran fauna.

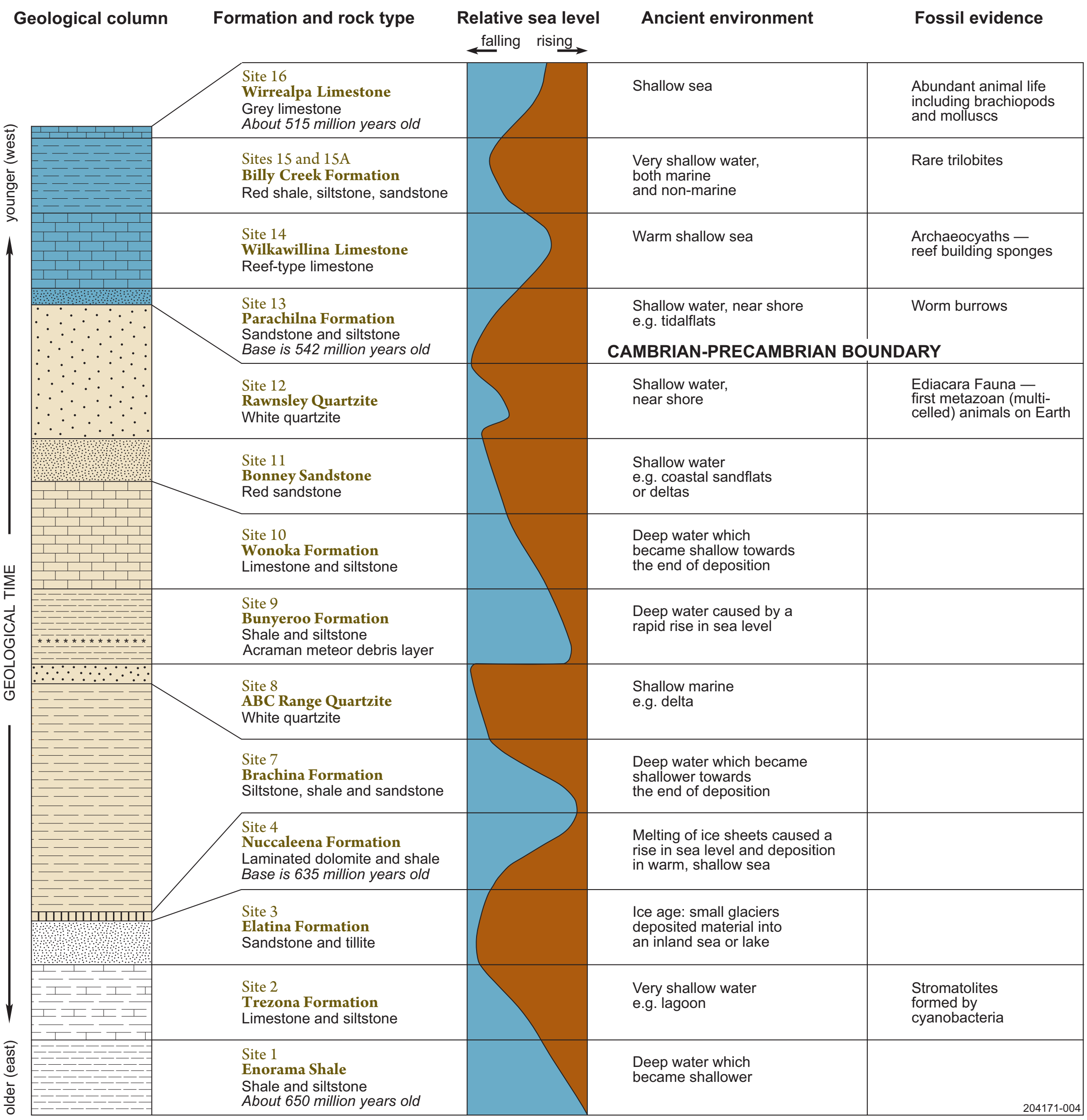


Figure 60 Precambrian and Cambrian palaeoenvironments, fossils and geology in Brachina Gorge (modified from Hiern and Krieg 2015).

It should be noted that recent research has modified the estimates of the ages of beds in this rock sequence (updated ages included in these notes) from those appearing on the trail signs.

