'Geo-Log' 2014

Journal of the Amateur Geological Society of the Hunter Valley

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Journal of the Amateur Geological Society of the Hunter Valley Inc.

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Presidents Introduction.

Hello members and friends,

I'm sure everyone feels that the year has gone by so fast our feet have barely touched the ground. But the local enthusiasm for earth sciences and nature in general never seems to diminish and this is reflected in our very strong membership and enquiries received on our website. Our greatest attribute as a society is that no-one needs to know anything about geology. We have plenty of members well-versed in that and other disciplines and all that new members require is an eagerness to observe and learn.

The activities of the Society have for many years extended well beyond the Hunter Valley, and indeed outside New South Wales as our search for new areas to explore continues. Only occasionally are old areas re-visited as new information becomes available. In 2015 we will return to Alum Mountain with its magnificent bush scenery now that access is again possible after the completion of the Buladelah Bypass. This is one of the most scenic and geological gems in the state. Our extended excursion this year was to northwest Queensland and the Dinosaur Triangle where 5 weeks were spent exploring the scenery, geology and fossils of the Mount Isa Inlier and the surrounding sedimentary basins. The highlight of that trip was the full day spent with Mike Archer at Riversleigh, made possible through an introduction via Joan Henley who used to work with Mike at the Australian Museum. Despite his American accent Mike is Australian and fiercely proud of it. The length of the trip and variety of sites covered required a very lengthy report, making this issue of the Journal the largest ever.

Very special thanks go to the Social Committee for their rarely acknowledged input, particularly at Soup and Slides and the Christmas Social. Thanks to Sue and Ian Rogers who made their home available for both Soup and Slides and the Christmas party, the latter organised almost wholly by Sue since Ian had landed himself in hospital a few days beforehand after a heart attack. At the time of writing he was recovering and doing well. Grateful thanks also to Treasurer Leonie Mills, who has kept our finances legal and in order. Our Secretary Ian Rogers continues to get our newsletters out in plenty of time for members to plan ahead and also oversees the Society website.

Thanks to those members who organised and ran our activities and contributed to the Journal. Special thanks to Life Member Ron Evans for his dogged determination and dedication in producing another great edition of the Journal. Accolades from the scientific community and the general public continue to come in. I have no doubt that this is the most professional journal of its type in Australia.

With very best wishes,

Brian.

Pinny Beach and Swansea Heads

Leader: Chris Morton.

Attendance: 27 members; 8 visitors.

Date: Thursday 30th January, 2014.

At the risk of overstating the description of this activity, the single word that comes to mind when I think back about this brief geological adventure is stunning. Stunning for the unbelievable attendance and a beautiful sunny afternoon with 27°C and a gentle northeast breeze. Stunning scenery; the blue of the Tasman Sea, the golden sands of our iconic beaches, and the vibrant green of the sea grasses that dominate rock pools revealed by the falling tide. The kaleidoscope of colour that saturated the coastal rock escarpment provided the perfect backdrop for the completion of the walk north from Pinny Beach that we started last year but could not complete then due to the unexpected abundance of fascinating geological features exposed.

Geological Background.

This area of coastline south of Newcastle comprises rocks belonging to the Boolaroo Subgroup of the Late Permian Newcastle Coal Measures (Herbert and Helby, 1980). In this section the dominant exposures comprise the Reid's Mistake Formation that separates the Lower Pilot coal seam in the rock platform and the Upper Pilot coal seam exposed in the adjacent sea cliff. The escarpment above this sequence consists of massive conglomerate and intercalated sandstone beds of the Belmont Conglomerate Member, one of several isolated channel-filling conglomerates present within the Newcastle Coal Measures.

Numerous tree stumps (probably the species *Dadoxylon*) are preserved in situ in the rock platforms. These are the remnants of a fossil forest which grew in the sediments that later formed the Lower Pilot seam. Within the seam the fossil trees were converted to coal and dark brown siderite. The presence of this fossil forest was recorded by Edgeworth David (1907) who stated in his work on the geology of the Hunter River Coal Measures "The oldest forest growth which went to form the lowest seam was killed off suddenly by being buried under dense showers of volcanic ash".

This volcanic ash now forms the thin blocky tuffaceous beds in the Reid's Mistake Formation exposed in the sea cliffs and nearby rock platforms. In this tuff only the cores of the tree trunks were coalified, the remainder being replaced by chalcedony due to the abundance of silica in the enveloping ash.

1. Leader Chris delivering a short geological explanation of the features to be found.

The Excursion.

Participants listened intently to the short geological introduction delivered at the top of the stairs leading down to Caves Beach from the car park off Caves Beach Road opposite Bligh Avenue *(photo 1)*. The scenery and pleasant coastal surrounds here would have satisfied any tourist but the cliffs, rock platforms and sea caves along this stretch of coastline hold enough features to keep geology enthusiasts occupied for many hours. Whoever said sedimentary rocks were boring has never experienced the incredible variety of structures and rock types exposed along this coastline. To the experienced scientist all can shed light on past environments and climatic conditions.

Walking south along the beach from the base of the stairs we found a number of interesting structures representing various aspects of fluvial sediment deposition. At the base of the Belmont Conglomerate were many examples of cross bedding and evidence of point bars in those ancient stream beds *(photo 2)*. But the most fascinating outcrop was an excellent transverse cross-section of one of the anastomosing stream channels characterizing the braided rivers that were active in this region *(photo 3)*. This streamlet had gouged a deep channel across earlier deposited river sediments and then laid down its own sequence of draped sediments within the eroded channel to form what sedimentologists call a scour and fill structure. At the edge of the channel lay a great example of partial stream bed collapse, a large chunk of bedded sandstone lying at a different angle to the other channel fill sediments. Also present were occasional sections of tree branches deposited along the edges of the channel as driftwood.

Exploring the first of the sea caves, the group found a narrow crevice at the back of the cave, which led into a

2. Fluviatile channel deposits near a sea cave.

4. Lower Pilot Seam underlying Reid's Mistake Fm.

narrow amphitheatre with towering rock walls.

Most of the group could have lingered here longer to explore the other sea caves and more of the fascinating sedimentary features. However, not wishing to make the same mistake as last year in not completing the day's program, it was time to move on. There was an equally stunning area to be explored at Reid's Mistake (Swansea) Head, just a few kilometres to the north at the end of Northcote Avenue, Swansea Heads.

The geological section exposed here is identical to that seen at Caves Beach, but the rock platform here at low tide provides a much better exposure so that each layer can be examined in close detail in cross section. This is due to the shallow 8° dip of the beds to the west as they slope in towards the centre of the Sydney Basin.

In the cliff below the Pilot Station lies the basal part of the Belmont Conglomerate. Below this the rather indistinct outcrop of the Upper Pilot seam can be made out as a black shaley layer partly obscured by scree from the overlying conglomerate. Then comes the Reid's Mistake Formation, comprising a very distinct dense ash fall bed capping thin convoluted base surge tuff beds, massive tuff, and then more convoluted tuff beds, the lower part of which extends out across the rock platform *(photo 8, page 5)*.

The sharp demarcation between the tuff beds at the base of the Reid's Mistake Formation and the underlying top of the Lower Pilot seam lies midway out across the rock platform *(photo 4)* with a trend approximately parallel to the coastal cliffs. Within this relatively thin coaly shale bed lie the impressive remains of a large fossil forest in growth position, the trees felled around 260ma by ash flows from volcanoes located to the east around 30 kilometres off the present coastline. The trees are rooted in the coaly shale and many of the stumps project well into the overlying tuff, by as much as 10 metres as seen by Edgeworth David in the nearby Government quarry back in 1907 (David, 1907). But on the rock platform only the stumps remain, the rest of the trees having been removed by marine erosion. David found that the diameter of the trees ranged up to 0.4 metres with an average spacing of 1.5 to 2 metres. The roof of the Lower Pilot seam also contains flat-lying tree trunks, most of which are aligned east-west, indicating the direction from which the destructive ash flows came. An excellent account of this locality (by Life Member Ron Evans) is to be found in Geo-Log 2010 (pages 9-11).

The soft claystone band between the top coaly shale bed enclosing the tree stumps and the next coaly layer held a

3. Stream channel deposits.

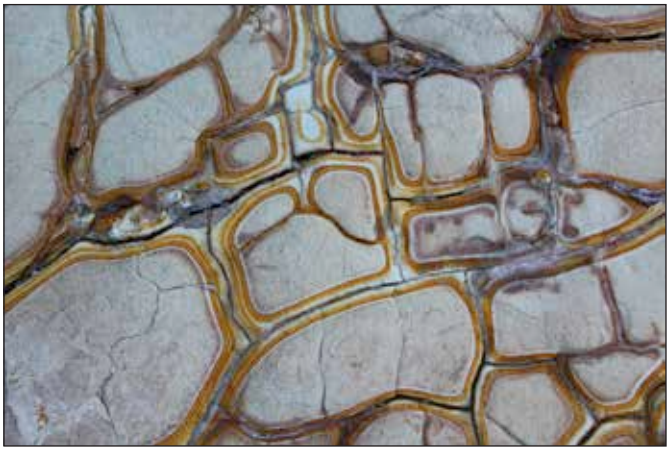
5. Vertical stellate *Vertebraria* rhizomes in sandstone.

6. *Glossopteris* leaves within a fine grained tuff.

great surprise. Sharp-eyed Diane Kemp called the other geologists in the group over to explain an abundance of stellate markings up to 3 centimetres across scattered over the surface of the pale grey rock. These were immediately identified as *Vertebraria*, thought by many to be the pithy segmented root system of the *Glossopteris* flora *(photo 5)*. These too are in growth position, all extending vertically from the base of the coaly shale. No other fossil vegetation was detected in the claystone, the *Glossopteris* leaves themselves being confined to the coaly shale above. The vertical alignment of these fossils may suggest that the plant desperately sought moisture in the underlying sands during extended dry periods. Our group had not seen the *Vertebraria* on any previous excursions, nor are we aware of any record in the scientific literature. But it must be pointed out that the tide during our visit was unusually low and perhaps therein lay the reason.

After such an exciting and thought-provoking discovery we moved back to the cliff line where a number of grey sandstone blocks were split along bedding planes to reveal excellent examples of *Glossopteris* leaves *(photo 6)* and other flora which grew in the coal swamps.

Our newer members enjoyed discovering the fossil forest and having the catastrophic events that led to both its



7. Tesselated pavement developing Liesegang Rings.

8. Reid's Mistake Fm. Parallel beds of tuff, some contorted.

destruction and preservation explained to them. But time had beaten us once again and all too soon it was time to leave.

On the way back to the car park we found a small area of fine tuffaceous sandstone forming a tessellated pavement, which displayed unusually spectacular Liesegang banding. These rusty-coloured patterns of iron oxide staining made for some great photography *(photo 7)*.

Our final stop for the day was at John and Alison Hyslop's home for a well-earned afternoon tea break. Their hospitality in opening their home to such a large number of tired and thirsty people was appreciated by all.

Some of the Newest Rock on Earth!

As well as having been able to study the demise of an ancient forest caused by volcanic ash flows back in the Late Permian, we were also fortunate to witness the results of some of the Earth's most recent volcanic activity.

No-one could have failed to notice the unusual abundance of rounded lumps of pumice, some as large as footballs, nestled on the sand at high water mark. We are accustomed to finding the occasional pumice pebble on east coast beaches, but this was extraordinary! The day after the excursion I happened to catch an interview on ABC radio, which explained its origin. The pumice came from the July 18th, 2012 eruption of Havre seamount (underwater volcano) in the Kermadec Islands 1000 kilometres north of New Zealand (Klemitti, 2012). The summit of this volcano lies 700 metres below sea level and erupts every 4 to 5 years. However the July 2012 eruption was one of the

biggest in the last 50 years. A tourist who saw the floating pumice from the air, sent photographs to the Queensland University of Technology. Apparently it looked like a huge brown patch floating on the ocean. Passengers on a cruise liner reported that the ocean had the appearance of a desert as far as the eye could see. The actual eruption occurred at night and went un-noticed. Pieces up to the size of a football washed up on beaches along the east Australian coast and as far north as Tonga, Torres Strait and south to the east coast of Victoria. It spread as far east as New Zealand. The pumice first appeared along our coastline between March and July 2013 and then again between Christmas and New Year 2014. The fragments are well-rounded due to abrasion and are generally coated in barnacles and other sea life. While rather odious when collected due to rotting fauna attached to them, a thorough wash with a high pressure hose removes all traces of organic matter and also the awful smell.

Report by Chris Morton and Brian England.
Photographs by Ron Evans.

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Foreshore Geology - Nobbys Head to Newcastle South

Leader: Ron Evans.

Attendance: 22 members; 2 visitors.

Date: Saturday 1st March, 2014.

The activity commenced with participants meeting at the Royal Newcastle Yacht Club where a convivial lunch was enjoyed by all before proceeding to Nobbys Beach carpark, the starting point for the walk.

The weather was overcast with a slight chance of rain (which did not eventuate), perfect walking weather.

Ron explained the purpose of the walk and gave a brief introduction to the geology of the area to be visited. More details were provided at each stop along the walk.

Nobbys Headland.

Nobbys Head (originally called Coal Island) was a small island when Newcastle was settled. Governor Macquarie ordered a pier (Macquarie Pier) to be built to join Coal Island to Collier Point. The pier was started in August 1818, convict labour being used in its construction. It took 28 years to complete the pier, and during this time numerous convicts were lost to the sea due to them having to work through all sea and weather conditions, night and day.

Nobbys Head was thought to have been originally 62 m (203 ft.) high. However, work done by the Coal River Working Party in 2010 has concluded that the original height was more likely 43 m (141 ft.). It was reduced to its current 28 m (90 ft.) height because sailing ships were losing wind in their sails as they rounded Nobbys Head. The rock taken from Nobbys to reduce its height was used in the pier's construction. The lowering of the island was essential for the future construction of a lighthouse.

During the 1850's, convict labour was used to dig tunnels into Nobbys Head. Explosives were to be placed in the tunnels, the aim being to destroy the island. Public opinion prevented its destruction.

The present causeway now consists partly of blocks of Waratah Sandstone quarried at Braye Park, Waratah. Sandstone blocks quarried from the west side of Signal Hill were originally used. However, this sandstone was

not strong enough and quickly broke down. Today, a sand beach 'ties' Nobbys to the mainland (structurally, its now a tied island).

Blocks of Waratah Sandstone beside the causeway show beautiful examples of honeycomb weathering *(photo 1)*. This particular weathering is predominantly a sea coast phenomenon and is not observed in the sandstone at Waratah. It is due to the salt spray settling on and saturating the surface of the rock. As it dries, salt grains crystalize. In doing so, they disrupt sand particles. The wind then blows away the loose sand leaving a small cavity that is enlarged when more crystallisation occurs and wind blasting the rock causes sand grains to be swirled around in the cavity.

As stated, the headland was originally much higher, but was lowered to help fill the gap and to construct the lighthouse and signal station built in 1857 and opened in 1858. Alexander Dawson designed the lighthouse. The original light had an intensity of 20,000 cd and was attended by three lighthouse keepers. In 1934 the light was electrified and automated. The current light source is a 120 volt 1,000 watt quartz halogen lamp, the power source being mains electricity with a diesel generator backup.

Today, Nobbys is 28 m tall with a cliff of 25 m. The cliff consists for the most part of regularly stratified beds of a chert-like rock now called Nobbys Tuff. This rock is a very fine grained volcanic tuff composed of feldspar and volcanic glass, which can only be recognized in a thin section under a microscope. Its source was from volcanic eruptions to the east some 250ma. Wind blew ash clouds over the Hunter region, which at the time consisted of a low-lying alluvial and deltaic plain covered by vast wetlands (swampy forests and lakes) separated by rivers. The shoreline lay further to the southeast than it does today. After the eruptions ceased, the volcanic ash layers were buried by more swamp, lake and river deposits and compacted to form the rock tuff.

1. Honeycomb weathering in Waratah Sandstone.

2. Well jointed Nobbys Tuff between layers of soft shale.

Nobbys Tuff is grey in colour, very hard and breaks with a conchoidal fracture. Interbedded with the cherts are dark grey shales and tuffaceous sandstone *(photo 2)*.

These sediments weather differentially. The harder and more resistant tuffs jut out while the softer shales and sandstones have worn away. As the rocks are jointed (cracked) in a regular pattern due to stresses within the Earth's crust, it is not uncommon for the over hanging tuff to break along a joint and the rock debris to topple down forming a talus deposit.

In the tuff beds of the Newcastle Coal Measures exposed in the sea cliffs along the coastline south of Newcastle, spectacular and perhaps unique coarse brightly coloured lace-like dendrites varying from yellow to almost black have developed along vertical joint planes. The best exposure lies in the cliff face below the weather station on Nobbys Head, on the southern side of the entrance to Newcastle Harbour.

The tuffs at Nobbys Head belong to the Nobbys Chert of the Shepherd Hill Formation and are interbedded with thin shaly layers. The tuff is sandwiched between the Victoria Tunnel Seam at the top of the cliff and the Nobbys Seam at the base (usually covered by sand) (Nashar, 1964; Herbert and Helby, 1980). Towards the base of the cliff dendrites covered large areas of the rock face, contrasting sharply with the light grey tuff on either side of a large weathered dolerite dyke. Unfortunately, following the savage storms of June 2007, most of the exposed dendrites have been effectively blasted from the rock, but new areas will surely be exposed by future rock falls.

Chemical analysis of the Nobbys dendrites showed them to comprise a mixture of iron hydroxide (goethite) and silica (chalcedony). The variation in colour is due mainly to differences in crystallite size and packing density of the goethite, with the bright yellows resulting from fine grained earthy goethite and the dark browns by coarser,

denser material *(photo 3)*. The source of the iron was probably decomposing pyrite in the Victoria Tunnel Seam at the top of the cliff and the nearby dolerite dyke may have acted to impede the lateral movement of the mineralised groundwater and hence localise dendrite development. (England, in preparation).

In an attempt to arrive at an explanation for the unusual and diverse patterns in these dendrites, it is interesting to compare their morphology with the patterns developed in any gel-like substance sandwiched between two flat surfaces when these surfaces are pulled directly apart. From this it seems likely that the patterns were formed when soft iron hydroxide/silica gels filling joints in the chert were placed in tension as the joint surfaces moved apart laterally towards the cliff face under the weight of the overlying rock strata. (England, in preparation).

Visitors to this site must bear in mind that removal of rocks from the Nobbys cliff face is not permitted. In any case the collection of specimens from the outcrop is extremely dangerous as the cliff above the occurrence overhangs considerably and the tuff is heavily jointed so that large blocks may fall away without warning.

At sea level (and generally covered by sand), is an outcrop of the Nobbys Coal Seam underlying the tuff. First settlers worked this about 1802. At the top of the cliff, thin coal seams underlying the Victoria Tunnel Seam overlie the tuff. The main Victoria Tunnel Seam does not appear in this section due to removal of rock from the top of the island. Merewether Conglomerate may also have been present overlying the Victoria Tunnel Seam.

Cutting through Nobbys cliff in the direction S 36° E is

3. Goethite dendrites on a joint plane in Nobbys Tuff.
Brian England Collection (M 72.1.1) 20 cm across.

4. Dolerite dyke cutting beds of Nobbys Tuff. Note the dark shaly coal on top of the cliff.

a basalt (or fine grained dolerite) dyke *(photo 4)*. This dyke provides an excellent example of differential weathering. Weathering on the seaward side has been mechanical (abrasion by waves and wind) whilst on the opposite side, the dyke has been chemically weathered by acid groundwater into the clay kaolinite. Vegetation and buildings prevent this outcrop from being seen. A narrow contact aureole beside the dyke has been weathered most rapidly resulting in a narrow channel beside the dyke.

On the northern side of Nobbys jutting out of the present breakwater is a continuation of the dyke, only observable at very low tide. The dyke is 3.8 m wide and has a 2 m wide contact aureole of baked coal.

Signal Hill and adjacent Rock Platform.

In the cliff behind Nobbys Surf Pavilion is a kaolinised dyke *(photo 5)*. The original basalt has been chemically weathered and practically all the components except alumina, silica and a small amount of iron, have been leached out. The material left behind is kaolinite. Newcastle Council has recently covered the exposure with concrete.

In the east side of Flagstaff Hill (Fort Scratchley) along Shortland Esplanade between Nobbys and the Ocean Baths, a fine conglomerate (stratigraphically between the Dudley and Nobbys Seams) may be observed. Above this are two splits of the Dudley Seam, which are separated by about twenty feet of dark shales with fossil plants.

A basalt dyke, most likely a continuation of the same one behind Nobbys Surf Pavilion, cuts across the rock platform

5. Kaolinised dyke on northern side of Flagstaff Hill.

6. Dolerite dyke intruding rock platform and Flagstaff Hill.

opposite Flagstaff Hill just north of the Ocean Baths *(photo 6)*. The dyke has been intruded along a joint plane and in some places it has eroded more quickly than the surrounding sandstone to form a ditch. In other places the sandstone has eroded faster than the dyke, which stands out as a low ridge. Prominent joints (columnar jointing) cut across the dyke. Several phases of magma injection formed the dyke. Proof of this is the coarse/fine zones of rock within the dyke. Core drill holes are present in parts of the dyke. Samples collected would have been used for paleomagnetism studies.

The rock platform is well-jointed and fossilized tree stumps and stems are present. The fossilized remains are brown because iron rich minerals (mainly siderite) have replaced the wood over time.

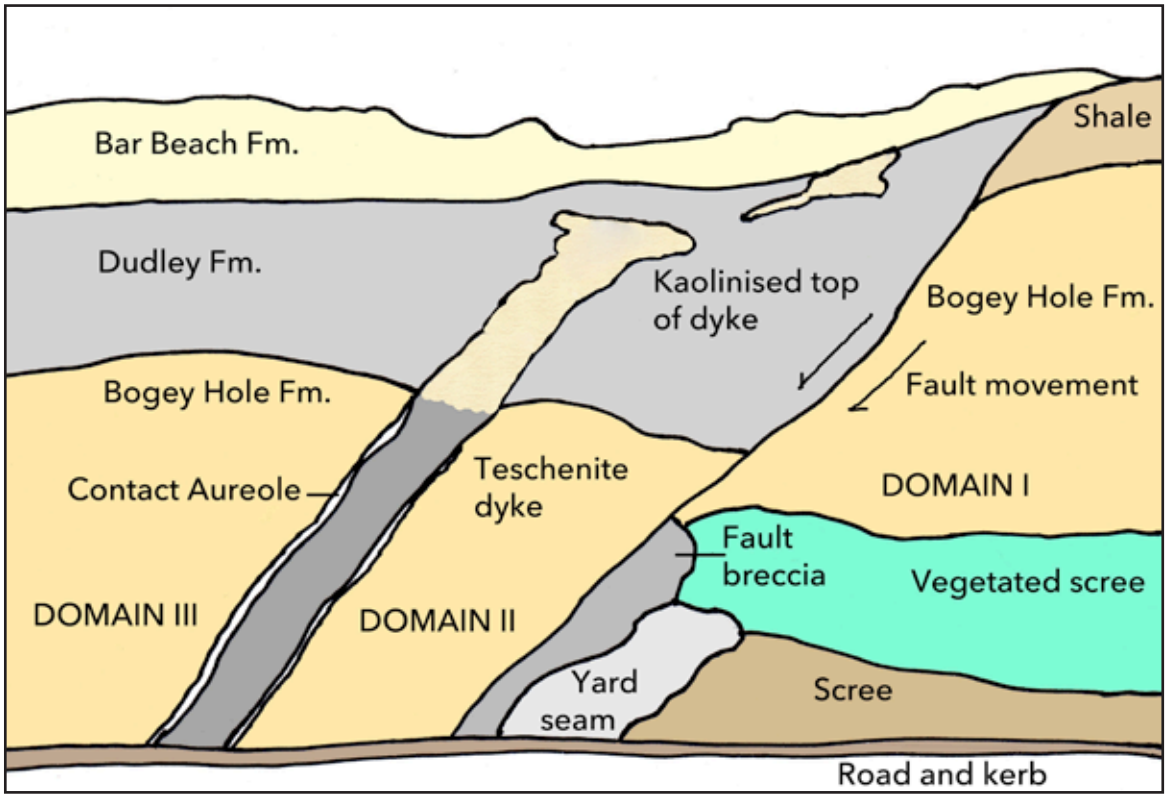
Shortland Esplanade behind the Skate Park.

Excellent exposures of the Lambton Formation occur in the cliff from here to the south. A strong normal fault is present (the inclination of the fault plane varies) bringing coal (Dudley seam) and grey shale against sandstone. The fault has a downthrow of approximately 3 m to the southwest. The Dudley seam was mined here quite early in the history of Newcastle. Old mine workings were exposed during construction of extensions to the Royal Newcastle Hospital in the 1980's. (Branigan and Packham, 2000).