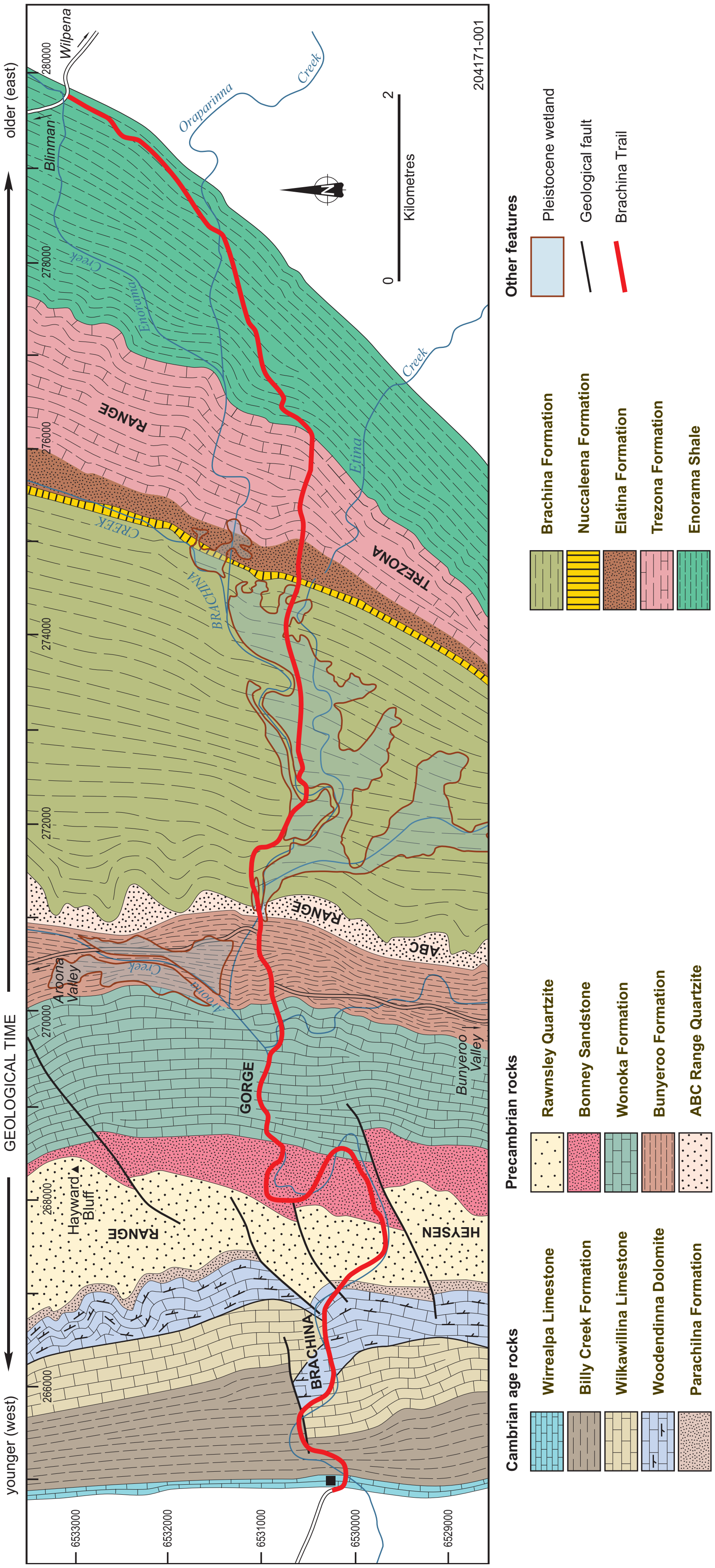


Figure 61 *Geological map of Brachina Gorge spanning **ca** 650-515 Ma (from Hiern and Krieg 2015).*

Stop 1

Piedmont slope. Our first stop will be on the rise at the entrance to the gorge. Here we can see a westward dipping pediment (Fig. 62), a remnant land surface dating from the time before uplift of the ranges.

From the carpark at the entrance to the gorge we can also see the **Wirrealpa Limestone**, a buff to light-grey limestone, 515-510 Ma in age, exposed in the creek bank below the parking area at the information booth. Trilobite, brachiopod (lamp shells) and stromatolite fossils are known from this formation.