Close to the fault is a teschenite dyke that intruded N 31° W (strike) and 86° SW (dip). The chilled margins of the dyke have weathered more rapidly than its centre *(photo 7)*. Adjacent sandstone has been hardened by contact metamorphism. Small horizontal dyke offshoots (sills) are also present although difficult to see. Towards its top, as the dyke leaves the Bar Beach Fm and enters the Dudley coal seam, it becomes lighter in colour *(photos 7 & 8)*. This is due to chemical weathering by ground water, which is altering the teschenite to the clay kaolinite. Note also that when the dyke intrudes the coal, it bulges out and changes direction and shape *(photo 8)*. The reason is that the coal is not struturally strong like the sandstone below it and

7. Teschenite dyke intruding the Bogey Hole Fm. and the black Dudley coal seam above. To the right note the plane of the normal fault truncating the Dudley coal seam.

8. Kaolinised top of the dyke bulges out and changes direction within the Dudley coal seam.



Simplified diagram of structures within the cliff behind the skate park, Shortland Esplanade, Newcastle NSW.

so provides no restrictive joint along which the teschenite could intrude.

It also appears that the dyke ceased intruding upwards at the boundary of the Dudley coal and overlying Bar Beach Fm (See diagram above and *photo 7 & 8*).

A second fault, a reverse or thrust fault, is situated a few metres north of the normal fault, but is obscured by vegetation. This means that a small horst block has been lifted up between the adjacent strata.

The tectonic activity of dyke intrusion and faulting have affected the dip and strike of intersecting joint patterns south of the dyke, between the dyke and normal fault and in the horst block between the two faults. These three domains are indicated on the diagram.

Sets of large, well developed intrinsic joints striking NW are the most obvious structures in the exposed strata, although sets striking NE are also well developed. Next to the dyke the frequency of the joints increases, as it does close to the upthrow side of the normal fault *(photo 9)*.

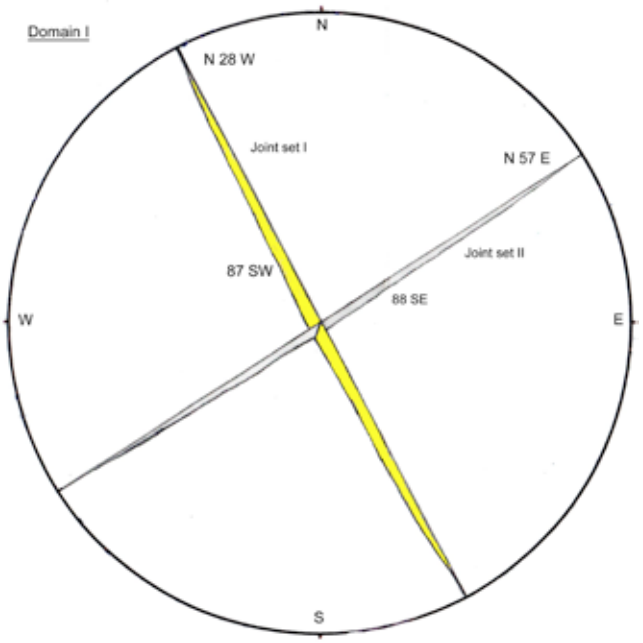
To analyse such joint patterns, a large number of dip/strike measurements were made using a Brunton compass. Collected data were then plotted separately on stereographic projections using a Schmidt Net. Statistical analysis then determined the dominant joint patterns for the three domains. (Evans, 1975).

9. Normal fault - note the wedge of fault breccia to the right of the fault plane and close jointing of shale on the upthrow side under the coal seam (Yard seam).

The Result of Joint Analysis in Domains I, II and III.

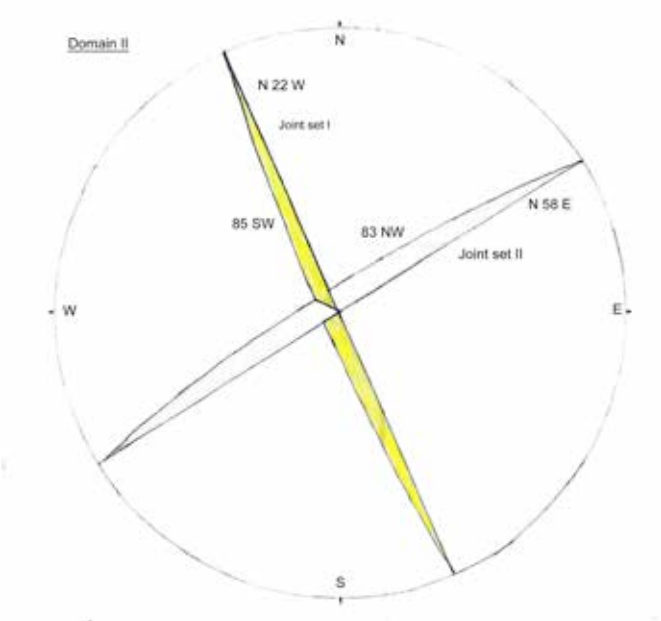
DOMAIN I

Joint set 1: Strike: N 28° W and Dip 87° SW
Joint set 2: Strike: N 57° E and Dip 88° SE



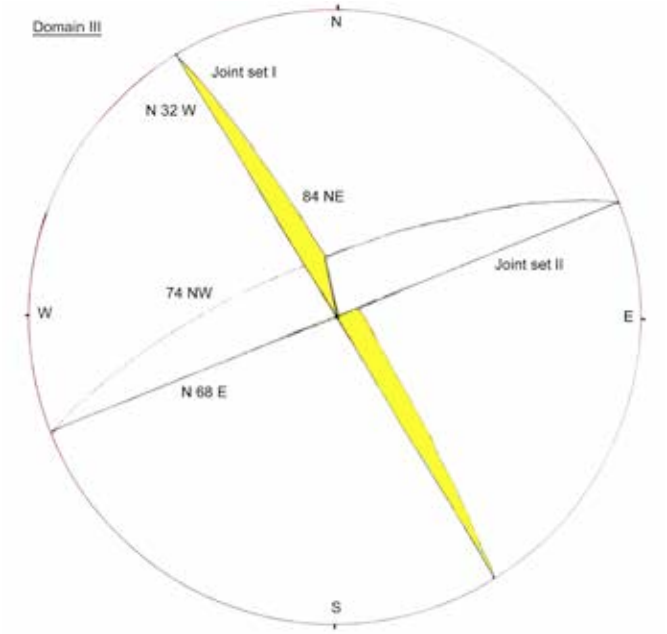
DOMAIN II

Joint set 1: Strike: N 22° W and Dip 85° SW
Joint set 2 : Strike: N 58° E and Dip 83° NW



DOMAIN III

Joint set 1: Strike: N 32° W and Dip 84° NE
Joint set 2: Strike: N 68° E and Dip 74° NW



The intrinsic joint sets in domain III can be considered to be the main reference joints in this area because the dyke and normal fault are obviously joint controlled as there has been no major disruption to the strikes (NW) in domains I and II. They must have been present before intrusion and faulting which exploited weakness in the NW joints.

As a result of the forces associated with the injection of magma with associated heating (and expansion) and cooling (and contraction) of the country rock, a new set of intrinsic joints parallel to the dyke formed. These increase in frequency adjacent to the dyke. These new joints also strike NW (as do those in domain III), but the dip of the main set has been rotated from the NE (as in domain III) to the SW to parallel the dip of the dyke (see yellow plot).

Following intrusion, faulting occurred. Small pieces of cindered coal in the fault breccia suggest this order of events. Faulting was essentially a vertical uplift to form a small horst block. Faulting also affected the joint pattern. Joint frequency greatly increases next to the fault side on the upthrow side. Moving north sees a decrease in joint frequency. A consequence of faulting has been the rotation of dip until almost vertical (87° and 88°) respectively in domain I.

These changes reflect the nature of forces and subsequent movement that occurs during faulting. Comparing the dips in domain I with domain III, one can see that both dips

have rotated from NE to SW and NW to SE respectively. Note also that the dip in the second joint set in domain II (83° NW) has changed from that in domain I (88° SE). The attitude of the joints sets in each domain is a direct reflection of the tectonic activity in the region following diagenesis of original sediments.

Report by Ron Evans.
Photographs by Ron Evans.

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AGSHV members and visitors at Shortland Esplanade examining geological features exposed in the cliff.

Sea Caves at Snapper Point, Munmorah State Conservation Area

Leader: Chris Morton.

Attendance: 17 members; 1 visitor.

Date: Saturday 15th March, 2014.

This excursion was a continuation of the exploration along the coastline south of Newcastle in Munmorah State Conservation Area, where the Moon Island Beach Sub-group of the Newcastle Coal Measures (260ma) is exposed. Ancient riverbed deposits (mainly conglomerates and sandstones) dominate the rugged and sometimes dangerous but spectacular rocky shoreline.

Geological Overview.

The Newcastle Coal Measures is the top stratigraphic group in the Permian sequence in the Sydney Basin. The group extends from the eastern flanks of the Lochinvar Anticline between Maitland and Cessnock eastwards to the coast.

Newcastle Coal Measures stratigraphy is complex with many coal seams splitting and/or coalescing repeatedly. The strata visited on this excursion are the uppermost strata in the Moon Island Beach Sub-group, which is itself the uppermost sub-group in the Newcastle Coal Measures. These strata include the Karignan Conglomerate, which is overlain by the Vales Point Coal Member, the uppermost Permian unit.

Munmorah Conglomerate, the lowest unit in the Triassic Narrabeen Group, overlies the Vales Point Coal Member, usually with an eroded contact.

The table on the next page shows the stratigraphy at the Permian/Triassic boundary. This boundary between the Permian and overlying Triassic rocks spans the Permian/Triassic (P-T) mass extinction event (253ma) in which an estimated 57% of all biologic families and 95% of all species of marine animals became extinct. The Cretaceous/Tertiary (K-T) extinction is small in comparison.

Excursion Detail.

The Sea Caves at Timber Beach can only be entered at low tide and calm seas and an intense low pressure system off the coast was of concern. Fortunately the swell, although rising, was still small enough to enable the visit.

Stratigraphic Column of the upper part of the Permian Moon Island Beach Subgroup and the lower part of the overlying Triassic Narrabeen Group. (Williams 2012)

Period	Rock Units		Lithology
	Group	Sub-Group	
Triassic	Narrabeen Group	Clifton SG	Munmorah Conglomerate
Permian	Newcastle Coal Measures		Vales Point Coal Seam Member Karignan Conglomerate Member Wallarah Tuff member Wallarah Seam
		Moon Island Beach SG	Teralba Conglomerate member

From the car park above Timber Beach the view to the north is stunning. Looking across to the eroded hillside, the prominent Vales Point Coal seam (which overlies the Karignan Conglomerate) is exposed.

Near the top of the coal seam is a tuff band weathered to white clay swathed in green vegetation. This is against the backdrop of the famous local golden sun-drenched beaches stretching up to Stockton Beach. Looking down from the car park, Flat Island and Ghosties Beach can be seen bordered by the beautiful mottled blue of the Tasman Sea. The mottling was caused by shadows from the intermittent cloud cover, submerged rocks and the ruffling of the water by the cool and light NE breeze.

The track down to Timber Beach is very steep and badly eroded but care was taken. There are some good examples of red ochre (iron oxide) concretions *(photo 1)* in the indurated sand that overlies Karignan Conglomerate. The regular foot traffic on the track has worn away the soil layer, leaving the distinctive red outline of the oxide concretions.

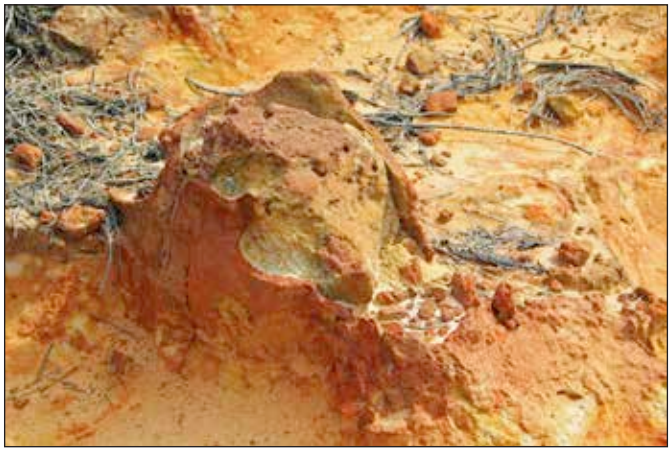
Timber Beach is a small alcove that has been eroded out of Karignan Conglomerate beds formed from ancient river deposits. The cliffs that line the small beach expose a cross section of a riverbed deposit which has many sedimentary and fluvial structures including cross-bedding, bedding planes, channel bars, point bars, concretions and fossilised branches from trees that have been buried in the river bed *(photos 2 & 3)*. Also visible is the imbrication of pebbles, which can indicate the flow direction of the river.

The erosion of the cliffs to form the beach has occurred from two directions. Firstly, from below where a small cave would have formed along a joint allowing the sea to mechanically wear away at the conglomerate.

Secondly, from above where creek water tumbling down the hillside would have further eroded the rock from the top *(photo 4)*. As the two erosive fronts progressed landwards and towards each other, a significant gap in the cliffs would have formed allowing further erosion to expand the gap forming the current Timber Beach.

Access to the sea cave is best attempted between February and early April due to the amount of sand deposited on the beaches and the very low tides at this time of year. Planning an exercise such as this should be taken with the utmost care.

The cave entrance is difficult to locate and entry is dependent on surf conditions that may vary from ankle deep to waist deep water *(photo 5)*. Access is through a small cave at the base of the cliff that has a large column supporting the overhead hillside and the two other caves



1. Iron oxide concretion on track to Timber Beach.

2. Petrified wood within Karignan Conglomerate.

3. Cross-bedding, concretions, scour and fill features.

5. Approaching a cave entrance at the base of the cliff.

adjacent to it *(photo 6)*. The small cave, once entered, has a very low ceiling of the jagged and rocky Karignan Conglomerate. Within about 20 m, the small entrance opens into a vast cavern, which has been eroded out by the relentless wave action along a joint plane, a common feature of the conglomerate.

The approximate dimensions of this enormous cave are 60 m wide, by 100 m long and 10 m high *(photo 7)*. There are many openings for the sea to come crashing in, with one particularly large entrance on the south-eastern end. The effect of the waves filling the cave entrances and dimming the light, and the noise of the waves reverberating around the cave can be somewhat overwhelming.

It is unusual that safe access to this cave is limited to 2 or 3 months of the year so, unlike other more accessible areas, the animal life here has flourished. There are many sand and waratah anemones, crabs, elephant snails, turban shells, star fish, cunjevoi (sea squirts), tube worms and the odd moray eel, to mention a few. The walls of the cave have a subtle pink hue due to a pink coralline algae, and in some places, there is also some orange coralline algae growing.

Society members moved from rock pool to rock pool with their torches in hand or just stood transfixed trying to take in this rare and exciting experience, while others tried to capture the ambience with their cameras.

The rising tide and sea all to soon required the group to exit the cave and move to the northern end of the beach where the remains of fossilised tree branches were found at the edge of the rock-shelf.

The cliff face towering above this area has many interesting fluvial sedimentary structures *(photo 8)*. There are multiple examples of cross bedding, evidence of point bars in those ancient stream beds, and excellent transverse cross-sections of anastomosing stream channels characterizing the braided rivers that were active in this region.

A small cave here contains a good example of calcite flowstone on its ceiling. The calcite has leached out of the overlying rock and has built up over the uneven upper areas to form some small stalactites.

Erosion along the bedding plane that forms the floor of the small cave, revealed a definite demarcation in the fluvial struture that can be observed at the northern side of the opening. The floor of the cave has been eroded along joints to create an interesting blocky structure *(photo*

4. Stream erosion of Karignan Conglomerate.

6. Entering a passageway leading to the main cave.

7. Main sea cave located under the cliff of conglomerate.

9. Differential weathering in jointed conglomerate.

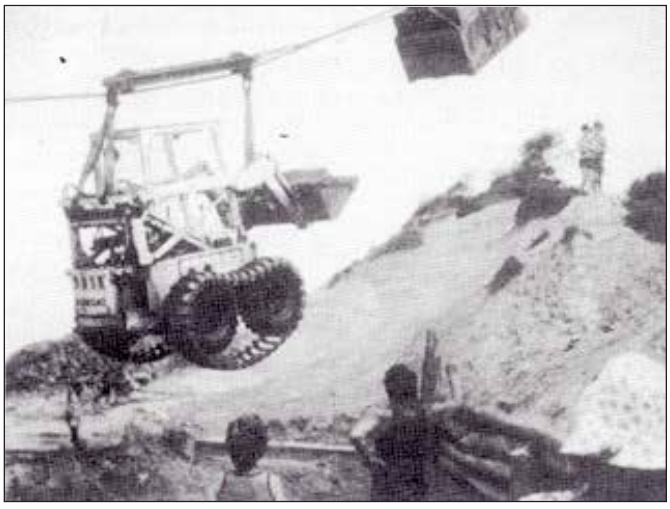
9). In the beds above the cave, there are some prominent concretions that have a thin shell of iron oxide. On the rock platform below, a few smaller concretions can also be found and some of these have had the outer shell of the concretions abraded by wave action, allowing the shell and inner parts of the concretion to be examined.

From Timber Beach the group trudged up the hot sweaty ascent to the car park at the top to then drove to Snapper Point where a very large spectacular cave entrance at the end of a small inlet can be viewed from an area fenced off from a precipitous cliff *(photo 10).*

10. Large sea cave with Vales Point Coal Seam above, observed from the lookout at Snapper Point.

This seemingly inaccessible cave has an interesting history. In the 1950's, a Mr Frisby operated a pebble mining operation here as the cave contains pebbles weathered out of the conglomerate. To remove the gravel from the cave, a gantry was built on the headland and a cable anchored into the cave about 25 m from the top of the cliff face. This enabled a bobcat to be lowered down into the cave *(photo 11)*, approximately 100 m away, followed by a skip which was loaded by the bobcat, then hauled back to the top where the gravel was loaded onto trucks. When the work was completed, the skip followed by the bobcat was then hauled back to the cliff top.

8. Many sedimentary structures are present in the cliffs.



11. Mr. Frisby's bobcat being lowered into the cave.

The gravel was used as aggregate for decorative concrete in various parts of NSW, including the Bankstown Civic Centre, the facia of Wynyard Station and as far away as Broken Hill.

Mr Frisby continued his operation until his permissive occupancy was revoked when the land became part of the State Recreation Area in 1977 (Butler, 1992). It has since changed status to a State Conservation Area. All except the concrete foundations of the gantry have been removed for safety and aesthetic reasons.

From the viewing position, a small normal fault (with a displacement of about 1 m) could be seen in the cliff above the cave entrance *(photo 12)*. The fault plane would have provided a zone of weakness for erosion to form the cave.

Above the faulted Karignan Conglomerate, the dark Vales Point Coal Seam Member could be seen, while overlaying it was the Munmorah Conglomerate of the Triassic Narrabeen Group. This view spans the Permian/Triassic boundary, the time at which the greatest mass extinction of life forms on Earth occurred.

From Snapper Point headland, the very picturesque and popular surfing and fishing spots of Fraser Beach and Wybung Head can be seen. The word Wybung is an aboriginal word said to mean dangerous seas (Butler 1992). Wybung Head has a prominent cleft in the headland and there is rumour that the aboriginals mined a coal seam using the cleft for access. It is interesting that long before Europeans discovered coal the aborigines were utilising coal. There is also reference to coal being found in middens a short distance from here at Mooney Beach.

The Use of Coal by Aboriginal People.

The Awabakal people of Lake Macquarie and Newcastle used coal for fire to prepare food and references to coal were made in their myths and legends. The territory occupied by the Awabakal people

12. Small fault above cave. Note displacement of coal seam.

13. Eroded shale bed indicates Permian/Triassic boundary.

encompassed Newcastle, Lake Macquarie, Central Coast to Wyong, the coalfields area and the Watagan Mountains to Wollombi, an estimated area of 1800km^2. In the Awabakal language the word for coal was "nikkin" and Lake Macquarie was called Nik-kin-ba meaning "the place of coal".

Coal was highly visible in the Newcastle landscape at Reid's Mistake at the entrance to Lake Macquarie, and at Nobby's Head. In 1830 Sir Edward Parry had commented that the seam of common coal at Reid's Mistake was 8 feet thick and of good quality, "close to the beach, indeed upon it" and that the "coal crops out in a broad seam upon the rocks which are dug at low water". The Rev. Lancelot Threlkeld (1788-1859) stated that open burning coal was visible in Lake Macquarie "upwards of twenty miles from East to West and in some places eight miles from North to South". Furthermore, three or four miles from Reid's Mistake underneath a "point called by the Aborigines Mu-nu-kan...there crops out a seam of canal coal, beneath which is a seam of superior common coal, both jet into the sea in three or four fathoms of water". He also noted that Lake Macquarie had "a projecting seam of excellent coal of the caking description" which burnt "with a bright flame, throwing out great heat". Evidence of coal use has been found in beach and dune middens in Lake Macquarie at Swansea Heads and Ham's Beach, and on the Central Coast at Mooney Beach. It shows that coal was used by the Aboriginal people for cooking fish, shellfish and abalone. Dating of the occupation level of a beach midden at Swansea found that coal was used well over one thousand years ago. The women of the Awabakal tribe fished with hand lines from canoes with a small fire burning on a clay pad in the canoe. Percy Haslam in his lecture on the Awabakal people in 1981 described the canoes and their fires: "Bark canoes made from a single flawless sheet of stringy bark, were used to criss-cross Port Stephens, Lake Macquarie and other waterways in the region. There was always a characteristic clay mound, often in the stern, where a small fire was kept burning while the canoes were in use." Threlkeld noted that the fires were used not only to warm hands and feet, but principally used to roast bait of either cockles, fish or flesh from the star. The women also cooked fresh fish whenever they were hungry. (Sherwin, 2013)

This part of the coast in particular is a very dangerous area. The memorial cairn erected by Toukley Rotary Club at Snapper Point headland is testimony to this. Not all, but many of the poor souls that have perished here have had their names engraved on the plaque, which has been secured to the memorial. Many surf lifesaving rescues are carried out every year, not always successfully, necessitating the installation of a number of lifebuoys secured along the rocks as a safety precaution for the many fishermen and tourists who visit this area.

Another of the features here are the well developed joints filled with iron oxides which have precipitated out of the water permeating through the rock. One of these joints closer to the water has been weathered out to create a fissure the length of the rock platform, leaving a 600 to 800 mm wide step-over from one side to the other. Any miss-judgement would cause a plunge into the crevice to be dashed against the walls by the surf, with no way out. Sadly there is a plaque on the memorial for a young girl who suffered this fate.

Permian/Triassic Boundary.

To conclude on a more positive note, this area has long been one of the few sites in the Sydney Basin where the Permian/Triassic boundary is exposed, although usually an eroded contact, making this area an important site for future research *(photo 13).*

In her thesis: The Permian-Triassic mass extinction event in the Sydney Basin, Eastern Australia, Megan L. Williams (2102), concludes that:

"New evidence regarding the position and nature of the Permian/Triassic Mass Extinction (PTME) in the Sydney Basin has been obtained. The PTME occurs within approximately 1 m of the top of the last Permian coal and takes the form of a closely-spaced double negative $\delta^{13}C_{org}$ excursion rather than being instantaneous, a feature not observed before in this region. This uniformity of a $\delta^{13}C_{org}$ signature across a non-marine basin stands in contrast to the latest results from Karoo Basin.

With this evidence and that from other sources, it is reasonable to conclude that the Permian/Triassic Boundary, the most significant mass extinction the earth has experienced, may be in evidence within the sediments at the top of the Vales Point coal seam at Snapper Point, Munmorah State Conservation Area.

Report by Chris Morton.
Photographs by Ron Evans.

References:

BUTLER, V. (1992). *Links with the past of Munmorah State Recreation Area.*

SHERWIN, M. (2013). *The Use of Coal by Aboriginal People.* People and Place/coal and Community University of Newcastle & Allied Coal. http://www.coalandcommunity.com/coal-and-theaboriginal-people.php

WILLIAMS, M. L. (2012). *The Permian-Triassic mass extinction event in the Sydney Basin, Eastern Australia.* http://ro.uow.edu.au/cgi/viewcontent.cgi?article=4544&context=theses

An interesting feature below the Permian/Triassic boundary was dome tessellated pavement in a grey sandstone.

Note the iron oxide enriched joint planes running through the sandstone.

Mulbring Quarry

Leader: Ron Evans.

Attendance: 27 members; 7 visitors.

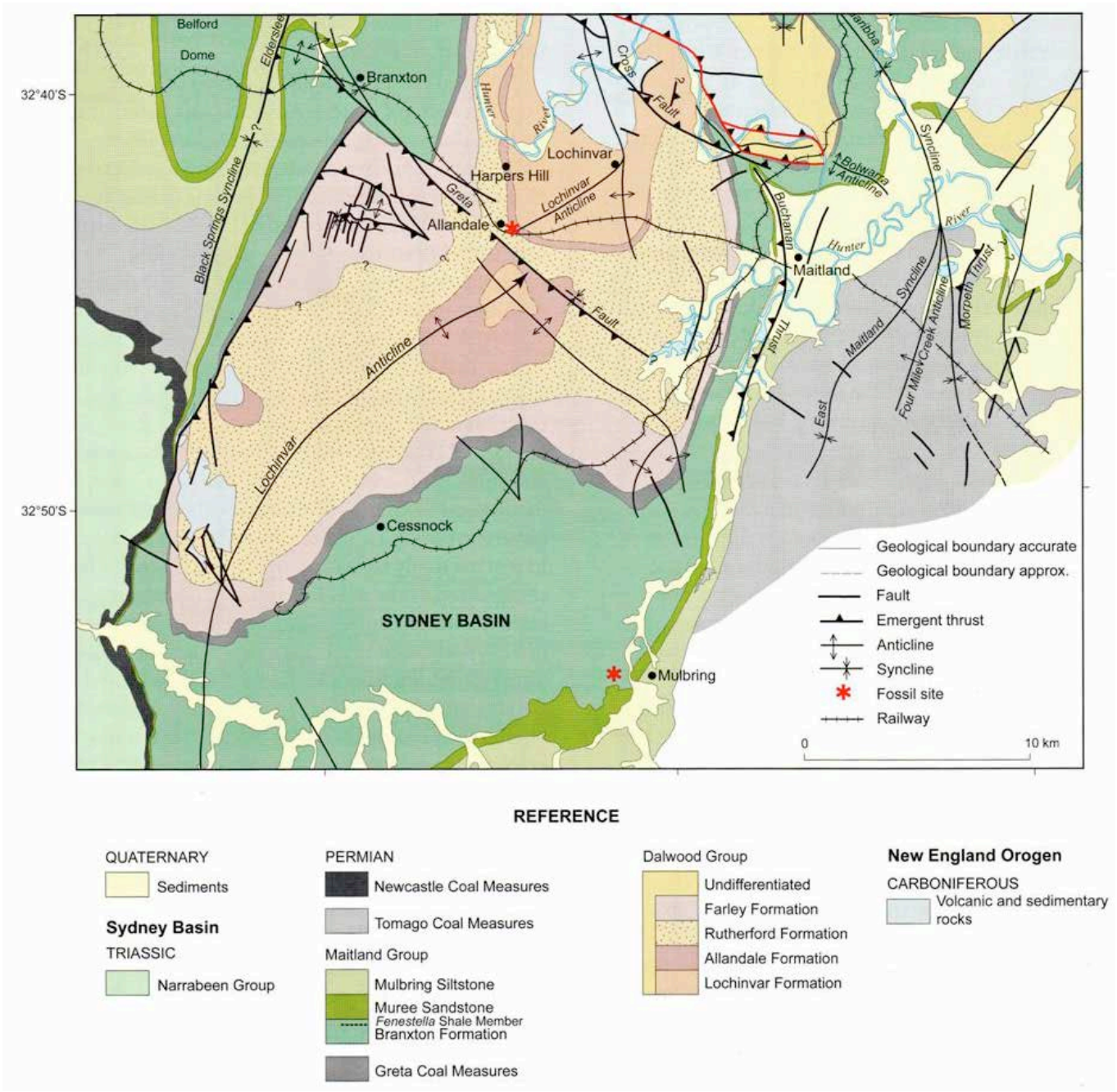
Date: Saturday 5th April, 2014.

Mulbring quarry is on private land and was once used as a source of road base by Cessnock City Council. It was first noted as a fossil locality by Branagan and Packham (1967). Despite the wealth of fossils found at the quarry, very few specimens from there have been described in the scientific literature, and the stratigraphy and depositional environment of the strata at the site have only recently been documented in an unpublished thesis (Vanderlaan 2007). Percival, *et. al.* 2012, gives an exhaustive overview. Access to this site is strictly at the discretion of the landholders, and their permission must be obtained prior to entry.

Stratigraphy.

In Mulbring quarry, the Fenestella Shale member of the Branxton Formation, the lowermost unit of the Maitland Group, is exposed. The Fenestella Shale Member is 30 to 60 m thick, and consists of interbedded yellowish brown micaceous shale and siltstone, with sparse bands of very thin calcareous mudstone (Booker 1957).

Regional geology map showing the site of Mulbring Quarry. (Percival, et. al. 2012)



Stratigraphic Column of the Permian Period, Hunter Valley. (Nashar, 1964)

Era	Period	Rock Units		Lithology	Fossils
		Group	Sub-Group/Fm		
PALAEOZOIC	Permian	Newcastle Coal Measures	Moon Island Beach SG	Coal, tuff, massive conglomerate	Plants
			Boolaroo SG	Irregular coal, tuff	Plants, insects
			Adamstown SG	Massive conglomerate, tuff, coal	Plants
			Lambton SG	Coal, sandstone, shale, minor conglomerate	Plants, insects
			Waratah Sandstone	Cross-laminated sandstone	
		Tomago Coal Measures	Hexham SG	Shale, mudstone, sandstone, thin coal seams, clays	Plants
			Four Mile Creek SG	Sandstone, shale, mudstone, coal seams, tuff	
			Wallis Creek SG	Sandstone, shale, mudstone, thin coal seams	
		Maitland Group	Mulbring Siltstone	Sandstone, siltstone, conglomerate	Rich marine fauna
			Muree Sandstone	Tillitic conglomerate, sandstone, erratics	
			Branxton Formation	Sandstone, sandy siltstone, erratics	
		Greta Coal Measures		Sandstone, shale, lenticular conglomerate, splitting coal seams	Plants
		Dalwood Group	Farley Formation	Sandstone, shale, mudstone, siltstone, erratics	Rich marine fauna
			Rutherford Formation	Lithic sandstone, micaceous siltstone, mudstone, shale, erratics	
			Allandale Formation	Lithic sandstone, tuffs, conglomerates	
			Lochinvar Formation	Lithic & feldspathic sandstone, siltstone, shale, tuffs, erratics, basalts	

The site represents the best exposure of the member with macrofauna dominated by abundant bryozoans and brachiopods, associated with bivalves, gastropods, and echinoderms. Some beds contain fossil debris, including fragmented gastropods, isolated echinoderm ossicles and small brachiopods. Percival, *et. al.* 2012.

Fossil Fauna.

A diverse range of fossils are found in the rocks of Mulbring quarry, with bryozoans (fenestellids) and brachiopods (spiriferides and productoids) being the most common with bivalve molluscs the next most abundant.

Minor groups include gastropods, rostroconchs, corals, trilobites and several types of echinoderms, including crinoids and blastoids (the latter exceptionally rare). Foraminifers are common in thin sections of a breccia horizon.

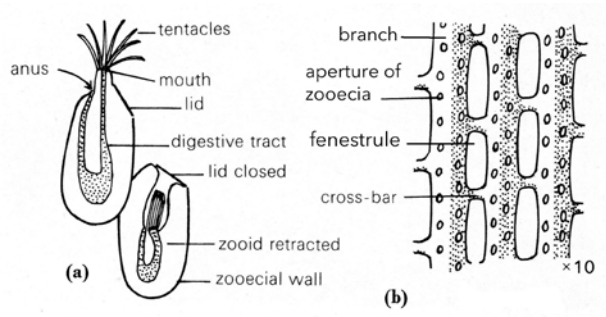
A large proportion of the fossils found are predominantly complete and unfragmented. Brachiopods and bivalve molluscs exhibit high levels of articulation (segments are found still attached together), indicating a low-energy environment on the marine shelf, below wave base for much of the time. There is very little evidence of predation or predators. Percival, *et. al.* 2012.

Rare fossils have been found from time to time. These include nearly complete stalked crinoids (an Echinoderm), the trilobite *Doublatia inflata*, and the blastoid *Calycoblastus casei* Brown is known from one specimen.

Common Fossils found at Mulbring Quarry.

Bryozoans.

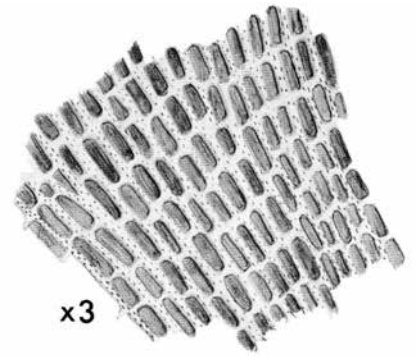
Bryozoans are tiny sessile aquatic animals that grow a protective skeleton, most commonly calcareous. Bryozoans live in colonies called a zoarium, the individual animal being called a zooid. They feed by filtering micro-organisms from water.



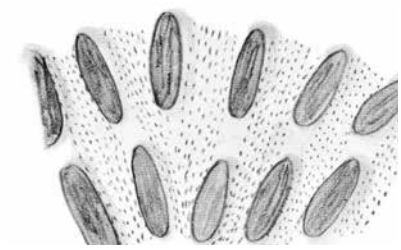
(a) Two zooecia showing the position of zooids (animals) when open and closed.

(b) Structure of *Fenestella* zoarium (colony). Note the two rows of zooecia per branch, a feature of *Fenestella*. (Black, 1970).

The most common Bryozoans found are *Polypora* sp., *Fenestella sp.* and *Stenopora sp.*



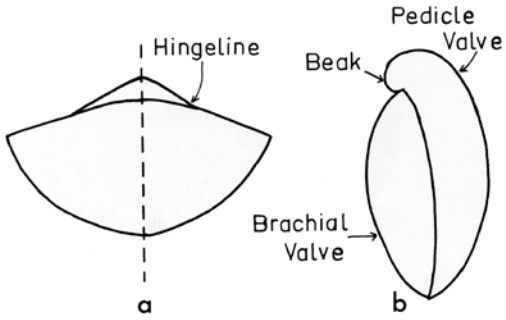
Fenestella sp. Two rows of zooecia per branch.



Polypora sp. Many rows of zooecia per branch.

Brachiopods.

Brachiopods are marine bivalve organisms. The shells are unequal in size, but are bilaterally symmetrical (see diagram). The valves are joined along a hinge-line above which is the beak. The size of the shells, ornamentation and length of hingeline varies. They evolved in the Cambrian Period, were once the most abundant life forms and still exist today in reduced genera.



a. Bilaterally symmetrical; b. Unequal valves

Common brachiopods found in the Mulbring Quarry include spiriferides such as *Notospirifer sp., Ingelarella sp., Trigonotreta spp.* and *Echinalosia* (a productoid).

Ingelarella

Spiriferoide
Ribbed valves with a hinge-line longer than shell height

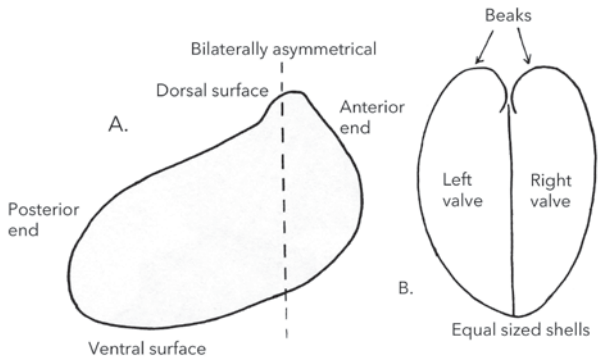
The productoid *Dictyoclostus*. Note small brachial valve

Molluscs.

Molluscs are soft-bodied invertebrates, most of which secrete a protective hard external shell. There are three extant classes: bivalves, gastropods and cephalopods, which have many prehensile arms. e.g. octopus, squid, cuttlefish, nautilus.

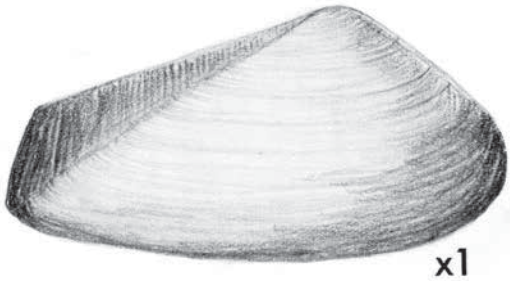
a) Bivalves.

These organisms have a laterally compressed body that lives between two calcareous valves that have equal valves but are bilaterally asymmetrical.

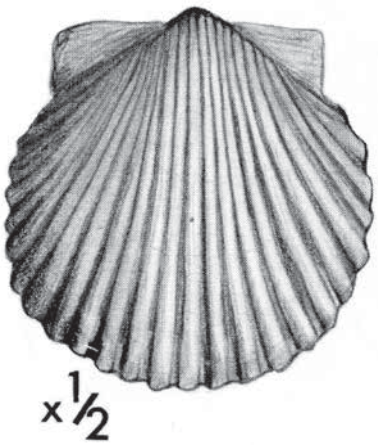


The group is entirely aquatic with most living a sedentary life in shallow waters.

Bivalves commonly found at Mulbring quarry include *Myonia sp.* and *Deltopecten squamuliferus*, which can grow very large.



Myonia sp. Note the straight shell on the dorsal surface

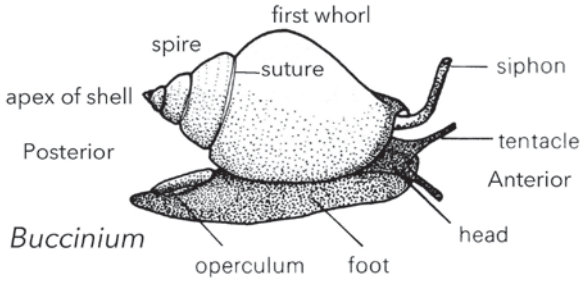


Deltopecten sp.

Note: Unless otherwise indicated, drawings are from Nashar, 1964.

b) Gastropods.

Gastropods have an asymmetrical body (it is coiled) with a distinct head at the anterior end, and a muscular creeping foot at the ventral surface. The body is protected by a single shell (univalve) that tapers and coils usually in a right handed spiral (see diagram of *Buccinium*), Black, 1970.



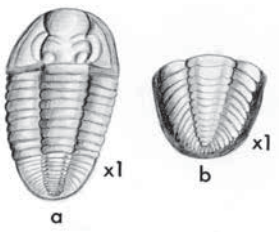
Gastropods are the most abundant group of molluscs today occupying the greatest range of habitats. The majority live in the sea while others live in fresh water and on dry land.

Keenia sp. may be found at Mulbring Quarry

Other Fossils.

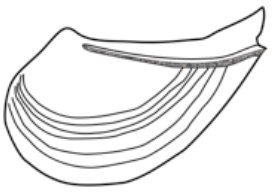
Corals.

Solitary rugose corals such as *Zaphrentis* may be found.



Trilobites.

Moulds of the trilobite *Doublatia inflata* have been found, either as a whole specimen or in parts.

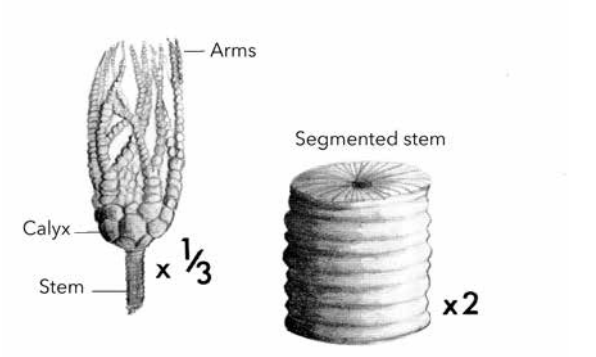


Rostroconchs.

Generally small (2 cm) molluscs that had a pseudobivalved shell (no hinge).

Crinoids.

These belong to the phylum Echinodermata. They are marine animals that have an exoskeleton of calcareous plates. Calcareous stems form the most common fossils found. However rare complete crinoid fossils have recently been found at the Mulbring Quarry.



One specimen of a minor echinoderm, the blastoid *Calycoblastus casei* Brown was a rare find.

Palaeoenvironment.

The palaeoenvironment and conditions of deposition at Mulbring quarry has been the subject of academic research, summarised in Percival, *et. al.* 2012. Vanderlaan (2007) concluded that the deposition of the specimens took place in a quiet shallow marine, low energy environment.

The shells and skeletal remains within the Fenestella Shale member strongly suggest that the faunal assemblages were deposited after death. Random orientations of shelly fragments, persistent loss of the calices in crinoids (although large stem sections are well preserved), minor overlapping and nested valves of brachiopods, and alignments of fenestellid skeletons suggest minimal transport postmortem, indicating the presence of death assemblages.

The position of the site on the continent can also be inferred by the high levels of lithic material and the presence of wood fragments (Vanderlaan, 2007) indicating that the original site of deposition was mid-continental shelf below the normal wave base and at high latitude. Vanderlaan (2007) notes that the presence of drop stones is an indicator of a cold-water environment with seasonal ice cover. The drop stones and wood fragments however are quite small and are not common but still occur.

Excursion Details.

Members and guests gathered in Mulbring Park on an overcast morning. Ron welcomed new members and guests and thanked the large group for attending. A brief geological outline of the environment that was thought to have existed in the area at the time of deposition was given, as well as an explanation of how the environment determined the species of fossils found.

Ron briefly explained that most of the fossils to be found in the Mulbring quarry were moulds or internal casts because the original hard material (shells for example) had been dissolved away by groundwater. He demonstrated how a piece of plasticine could be used to make a quick cast of a fossil specimen to get a more accurate picture of its shape and structure.

Examples of fossil species likely to be found in the quarry were passed around while Ron outlined distinguishing features of the different fossil groups and invited participants to ask plenty of questions in the quarry while fossicking.

All present then drove into the quarry, parked and spread out to fossick *(photo 1)*. Interesting specimens were placed on central slab of rock so others could look at them.

After 1½ hours, Ron gathered the group around the collected specimens and answered questions pertaining to the fossils found and how they formed. Many fine specimens had been discovered. (See photos pages 23 & 24) Most of the group then drove into the Kurri Kurri Bowling Club where a fine lunch as enjoyed by all.

Report By Ron Evans.

Photographs by Ron Evans and Barry Collier (1 and 2).

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1. Mulbring Quarry - starting to fossick.

2. 'People, look what I've found!'

Split slab of fine sandstone displaying a fossil assemblage typical of the Fenestella beds in Mulbring quarry. Fossils present are two species of bryozoans *(Polypora and Fenestella)* and two groups of brachiopods (productoids and spiriferides). The red/brown colouration is due to iron oxides that leached into the spaces left when the original fossil material was dissolved out of the rock.

Small fan-shaped *Fenestella* colony. The original calcareous skeleton is preserved. Rows of zooecia can be seen along the arms.

Iron stained *Polypora* (bryozoan) mould displaying many rows of zooecia per branch.

Mould of a Crinoid stem and supporting root-like growth (bottom left). Note the ribbed sections in the fossil. These were formed by calcareous platy discs making up the stem.

Stenopora (mat bryozoan) displaying zooecia along its branches. A small gastropod (spiral shell) can be seen under the lower branch.

Brachial valve of a productoid brachiopod showing the position of its spines (small holes).

Small *Deltopecten* fossil.

Ribbed spiriferide shells, bryozoans and a gastropod.

Split rock slab exposing *Myonia sp.* fossils.

Zaphrentis, a solitary coral. The centre of the fossil is a rock cast showing internal structure. The slits were made by calcareous septa that supported the soft tissue of the living coral polyp.

South Maitland Coalfield

Leader: Winston Pratt.

Attendance: 17 + 15 members.

Date: Wednesday 2st May & Saturday 1st June, 2014.

Introduction

The name South Maitland Coalfield, as used when the field was in its heyday and will also be used for this excursion, has been superseded as it is now included in the Newcastle Coalfield.

The dominant structural feature of the South Maitland Coalfield is the shallow, southerly plunging Lochinvar Anticline. In the northern half of the anticline the axis gradually swings to the north-east before being truncated by the Greta Fault. The axis is then shifted westwards and continues in a north-easterly direction from Allandale to Lochinvar where it the turns north-westwards before being terminated by the Hunter Thrust Fault *(see page 18)*. This north-western flank is also known as the Greta Coalfield.

Along the axis of the Lochinvar Anticline erosion has exposed the basal Carboniferous rocks in the far north. Southwards the stratigraphy is exposed in sequence with the lowest Permian unit, the marine Dalwood Group, comprising in ascending order: the Lochinvar, Allandale, Rutherford and Farley Formations. This group is overlain by the Greta Coal Measures which subcrop almost continuously along the eastern, southern and western flanks of the Lochinvar Anticline. The Greta Coal Measures are then overlain by the marine Maitland Group comprising in ascending order: the Branxton Formation containing the Fenestella Shale member; the Muree Sandstone and the Mulbring Siltstone.

The Greta Coal Measures are 63 m thick in the type area near Greta, reach a maximum thickness of 90 m, and consist of conglomerates and sandstones with subordinate siltstones and mudstones, often carbonaceous.

Several coal seams occur as the two main seams, the Greta Seam and the underlying Homeville Seam each of which split and coalesce throughout the Coalfield. On the southern nose of the Lochinvar Anticline the Greta Coal Measures have a shallow dip, but along both the eastern and western flanks the dips become steeper.

In its heyday there were up to 26 mines operating simultaneously on the South Maitland Coalfield and 3

on the Greta Coalfield. Today there is only the Austar Coal mine, an amalgamation of the former Ellalong, Pelton, Cessnock No. 1, and South Bellbird collieries, still operating and mining the Greta Seam.

The Excursion.

Part 1 - Northern Section

On Wednesday morning 24th May 2014 in perfect weather, 17 members met at the 'Log of Knowledge' Park in Kurri Kurri for Part 1, the northern section of the South Maitland Coalfield Excursion.

'Log of Knowledge' Park

In the early 1900's a bullock wagon master delivered 4 logs to the township of Pelaw Main from Brunkerville. The logs were situated in Neath Street, Abermain Street, Stanford Street and Pelaw Main Colliery. The senior men of the Pelaw Main area, after working in the local mines, would meet at the logs (as clubs and halls were not available) and discuss local issues.

These logs have now been relocated and arranged as a heritage memorial together with some explanatory plaques at the 'Log of Knowledge' Park *(photo 1).*

Swamp Creek, Abermain

After car pooling in Kurri Kurri CBD, the group viewed the location at Swamp Creek, Abermain, where Sir TWE David located outcrop of the Greta Coal Measures in the bed of Swamp Creek. These Coal Measures were already known from the Maitland district and following this discovery David was then able to map them back towards Maitland and further south-west to beyond Paxton. This enabled the exploitation of the Greta Coal Measures through the development of the South Maitland Coalfield. While early photos show outcrop in the stream bed, sediment deposited since, probably from mining activities, and combined with vegetation has obscured any sign of outcrop (*photo 2).*

Great North Road, Sawyers Gully Precinct

The group then headed north meeting the Old Maitland Road, (one of the branches of the Great North Road which was included in an earlier excursion), at The Sawyers Gully Precinct where several of the original stone culverts have been restored. The narrow and winding road and lack of safe parking precluded a visit.

Ravensfield Sandstone

Further north a stop was made to examine some blocks of the Ravensfield Sandstone which had been relocated to the roadside from the famous but now disused and not accessible quarry. Unfortunately since the reconnaissance the blocks had been removed for roadworks, but at least a sample was passed around. The marine sandstone is fine grained and is a high quality dimension stone which has been widely used in the Maitland district.

Farley Formation & T W E David's Camp Monument

Immediately after passing under the Great Northern Railway bridge on the eastern side of the road was an outcrop of the Farley Formation with marine fossils which have now been almost completely picked over by fossil collectors. A few hundred metres to the west is the Memorial Stone marking the site of David's camp while he carried out his mapping work. The site is on private property and access is not permitted.

1. Church Log at 'Log of Knowledge Park", Kurri Kurri.

2. Location of David's discovery of the Greta Coal measures at Swamp Creek, Abermain.

Exposure of Greta Coal Measures

At Telarah a weathered outcrop of the Greta Coal Measures and its enclosing sediments were examined *(photo 3).* The exposure revealed a small shallow plunging anticline with some small parasitic folds on the limbs.

At the junction of the now Wollombi (Old Mailtand) Road and the New England Highway there are overgrown adits to the Greta Coal on the east at the bottom of a partially filled quarry.

3. A weathered seam of the Greta Coal Measures exposed at Telarah.

Old Toll Gate

On 21 September 1863, at the Toll Gate located at this intersection, the bushranger Fred Ward gained his alias 'Thunderbolt'. It was 6 am when Fred began knocking loudly on the Toll Gate house to rouse Mr O'Brien, the gatekeeper. O'Brien looked out of the gatehouse window and called out "who dares to make such a thundering noise?" Fred replied "I am 'Thunderbolt', the noise I made was the thunder, while this is the bolt", pointing a revolver at O'Brien's head and ordering him to 'bail up'.