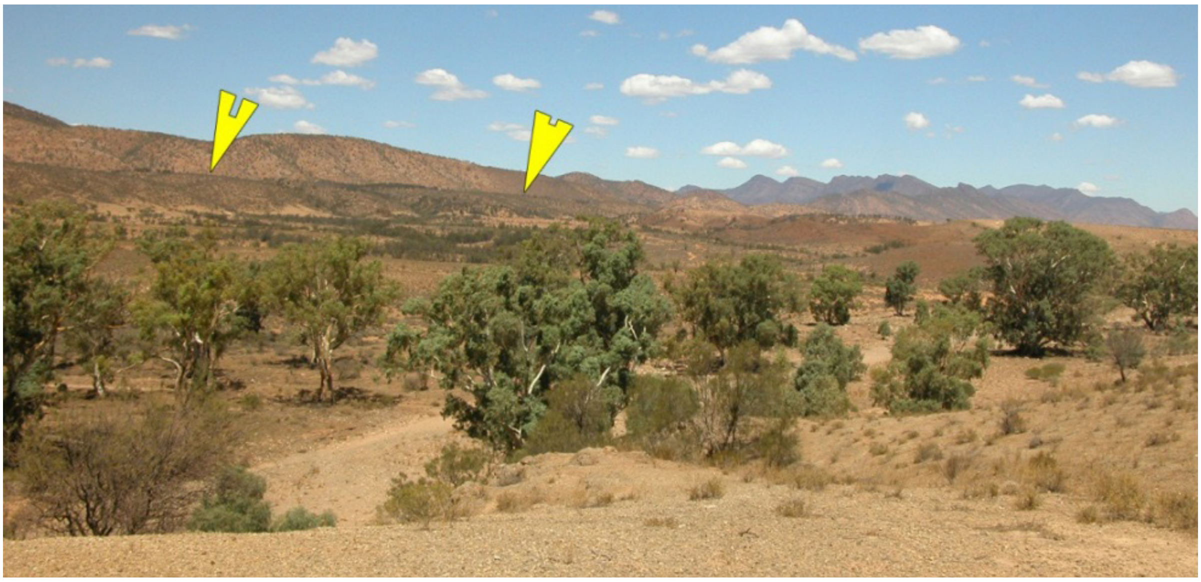


Figure 62 *Piedmont slope on western side of range (photo Rod Wells).*

Stop 2

Cambrian archaeocyath reefs. Here in the creek bed we find reefs composed of archaeocyaths 530-520 Ma in age (Fig. 63). These are the world's oldest fossils with a mineral scaffold (Fig. 64), and the oldest animal framework reefs on Earth. Pour some water on the outcrop to see the cross-sectional shapes.

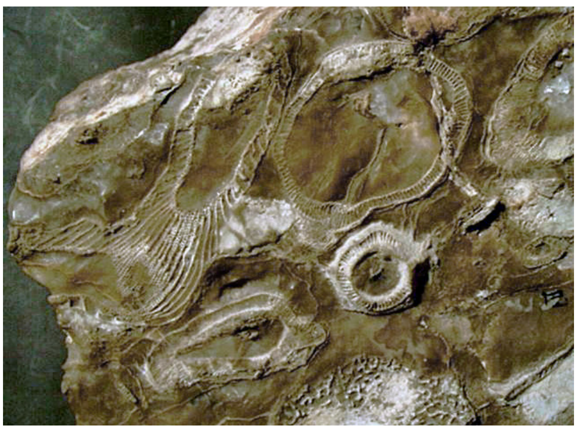


Figure 63 *Archaeocyath limestone (photo Jim Gehling).*

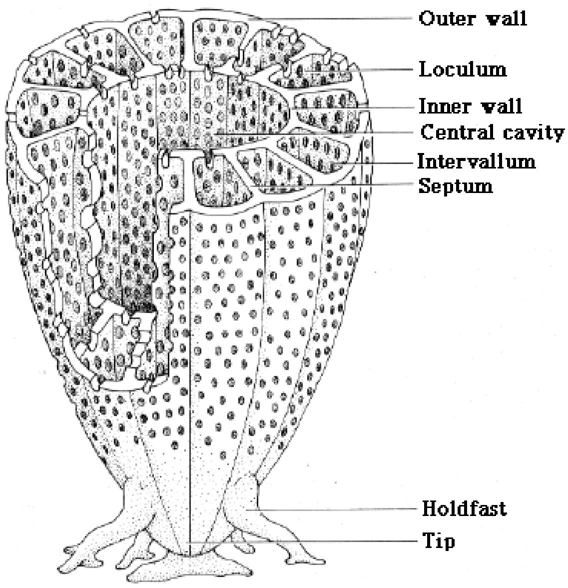


Figure 64 *Archaeocyath structure. From* paleo.cortland.edu

Stop 3

Ediacaran–Cambrian boundary. This is dated at 541 Ma (global reference level volcanic ash Russia) and is represented here by the boundary between the Rawnsley Quartzite and the Parachilna Formation (Fig. 65). Closely examine the yellow, crumbling sandstone of the Parachilna Formation. It is completely scrambled by U-shaped burrows, *Diplocraterion yoyo* (Fig. 66), made by soft-bodied worms or shrimp. This marks the beginning of the Cambrian 'explosion' of life.

Zinc, lead and copper deposits are common throughout the Flinders just above the *Diplocraterion* burrow level. The weathering of sulphide minerals here produces iron oxides (limonite, goethite, haematite) varying in colour from yellow to red-brown to deep red. This is the ochre used by Aboriginal people in their ceremonies.

Faults. Compression of the brittle folded rocks of the Flinders Ranges has led to a shatter zone of fractures and faults, with one visible 50 m south of the track (Fig. 67). Earthquakes and tremors are associated with continuing uplift of the ranges.

Figure 65 *Rawnsley Quartzite–Parachilna Formation (Ediacaran–Cambrian) boundary (photo Rod Wells).*

Figure 66 Diplocraterion yoyo *burrows of Parachilna Formation (photo Jim Gehling).*

Figure 67 *High-angle fault: left down/right up (photo Jim Gehling).*

Stop 4

Ediacaran fossils. The hard, white, well-cemented sandstone, 560-550 Ma in age, forming the spectacular high ridges in this part of the Flinders Ranges, including Wilpena Pound, is the Rawnsley Quartzite. It is about 400 m thick and weathers to an orange colour near the surface, it was deposited in a quiet shallow sea and displays many sedimentary structures, including cross-bedding and ripple marks. The middle part of Rawnsley Quartzite is called the Ediacara Member, from which the internationally significant Ediacaran assemblage of soft-bodied multicellular fossils (Figs 68-69) are found in several locations in the Flinders Ranges. The best exposure of the Ediacaran fossils in this area is at the narrowest part of Brachina Gorge. Fossil beds are exposed either side of the gorge.

This is a dangerous site: DO NOT attempt to climb the slope.

Figure 68 Spriggina floundersi.

Figure 69 Dickinsonia species *(photos Jim Gehling)*.

Stop 5

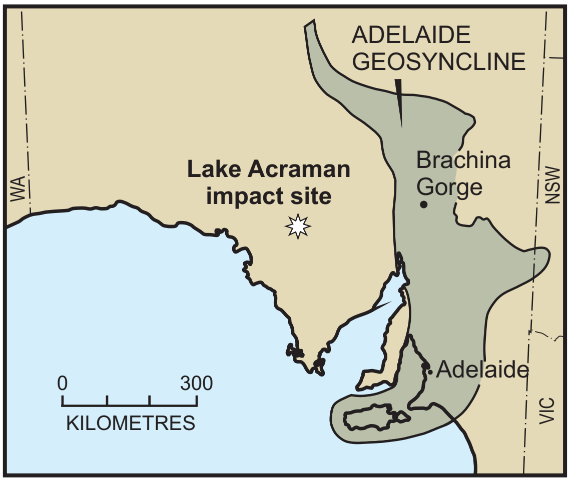
Bonney Sandstone. The Bonney Sandstone consists of cyclic sequences, each 20-30 m thick, of red micaceous siltstone and red medium-grained sandstone with cross-bedding, ripple marks, mudclasts and mud cracks. It has an estimated age of 570-560 Ma. The red sandstone blocks provide a perfect camouflaging backdrop and refuge for Yellow-footed Rock Wallabies, *Petrogale xanthopus* (Fig. 70). The wallabies can be seen here at any time of day but you may have to look closely to spot them or wait for them to move. The east-facing scree slope of sandstone boulders is produced by a moving fault line and is too unstable for trees.