Allandale Railway Cutting

The next stop was at the Allandale Railway cutting where the exposure is designated as the type section of the Allandale Formation. A pebble conglomerate bed within the enclosing sandstones and containing Lower Permian marine fossils is exposed in the cutting. Recently the cutting has been widened considerably to accommodate an additional rail line and access road. This work necessitated the removal of the brick bridge over the cutting and the removal of a considerable amount of rock which contained many fresh fossils.

4A. <u>*Eurydesma cordatum*</u> showing the thick shell of the left valve.

The fossils at this location were discovered during the construction of the Great Northern Railway in the 1860's. The fauna at this site is dominated by the bivalve *Eurydesma cordatum* with the gastropod *Keenia ocula* a lesser component. *(photos 4A & 4B)* The *Eurydesma* species *cordatum* has a greatly thickened umbo region of the shell, in comparison with the species *hobartensis*, and this is thought to be an adaptation to aid survival amongst the larger pebbles and boulders in the conglomerate at this location. Percival *et. al.* 2012.

4B. <u>*Keenia ocula*</u>, a gastropod.

Harpers Hill

Returning to the New England Highway, the route climbed Harpers Hill where a realignment of the road in the 1970's has exposed the Allandale Formation. Permian marine fossils were recorded from this locality in 1831 by

Survey-General Major Thomas Mitchell.

The suite of fossils found in the Allandale Formation together with those found in the underlying Lochinvar Formation is known as the 'Allandale fauna'. This Allandale fauna is considered to be amongst the earliest Permian faunas in the Sydney-Bowen Basin.

These fossil sites together with those in the Farley and Rutherford Formations helped define the initial Permian stratigraphy comprising the Lower Marine Series (Dalwood Group) overlain by the Lower Coal Measures (Greta Coal Measures), overlain by the Upper Marine series (Maitland Group) in turn overlain by the Upper Coal Measures (Tomago and Newcastle Coal Measures)

Greta Cemetery

Continuing on to Greta, the group visited the cemetery and the grave of Norman Laurence Brown. His headstone topped with a broken column signifying a life cut short *(photo 5)*. On 16th December 1929, Norman Brown was killed in the Rothbury Riot, the site of which was subsequently visited. Also of note was the disproportionate number of Mediterranean and eastern-European names on the headstones. This is a result of the over 100,000 Displaced Persons (immediate post- war migrants) passing through the nearby Greta Migrant Camp, the site of which was also subsequently visited.

Greta Rotundas

The Lunch stop was in the park at Greta alongside the New England Highway. In this park are two rotundas, a larger one in the east and a smaller in the west. At the end of the path on the eastern side of the larger is a memorial stone with a plaque inscribed "In recognition of all the nationalities who lived and worked in the Greta Migrant Camp between 1949 and 1960. Their contribution to and enrichment of Australian life is remembered with pride and appreciated."

The western and smaller rotunda has some interesting panels detailing the history of Greta and also detail and many photos of the Greta Army and then Migrant Camp *(photo 6)*.

The Branxton Inn

Travelling westwards on entering Branxton, the Branxton Inn was seen. The Branxton Inn was built on the site of the Shamrock Inn and some of the parts of the Branxton Inn date back to 1834 *(photo 7)*.

5. The grave of Norman Laurence Brown with its broken column signifying a life cut short.

6. Western Rotunda with information panels at Greta.

7. The 'Branxton Inn' built on the site of the 'Shamrock Inn' which was held up by the 'Jewboy Gang'.

In 1825, the Jacob's Mob gang of four, the first organised gang of bushrangers in the Lower Hunter, robbed the homestead of Mr Lesly Duguid. A detachment of several soldiers caught up to the gang at Back Creek, just west of Branxton. In the ensuing gunfight Riley was fatally shot and Cleary was severely wounded. Clinch and Price escaped but were later captured by workers on the Duguid estate. The property on which the Allandale quarry (to be visited possibly next year) is sited is named 'Glen Duguid'. The Jewboy Gang was also active in this area on 1st December, 1840 when they held up the Shamrock Inn. The 'Jewboy' Gang was mentioned in the earlier 'Great North Road and Wollombi Valley' excursion and will be met again at the Red House Inn in Part 2 of this excursion.

8. The Rothbury Riot Memorial plaque.

Rothbury Riot Memorial

Southwards from Branxton stands the Rothbury Riot Memorial *(photo 8)*, which commemorates the Rothbury Riot in which 29 year old miner Norman Brown, whose grave was visited in Greta Cemetery was fatally shot by police and 45 other miners were injured.

In 1929 mine overproduction combined with falling coal prices significantly decreased the profitability of Hunter Coalfield mines. On Thursday 14th February 1929, the Northern Collieries Association (the colliery owners) gave their 9,750 employees 14 days notice to accept new conditions which the miners refused to accept as they were under a Federal award which had another year to run and these conditions were below the award conditions and hence illegal. The Association responded on Saturday 2nd March 1929, when all miners were 'locked out' of their employment.

The State Government had taken over the Rothbury Colliery and introduced non-union labour into the mine and called in 400 police officers from districts outside Newcastle to protect the mine and allow entry of non-union labour. On 16th December 1929, about 4000 miners, led by a pipe band, marched to the mine gate for an initially peaceful protest. At the gate the miners were stopped by the police and, after an altercation, the miners became enraged and rushed onto the property only to suddenly be met with savage baton charges by the police. The miners were unarmed apart from sticks and stones. Then the police drew their revolvers and repeatedly shot into the crowd killing one miner, Norman Brown. He was shot in the back and died on the way to hospital.

At Norman Brown's funeral about 6000 miners and their families, led by a pipe band, marched from Brown's home to the cemetery at Greta.

After 15 months of living in abject poverty and starvation and being harassed by the police 'basher gangs', the miners capitulated and returned to work on reduced contract wages on Monday 2nd June 1930. However, the lockout failed to break the resolve or organisation of the miners' union, particularly as many of the miners were WWI veterans, and being shot at and killed by their own countrymen under government orders was incomprehensible. This and the brutality of the police engendered strong feelings of solidarity and resentment and distrust of the police.

Greta Army and Migrant Camp

The return route to Kurri Kurri was via Camp Road which is named after the Greta Army Camp. The Camp was constructed in 1939 for training of soldiers during WWII and was one of the Australian Army's largest camps.

The camp facilities were expanded during the war, with two parts of the camp known as 'Chocolate City' , due to the brown coloured oil stained timber weatherboard buildings in that part of the camp and 'Silver City, due to the corrugated iron Nissan huts built in that part of the camp. Up to 60,000 troops trained here during the war.

In 1949, Greta Camp was transferred to the Department of Immigration and until 1960 it was the second largest migrant camp in Australia. At one stage, 17 different nationalities were represented in the camp.

The Army resumed control of the land in 1962 and after being used intermittently for training exercises it was sold in 1980.

The foundations of several buildings were seen from the road and other structures, including rifle range butts, also remain. Many of the original huts were bought privately and moved to other sites. The blue dwelling on the western side of the road *(photo 9)* was formerly the shop.

Lochinvar Anticline

A stop was made on Majors Lane at a point on the axis of the Lochinvar Anticline. Here the view to the south-west clearly showed the shallow south-westerly plunge of the Anticline while to the north-east the land rose to a shallow dome structure and the site of the igneous intrusion of the Allandale quarry *(photo 10)*.

Sir T W E David Memorial Museum

Arriving back in Kurri Kurri, the final stop was at the Sir T. W. E. David Memorial Museum housed in the old Pokolbin Public School building which was relocated into the grounds of Kurri Kurri High School.

The Museum is an outstanding resource and holds over 4000 items representing the rural and coalfields heritage of the region. To retain the character and function of the building its two classrooms still contain original fittings such as desks and forms, blackboards and wall maps. Rare and old books dating from the 1830's are a feature of the Museum.

Sir T. W. E. David *(photo 11)*, one of the great pioneers of Australian geology, moved from his birth country Wales to take up a position as Assistant Geological Surveyor to the government of New South Wales, Australia in 1882. In April 1886 he began surveying the Hunter Valley Coalfields and in August he discovered the Greta Coal Measures and spent most of the next 4 years mapping and proving up the deposit.

In 1891 David was appointed Professor of Geology at the University of Sydney, a position which he held until his retirement in 1924. After his return from Distinguished Service in World War I, he commenced writing the definitive work 'The Geology of the Commonwealth of Australia'. He unfortunately died before its completion, which was undertaken by his chosen collaborator, Associate Professor W. E. Browne.

Also housed in the Museum is the Jim Comerford Coalfield Library and Archive which contains 60,000 pages of the history of some 26 local towns. This unique history reference library is considered amongst the best in the state.

Jim Comerford was a 15 year old underground pitboy who was present at and witnessed the Rothbury Riot. He subsequently became a Trade Union activist and a highly regarded historian.

The Museum is open on Wednesdays and Sundays from

9. This dwelling on Camp Road was formerly an old shop.

10. Looking NE along the axis of the Lochinvar Anticline where it crosses Majors Lane.
The Allandale quarry is just beyond the low rise in the background.

11. Sir TWE Edgeworth David.

11:00 am to 4:00 pm (Ph 4937 4418) and our appreciation is extended to Mr Brian Andrews, our host at the Museum.

Part 2 - Southern Section

On Sunday morning 1st June 2014, 15 members met at the entrance to Richmond Vale Railway Museum near Kurri Kurri for Part 2, the sourthern section of the South Maitland Coalfield Excursion.

Richmond Vale Museum

The cooling towers for the Richmond Main Colliery's power station could be seen in the distance inside the grounds. These and their pondages for the cooling water would be seen at the end of the excursion *(photo 12)*.

12. The twin cooling towers of the Richmond Vale Power Station, pondage and remains of the Power Station.

John Brown became General Manager of the J & A Brown Mining Co. in 1893 and in 1896, with his foresight, purchased the Richmond Vale Estate. The rail line was then extended from Pelaw Main to provide company-owned rail access to the Richmond Main Colliery (renamed from Richmond Vale by John Brown).

John Brown's foresight was again evidenced in the siting of the power house at Richmond Main, contrary to his engineers' preferred site at Hexham where there was an adequate supply of cooling water. A dam was constructed nearby to pipe water to a pondage and cooling towers at Richmond Main. Modern practice has affirmed John Brown's concept of siting the power station where the coal to fire it is mined.

13. Richmond Vale Dam, spillway, wall and remains of pumping station on far bank.

Richmond Vale Dam

The group then drove to Richmond Vale Road from where the extent of the Richmond Vale Dam and the remains of the pumping station to supply cooling water to the power station at the Richmond Main Colliery could be seen *(photo 13)*.

Tunnel No. 3 & 'Cone-in-cone' structures

Further on, the junction of the Richmond Vale Road and George Booth Drive is located almost above the No. 3 Tunnel on the Richmond Vale Railway. Due to the road traffic on this main road, the difficulty of access and private property, the tunnel portals are out of view. However the approach cuttings and the strata they reveal can be seen. On the eastern side the dominant siltstone strata at this location of the Tomago Coal Measures have a shallow dip to the east. On the western portal the dominant sandstone strata at this location of the underlying Mulbring Siltstone dip to the west at a steep much angle suggesting a faulted

14. Cone-in-cone structures in limestone above No.3 tunnel.
Brian England specimen (R 719) 50 cm across.

contact. (Nashar, 1964).

Limestone rocks near the parking area above the tunnel display 'cone-in-cone' structures *(photo 14)*. These deformation structures are usually found in limey sediments which have been subject to pressure. The lime may have been derived from the dissolution of shelly fossils in the marine Mulbring Siltstone, or more probably these rocks were originally concretions.

Neath Dyke

The route then headed through Kurri Kurri to Cessnock, passing the 'Log of Knowledge' Park and Swamp Creek, Abermain, both visited in Part 1 of the excursion. Between Abermain and Neath a dyke has been recorded in underground mine workings, although there is no outcrop in the swampy surface above. This dyke can be traced for 9 km to the south-east where it is visible in a cutting visited later in the day.

Jim Comerford Memorial Wall

At Cessnock the group visited the Jim Comerford Memorial wall. Jim was awarded an Order of Australia and also an honorary MA from the University of Newcastle for his lifetime of scholarship. His library of archives was visited in Part 1 of the excursion at the T. W. E. David Memorial Museum.

In 2000 a wall with the names of over 1640 miners who have lost their lives in northern NSW coal mines was named after Jim Comerford. The wall is in the gardens of the United Mineworkers Federation of Australia Office in Aberdare Road, Cessnock *(photos 15A & 15B)*.

Aberdare Central Colliery Flywheel

A morning tea stop was made at Turner Park where the Aberdare Central Colliery flywheel *(photo 16)* which came from the winder for 'A' shaft at Aberdare Central Colliery, Kitchener, is on display. It weighs 13 tonnes and when it was disengaged at full speed it took roughly 2 hours to stop. It took the wheel 60 seconds to haul from bank to bank from a 1230 ft (375 m) shaft. When commissioned in 1928 it was part of the biggest winder in the southern hemisphere. The flywheel was decommissioned in 1962. In 1968 the entire colliery was devastated by bushfire and a scrap metal company was sourced to clean up the site.

15A. The Jim Comerford Wall in the Gardens of the United Mineworkers Federation Office, Cessnock.

15B. Commerative sculpture illustrating the history of mining in the region.

16. The 13 tonne Abadare Central Colliery flywheel.

Austar Coal Mine

Between Bellbird and Paxton the route passed the entrance to the Austar Coal Mine, the only mine currently operating on the South Maitland Coalfield.

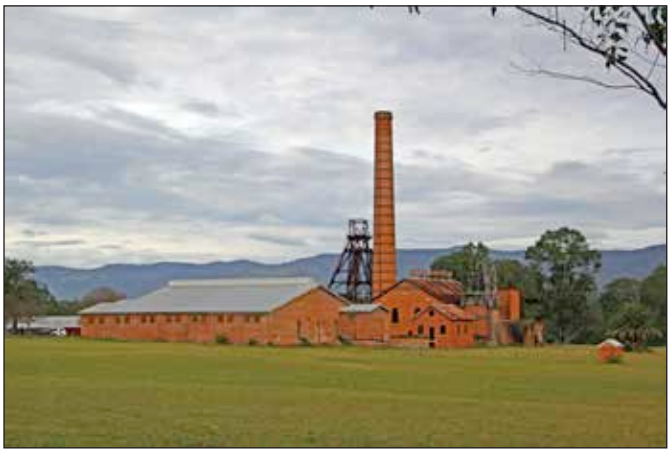
The mine, owned by the Yancoal Australia Group, and formerly known as Southland Coal Mine, was purchased in December 2004 when it changed name to Austar. Operation recommenced in 2006 as part of a $250 million capital investment program to insure long term viability and safety.

The mine is a deep longwall mine producing a premium semi hard coking coal from the Greta Seam and is characterised as the highest fluidity and lowest ash coking coal in Australia. The coal is exported and has become an integral part of many steel producers' coke blends on account of its high fluidity.

Ellalong Lagoon

At the junction of Middle, Millfield and Congewai Roads was a good view of the Ellalong Lagoon *(photo 17)* which is a significant bird habitat, particularly for migratory birds. The surrounding Ellalong Lagoon Conservation Area is 530 ha protecting a significant area of endangered Hunter Lowland Redgum Forest in which there are over 170 species of insects and rare birds. The lagoon hosts four endangered ecological communities, 17 threatened animal species, including a community of two rare frogs. There are over 250 different types of plants, some unique to the area.

17. The Ellerlong Lagoon looking south-east from the Congewai Road turnoff.



18. Main buildings, Stanford Main No. 2 Colliery, Paxton.

Recognised nationally for its bird and fauna qualities the site was acquired in 2012 by Port Waratah Coal Services as another major T4 offset area, with commitment to funding, restoring and protecting the site and opening it up for public use.

Paxton Colliery

At Paxton the buildings of the Stanford Main No. 2 Colliery were viewed *(photo 18)*. This group of buildings, structures and machinery is one of the most handsome, substantial and best preserved coal mine complexes in Australia.

The East Greta Coal Mining Co. opened a new mine, Stanford Merthyr No. 2 on the Ellalong Estate, on the western limb of the Lochinvar Anticline. By January 1923 the main winding shaft had been sunk to the Greta Top Seam, from which the coal was to be won. On 1st May 1931, following the take-over of the company by the newly amalgamated firm of J & A Brown & Abermain Seaham Collieries Ltd. ('JABAS'), the name of the colliery was changed from Stanford Merthyr No.2 to Stanford Main No.2 to indicate the change of ownership. Despite the new title, the mine remained locally known simply as Paxton Colliery.

Paxton Hotel

After shift at the Paxton Mine many of the miners would stop for at the local hotel for a beer on their way home. Many rode bicycles and would park their bikes against the pub wall. Over the years the scraping of bike handlebars and brake levers scratched the tile work glazing allowing coal dust to penetrate the ceramic base. These scratch marks are still visible today *(photo 19)*.

The hotel is an historic building, officially opened on 9th August 1924, and has one of the few original horseshoe bars remaining in New South Wales.

Rising Sun Inn

Travelling further westwards to Millfield, the next stop was at the Rising Sun Inn *(photo 20)*. Built in 1832, this is the oldest building in the district and has been continuously occupied since before Friday 18th December 1840 when it was subject to holdup by the Jewboy Gang of bushrangers.

This incident is the one for which the gang is most remembered in folk lore, although there are several differing versions.

The bushrangers made their way to the Rising Sun Inn where they recognised John McDougall, an emancipated convict. He had been an overseer for Iron Gang Number 7 on the Great North Road from 1821 to 1831 and was allegedly very cruel and merciless. He had also been a constable in the District of Wollombi.

The gang decided to give him a dose of his own medicine. They tied him to a post and gave him a brutal flogging. Recent historians note that "despite all the legend surrounding John McDougall, he actually had a long and productive life after his encounter with the bushrangers. His reputation as a brutal overseer was also much an exaggeration. He donated land for the building of a church, and was often said to be a respected member of the community."

The gang then went to the Red House Inn on the Maitland Road between the present towns of Millfield and Cessnock. This robbery was the sixth for the day and after the robbery they were so drunk that they could hardly stay on their horses.

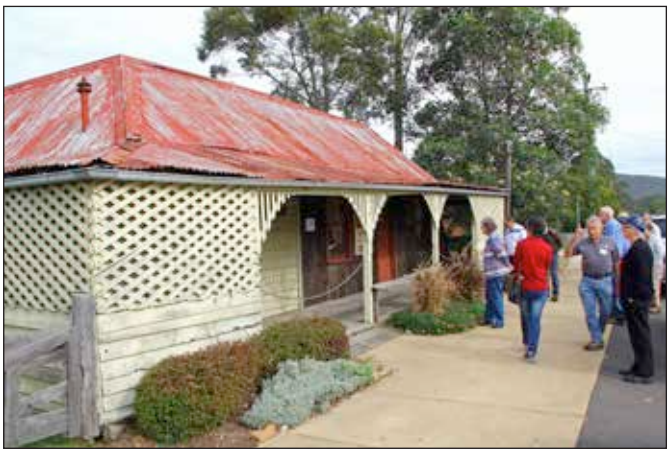
The building is now used as a craft and gift shop and there are plaques indicating that it was part of the Great North Road Precinct, being on the branch road from Wollombi to Maitland.

Bellbird Colliery Disaster

Heading back to Richmond Vale, the route passed the memorial to the Bellbird Colliery disaster *(photo 21)*. This memorial is to the 21 lives lost in a mine explosion at the Bellbird Colliery on Saturday 1st September 1923. A fire stated immediately after day shift left the mine and afternoon shift had gone to work. On the day shift 474 miners were underground in the northern (No. 1) workings and 159 miners in the southern (No. 2) workings. On the afternoon shift 20 miners were in the No. 1 workings.

All of the miners in the No. 1 workings were killed together with Mr John Brown, Manager of Aberdare Colliery, who

19. Bicycle scratch marks on the exterior wall tiles of the Paxton Hotel.



20. The Rising Sun Inn, Millfield.

21. Plaque on the Bellbird Mine disaster memorial.

was involved in the rescue efforts. All were deemed to have been killed by carbon monoxide poisoning.

Twenty-one lives were lost, 15 were recovered on the day and 6 were recovered after the mine was reopened although it was not until 19th May 1965 that the last body was found. The mass funeral was attended by 25,000 people and every pub and hotel in town closed for the funeral cortage which took 25 minutes to pass.

While the exact cause of the disaster remained unexplained, the inquest revealed: unsafe work practices; unreliable emergency phones; a lack of hazard reporting and control; the need for fire safety awareness; the need for emergency equipment and the need for trained emergency officers. Subsequent inspections after the reopening of the mine indicated that electrical installations were not the cause of the fire.

A positive outcome was, eventually after championing by the unionised work forces, the formation of the industry's Central Mines Rescue Stations. In these stations mine workers are screened for various operations and trained in all aspects of mine rescue.

Leggetts Drive Dykes

In the road cutting just north of the Lake Road and Leggetts Drive intersection is an exposure of a dyke swarm which can be traced 9 km north-westwards to Neath as mentioned earlier in the excursion. The several dykes are deeply weathered *(photo 22)* and intrude the Branxton Formation.

Richmond Vale Railway Museum

Returning to the Richmond Vale Railway Museum for lunch, the group was then able to have a closer view of the old mine buildings, power station and coolant pondages, the restored administration building, ride on the restored 7 km rail line to Pelaw Main and view the vintage locomotives and rolling stock. *(photos 23, 24 & 25)*

Unfortunately access to the colliery pit head, headframe, workshops and other associated buildings is no longer possible for safety reasons. The administration building was completed in 1910 and production commenced in 1914 in the 4.1 m thick Homeville Seam at 241 m with the establishment of the pit bottom.

Despite his reputation for industrial toughness, John 'Barron' Brown, the most powerful industrialist in Australia in the first quarter of the century, ensured that the miners in Richmond Main and Pelaw Main had the

22. A 250mm wide deeply weathered dyke (behind black tree), one of several intruding the Branxton Formation, exposed in the road cutting north of the Lake Road and the Leggetts Drive intersection.

23. Richmond Vale Railway Museum Visitors Centre.

24. Administration building (now a museum), Richmond Main mine.

25. South Maitland Railway loco No. 30.

best working conditions in the field and the most modern equipment available. However he was also ruthless in many ways, denying the ability of his workers to purchase from him the land on which their homes were built. In this way he could evict workers if they went on strike. John 'Barron' Brown is a most interesting person being both a breeder and racer of racehorses and owning a fleet of tug boats as well as other ships. He died on 5th March 1930 in Newcastle.

In 1926, Richmond Main set a world record for a shaft mine with 3454 tonnes of coal being wound up in an 8 hour shift. The mine reached its peak production of 515,112 tonnes of saleable coal in the year 1928, when it employed a workforce of 1200. Richmond Main Colliery was, at that time, the largest coal mine in Australia and a technological showpiece.

In 1967 Richmond Main was closed, the shafts sealed and the headframes dismantled. The track of the Richmond Vale Railway was also taken up for scrap and re-use. The power station continued to generate power, supplying the company's other mines in the area, until 1976.

Report by Winston Pratt.

Photographs by Winston Pratt (2, 4A, 4B, 5, 6, 7, 8, 9, 10, 13, 17, 19, 25)
Photographs by Ron Evans (1, 3, 11, 12, 14, 15A, 15B, 16, 18, 20, 21, 22, 23, 24)

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Dinosaur Triangle Safari

Leader: David Atkinson.

Attendance: 28 down to 14 members.

Date: Monday 16th June to Friday 11th July, 2014.

This was to be one of the largest group attendances on our annual safaris. Everyone made their own way to the Major Mitchell Caravan Park at Mitchell in Queensland where the trip was to officially begin on the evening of 16th June.

Tuesday 17th June

Today the group travelled more or less in convoy to Tambo via Morven, in the semi-arid southwestern part of Queensland where a short diversion was made to take a short stroll in the Tregole National Park. A former grazing property, the 7500 hectare Park was gazetted in February 1995 to conserve almost pure stands of ooline *(Cadellia pentastylis)* trees, now listed as vulnerable due to extensive clearing over much of its range. The forest is a mosaic of mulga ridges, undulating brigalow plains and poplar box floodplains. The ooline has rainforest origins dating back to the Pleistocene when most of Australia was much wetter. The large ooline forest in the Park is unusual given the current hot dry climate. The occasional rare black orchid Cymbidium canaliculatum was seen perched on tree trunks but most had succumbed to the prolonged drought, as had many of the trees. A 2.1 kilometre loop track along which numbered markers identified the tree species, led from the day-use area and back.

Some travelers spent the night in the caravan park while others took advantage of the magnificent free camp at Stubby Bend alongside the Barcoo River. The only problem here was the lack of firewood.

Wednesday 18th June

Another magnificent day weather-wise saw us travelling from Tambo to Barcaldine (Barcy) via Blackall.