Figure 70 *Yellow-footed rock-wallaby against Bonney Sandstone backdrop.*

Stop 6

Aroona Valley Lookout. We then move through the Wonoka Formation and to the Lubra Waters, which are permanent springs where Brachina Creek is damned by the ABC Range Quartzite. The soft reddish-brown to grey-green siltstones and shales of the Bunyeroo Formation are easily eroded giving rise to the Aroona Valley. Evidence of the Lake Acraman meteorite impact event around 580 Ma is provided by a single 1–150 mm-thick band of green rock with pink fragments of older Gawler Range Volcanics. Ejecta sprayed 300 km into deep water of the 'Adelaidean Ocean' (Figs 71-72).

Figure 71 *Ejecta layer in Bunyeroo Formation. (Photo Rod Wells).*



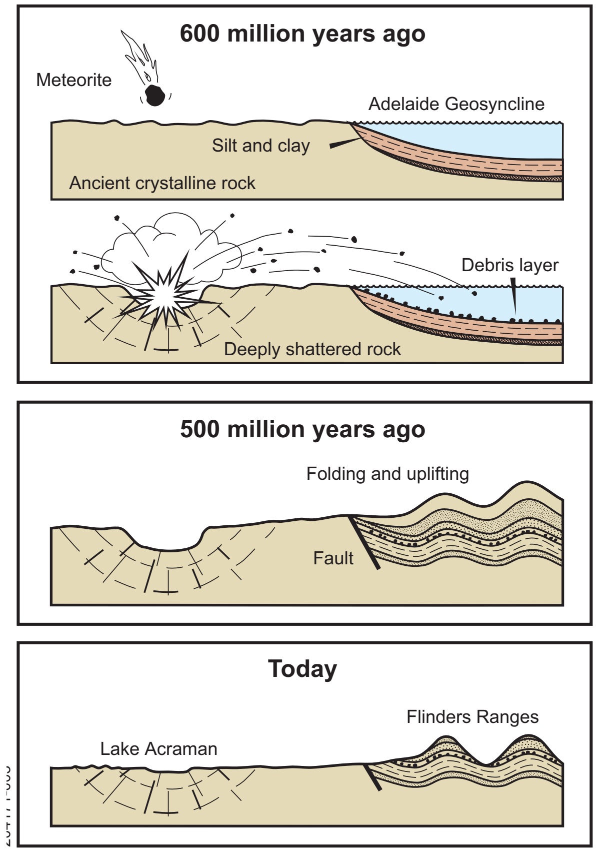


Figure 72 *Lake Acraman impact site and diagrams illustrating how Gawler Range Volcanics became incorporated into Bunyeroo Formation (figure modified from Hiern and Krieg 2015).*

Stop 7

Slippery Dip site. After crossing the ABC Quartzite we come to the Slippery Dip site where a Pleistocene ice age swamp overlies the 630-620 Ma reddish-brown siltstone of the Brachina Formation (Fig. 73). These layered grey, clayey and silty Pleistocene deposits containing gastropods, diatoms and phytoliths consistent with shallow water flow under fresh to brackish conditions. They represent somewhat of an enigma as they were deposited *ca* 32-17 ka in a cold, dry, windy environment (Williams *et al.* 2001, 2006). Reduced temperatures led to reduced evaporation and reduced incursion of summer rainfall. These wetland sediments are now being dissected by Brachina Creek under the present climate regime as the ranges continue to rise.