The Blackall area was explored in 1846 by Sir Thomas Mitchell and was opened up for pastoral leases in 1861. The town was officially surveyed in 1868 and named after Sir Samuel Blackall, Queensland's second Governor. Anything west of Blackall was said to be "beyond the black stump". Located behind the State School in Thistle Street, this permanently marks the Astro Station, which was established in 1887. Surveyors used the stump to rest

1. The Blackall Wool Scourer.

their transit for latitude and longitude observations. This is hotly defended as the origin of this well-known statement, although Coolah residents might disagree!

One local attraction of interest to geologists is the silicified fossil tree stump collected from a local property and erected in Shamrock Street. It is said to be a conifer related to the modern hoop pine, a dry rainforest species, and "is believed to be 1 to 225 million years old". That's a pretty wide range!!

One of the main reasons tourists pause in Blackall is the steam-operated Blackall Wool Scourer *(Photo 1)*. Located 4.2 kilometres north of town, this is the only fully intact steam-operated wool washing plant left in Australia. It operated commercially between 1908 and 1978. All machinery remains fully functional *(Photo 2)*, with a new boiler the only modern addition. It is poetry in motion! For those who had been on the Emmaville-Torrington safari in 2011 one particular point of interest was the intact and still functioning Babcock boiler *(Photo 3)*, identical to the one laying in ruins beside the Kathida mine at The Gulf.

For the first time on the trip, participants assembled as a group at Barcaldine Homestead Caravan Park that evening.

The camp was full with grey nomads, but I guess we were

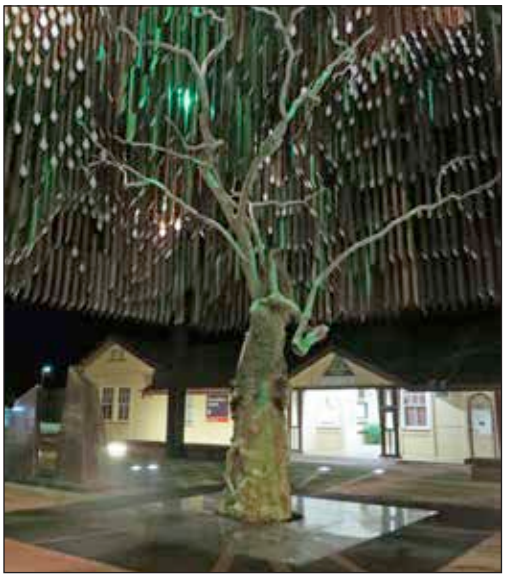
2. The steam engine that runs everything at the Blackall Wool Scourer.

3. Fully functioning Babcock boiler at the Blackall Wool Scourer.

part of that now. That night it was a rare privilege to sit around an open gidgee fire sipping billy tea and feasting on damper laced with treacle while listening to poems and tall tales narrated by local identity and legend Tom Lockie. Tom runs day trips to the gorge country north of Barcaldine, visiting Amarac, Grey Rock and the Gracevale carving site. Many of the group vowed to do this trip on the return journey.

Thursday 19th June

Today was free for people to do anything or go anywhere they pleased. There are a number of attractions in Barcaldine itself, including the Australian Workers Heritage Centre set over two hectares in the grounds of the old Barcaldine State School, the Barcaldine and District Historical



4. The Tree of Knowledge in Barcaldine.

5. Historic graffiti at Grey Rock.
Photo Ron Evans 2007

6. One of the larger caves at the edge of the mesa in Horsetailers Gorge.

Museum and the Botanic Walk 9 kilometres south of town which features gidgee forest and eucalypt scrub. Outside the Railway Station is a much-revered dead tree enclosed by a gigantic wooden structure housing a network of enormous wooden chimes that move in the breeze *(Photo 4)*. This is the Tree of Knowledge, a ghost gum that had grown on the site for over 180 years before it was poisoned in 2006. It symbolizes the Great Shearers Strike of 1891, which was to profoundly affect Australia's future. The tree has been preserved by Barcaldine Regional Council and incorporated in the spectacular architecturally designed memorial opened in 2009. It is included in the National Heritage List.

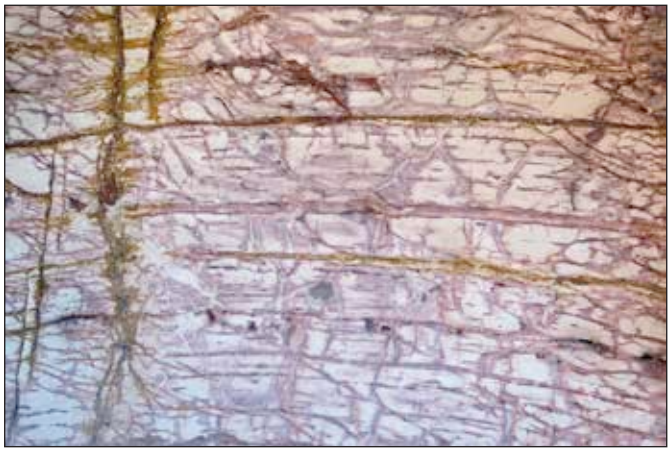
Those who ventured out to Gray Rock, Mount Lonely and Horsetailers Gorge were in for a great surprise in terms of both geology and scenery. Looking to the east on the way out towards Amarac one could be excused for thinking the coast lay not too far off, the flat top of the Great Dividing Range having the appearance of a line of blue water along the horizon.

Amarac developed a worldwide reputation for wool, which at the time was propping up the Australian economy. Up to 70 teams a day hauled wool to the Amarac railhead, since abandoned, relying on water from Government bores every 10 miles. Breaker Morant spent time in jail here before the Boer War. It was also the home of Harry Redford, better known as Captain Starlight. The first P&O liner was named Amarac, because wool paid for it!

The changes in vegetation between Amarac and the turn into Gray Rock were astonishing, with alternating stands of leopardwood, ghost gum and ironbark. A few brolgas were also seen close to the road. In such flat featureless country we had begun to wonder how gorges could possibly be present. Then in the near distance low ridges began to appear and soon we were looking across to lines of low cliffs of brown and white sandstone.

Located on a spur of the Great Dividing Range 35 kilometres east of Amarac, Gray Rock is of significant historical interest. It was an ideal place for the establishment of a hotel. The Wayside Pub and horse yards began operation in 1877, providing a staging post for Cobb & Co coaches travelling between Clermont and Amarac before the Central Western Railway was completed on 7th June 1886. The Pub was demolished the year before the rail line was completed. The sandstone in the line of low cliffs here belongs to the Lower Cretaceous (125ma) Wallumbilla Formation and comprises dense yellow-brown sandstone overlying much softer pale grey clay-rich sandstone, each around three metres thick, laid down on a small marine shelf. Along the lower part of the cliff the names of hundreds of travelers dating back to the early coaching days had been engraved into the soft rock *(Photo 5)*. Strange indeed that this century-old vandalism is now revered as a slice of the region's history! In July 1965 it snowed at Gray Rock, and also at Mount Sugarloaf near Newcastle.

A further 1.2 kilometres down the Jericho Road and just beyond the property boundary fence, a narrow dirt track leads off to the west into Horsetailers Gorge. After a brief sandy stretch it begins to follow the low cliff line forming the edge of the sandstone mesa rising up to 30 metres above the wide floodplain, and eventually rejoins the Amarac-Jericho Road. All along this cliff line a 2 metre bed of soft grey claystone lies beneath a harder more resistant cap of yellow-brown sandstone. Differential erosion of this succession has resulted in a series of surprisingly deep overhangs and caves, some reaching over 30 metres beneath the mesa *(Photo 6)*. Leaching of the soft claystone by groundwater has formed astonishing patterns *(Photo 7)*, but the greatest surprise lay in the occasional vertical pipes penetrating both the grey claystone and the sandstone layer above. These are up to 30cm in diameter, circular in cross-section, and rimmed by a resistant layer of precipitated iron oxides and secondary silica *(Photo 8)*. Most reach right through to the ground surface. In the deeper caves where the soft grey claystone



7. Patterns in claystone in the back of one of the caves in Horsetailers Gorge.

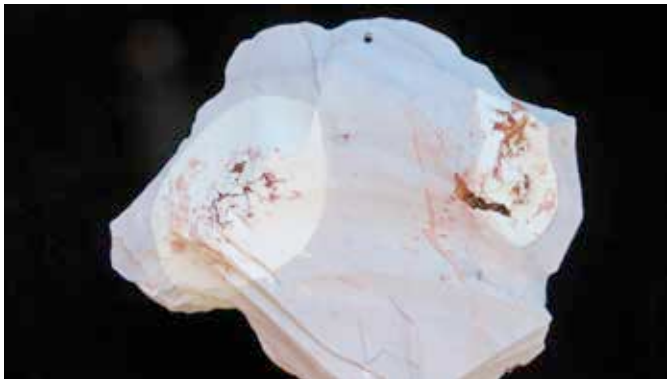
9. Hole in cave roof, once part of an ancient water conduit.

has been washed out these structures appear as circular holes in the roof. The claystone in the vicinity of these holes is strongly fractured, in some cases forming laterally extensive zones of breccia. A search of the literature on sedimentary structures indicates that these are very likely water-escape features. Wet fine-grained unconsolidated sediments buried beneath more competent layers become compressed as the confining pressure caused by continued sedimentation increases, forcing the contained pore water to migrate laterally to areas of weakness in the overlying material where it escapes to the surface as cylindrical pillars of liquefied sediment (Conybeare and Crook, 1968). When the upwelling of water ceases and the sediments become consolidated the columns are preserved as cylindrical structures. Where these structures have been exposed by undercutting of the cliff line the material filling them has been eroded out, leaving circular holes in the cave roofs *(Photo 9)*. A modern analogy may lie in present day mud and sand volcanoes or in the mound springs formed above the Great Artesian Basin. Unfortunately the grey clay band is largely hidden behind hundreds of years of wasp nests, making structural interpretation difficult! No Aboriginal carvings or paintings were seen anywhere in this section and fortunately the rock outcrops were free of modern graffiti.

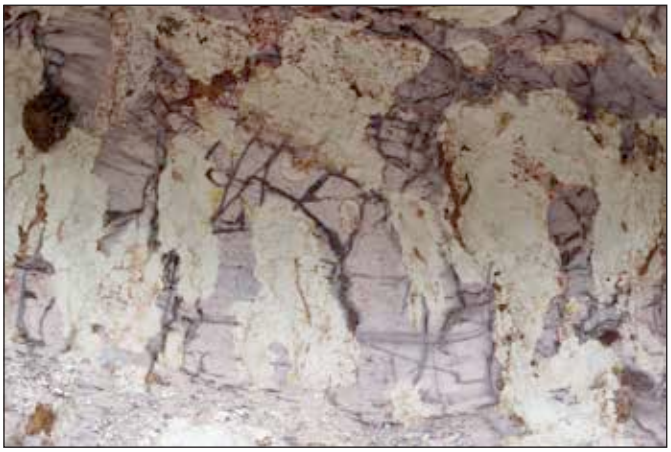
Drovers used Horsetailers Gorge as an overnight camp. The rock face acted as a pound, preventing the horses escaping at night. The horsetailers' task was to look after the horses, ensuring they were fed, and that they were back in camp by daylight the next morning. The wide floor of the gorge is covered by spinifex, with over a dozen native tree species growing adjacent to the sinuous rock face. Numbered pegs along the track identify each species.

Located midway between the turns into Gray Rock and Horsetailers Gorge on the eastern side of the Jericho road, Mount Lonely hosts even more geological surprises in its cliffs, from deep caves to strange structures and patterns in the rocks. The grey lake bed claystones here, lying sandwiched between massive beds of flood sandstones, display enigmatic vertical columns from which the coloring agent has been leached to leave pure white rock *(Photos 10 & 11)*. These columns appear to be centred on remains of vertical plant roots reaching down from the top of the clay bed. Fossil plant roots are fairly common in sediments that originated in coastal marshlands. The completely structureless lower sandstone bed contains scattered white

8. Ancient water conduit at the back of a cave in Horsetailers Gorge.



10. Circular leached areas around fossil plant roots in shale, transverse section. 20 cm across.



11. Vertical section through leached columns exposed in the cliff face at Mt. Lonely.

fossil bone (?) fragments.

Back in camp we were again treated to billy tea and damper around a roaring fire while enjoying more of Tom Lockie's bush poems and stories.

Friday 20th June

The group left Barcaldine at 9am, heading along the Landsborough Highway to Christmas Creek 43 kilometres to the north. In camp last night we had been shown some fabulous fossils, including a large ammonite, which had been collected here just the day before. So we had to try our luck *(Photo 12)*. There was nothing in the dry sandy creek bed south of the Highway, but to the north between the Highway and railway viaduct lay a well-exposed bed of tough sandy limestone containing occasional shell fossils, but no ammonites. An hour or so was spent here before driving on to Ilfracombe for coffee at the General Store.

Ilfracombe is famous for the Great Machinery Mile, an astonishing variety of old cars, tractors, steam engines, bullock drays etc. lining the road and extending right through the town! A walk along here was like stepping back into history, a graphic timeline of pastoral evolution. Small huts sheltered collections of old bottles, local fossils, etc. and there was also a large petrified pine log. The site was peppered with "moon rocks" – limestone concretions gathered from the local countryside, all painted white and used as driveway borders and garden feature rocks.

The fossil display included a plausible explanation of the local geology. The land surface of the Shire is covered in the northern part by soils and rocks derived from sediments deposited in an inland sea during the Late Albian (102-98ma). Then Australia was still attached to Antarctica and lay at 60 degrees south. Modern analogies of this inland sea, with a single connection to the open ocean through the Gulf of Carpentaria are the Gulf of Mexico and the smaller Persian Gulf. In the southern part of the Shire the

12. Fossicking for fossils in Christmas Creek north of Barcaldine.

sediments were deposited in freshwater lakes, swamps and rivers after the saline water of the inland sea had retreated towards the Gulf. This is the Winton Formation. The source of much of the sediments that formed these rocks was a line of volcanoes, the remnants of which now lie in the Whitsundays. In earlier periods the volcanic debris was weathered before being washed into the sea by rivers, resulting in the mudstones of the Allura Formation.

Later, increased volcanic activity led to more rapid deposition of unweathered volcanic debris, forming the sandstones of the Mackunda and Winton Formations. The rocks from these two depositional episodes are so similar that they can only be distinguished by the marine fossils present in the Mackunda Formation. One feature of these rocks is the presence of the round nodules called moon rocks. The signage states, "A scientific explanation of their formation is now given by the application of chaos theory mathematics, which a lot of us do not understand". One wonders why!

Fossils found in the Ilfracombe Shire include crabs, yabbies *(Macrurous decapods),* ammonites, bivalves, fish (only a few isolated vertebrae due to the presence of efficient scavengers), crinoids, rare bryozoans, and a single dragonfly wing.

We set up camp for the night at the enormous Longreach Tourist Park on the eastern side of town, not far from the Stockman's Hall of Fame.

Saturday 21st June

Most of the group spent the morning in the Stockman's

Hall of Fame and Outback Heritage Centre. This was created from a vision by Hugh Sawrey in 1974. He wanted to create a memorial to the pioneers of the Australian outback. The first board of directors included R. M. Williams, Dame Mary Durack and Bob Katter Senior. The main building was designed by Feiko Bouman and built between 1985 and 1987. Queen Elizabeth II opened it in 1988. The six main galleries are Discovery, Pioneers, Outback Properties, Royal Flying Doctor, Stockworkers and the Hugh Sawrey Art Gallery. There is also a café, information centre and library.

After lunch in camp we drove out to Lilly Lagoon, an extensive wetland of abandoned river channels just off the Muttaburra road north of Longreach. This is an ephemeral series of waterholes fed by the nearby Thompson River during floods. The lillies from which the lagoon takes its name were of the *Nymphea* genus and were unique to the Thompson River System at Longreach. They once provided a magnificent spectacle but have been killed out entirely by feral pigs rooting in the lagoon mud after their bulbs. The lagoons are bordered by stretches of thick treacherous mud inhabited by mussels. With the lilies gone, the only remaining features of note are the many magnificent old coolabahs *(Eucalyptus coolabah) (Photo 13)* and unbelievably perfect reflections when the air is still *(Photo 14)*. For the bird lovers trees at the waters edge hide the huge untidy nests of whistling kites *(Photo 15)*.

From Lilly Lagoon we drove on out to Starlight's Lookout, also called Cassidy Knob, passing by large expanses of polished quartzite gibber lying as residual layers on gentle hill slopes. In the vast expanse of flat treeless plains the lookout came as a surprise, standing out as an isolated pinnacle *(Photo 16)* that could be seen for some distance before we reached its base. Looking up from the parking area we could see that the hill's summit comprised a mass of spectacular sandstone pillars *(Photo 17),* a delight for the photographers. The cross-bedded sandstone in this isolated outcrop consists of sub-angular transparent to translucent quartz grains typical of river sands, cemented by a secondary film of opal. Discontinuous thin bands of white quartz pebbles (lag deposits) occur throughout.

In 1870 Harry Redford (alias Captain Starlight) placed a lookout on this hill to keep watch while the rest of the gang were gathering the Bowen Downs cattle for their epic journey down to Adelaide in the greatest cattle heist in Australian history. We had afternoon tea at the base of this hill before returning to camp.

Sunday 22nd June

This was another day when people were free to choose what

13. Coolabah tree beside Lilly Lagoon near Longreach.

14. Reflections in Lilly Lagoon near Longreach.

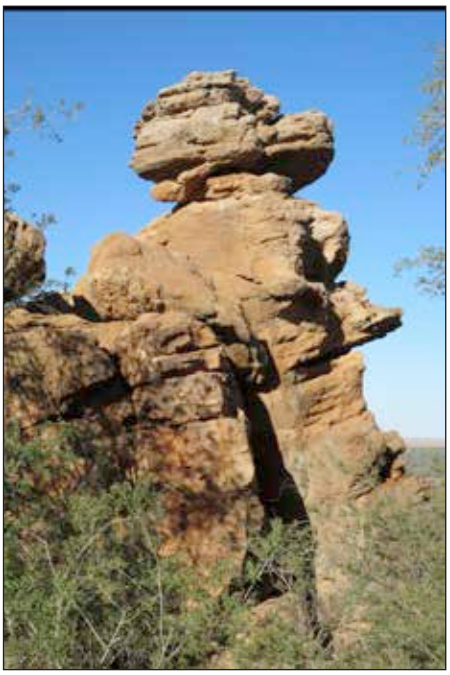
15. Whistling kite perched high on tree branch at Lilly Lagoon.

16. Cassidy Knob, also known as Starlight's Lookout.

they wanted to do. Some went back out to Lilly Lagoon to do a spot of bird watching while others explored the town of Longreach, the Qantas Founders Museum, or the Stockman's Hall of Fame. There was plenty to do.

Barry and others drove up towards Muttaburra and took the Bexley road back to the Landsborough Highway. There wasn't much to see. Just a few scattered deformed Acacia species and hectares of red quartzite pebbles covering the ground. There were more kangaroos here than I'd ever seen. One was clocked at 40kph! We also saw a number of wedge-tail eagles feasting on roadkill.

We had made a group booking at the Woolshed Restaurant for dinner that night and were entertained during the meal by a rather loud Elvis impersonator.



17. Sandstone pillars on Cassidy's Knob.

18. One of the impressive craft projects sent in by students of LSODE.

Monday 23rd June

Again everyone did their own thing. Those who visited the Longreach School of Distance Education (LSODE) could only be amazed at what they witnessed. This is one of seven such centres scattered across Queensland and this one alone has 170 distance education students from isolated stations enrolled this year. We began the visit by watching teachers run a spelling lesson for three kindergarten children and could watch their reactions on a monitor outside the soundproofed studio. Before beginning the guided tour we sat and watched a DVD explaining how the centre operates and the roles played by teachers, parents, tutors and volunteers. The tour proved very comprehensive and included viewing of the astonishing arts and crafts sent in by students as projects *(Photo 18)* and the extensive library from which students can borrow up to 40 items (books, toys, DVDs and games) for up to 6 weeks. Visitors are encouraged to purchase books for the library from a range displayed in the foyer. The centre puts on a musical every second year in which the students participate. There is also accommodation on site for students and parents.

The LSODE tour was followed by a visit to the Longreach Pastoral College a short distance down the Landsborough Highway where Customer Service Officer Colin Makenzie gave us another comprehensive tour.

Following individual arrangements for lunch, several people drove out to Iningai Nature Reserve on the eastern side of the Jundah to Windorah road on the southern side of town, after hearing it was a great place for bird watching. This is an area of natural open downs of Mitchell

19. The Thompson Belle on the Thompson River at Longreach.

20. Permanent residents on the Thompson Belle.

Grass *(Astrebla sp)* with old coolabahs *(Eucalyptus coolabah)* stretching out to the edge of the flood zone. Some of these trees may be up to 300 years old. The earthen walking track stayed close to the dry bed of Gin Creek, which flows into the Thompson River to the west of Longreach. After the long dry spell without decent monsoonal rains last summer the ground beneath our feet had become severely dehydrated, opening up extensive networks of deep cracks, some up to 10cm across. Out across the alluvial soils in the Reserve, Gidgee trees *(Acacia cambagei)* were quite common.

Several people had booked on either a morning or afternoon tour of the Bureau of Meteorology near the airport. Here the process of weather watching was explained and we watched as a hydrogen-filled weather balloon was launched and disappeared into the sky.

That evening we were picked up at the Caravan Park by the Kinnon & Co coach for the short drive out to their camp on the Thompson River for a sunset cruise on the diminutive Thompson Belle, a restored paddle wheeler *(Photo 19)*. The cruise up and down this great wide expanse of still water with drinks and nibbles provided was most enjoyable. But the greatest attraction was not the river, nor the setting sun or the dozens of small tortoises momentarily surfacing near the boat to gulp air, but quite literally lay in the very small on-board toilet! Two ringtail possums had commandeered the wash basin as a nest *(Photo 20)* and were vigorously defending their right to be there each time the door was opened. There was an endless crush of photographers trying to get in, but not to answer the call of nature the little room was built for!

We were back on shore and seated around a roaring Gidgee log fire for a feast of stew followed by dinkie-di apple pie and custard, all the while entertained by bush poetry and a clown with a very large black chook (Australian Croad Langshan). This was followed by a spectacular sound and light show projected onto a screen aboard a pontoon anchored to the shore. Then billy tea and brown damper (with raisins) rounded off a most pleasant evening before we were returned to the Caravan Park.

Tuesday 24th June

At last! What we came all the way up to Queensland for – Dinosaurs!

It was yet another fine sunny day with only scattered high cloud on the horizon as we headed off for Winton through gently undulating sheep grazing country with only a scattering of trees. After settling in at the Pelican Caravan Park we drove 13 kilometres back along the Landsborough Highway to the turn off to Australian Age of Dinosaurs, then 11 kilometres south on a well-formed dirt road to the summit of the Jump-Up, a large limestone-capped mesa.

Opened on 30th July 2008, the Museum and Preparation Laboratory lie at the northern end of the mesa, which is enclosed by high cliffs cut by deep erosion fissures. A number of vantage points provide panoramic views over the surrounding plains. Since its inception the Australian Age of Dinosaurs has grown rapidly to become the most productive fossil preparation facility in the Southern Hemisphere and also houses the World's largest collection of Australian dinosaur fossils.

The most famous local dinosaur is "Banjo" *(Australovenator wintonensis)*, the largest predatory animal ever found in Australia and a life-size model of this beast greets visitors at the entrance to the Museum *(Photo 21)*. Most of the dinosaurs in the Winton area however were gigantic plant-eating sauropods.

The Winton area 95 ma ago was covered by rainforest in which conifers reached a height of 100 metres. A number of species of fossil fern and other plants including cycads and ginkoes have also been found. But how did a region of forest and wetlands with such a richly diverse wildlife transform into the rolling plains of western Queensland?

21. Entrance to Age of Dinosaurs Museum.

The story of Winton's geological history is one of immense changes in landforms and climate. Between 98ma and 95ma Australia's great Cretaceous inland sea retreated northwards towards the Gulf of Carpentaria and western Queensland became a fringe of coastal wetlands. Rivers meandered northwards to the retreating sea where lungfish, turtles and crocodiles were common. Huge sauropods roamed the conifer forests and lush vegetation that blanketed the countryside between a myriad of lakes and swamps in which horsetails and dragonflies flourished. Rainfall was heavy and the climate humid and cool. During this time the Winton Formation sediments derived from volcanoes in the eastern part of the continent (now the Whitsundays) were deposited on the coastal plains along the margins of the receding sea. These silt deposits now entomb the skeletons of Australia's largest dinosaurs.

At 65ma the great mass extinction at the K/T boundary resulted in over 95% of plant and animal species, including the dinosaurs, to die out.

At 30ma the huge mesa known as the Jump-Up (only one of many in the area) was level with the surrounding countryside. Since then stream erosion has removed all but these spectacular remnants.