Figure 73 *Slippery Dip site. Sediments were deposited during last glacial maximum, during 22–17 ka. (Photo Rod Wells).*

Stop 8

Ediacaran 'golden spike' (Fig. 74). Below the Brachina Formation is the Nuccaleena Dolostone, a thin bed of buff to pale pink coloured dolomite (magnesian limestone) deposited in warm shallow water pools over a wide area of the Flinders Ranges after the sea level rose at the end of the glacial conditions of Elatina time. It is thought to have been deposited about 635 Ma at the beginning of the Ediacaran Period of geological time. Here, as recorded on the Geo-site Golden Spike marker post, a brass plaque '*marks the start of the Ediacaran Period of geological time, as the Earth warmed following glaciation. Multi celled organisms became widespread in maritime environments. The brass disc indicates its location where pink Elatina Formation glacial tillite is overlain by buff Nuccaleena Formation dolomite*'. This site in Enorama Creek was selected in 2005 when the base of the Nuccaleena Formation was adopted as the beginning of the Ediacaran Period of geological time by the International Commission on Stratigraphy Working Group on the Terminal Proterozoic Period. This represents the only geological period to have been named in the last 120 years (Preiss 2005).

Figure 74 *The 'golden spike' at base of Ediacaran System (photos AB Camens).*

Stop 9

Stromatolite reefs. Delving back in time past the glacial tillites of the Elatina Formation, we take the track to Youngoona Ruins and the trail northwest into Enorama Creek. A further 200 m up the creek we come to the fossil reef of the Trezona Formation. It consists of a sequence of interbedded siltstone with harder reddish limestone bands that form distinctive banded hill slopes in the landscape at the eastern end of the trail and along the main road to Blinman to the north.

The limestone formed in warm shallow seas. Microbial mats trapped lime sediments, building domed stromatolite reefs which appear as humps with internal hemispherical layering (Fig. 75).

These are some of the earliest expressions of life on Earth which first appeared in the geological record about 3500 Ma. Those here are thought to have lived *ca* 645-640 Ma.

We now leave the Brachina Trail and make our way south along Wilpena Road through the Flinders Ranges. There are many scenic stops along this route, including Wilpena Pound and Rawnsley Bluff. We will stop as time permits, arriving in Burra where we will stay at the historic Paxton Square cottages (Fig. 76). Dinner at the Burra Hotel at 7:30 pm.

Figure 75 *Stromatolites of Trezona Formation, ca 640 Ma (photos AB Camens).*

Figure 76 *Paxton Square Cottages were built by Cornish masons in 1851 to house mining families (www.travellingaustralia.info).*

Day 8 – Saturday 23 July

Redbanks Conservation Park and back to Adelaide

Today we will depart Burra and head out to Redbanks National Park where Flinders University palaeontologists have been excavating fossils for 15 years. We begin at the old Redbanks cricket oval (Fig. 77) and work our way up river.

As we make our way along the interpretation trail keep an eye out for the footprints of the animals that live in the park, the wet clay can often preserve their prints in exquisite detail. The park is home to three species of kangaroo- the Red Kangaroo (*Macropus rufus*), the Western Grey (*Macropus fuliginosus*) and the Euro (*Macropus robustus*) as well as the Southern Hairy-nosed Wombat (*Lasiorhinus latifrons*) and various reptiles and birds. The grasslands in and around the park are also home to the Pygmy Bluetongue skink (*Tiliqua adelaidensis*). Until its rediscovery in 1992, it was thought to be extinct, but it is now known to occur throughout the region, where it lives in vacated spider burrows in unploughed native grasslands (Fig. 78).

We will visit several sites where articulated skeletons of the two-tonne marsupial herbivore Diprotodon have been found (Fig. 79) and we will have a chance to prospect for newly exposed fossils through the gullies of the park.

Always approach gullies from the bottom and do not venture too close to their rims from above; they are often undercut.

Figure 77 *Cliffs near the old cricket oval that give Redbanks Conservation Park its name. Unit at base of cliffs is Middle Pleistocene in age, and gravels and silty clays comprising bulk of cliffs are of Late Pleistocene age.*

Figure 78 *Pygmy Bluetongue* (Tiliqua adelaidensis) *is endemic to mid-north (photo Angus McNab).*

This section of Baldina Creek is fed by a permanent spring that was used by both the Aboriginal community and by stockmen as it represents the junction of four major stock routes.

Figure 79 *Various* Diprotodon optatum *bones (bottom); and pelvis of* Thylacoleo, *the marsupial lion (top), collected from Baldina Creek site two.*

We will then return to Burra township and visit the old railway station that has recently been refurbished as a museum, where some of the fossil discoveries from Redbanks are now housed.

This concludes the trip and we will arrive back in Adelaide late afternoon or early evening.

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