At 8ma came a time of global drying and cooling. As ice rapidly accumulated at the poles, sea levels fell, rainfall decreased and the once extensive rainforests retreated. Plants and animals better able to adjust to their changing habitat took the place of those who could not. Winton area now lies within the temperate arid zone with a rainfall of less than 400mm per annum. It is subject to the northern monsoonal season with most of the rain falling in January-February. But the monsoon rains did not come this year and the region is extremely dry. Even the native *Eremophilas* are dying!

In 1960 the dinosaur stampede at Lark Quarry was discovered. Then in 1999 David Elliott stumbled on a very large fossil bone while mustering sheep on his Elderslie

22. Volunteer preparing plaster-encased dinosaur fossil.

Station property. This proved to be the thigh bone of the largest Australian dinosaur known at the time. It was named "Elliott" in his honor by the Queensland Museum, who excavated the remaining bones from an area the size of four football fields. This fossil has been dated at 98.5ma. In 2002 the Australian age of Dinosaurs began work in western Queensland. Near Winton in 2005 came the discovery of Wade and Matilda, two massive sauropods. The bones of these individuals were all found at the one site so all belong to the same animal. So far only one Matilda and one Banjo have been unearthed. Today deep weathering and erosion have removed nearly all the surface outcrops of the Lower Winton Formation and covered the bone-bearing horizon with up to 10 metres of black soil. Vertical cycling of this soil over time detaches bones from the host rock and raises them to the land surface where they are found, often accidentally. So once surface indications have been found, fossil hunters must dig down into the soil to recover the remainder of the bones. Most of the animals so far discovered had become stuck around the edge of muddy waterholes where they went in to drink. In most cases the carcasses were eaten by scavengers, so only the leg bones are preserved.

The 40kg Winton Belmont meteorite was also found on Elderslie Station and an exact copy of this visitor from outer space is also on display in the Museum. The original is in Japan where its mineralogy is being researched.

At the Fossil Preparation Laboratory we watched in awe as 8 volunteers carefully and meticulously scratched away at plaster-encased lumps of rock to reveal dinosaur bones *(Photo 22)*. One worker was busy with a dentist drill removing rock from vertebrae of Matilda, a project he

23. Cretaceous ammonites on display at The Age of Dinosaurs.

25. The Yellow Jimmy opal mine adjacent to Lark Quarry.

had been working on for one and a half years! In most cases it is surprisingly difficult to differentiate the bones from the encasing rock. Extensive storage shelves beside the preparation area held dozens of plaster-encased rocks some labeled just "mystery" or "looks interesting". On display in the Laboratory are superb examples of Cretaceous ammonites *(Myloceras plectoides) (Photo 23)* and crabs *(Homolopsis etheridgei) (Photo 24).* Restricted by climatic conditions, there are only three weeks of digging per year. Week long experiences called "Dig-a-Dino" during which volunteers become involved with Museum staff, paleontologists and other dinosaur enthusiasts can be pre-booked through the Museum. It is also possible to book a "Prep-a-Dino" experience where members of the public can become involved in fossil preparation.

By the time our Museum guided tour had finished the coffee shop was closed but we were grateful indeed when they re-opened just for us so we could enjoy cappuccinos on the terrace overlooking the plains back towards Winton. There is also an excellent shop at the Museum where mementos, dinosaur models and books can be purchased. The Museum also publishes an excellent annual journal called "The Age of Dinosaurs".

The story of the Age of Dinosaurs Museum is far from

24. Cretaceous crabs enclosed in concretions displayed at The Age of Dinosaurs.

over. Plans are afoot to produce life-size models of all the local dinosaurs and place them amongst the trees around the rim of the Jump-Up. But these will cost money, and lots of it. Maybe Clive Palmer should get involved.

Wednesday 25th June

Another day in the shadow of dinosaurs!

We departed camp in convoy at 8:35am and headed southwest along the Jundah road to the Lark Quarry Conservation Park, 110 kilometres south of Winton. The road was sealed till 60 kilometres from the quarry, but then there were numerous sealed "overtaking opportunities". Some of the road had been designated emergency aircraft landing strips.

We arrived at Lark Quarry at 9:50 and while waiting for our special guided tour to begin specked around the ground adjacent to the carpark, finding interesting fragments of common opal, spectacular banded goethite concretions and iridescent goethite coating rock joint surfaces, which some people thought might have been copper staining.

Glen Seymour discovered the first dinosaur prints while fossicking for opal at the nearby Yellow Jimmy opal mine *(Photo 25)* on Cork Station in the early 1960's. Local grazier Peter Knowles immediately guessed the tracks had been made by dinosaurs, probably the size of domestic hens. Dr. Alan Bartholomai confirmed this when specimens were shown to him at the Queensland Museum. But nothing more happened till the summer of 1971 when a small field party led by Dr. Bartholomai and Richard Telford from the American Museum of Natural History arrived in Winton to search for evidence of the first Cretaceous animals in Australia. Their enquiries led them to Peter Knowles. At the original location, now called Seymour Quarry, Telford took a level across the gully to the outcrop on the other side that seemed to be a continuation of the same bed. When the first slab was lifted there were tracks

26. Theropod, Ornithopods & Coelurosaur footprints plus drag mark from logs. Photo by Ron Evans 2007

27. Large (51cm) Theropod footprints.
Photo by Ron Evans 2007

identical to those in Seymour Quarry and all the tracks headed in the same direction! That's how Lark Quarry was discovered. The quarry was named after Malcolm Lark whose efforts were largely responsible for the excavation of the site, during which over 60 tonnes of overlying rock were removed. The prints were covered by a thin ironstone band, which made separation of the overlying rock easy. The full story of the discovery and preservation of the site can be found in Meiklejohn, (2004). The present building was completed in 2002 at a cost of $2.3 million, funded largely by the Department of Arts Sports and Tourism.

Before beginning the tour we spent some time drooling over the magnificent collection of local Cretaceous fossils on display in the foyer. Then entering the stampede area along a raised walkway we stood speechless and in awe at what lay beneath our feet.

At 95ma western Queensland was quite different to the spinifex studded red earth of today. Rainfall exceeded a metre a year. Conifers and ferns dominated a flat landscape of creeks and rivers meandering northwards into a retreating inland sea. A herd of around 300 dinosaurs, some as small as chickens *(Coelurosaurs)* and some around the size of an emu *(Ornithopods)*, were drinking on the muddy shore of a freshwater lake. The approach of a large carnivorous dinosaur panicked the animals, which began a frantic dash for escape. Trapped by the water the animals ran back towards the predator, colliding with and running over each other until they eventually passed the predator, reformed into a heard and continued to run from the site. As a permanent record of this stampede, a total of 3300 prints *(Photo 26)* are preserved in the quarry floor, with up to three inside each other. Calculations have suggested the small dinosaurs ran off at around 14kph while the carnivore reach a speed of 19kph. The small ones had little chance! Subparallel grooves across the surface of the trackway *(Photo 26)* are drag marks made by tree branches pushed across the wet and slippery mud by strong winds or a small flood. They were made before the trackway. The Cretaceous inland sea had moved north towards the Gulf of Carpentaria by this time so there are no marine fossils here.

In 2010, during preparation for the filming of the documentary "Dinosaur Stampede", the team at Australian Age of Dinosaurs began preparing fossils of "Banjo" *(Australovenator wintonensis)*, Australia's most complete carnivorous theropod dinosaur, with particular emphasis on the feet. Although the foot bones available came from different feet of the same animal, CT scans enabled the bones of one to be reconstructed with a remarkable degree of accuracy. It was huge! It was so huge that it might just fit the prints of the enormous carnivore at Lark Quarry *(Photo 27)*. The CT scans allowed the bones to be fleshed out and a full size 3-D model to be constructed. When the completed model was placed in the large prints at Lark Quarry it fitted exactly! As the model's claws slid into the grooves and the fleshy under parts of the toes conformed precisely to the impressions left in the mud there could be no doubt. *Australovenator* was indeed the Lark Quarry carnosaur! The model *Australovenator* leg is on display at the Australian Age of Dinosaurs. The documentary that precipitated this discovery was shown on ABC TV in late 2011. The dinosaur stampede in Stephen Spielberg's classic film Jurassic Park was modeled on the Lake Quarry trackway.

Samples of shale collected from the pathway leading up the hill above the Museum showed fine bedding typical of lake deposition and vertical burrows (bioturbation) made by freshwater worms.

28. Countryside view from the top of the mesa on the Big Walk.

Some people did the Big Walk, a 3.5 kilometre 1.5 hour scramble around the edge of the mesa, capturing some great photographs of the surrounding countryside *(Photo 28)* and marveling at the incredible variety of colours in the rocks and regolith *(Photo 29)*. We came across one group who had turned back, unable to find the track, but we had no problems.

We left Lark Quarry at 2pm and headed back to Winton along the Cork Mail Road through Carisbrook Station. After being open to the public since 1962 Carisbrook is now closed due to its impending sale. We were back in camp for happy hour at 5:30pm.

Some people at the Caravan Park in Winton had passed disparaging remarks about the odour of the water. The town water comes from 4 bores sunk 1.2 kilometres into the aquifers of the Great Artesian Basin, emerging at 83°C and cooled to 44°C before reticulation into the town supply.

29. Unusually coloured ground on the Big Walk at Lark Quarry.

30. The view north from Scrammy Lookout.

The water has a strong initial smell of hydrogen sulphide gas, which comes up with the water. But let the gas escape naturally or by boiling and the water is "magnificent".

Thursday 26th June

Our convoy left Winton at 9am to explore the Scrammy Drive in Bladensburg National Park 7 kilometres to the south. It was a cloudless morning, with a temperature of 14°C at 9am, but it had dropped to a very cold 2°C overnight. The humidity was an unbelievable 0.4%. Around town the countryside appeared to have had at least some recent rain but further out it became noticeably drier.

Scrammy Jack was a boundary rider turned hermit, locally termed "hatters" in reference to their hat sheltering their entire family, ie they lived alone. Jack's right hand was crushed under a wagon wheel and scrammy is an old English term meaning left handed. He worked for Vindex Station around 1900.

The drive began at Bladensburg Homestead, the two-wheel track heading out past the old racecourse, swinging across flat Mitchell grass downs and dry creek crossings with the creeks lined by Gidgee. Parts of the track were a bit sandy on the flats but it then rose into a region of rocky hills with the distinct ridge of the Tully Range off to the west. There were many termite mounds here amongst the leopardwood and spinifex. Close to the ridges the ground was covered in stones but in the wide hollows white clay pans had formed during thousands of years of internal drainage.

Then came a short rough climb to the flat top of a lightly wooded mesa, with hardy Acacia (lancewood and bendee)

31. Aboriginal artifacts on the ground around Scrammy Rockhole.

bent into the most fanciful shapes imaginable dotted amongst the dark brown pebbles covering the ground. There was also the occasional ghost gum, including one called the Octopus Tree. One difficult creek crossing around a deep waterhole caused some consternation – it was either get it right or take a swim inside the vehicle! We had chosen to drive directly to Scrammy Lookout at the end of the track and then work backwards to the other points of interest.

Scrammy Lookout was located on top of a low grassy tree-covered ridge perched on the northern edge of the mesa. Here the ground fell away sharply to give astounding views over the vast plains drained by Campbell Creek flowing to the northwest *(Photo 30)*. We did the 400 metre walk down onto the plain and back up to the vehicles then retraced our path south to visit the other points of interest. The first was the Scrammy Rockhole, only 2 metres deep but rarely dry. Here a small crab was found under a rock near

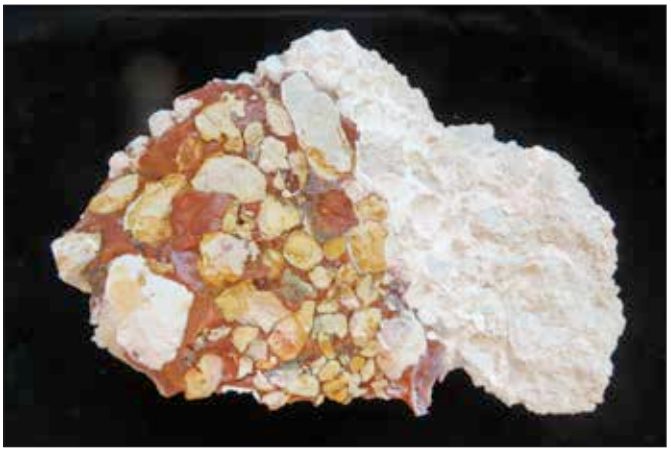
32. Looking towards the brink of Scrammy Gorge. Note the cracks in the foreground.

33. Cracks formed around the edge of Scrammy Gorge as the mesa surface collapses into the hole.

the water's edge and there were many crab holes along the mud banks. Worked flakes and cores of chert were found scattered over the ground surface around the waterhole *(Photo 31)* and it was obvious this was a place of great significance to the Aboriginal people. These little pieces of native occupational history were left where they were found.

Moving on south the next stop literally took our breath away! From the dead flat top of the mesa Scrammy Gorge simply fell away into a great abyss over a hundred metres across *(Photo 32)*. Before we could even see the gorge, great open bifurcating cracks up to a metre wide and penetrating several metres into the ground *(Photo 33)* were a sobering indication that the whole surrounding area was unstable. Some of these cracks were only a few millimeters wide and obviously fresh, evidence that the area was in a continuing state of collapse. So even approaching the edge of the gorge seemed fraught with danger. But any fear we had was

34. Ghost gums on the rocky floor of Scrammy Gorge.



35. Brown opal in claystone from the Age of Dinosaurs walking track. Brian England specimen (R 726). 21 cm.

pushed aside by the urge to find out what was going on, so we continued with some trepidation along the very edge of the gaping hole until a way down could be found amongst the teetering boulders bordering its rim. Down the bottom Scrammy Creek lay largely hidden under massive boulders, with an open forest of ghost gums fighting to find space between them *(Photo 34)*. Scrambling to the head of the gorge we faced a massive undercut, where a thick bed of soft white claystone was being eroded out from beneath a darker claystone hardcap. This explained the massive crack networks on the mesa above, the top layer of rock collapsing in great sheets as the supporting rock beneath it was eaten out by erosion.

Exploration of the gorge had taken much longer than expected and we had to find a quick exit without having to follow the creek out. Barry though he had found a kangaroo track up the southern wall that would lead us directly back to our vehicles, but this proved quite a scramble and half way up we found the kangaroo – dead and dehydrated!

We took the shorter more direct route back to Bladensburg Homestead where time was spent exploring the displays, the large chunks of petrified wood bordering the carpark, and the nearby historic garbage tip. There were hectares of old trash there! Once Bladensburg Station, one of the

36. Hardcap layer above the opal-bearing claystone at Age of Dinosaurs.

37. Erosion gullies formed along the edge of the Jump-Up at the Age of Dinosaurs.

original grazing properties established in the late 19th Centuary, the National Park was officially gazetted in 1994. It conserves 85,000 hectares of Mitchell and Flinders grass downs and channel country, along with mesas and residual sandstone ridges. Following afternoon coffee on the verandah of the shearers' quarters we returned to Winton, arriving at around 3:30pm.

Some people walked around the various opal shops in town but nothing of interest was found. Surprisingly one of the better shops had good fossils from the Jurassic Talbragar Fish Beds near Gulgong at quite reasonable prices, but was also selling very poor Mt. Isa dravite (tourmaline) crystals at $95 each!

That evening we held a group dinner at the Daphne Mayo Dining Room in the famous North Gregory Hotel, where the first public performance of Waltzing Matilda is reputed to have taken place. The dinner was memorable and we were served by young Histonian waitresses! The first of the Numbat Awards was handed out that evening.

Friday 27th June

Today was another free day to give people an opportunity to visit local attractions of their own choice without everyone having to tag along.

Some returned to The Age of Dinosaurs to follow the walking track along the base of the mesa and back up to the visitors centre for coffee. Part way along this track they found a claystone boulder that had been split by tree roots to freshly expose unusual pellet-like textures and irregular cavities infilled by brown opal *(Photo 35)*. Black patches

in the clay appeared to be fossil tree roots. The hardcap *(Photo 36)* above this claystone appeared to be limestone around 2 to 3 metres thick in which narrow erosion gully networks *(Photo 37)* eroded along the edge of the mesa provided good foreground for photographs.

Saturday 28th June

Most of the group left Winton and headed south to drive the Route of the River Gum located along the western edge of Bladensburg National Park. The first stop was at the Long Waterhole 2 kilometres southwest of Winton and 1.5 kilometres to the east of the road. Long Waterhole is a manmade oasis once used during the outback festival as the site for the World Crayfish Derby. It is now a popular camping and fishing spot. Of great interest here were the prominent polygonal crack networks in the dehydrated soil *(Photo 38),* a spectacular indication of just how dry it had been. There were lots of emus here and a mob of very curious cattle that came over to see what we were up to. Just a few kilometres further south we crossed Mistake Creek, site of around 9 Chinese market gardens back in 1895.

After travelling 5.5 kilometres from town we left the Winton-Jundah road and headed down the Route of the River Gum, ignoring the turn into the ranger station at 11.6 kilometres and taking the right fork in the road. We soon came upon excellent examples of white clay pans, totally devoid of vegetation but enclosed by grassy areas on which dozens of kangaroos were grazing. At the Engine Hole, on an un-named tributary of the Western River to the north, some time was spent chasing magnificent reflections of the river gums in the long crescent-shaped body of water. This was once the site of brick making. Flitting through the trees here were flocks of budgerigars and wood swallows.

Further south we drove up onto the Little Jump-Up, a local term used to describe a steeply rising land surface. This was covered in spinifex, lots of termite mounds and the occasional bloodwood apple. South again and 2 kilometres southwest of the road we found the Skull Hole, a narrow deeply incised creek bed rimmed by hard sandstone caprock. This was the site of an Aboriginal massacre by black troopers in retaliation for the murder of a teamster. It was here that we met up with a tag along tour from Winton that some of our people had joined. Leading the tour was a very informative Aboriginal guide and an ABC television reporter accompanied the group. Apparently they were visiting sites where local films had been made. Further down the drive at Bough Shed Hole on Surprise Creek we stopped for lunch beneath the river gums, trying to shelter from the clouds of dust entrained by the strong wind that had just sprung up. The wind ruined any chance of photographing reflections in the creek. We then drove on to Top Crossing, a broad flat rocky crossing over Surprise Creek. Here there were interesting examples of gully (badlands) erosion on the eastern bank. Immediately across the creek the bush changed abruptly to dead finish acacia, then just as abruptly back to mulga, spinifex and termite mounds.

The road then passed through the Allen Range, a region of low but spectacular rocky ridges *(Photo 39)*. The first of these lay along the edge of another jump-up and demanded closer inspection. Here we found grey thinly laminated lake bed sediments overlain by cross-bedded fluvial sandstone/greywacke. Some of the lake bed shales had been brecciated by sudden water inflow (torn up mud clasts) and areas of the same rock showed unusual white bleached zones migrating in from joint sets. Limonite concretions weathered from the sandstone lay scattered around the lower slopes. A small quarry on the other side of the road revealed more interesting rocks and spectacular polygonal mud cracks in a dried up pool. Within the Allen Range lies Crag's Bouser. Richard Cragg was a mail contractor who died under mysterious circumstances back in 1888. His descendants still live in the Winton area.

Just before reaching the Opalton road we noticed a sign to

38. Cracks in dehydrated soil at Long Waterhole near Winton.

39. Rock ridge in the Allen Range, Bladensburg National Park.

40. Creek bed erosional features at Logan Falls.

41. Combo Waterhole on the Diamantina River north of Winton.

Logan Falls at a turnoff leading to the south. With time to explore we ventured down the track, ending up at what proved to be the most spectacular landform feature on the whole drive. And it was neither listed nor described in the tourist brochures! In the wet season the deeply incised meandering creek plunges over a vertical rock face into a spectacular pit bordered by sandstone cliffs, now glowing orange in the afternoon sun. Scattered eucalypts had found a precarious footing at the base of the pit and crabs had excavated holes in the mud at the water's edge. Further upstream we came upon fascinating potholes, arches *(Photo 40)* and other unusual water-carved features.

We returned to Winton around 3:50pm along the Opalton and Winton-Jundah roads, rounding off the day with a most welcome iced coffee at the Musical Fence Café.

Sunday 29th June

We left in convoy at 8:50 am for the journey to Cloncurry, 350 kilometres to the north of Winton, through the flat to gently undulating grazing country of the Eromanga Basin. Only a range of mesas capped with hard sandstone interrupted the monotony of the landscape. The only fauna seen was a single emu and a few wedge-tail eagles.

An 8 kilometre detour off the Landsborough Highway 132 kilometres northwest of Winton saw us at Combo Waterhole on one of the braided channels of the Diamantina River. There was a short break for morning coffee before we began the walk to the waterhole *(Photo 41)* along the old coach road, passing several unique flagstone overshots (stone-faced walls) built around 1890 for Dagworth Station by Chinese labour. Teams of men used horse and dray and baskets to carry in carefully selected stone and dirt. The stones were laid in tightly packed and interwoven rows strengthened by keystones to withstand the flowing water. Water flows over these walls until it drops to overshot level and is captured in the Combo and other waterholes, about a metre higher than the natural level. The fact that these structures are still in place and are still doing what they were built to do is an astounding monument to the men who built them *(Photo 42)*. An additional use today is to provide dry all-weather crossings.

As well as a record of the ingenuity of the early pioneers, the overshots also provide a window into the local geology, which is largely hidden by soil in this region. The rocks appear to be fine-grained lake bed sandstones containing layers of imbricated ripped up mud clasts, with later formation of overlying concretionary limestone bodies.

The Cobb & Co coaches that provided the No.7 mail service between Cloncurry and Winton followed the Diamantina River once or twice a week between 1899 and 1915, watering the horses at Combo Waterhole. Old Dagworth station homestead to the southeast was converted to a mail exchange hotel, providing an overnight stop between Kynuna and Winton.

Banjo Paterson visited the area in 1895 and is said to have written Waltzing Matilda here following the second of the great shearer's strikes centred on Winton in 1894. One of the legends behind the famous poem is that a trooper had been pursuing a man who had beaten an Aboriginal to death and came across a swagman who had killed a sheep for food. The swagman drowned when he tried to escape by jumping fully clothed into a waterhole.

Some stayed at the Combo Waterhole picnic area for lunch while others drove on to the McKinlay Crocodile Dundee Hotel. But the much anticipated cappuccinos were not available here, only Nescafe satchels, which of course we could provide ourselves!

The country was fairly bushy north of McKinlay with scattered ghost gums and thousands of termite mounds. These are nature's climate-controlled high-rise apartments. In dry tropical regions, where earthworms do not survive, termites play an essential role in recycling dead dry wood, roots and leaves. They can digest wood cellulose and provide food for numbats and echidnas. Termites have been around for between 130 and 150ma and pre-date other social insects such as ants and bees by tens of millions of years.

The first indication that we were entering an area of high mineralisation came with the turn into the Chinese-owned Eloise copper mine, 8 kilometres off to the east. The road then followed a very prominent line of rocky hills and soon we began to leave the plains of the Eromanga Basin and enter the metamorphic rocks and granite outcrops of the Proterozoic Eastern Fold Belt. We arrived in Cloncurry at 4pm and set up camp in the Oasis Caravan Park opposite the Mary Kathleen Memorial Park, Tourist Information Centre and Museum. This would be just an overnight stay and we would return towards the end of the trip to spend more time here.

Monday 30th June

Still in travel mode, today we headed northwest along the Burke Development Road passing just within the sharply defined eastern edge of the Eastern Fold Belt, here a north-south zone of metabasalt and felsic volcanics. Between Cloncurry and Quamby these rocks outcrop as spectacular rocky knolls and ridges. This region forms the eastern part of the Early to Middle Proterozoic Mount Isa Inlier, which is enclosed by the Georgina Basin in the west, the Carpentaria Basin to the northeast and the Eromonga Basin to the southeast. Particularly striking exposures of strongly deformed gneissic granites in the Naraku Batholith, which intrude the rocks of the Eastern Fold Belt, were seen in road cuttings just out of Cloncurry. An indication of the importance of this region as part of Australia's mineral wealth is the location of the huge newly developed MMC mine at Dugald River to the west of the road. As we continued north, the rocky hills of the Eastern Fold Belt gradually veered away to the west and we briefly returned to the flat grassy plains of the southern Carpentaria Basin.

After pausing for refreshments at Burke and Wills

42. One of the many overshots on the creek at Combo Waterhole.

Roadhouse we turned to the northwest onto the Wills Development Road, travelling through blue gum forest devoid of kangaroos or emus for several kilometres before passing through isolated patches of open grassland. Enormous herds of Brahman cattle were seen sheltering along the edge of the treeline. We reached Gregory Downs at 1:20pm and set up camp in the small but very pleasant caravan park behind the Gregory Hotel.

After lunch we explored the land behind the caravan park, finding a rough path down to a deeply-incised dry creek which we followed for several hundred metres to the southern bank of the Gregory River. Along this meandering sandy creek bed thousands of ant lions had set their traps, some of them unusually large. At the river we found crystal-clear water flowing over wide pebble beds with quiet pools along the edge rimmed by a narrow dense forest of huge paper barks, pandanus and cluster figs. A more idyllic scene could hardly be imagined. But across the river, dozens of caravan camps had been set up illegally on the flat gravel banks.

Most of the group had dinner that night at the Gregory Hotel and I must say that I had the best chicken in pyjamas ever!

Tuesday 1st July

We left Gregory Downs at 8:45am in groups of two vans. The road west to Adel's Grove was sealed part way before it turned to dirt, but then became unbelievably rough and corrugated beyond the turnoff into the Century mine. Enormous termite mounds had begun to appear several kilometres before we arrived at Adel's Grove around 12pm. It was disappointing to find that our sites were widely scattered, some located in the Grove and others some distance away in the van parking area. But in the end everyone was satisfied with their location and their pleasant surroundings. Adel's Grove is the main access

43. Flowering water lily in Lawn Hill Creek at Adel's Grove.

point to Lawn Hill Gorge, one of Queensland's prime natural attractions, and the Riversleigh fossil deposits.

The property covers 80 acres of Gulf Savanna Country within the Lawn Hill Cattle Station and was first surveyed in 1904. It was gazetted a miner's homestead perpetual lease in 1920, being located in what was then the Burketown Mineral Field. This included the hills to the east and south of Adel's Grove and now forms part of the Carpentaria Mineral Province that has produced lead, zinc and silver since the late 1800's. The currently operating Century zinc mine lies within this province and is only 12 kilometres due east of Adel's Grove. At night the lights at the mine produced a visible glow above the hills and the incessant low drone of machinery could be heard throughout the camp.

French botanist Albert De Lestang purchased the property in 1930 and he used the land to experiment with the growth of tropical trees and fruits. By 1939 he was growing more than 1000 tree and shrub species, many of which had been imported from Africa, Asia and America. But in the early 1950's a fire that escaped from one of the small mining ventures to the south accidentally destroyed the garden complex. Albert was then in his early 70's and with all his garden and records gone he succumbed to severe depression and died aged 75 at a home in Charters Towers in 1959. Since then the property changed hands several times. But none of the later owners showed any interest in continuing the botanical aspect of the Grove and only a few of the original plants remain. The Grove is now a fauna sanctuary and protects a wide range of animals including many snakes, freshwater crocodiles and an abundance of birds.

After lunch there was ample time to explore the nature walk along Lawn Hill Creek, again amongst a narrow zone of thick forest comprising massive paper barks and pandanus. Fragments of tufa lay under foot, perhaps washed down from Tufa Falls. Magnificent deep clear

44. Termite mounds near Adel's Grove.

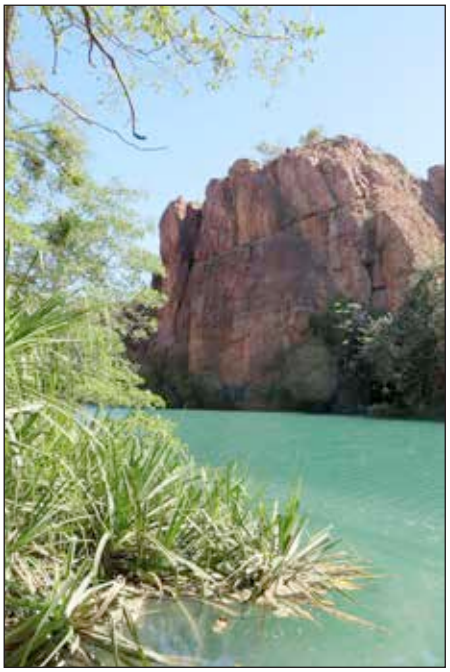
pools perforated the edge of the stream, some carpeted by native water lilies in flower *(Photo 43)*. These provide shelter for up to 20 species of freshwater fish. Turtles and file snakes shelter in the ferns, sedges and bulrushes fringing the creek. The track eventually turned away from the creek and wound up the side of Lookout Hill, which provides walkers with expansive views over the surrounding area. But some of the group were distracted away from the track by enormous termite mounds scattered over the top of a grassy ridge a few hundred metres off to the north *(Photo 44)*.

That evening we attended the first of several talks by Professor Michael Archer who would be our guide for the Riversleigh World Heritage Area day after tomorrow. His lecture, an over view of the Riversleigh fossil deposits, was presented with a level of enthusiasm and humour that very few people in any field of science can match. He began by apologizing for his American accent, emphasizing that he was indeed Australian and fiercely proud of it! Even the children in the large audience sat spellbound throughout.

The Riversleigh fossil site is located in the southwest corner of Lawn Hill (Boodjamulla) National Park. Fossils were first discovered there in the early 1900's but it was not until the 1960's that the first serious exploration took place. Then in 1976 Mike Archer began to explore the area with the Queensland Museum. This exploration was taken over by the University of New South Wales, which now conducts annual digs. The region was given World Heritage listing in 1994.

The fossils provide evidence of key stages in the evolution of Australia's unique fauna. It is outstanding for the phenomenal diversity and quality of preservation of

45. Some of the rock walls of Precambrian Lawn Hill Sandstone along the entry to Lawn Hill Gorge.



46. The southern end of Middle Gorge at Lawn Hill Gorge.

fossils. It has enabled scientists to understand the history of mammal lineage in modern Australia. The variety of deposits over a 15-25ma time span has led to an understanding of how the environment changed from a richly diverse rainforest habitat to a semi-arid grassland, and how the animals adapted to this change in climate.

The Gulf snapping turtle *(Elseya lauarackorum)* was first described in 1994 from a fossil found at Riversleigh. It was thought to be extinct but then a living turtle matching the fossil was found. This is Australia's first living fossil and largest freshwater turtle.

Wednesday 2nd July

Some campers complained about the sound of barking dogs in the camp early in the morning but this was later found to the dog-like call of the barking owl. Blue winged kookaburras added to the pre-dawn cacophony.

Most people spent the day exploring Lawn Hill Gorge on foot. The road enters the National Park along a narrow rock-walled valley *(Photo 45)* of Precambrian Lawn Hill Sandstone 1.6 billion years old, deposited as sand infilling a shallow sea. Ripple marks in these rocks are common, evidence of their watery origin. Life in those Proterozoic times amounted to little more than algal mats (stromatolites). Then in the Cambrian (530ma) another shallow sea formed, lapping against the Proterozoic sandstone hills from the south and west. Sediments rich in calcium carbonate and silica then accumulated to form limestones containing the remains of sponges and trilobites. These grey limestones containing nodules of chert now outcrop in the Upper Gorge and west of Riversleigh.

Lawn Hill Creek is fed by rainfall but also from springs in the limestone of the Upper Gorge. These springs arise from aquifers in the Georgina Basin to the southwest. The creek flows all year round. Aboriginal pre-history goes back at least 17 000 and perhaps even 30 000 years. The traditional land owners, the Waanyi People, called the area Boodjamulla or rainbow serpent country.

From the visitor centre we set out on foot to the base of the steep track up onto the Island Stack, along the way passing through the magnificent old growth forest along the western branch of Lawn Hill Creek. On top the 1.7 kilometre circuit track wound along the edge of the cliffs through undulating savanna grassland with only scattered trees finding a foothold in the more rocky areas. There were dizzying views over the cliff edges down into the narrow chasm of Lower Gorge and across the central basin to Middle Gorge.

After lunch back at the visitors centre, we walked along the track to the southern end of Middle Gorge *(Photo 46)*, the emerald green water here fringed by paper barks, cabbage palms *(Livistona rigida)*, pandanus *(Pandanus aquaticus),* Leichardt trees and cluster figs *(Ficus racemosa)*. From here we tackled the steep climb up to Duwadarri Lookout, passing interesting patterns in the sandstone formed by bands of heavy minerals *(Photo 47)*. Here the views down into the Middle Gorge with its narrow deep green fringe of riverine forest finding a precarious toehold close to the water were spellbinding.

47. Patterns in Lawn Hill Sandstone formed by layers of heavy minerals.

The track then skirted the precipitous edge of Middle Gorge to Indarri Lookout on a rocky crag overlooking the Tufa Falls. At the Falls, water rich in calcium carbonate has for thousands of years flowed over obstructions in the creek bed, depositing thin skins of calcite which have trapped plant and animal matter. The resultant rock is brittle and very porous but has built up to such an extent here that semi-permanent dams and other structures have formed in the creek bed, connecting patches of vegetation growing midstream *(Photo 48)*. Climbing down to the edge of the creek at the falls we found some of our people enjoying a swim with the native fish in the cool glass-clear water. It was very tempting. As the track plummeted down

48. Tufa dam in Lawn Hill Creek at Tufa Falls.

to the falls unusual finely spaced banding in the sandstone similar to Leisegang banding resulted in some spectacular patterns in the rock *(Photo 49)*. We returned to the cars following the track anticlockwise, en route passing a massive bed of conglomerate as it plunged down to creek level.

That evening Mike Archer gave another talk to the assembled campers, this time on "de-extinction". Again we listened spellbound, with Paul again asking some leading questions at the end of the talk.

Thursday 3rd July

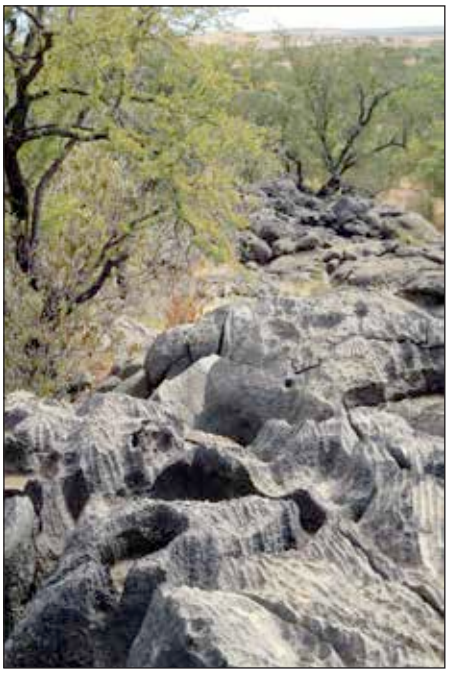
Together with the Waterhouse Group from Adelaide, we spent the day out at Riversleigh with Mike Archer and the crew from the University of New South Wales. On the way out we paused at the Lilydale silver-lead mine, located on the side of the road at the foot of a small hill 20 kilometres south of the Lawn Hill road, to scratch in the dumps for samples of galena. A more thorough investigation of this mine and its history would be carried out the following day by a few of our members.

Our first stop was at Site D, the tourist site, where grey Late Oligocene (24ma) limestones cap a ridge of orange conglomerate containing abundant chert clasts. The basal rock at Riversleigh is a Cambrian (530ma) limestone. This site was discovered around 1900 beside what was then a major stagecoach route. Here a large rock, called "pee rock", had rolled down from the adjacent cliff and landed upside down on the regolith. As the name suggests the rock had been used as a relief point by travelers, who noticed white bone fragments in the limestone. Those same bones are still visible today.

An artfully designed hollow limestone bounder had been constructed nearby by the Queensland Government Parks and Wildlife Service to house an impressive interpretive display. Inside we found ourselves in a reconstructed

49. Patterns in Lawn Hill Sandstone above Tufa Falls on Lawn Hill Creek.

50. Gizzard stones in the stomach of a Dromornithid bird at Riversleigh Site D.



51. Weathered limestone outcrops near Bitesantennary Site at Riversleigh.

limestone cave environment, the walls of which held explanatory displays and life-size reconstructions of two of Site D's most famous fossil discoveries. The huge flightless Dromornithid bird ("Thunderbird") stood 2.5 metres tall and weighed between 250 and 300Kg. It is only known from Australia and belonged to the heaviest group of birds that ever existed. Surprisingly it is not related to modern flightless birds such as emus, cassowaries or ostriches but to a group of birds which includes the modern domestic duck! The huge freshwater crocodile *Baru wickeni* discovered at Site D reached 5 metres in length and is the longest crocodile recorded at Riversleigh. It was a freshwater carnivore that preyed around the margins of lakes and rivers. But at Riversleigh there were at least 9 crocodile species including specialized fish-eaters and semi-aquatic ambushers as well as terrestrial carnivores which ran down their prey in the forests.

Only a very brief account can be given in this report and readers are referred to the brilliantly written, beautifully illustrated and very detailed account given by Michael Archer, Susan Hand and Hank Godthelp in their 1991 book simply called "Riversleigh" and published by Reed Books.

In the Late Oligocene the lowlands around Riversleigh were a region of dense species-rich rainforest. Here at Site D, lakes covered with water lilies and fed by springs provided habitat for large turtles and other reptiles, as well as fish and snails. Crocodiles ran down their prey in the forests and pythons (including *Montypythonoides riversleighensis*) slithered around the edge of the waterways where huge *dromornithid* birds came to feed. There were also kangaroos, lizards, *thylacines* and *diprontontids* here. Periodic deluges of rain washed fragments of this paradise into the lakes, to become fossilised along with the remains of the lake fauna. There is no evidence for a fluvial environment at Riversleigh. All drainage was apparently internal.

Along the short walking track at site D we were shown a boulder that had split to reveal the thigh bones of one of the giant huge flightless *Dromornithid* birds. Alongside lay a large oval concentration of well-rounded chert pebbles, which had been used by the bird to grind food in its gizzard *(Photo 50).*

From Site D we drove back along the Riversleigh road and turned west onto the narrow track winding through Bitesantennary Valley. This would eventually lead us to a number of sites currently under investigation. Just after turning off, a tyre on one of the vehicles had succumbed to the rough stony road, so it was unanimously decided to pause for morning coffee beneath the limestone escarpment, which here lay on top of undated conglomerates and other sediments lying stratigraphically directly beneath Site D.

Back on the track, winding like a dreamtime serpent along gullies and over grassy lightly timbered ridges, we pulled off into the grass below a spectacular limestone ridge along the summit of which lay the famous Bitesantennary Site. A short single-file scramble up a well-defined track weaving crazily amongst beautifully sculptured limestone boulders *(Photo 51)* brought us to the northern side of the summit, where one of the richest of the Riversleigh fossil sites had been found. This site was the floor of an ancient cave whose roof and walls have long since vanished. For

52. Fossil bones in limestone outcrop near Bitesantennary Site, Riversleigh.

54. Volunteers at work, Riversleigh.

many of the animals living in the Riversleigh rainforests in the Early Miocene (20ma), caverns eroded in the limestone under the forest floor by percolating water charged with carbonic and humic acids became passageways to eternity for the unwary. The roofs of these caves eventually collapsed and bats colonized the newly accessible walls and ceilings. Pythons found these bats easy prey. Pools of water in the caves nourished huge colonies of snails and algae and hundreds of generations of bats produced their own steady rain of guano, which accumulated as bone-rich domes. Bandicoots and other forest fauna sometimes fell into these pools and unwittingly added their bones to the incredibly rich Bitesantennary fossil deposit. The Riversleigh region was riddled with such caves by the Middle Miocene.

Only a small part of the cave floor at Bitesantennary has been excavated. But a 2 metre square pit sunk at its western end proved to be a treasure trove of fossils. There were thousands of bat skulls and tiny bat bones. But most extraordinary of all finds were the ostracods containing fossil sperm! One of the many lumps of coarse brown calcite speleothem scattered around the site returned an age of 17ma. This was the only site where we were invited to take away samples of the rock.

53. Calcite ooliths in cave floor deposit near Bitesantennary Site, Riversleigh. 15 cm.

Scrambling further east along the side of the ridge, finding evidence of bones in every rock *(Photo 52)*, we came to another cave floor deposit about 200 metres from the Bitesantennary dig. Here weathered limestone cobbles showed superb examples of cave pearls, concentrically-zoned calcite ooliths which grew in the cave pools *(Photo 53)*.

We clambered back down to the vehicles and continued along the track for several kilometres, following the northern outcrop of Paleogene limestones to a clearing near Site AL90, where we pulled in for lunch with Mike and the team. It was here that Dawn and Stan watched the first snake to be seen on the entire trip beat a hasty retreat off though the spinifex.

As we were packing up ready to leave, Mike came across and asked if we were sick of fossils yet! Of course it was an emphatic and unanimous no, so the half day we had expected turned into a full day exploration of the Riversleigh sites, all the while Mike expounding enthusiastically on the various finds, with a good deal of wit and humour thrown in for good measure.

A short stroll across the spinifex-covered hillside brought us to Angela's Sinkhole, where workers were busy digging out limestone boulders *(Photo 54)* embedded in the cave fill. Some were too large to handle and had been broken up by low-power explosives. The fragments would later be re-cemented using epoxy then placed in an acetic acid bath back in the laboratory to fully reveal the fossils.

Further across at Site AL90 we watched excavations being carried out in the top of a large terra rosa –filled cave, originally located because of bones poking from the ground. Here bones encased in limestone layers on the cave floor included a *Thylocene* skeleton. One corner of this massive bone-rich cave has been radiometrically dated at 15ma. The importance of this site lies in its documentation of massive climate change. Dense rainforest existed here

around 15ma. Then Papua New Guinea was uplifted during the collision of tectonic plates, causing a rain shallow effect over much of northern Australia. The region slowly dried out as direct result. Changes in the fauna seen at Site AL90 document both these climatic changes and the adaptive changes in the flora and fauna.

A total of 250 fossil sites in the Riversleigh area have been logged by GPS. Although illegal collecting of fossil material has been and unfortunately will continue to be a real problem, most of the sites are protected simply by their remoteness. It costs around $40K to organize and run each collecting expedition and currently there are around 120 people working on the Riversleigh fossil record.

Some people paused briefly at the Lilydale mine but we were all back in camp around 4:30pm with time to prepare dinner and attend the evening lectures. Down in the main dining area Robin Beck gave an excellent presentation entitled Marsupial origins – a 125ma oddesy. This was followed by David Cohen on Portable EDS XRF. This last talk prompted quite a few enquiries from two of our members who had during their working lives been heavily involved with XRF and other X-ray analytical techniques. I had seen these hand-held devices before, but continue to be amazed at such analytical power delivered by such a small readily portable machine, although they have their limitations.

Friday 4th July

This was another free day to enable people to do their own thing. David, Chris and I headed off down the Riversleigh road again to fully investigate the Lilydale silver-lead mine *(Photo 55)*, located beside the Riversleigh road one kilometre south of the property boundary and 20 kilometres south of the Lawn Hill road.

The Lilydale mine exploited one of a number of brecciated sediment hosted deposits in extensional sites associated with a zone of intensive northeast-trending strike-slip faulting in Late Precambrian rocks of the Lawn Hill Platform within the Lawn Hill Mineral Field. The region lies in the Mount Isa Inlier. The host rocks are shales of the Lawn Hill Formation which comprises sandstone, siltstone, carbonaceous shale, tuff and felsites. The lodes occur as narrow quartz/siderite veins along faults and associated fractures and the vein walls are characterized by strong brecciation, as seen in the shales on the dumps. The shale beds are steeply dipping due to the proximity of the mine to a southwest-plunging syncline. Outcrops were delineated by well-developed gossans composed mainly of iron hydroxide (goethite) formed by the oxidation of the siderite (iron carbonate) in the veins. This oxidation and leaching extends to a depth of 30 metres, which is the limit of development at the Lilydale mine. Although the gossan contains small oxidation cavities and cracks lined with the lead carbonate cerussite, the major ore mineral appears to have been the lead sulphide galena. In the dumps this occurs as coarse-grained pods rimmed by cerussite and shows distinct shearing textures, suggesting it was remobilized along structures in the shales. The galena pods are probably remnants of primary ore located within the oxidised zone above the water table. The galena at Lilydale is low in silver with only 1 to 3 pennyweights per one percent of lead. However pods gleaned from the dumps make handsome specimens when broken open.

55. Lilydale silver-lead mine on Riversleigh Station.

Afghan miners between the 1890's and 1930 developed the Lilydale mine, with the ore being hauled out to Burketown by camel. Today three open pits to 5 metres and several shafts, the deepest around 30 metres, plus extensive dumps of shale and barren gossan attest to the massive effort expended by these early miners. Lumps of metallurgical coke and rare blocks of slag scattered around the site suggest that at least some processing of the ore had taken place before shipping, but apart from the slag there was no indication of any smelting operation. Perhaps the galena was simply melted into ingots to make transport easier. Rusting gears near the dumps indicate that a small crushing plant may have operated here at some stage in the mine's history. There were indications of an old camp on the opposite side of the road, but this may have been associated with more recent work indicated by the presence of a number of scattered rusting 44 gallon drums and a short rail line along the length of the main dump. Scattered conical piles of gossan and small pits along the outcrop may have been part of systematic sampling during a diamond drilling program which took place in 1930.

Other mines, the most important being the Silver King, lie approximately 12 to 15 kilometres to the north, adjacent to the old coach road. The galena from these mines is reportedly much richer in silver.

We arrived back at Adel's Grove around 11:30am loaded with quite heavy but interesting specimens. After lunch a small posse of people drove out to the National Park to check out a fossil site just within the Park boundary that Mike Archer had spoken about out at Riversleigh yesterday. Supposedly there were Cambrian rocks rich in trilobites and other things, but all we found after a few hours of scrambling along the ridgeline were areas of ripple marks, some showing interference patterns. It was obvious that we had not listened intently enough to Mike's directions.

For most of the group dinner that night consisted of Barramundi and chips from The Shack eaten around a roaring campfire that threatened at times to engulf my tent, or at least fill it with smoke! During dinner the second round of Numbat awards were handed around, causing considerable embarrassment to some as was intended.

We found a sign on the toilet doors in the amenities block quite amusing: "Please keep lid down. It keeps the frogs out and those who come in to eat the frogs". This is a less than subtle indication of the abundance of snakes at Adel's Grove!

Again Mike Archer provided the evening's entertainment with a talk entitled "Australia is NOT a nothing place". With his usual rare enthusiasm and fierce support of everything Australian, We sat absolutely spellbound at the long list of Australian firsts in the fields of geology, paleontology and botany. A complete list would take up many pages but some include the World's largest ever dinosaur at Broome in Western Australia (Its tracks measure 1.7m across, but the animal itself has not been found), the World's oldest zircon crystal at North Pole in Western Australia, the first record of sex in animals and the first song birds in the World. The Worlds tallest trees are not the giant sequoia in California but a species of mountain ash in Tasmania. And so it goes on, and on, and on!! This really makes one proud to be Australian and it would be really great to see the full list published and be made accessible to those people who love to rubbish this wonderful country.

Saturday 5th July

We left Adel's Grove at 7:50am to drive back to Cloncurry. The trip out across those terrible corrugations saw a number of people come to grief. The microwave oven in Ian and Sue's van fractured its mountings and did a death dive to the floor to end up as a work of abstract art incapable of cooking anything. The suspension on Brian and Barbra's van simply gave up and refused to provide any further support. We were amused at the Burke Shire Council signs along this part of the road "extreme dust hazard on these roads". What about the bloody corrugations!!

Most had reached Gregory the worse for wear by around 10am. Some paused briefly at Burke and Wills Roadhouse for fuel. Most had arrived in Cloncurry by 2:30pm.

Our return to Cloncurry had coincided with the second day of the Gem and Mineral Festival held at the Mary Kathleen Memorial Park in McIlraith Street, almost opposite the Cloncurry Oasis Caravan Park where we were staying. But it wasn't a big show and there was not a lot to see. Certainly there was little if anything to interest a mineral connoisseur, although some nice local fossils were up for grabs, including some superb ammonites from the Richmond area. There was plenty of opal around and informative displays by the mining interests at Enst Henry and Dugald River. Spectacular drusy quartz from a prospect near the old Hardway mine drew some attention, but prices were much too high. Then there were a number of showy specimens of yellow pyromorphite from the Black Star open cut in Mount Isa collected some years ago by Neville Whitworth, a retired metallurgist from Mount Isa Mines, who turned out to be a great mate of a great mate of mine in Canberra! Neville also had a number of polished slabs of Selwyn amethyst crystals sectioned transversely showing Brazil-Law twinning with alternating triangles of purple and colourless. These made nice jewellery.

I had been told by some of our group that I just had to go and see the mineral and rock display in the little museum called "Cloncurry Unearthed" attached to the Visitor Information Centre. Apparently there was a fossil fish from Bugaldi chalk mine on display that wasn't from Bugaldi, but it had by name prominently attached to it! The displays were extensive, comprehensive and nicely arranged in glass cases down the centre of the room with more stored in drawers along one side. But even in the first case I could not believe what I was looking at! Specimen after specimen had my name attached as being the source and in all these amounted to over 50 pieces!! Some I could vaguely remember owning, but over 40 years ago. I ran out into the information centre and raked out the curator, Gail Wipaki. We both returned excitedly to the display where I pointed out each specimen that was once mine. The penny dropped when Gail explained that most of the collection had come from a collector called Sylvia Fowler in Mount Isa, whose daughter now runs the Mount Isa Rock Shop. That explained it all – back in the early 70's I had exchanged a lot of material with a collector in Mount Isa – Sylvia Fowler! She had passed away last year and the collection came to Cloncurry Unearthed. The Bugaldi fish was indeed not from Bugaldi but was a freshwater fish from the Talbragar Fish Beds near Gulgong. But it had my name on it! Sylvia had somehow transposed the original labels. In fact there were many errors in both provenance and species throughout the display, something that I have

to correct once this report finally goes to print.

Sadly it was reported in the North West Star on Thursday September 4th that a display case in the museum had been accessed using a screwdriver and 14 specimens stolen during daylight hours. The thief evidently had a preference for fluorite (11 specimens). Other pieces stolen were tourmaline, calcite and malachite and included specimens from Mount Isa, Cloncurry, Quamby and Mary Kathleen. Cloncurry Shire Council is now updating security.

Sunday 6th July

Most of the group spent the day in Mount Isa, just 122 kilometres to the west. We began at Outback at Isa for an overview of what there was to see in this very isolated and historic mining town. Mount Isa was built on the blood, sweat and tears of people from many nations. Highways in and out of the city were built by the Americans during World War II, the rail line by the Afghans and the mines by the influx of Scotts, Irish, Finns and Hungarians. It remains one of the most culturally diverse cities in Australia with people from more than 50 nations calling it home. For a detailed account of Mount Isa's history readers should refer to BLAINEY, G. (1960). Mines in the spinifex, Angus and Robertson.

In 1942 Mount Isa was on a war footing. The Japanese had bombed Darwin and it was feared Mount Isa could be next. The Mount Isa Hospital Board decided a safe underground hospital was needed to care for patients and casualties if the city was attacked. Mount Isa Mines (MIM) miners built it and MIM supplied the materials. Surgical, maternity and medical facilities, outpatients and operating theatres were all part of the construction. But thankfully it never had to be used for that purpose and for some years was used only as a resting place for nurses on night shift at the above ground hospital and as a storehouse. It eventually fell into disuse and in the 1950's the entrance was sealed with earth. The tunnels were not rediscovered till 1977 when workers began looking for the cause of local subsidence. There is an excellent one hour guided tour of this historic facility.

56. *Bullockornis*, a giant flightless bird that lived till 26 000 years ago.

Back at the Information Centre there was plenty more to see. At the Riversleigh Fossil Centre tourists can experience an overview of the Riversleigh story and its astonishing fossil record explained using a variety of displays, including dioramas *(Photo 56)* and the skull of a diprotodont from Site AL90. But most found it a bit tame after our personally conducted tour of the actual sites. There is also the Rex Pickhera collection of polished ornamental stones and the Outback Park, showcasing plants of the Mount Isa region and a waterfall modeled on the tufa dams on Lawn Hill Creek in Boodjamulla National Park.

By far the greatest attraction and the reason for visiting The Isa was the Hard Times Underground Mine Tour adjacent to the Information Centre. This had to be booked ahead before leaving home. MIM had been running tours at its mine until the injury of a tourist brought that to an end, so to enable tours to continue $6 million was laid out to construct an exact copy of one of the levels in the Big Mine. Although not in the ore zone this provides tourists with an authentic underground experience. Every guide is a true blue, dirt-covered, rock kicking, hard of hearing, tough as nails Mount Isa miner who shares his stories of life underground at the Big Mine. After we trogged up with all the necessary gear – boots, orange paper overalls, lamp and battery just like a real miner wears, we spent the next 2.5 hours experiencing the day-to-day activities of a working underground mine. The 1.2 kilometres of workings house a vast collection of mining machinery, all donated by MIM, all in working order and all expertly demonstrated by our guide, including air drills and the enormous and deafening bogger machines which load the excavated material into mine cars to be hauled to the surface. At the end of the tour we shared tea/coffee and biscuits in a typical crib room where large and heavy samples of the various sulphide ores had been laid out for us to study. Our guide apologized for not being able to provide the sound effects of an underground blast as children who had tunneled under the steel entry door to the mine had stolen the equipment a few days before.

Before leaving The Isa Ian, Sue and I drove up to the end of Mines Road through the greatest concentration of mine infrastructure, taking several photographs of the

headframes and other mine structures. The wall of small cut at the head of Death Adder Creek opposite the Black Rock open cut displayed spectacular deformation in the Urquhart Shales.

Everyone was back in Cloncurry by 7:30pm.

Monday 7th July

We were away from camp at 8:30am and headed west for Mary Kathleen, pausing briefly at Chinaman Creek Dam Recreation Reserve just west of Cloncurry for photographs of the spectacular rocky hills reflected in the lake water.

We turned north off the Barkley Highway 64 kilometres west of Cloncurry and drove through a landscape of rocky hills and eucalypt forest towards the abandoned uranium workings. Although the road was sealed it has not been maintained since the mine closed and drivers were forced to play a game of dodge the pothole, or risk serious damage to vehicle and/or occupants. The concrete culvert just south of the old town site will cause access problems after the next flood or two, the approaches so badly washed out that even now the road is barely wide enough for a normal vehicle, let alone a caravan. But some vans had made it through and had set up in the very pleasant surroundings beside the creek. At the track junction we followed the rudimentary road sign and turned right into the old town site, now just a scattering of concrete slabs in the grassy clearing where homes had once stood amongst the trees. A dry creek bed encircled the site with an almost continuous crescent of magnificent ghost gums. And there were poignant reminders of those who had once lived and worked here, including a welcome mat on one of the abandoned concrete slabs.

In the winter of 1954 the quest for uranium had grown intense and a syndicate of prospectors stumbled on a really genuine cause for excitement. The syndicate leader, Mount Isa taxi driver Clem Walton had been shown a sample of pitchblende an old copper gouger named Jack Fountain had mined in the ranges near the Rosebud copper smelter. Walton and his team prospected the area where he believed the old gouger had found his unusual ore and on a steep hill overlooking a wide valley they found a grey rock that made their Geiger counter race. The ore was so rich that the syndicate accepted 250,000 Pounds for the lease barely a month after its discovery plus a royalty on all the ore mined. It was to earn huge profits for the discoverers and the Rio Tinto Company of England. One of the burdens in opening a mine in such a remote region was the expense of setting up a completely new community and all its amenities. This was left completely up to the investors and Government took no part. The town and mine were designed so that the existing trees and background landscape were preserved in such a way that is very rarely attempted by mining interests today. But the glory was short-lived and in 1963, with World supplies of uranium adequate, Mary Kathleen closed with the deposit still containing more ore than had been mined.

57. Macro-shearing in banded metamorphic rock from Mary Kathleen mine. Brian England specimen. (R 733) 9 cm.

An extensive drilling program was conducted between 1967 and 1969. Determined mineable reserves then stood at 6.43 million tonnes at a grade of 0.119% U_3O_8. Original reserves at time of discovery had been 9.483 million tonnes. Mining recommenced in 1976, finally ceasing permanently on 16th September 1982 when reserves were exhausted.

The orebody lay in a north-plunging syncline in Lower Proterozoic sediments of the Corella Formation within the Mount Isa Inlier. These rocks have been metamorphosed to calc-silicate rocks, garnetite, scapolitic metasediments and slate. The ore zone lies almost entirely within the garnetite, which contains the complex rare earth element (REE) silicate minerals allanite and stillwellite, the latter first described from Mary Kathleen. The uranium occurs as uraninite forming fine disseminations (0.1 to 0.01mm) enclosed by silica shell within allanite, making it unique amongst Australian deposits. The source of the uranium remains unresolved, but may have been remobilized from the sediments during metamorphism. The Mary Kathleen deposit is also Australia's largest deposit of REE, principally cerium and lanthanum, but this has not been exploited.

Several hours were spent exploring the dumps around the old plant before moving up the ridge to the abandoned open cut. Many interesting rocks were found in these dumps, including unusual examples of macro shearing *(Photo 57)* in the host metamorphics and lumps of very heavy pyrrhotite-riddled garnet/allanite/uraninite ore. At the open cut we stood spellbound at the colours in the walls cause by oxidation of the sulphides in the rocks *(Photo 58)*. Circumnavigating the water-filled pit along

one of the wide benches gave us a good idea of the mine geology, although much of the rock face was blanketed with finely crystallised gypsum.

Here Elaine found an old friend – a perfectly mummified snake, which of course she insisted taking home. Sadly, it did not make it! When it reached the high humidity of the East Coast the snake took its revenge by rapidly absorbing moisture and rising from its mummified state to emit the most four odour.

Down at water level we found a patch of half-submerged and skeletonised bushes bleached white by the sun that provided photographers with spectacular foreground for the colourful pit walls. Below water level the branches were draped with dark green algae, adding to the photographic effect when a polarizing filter was used to block out reflections *(Photo 59)*.

Assembling back at the abandoned mill site we had a picnic lunch under the trees before moving off to explore the area using mud maps Jan Hetherington had brought along. Driving off to the north, we missed the turn to the right we were supposed to take to some interesting mineral locations and continued on for 7.8 kilometres till we came to a cattle grid. Here we found piles of very coarse grey calcite, obviously bulldozed from the road bed during its construction. The track forked here and became much better maintained. Indeed it had been freshly graded, but why? Where did it go? Our map suggested the right branch headed back east towards Cloncurry, so we took it. From the photographers' point of view this proved to be a good move. There had been tantalizing glimpses of spectacular rocky hills through the bush. Then 2.2 kilometres from the grid appeared what we had been hoping to find, a stunning hill of boulders *(Photo 60)* that had the photographers in uncontrollable raptures! This alone had made the diversion worthwhile. But there would be more. A few kilometres down the road we came to a creek crossing where large blows of coarsely crystalline calcite had been exposed, and

58. The abandoned open cut uranium mine at Mary Kathleen.

59. Reflections in the abandoned open cut at Mary Kathleen.

other outcrops could be seen above the creek on the nearby hillside. The calcite contained silvery veins of pyrrhotite and, although oxidised in places staining the calcite dark brown, some good specimens were obtained. We turned back towards Mary Kathleen at this point, unsure where the road would finally take us if we continued on.

Five kilometres south of the cattle grid we came to the turn we had missed on the way out, just two wheel ruts swinging off at an acute angle through the grass. We explored this track for several kilometres, ticking off the various landmarks on the mud map as the rough narrow track wound along the hill slopes and over rocky ridges towards the high ridge we had seen on the way out. According to the map there was an interesting limestone quarry up there somewhere. But eventually the track became too rough, even for Barry, and tree branches leaning over its rocky surface threatened to inflict real damage. Time was getting on so we turned back and pulled in at a small clearing where piles of limestone had been dumped. This proved to be a geological treasure house. As well as piles of coarsely crystalline calcite (marble) there were dumps of limonite gossan, common opal containing intricate dendritic webs of iron or manganese oxides, and small bits of sandstone stained with azurite and malachite. All of this was obviously foreign to the site, but we had no idea where any of this had come from. As we drove back out to the Barkley Highway, the late afternoon sun cast magnificent light on the hills and several stops were made for photographs.

Another stop was made at Chinaman Creek Dam to catch the magnificent reflections in the lake, the rocky hills in the

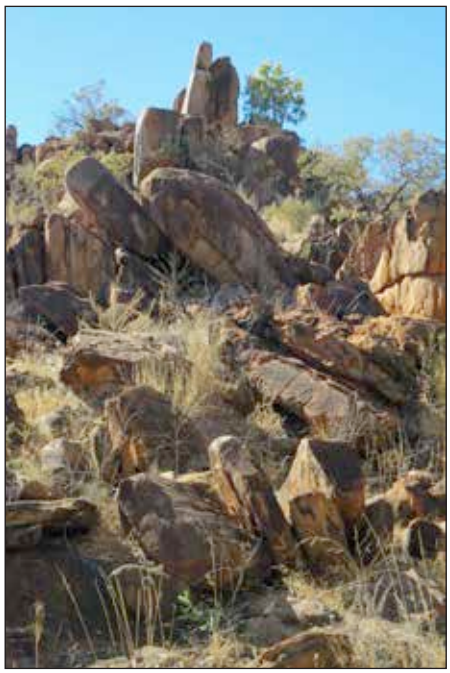
background now glowing orange in the light of the setting sun *(Photo 61)*. We were back in Cloncurry at 5:45pm and enjoyed a great dinner at the Gidgee Inn Motel.

Tuesday 8th July

The push was on this morning to reach Julia Creek before 10am to catch the dunnart feeding at the information centre, so most of the group was away by 8:30am. This had been the coldest morning in Cloncurry for 14 years, dropping to -2°C! But we had fared better than Glen Innes, which recorded -11°C. It was so bloody cold that even the mirages froze over!

After crossing endless flat grassland and the occasional tree-lined creek bed we arrived at Julia Creek around 10am, in good time to watch the dunnarts in a special display habitat behind a glass screen. Mean, lean and rarely seen the dunnart *(Sminthopsii douglasi)* is about the size of a large mouse, has sharp dog-like teeth and a pointed snout. Julia Creek is their only habitat. Females carry their young in a pouch-like fold of skin on their bellies. In the dry season they often live in the deep wide cracks formed in the black soil plains as the ground dries and shrinks. When these cracks close up or during floods, the dunnarts move to the tussocks of grass that grow profusely after rain. Julia Creek dunnarts are tough little hunters but are very shy and difficult to study in the wild. They are distinguished from other members of the dunnart family by a prominent dark stripe on the face and dark hairy rings around the eyes and ears.

Alongside the information centre is the "At the Creek" information area and museum, an initiative of the McKinlay



60. Hill of boulders near Mary Kathleen.

61. Late afternoon reflections at Chinaman's Creek Dam near Cloncurry.

Shire Council in partnership with BHP Billiton and the Queensland Government Q150 Legacy Infrastructure Program. It was opened on 11th December 2009. In the little park nearby, some innovative designer had used moon rocks to construct two sets of tables and stools for use by picnickers. Before leaving the town at 11:30am we found great coffee in the back of the Julia Creek Friendly Grocer.

With Richmond our next overnight stay we headed east along the Flinders Highway, encountering very extensive roadwork which resulted in long delays. The rail line adjacent to the highway was certainly well used, with three goods trains seen between Julia Creek and Richmond.

At Richmond we all set up in the Richmond Caravan Park. This overlooks Lake Fred Tritton, named after former Mayor and local grazier. Once a maze of ugly gullies the lake, opened in May 2004, has a capacity of 314 megalitres and enables local people to take part in water sports and fishing. It was initially filled with water pumped from the Flinders River during floods. In a joint project between Richmond Shire Council and the local indigenous community, a bush tucker garden was established between the lake and the caravan park to prevent soil erosion. The

62. <u>*Kronosaurus queenslandicus*</u> model (life-sized) at Kronosaurus corner in Richmond. Photo by Barry Collier.

plants are all local species and are named together with their traditional uses.

Lunch was followed by a short walk up to Kronosaurus Corner, the most spectacular fossil museum imaginable, easily identified by the life-size replica of *Kronosaurus queenslandicus* outside *(Photo 62)*. This was a 10 metre long marine reptile the first remains of which were discovered by Ralph Thomas at Army Downs, 50 kilometres north of Richmond in 1930. The skeleton was excavated by a group of American scientists and now resides in the Museum of Comparative Zoology in Harvard University. Australian paleontologists regard this as the "heinous theft" of the best specimen ever discovered. But at the time neither the Australian Museum nor the Queensland Museum was interested or could afford to participate in the recovery. The skeleton was encased in 15 large limestone nodules. The blocks were excavated using explosives, packed with wool into 86 crates and shipped from Brisbane aboard the SS Canadian Constructor on December 1st 1932. But this is just one of a host of spectacular exhibits, the remainder housed inside the building beautifully arranged in beds of sand.

Only a small number of Kronosaurus specimens have been found, most in the Richmond area. The first was a section of jaw with 6 teeth found near Hughenden in 1899. The Kronosaurus remains on display inside the Museum were found near Richmond in the 1990's and combine pieces from two similarly sized individuals. This marine reptile belonged to a group of short-necked Brachauchenid pliosaurs and was the largest marine animal living in the Eromanga Sea between 114ma and 98ma. It may have been the largest marine reptile in the world with a head growing to 2.3 metres. It was a predator at the top of the food chain, with teeth up to 30cm long developed for tearing off large chunks of flesh from large fish, squid, ichthyosaurs, turtles, ammonites and even an occasional smaller Kronosaurus.

Also on display is Australia's best-preserved dinosaur skeleton, *Minmi paravertebra*, with much of its skin intact as well as stomach contents. There are also the remains of Martin's Beastie, a huge plant-eating sauropod and Australia's largest fish fossil, Wanda. In 1996 a specimen of *Eromangasaurus australis* was unearthed at Grampian Valley outside Richmond and this is also on display. Remains of the 100ma fossil squid *Boreopeltis soniae*, the World's largest squid, are represented by the gladii of the 8 arms. Squid remains usually consist of chitin (similar to our fingernails) but in super saline water and with high summer temperatures this can be converted to the calcium phosphate mineral frankolite in days. This replacement has occurred in all the squid fossils on display here.

Turtles of the species *Notochelone* are a very common reptilian fossil in the Richmond area in rocks around 100ma. The most commonly preserved part is the inner part of the shell. The outer layer consists of keratin, which is not preserved. So only the large flat ribs from the upper shell (carapace) and flat bony plates of the lower shell are preserved. Skulls are rare.

Most people have heard of Ichthyosaurs, dolphin-like reptiles up to 7 metres long well adapted to marine life. The specimen on display was found on Sutherland Station 100 kilometres northwest of Richmond. *Platypterigius* is the only known species and *P. longmani* is the Australian

63. Ammonite display at Kronosaurus Corner in Richmond.

64. Uncoiled ammonites from Richmond Common at Kronosaurus Corner.

65. The Richmond Pliosaur skeleton.

66. Moon rock typical of those in the Cretaceous Toolebuc Formation.

Cretaceous ichthyosaur. These animals appear to have died out around 80ma and plesiosaurs survived them by at least 15ma.

Elasmosaurs were marine reptiles that were common in the Richmond area. They are related to both Kronosaurus and the Richmond Pliosaur. They had a small head and long neck that could be swung side to side to sweep up small fish. Fragments from the shoulder, pelvis, limb bone and vertebrae have been found preserved inside moon rocks. Although parts were missing in these finds, more complete skeletons have been found in North America and these have been used to construct a clear picture of the Australian animal. The Australian specimens were found 30 kilometres north of Richmond and their preparation and assembly has been a 5 year project for one of the Museum's paleontologists.

Cooyoo australis was a giant predatory fish in the Cretaceous Eromanga Sea and grew to a length of 3 metres. Examples of this family have been found in other parts of the world. The specimen in the Museum was excavated by Council workers at the Richmond fossil collecting site!

Ammonites *(Photo 63)* are a group of marine cephalopod molluscs closely related to modern squid and octopus. Their shells comprise a series of chambers connected by an arterial tube and a body chamber, which housed the animal. The back chambers were used as floats whose buoyancy could be controlled via the connecting tube. They first appeared in the Devonian (410ma), evolved quickly, and became an important part of the oceanic ecosystem until their demise at the end of the Cretaceous (65ma). Many ammonites show simple coiling but a few groups show hooked, uncoiled *(Photo 64)* and even corkscrew morphology. Ammonite fossils are locally abundant but difficult to find.

The sea covered the Richmond area 100ma ago. Dinosaurs roamed through conifer forests along the shore to the east and west around what is now Winton. Fossils of these forest plants have been found in moon rocks surrounded by small clam shells, suggesting they were washed out to sea before being fossilised.

But most spectacular of all and simply stunning to the extreme is the complete skeleton of the Richmond Pliosaur *(Photo 65)*, a Plesiosaur on loan from the Queensland Museum, housed in a separate room. This is Australia's best vertebrate fossil and the best example of the family *Polycotylids* discovered anywhere in the world. In age it pre-dates any other specimen of its kind. The exceptional preservation indicates the animal was quickly buried in the marine sediments in the absence of scavengers and currents, factors that would normally disarticulate and destroy the integrity of the skeleton. Limestone accretion around the bones further entombed the specimen, preserving it intact till it was discovered 100ma later.

The animal was an adult that had sustained an injury to its left pectoral region and some of the neck vertebrae. The injuries probably became infected, as shown by the body's natural response to infection shown by excessive growth of bone around the wound area. This injury did not kill the animal but would have seriously slowed its movement. The death stroke appears to have been delivered by a bite to the head, the top of the snout showing a set of impact fractures above and below. This is a strong indication hat the culprit was a Kronosaurus. The pliosaur managed to escape this death grip to swim away and die. We know this because there is no evidence of any part of the animal having been eaten. Instead its body bloated with its belly up for several days before intestinal gas burst the skin, sending the carcass to the sea floor.

Ian Levers on Marathon Station found this incredible and magnificent fossil in 1989, while he was out feeding a mob of cattle only 800 metres from the homestead. He noticed a strange object protruding from the bank of a small creek. He gave it a kick and a 15 cm section complete with teeth

broke off. Dr Mary Wade from the Queensland Museum accompanied a team that removed the one metre of soil covering the fossil and found it to be 98% intact and 4.25 metres long!

The fossil remains are typically enclosed in moon rocks *(Photo 66)*, rounded limestone concretions occurring within the Cretaceous (104-100ma) Toolebuc Formation which is present as discontinuous outcrops between Richmond and Hughenden, northwest of Richmond, on to Julia Creek and thence in a belt from McKinlay to the Hamilton River near Boulia. The concretions are a phenomenon of localised cementation around a nucleus and contain sedimentary bedding planes so were formed within the enclosing sediment and not at the sediment/water interface in what was then the Late Albian Sea. They formed at a time of falling sea level with variable but low oxygen sea bottom conditions. This is why few bottom-dwelling organisms are preserved. Two bivalves were overwhelmingly abundant, the large flat *Inoceramus sutherlandi* and a smaller species *Aucellina hughendenensis*. These could be identified in many of the moon rocks we saw in the Richmond-Hughenden area.

Following the Normanton Formation, the last of the Aptian Sea marine sediments, the huge volumes of sediment washed in by rivers filled the basin and after 30ma of marine deposition the Aptian Sea ceased to exist. It was followed by a place of lush open forests and floodplains dominated by huge conifers, intricate river systems and a comprehensive dinosaur fauna – the Winton Formation, host for the dinosaur fossils we saw at The Age of Dinosaurs.

The building also houses a World-class fossil preparation laboratory where visitors can watch preparation in progress through large windows. This laboratory has been involved in the preparation of some of Australia's most significant fossil finds.

Wednesday 9th July

Our group was now down to 14 people. This was a free day to explore fossil sites 1 and 2, 12 and 12.4 kilometres respectively west of Richmond beside the Flinders Highway. The rocks here are thinly bedded limestones and limy shales of the Cretaceous Toolebuc Formation which in other areas is only represented by moon rocks. The fossils are mainly fragmentary and include the bivalve clam *Inoceramus* reaching 50 cm, the smaller bivalve *Aucellina*, various fish remains, shark teeth, turtles, teeth and vertebrae of Ichthyosaurs, coprolites and various trace fossils.

Very little was found a Site 1, apart from a few small bivalve clams, and it was obvious that no-one had fossicked here for some time, or at least not since the last rains. But at Site 2, known as the Bush Site, the ground on the quarry floor had been freshly ripped by the local Council and a considerable area of limy shale lay exposed. It was simply a matter of carefully splitting the slabs of rock to hopefully reveal some fossils. But again the rock was largely barren and nothing really exciting was uncovered, apart from a few small fish jaws and fish scales, including several from the armored fish *Richmondichthys*. One of the more interesting finds was a section of a large ammonite, its identity confirmed by staff at Kronosaurus Corner when we returned there for coffee.

After coffee Barry, Elaine and I went exploring, driving east along the Flinders Highway and turning north along Dutton Downs Road. Several stops were made to photograph spectacularly distorted mulga and the ironstone gravel covering the ground. Near Washpool Creek we came upon a nest of moon rocks around a dry dam and thoroughly investigated them for signs of fossils. There were plenty, mainly of large bivalves *(Photo 67)* but also the occasional small ammonite. The most astonishing find, perhaps of the whole trip, came when I tripped over one of the moon rocks and saw the clear trace of a large

67. Fossils exposed on the surface of moon rocks. 20 cm.

68. An incredible find. A fish backbone across the edge of a moon rock. Brian England specimen (R 737). 26 cm.

fish backbone weaving across its edge *(Photo 68)*.

After passing the junction of the Dutton Downs Road and the Old Richmond Road we crossed the wide dry sandy expanse of the Flinders River *(Photo 69)*. With a length of 1004 kilometres, this is the longest river in Queensland and flows into the Gulf of Carpentaria. Lt. Stokes of the HMS Beagle named it after Matthew Flinders in 1841. Further north as the road crossed a low ridge above the plains we came to an even better patch of moon rocks. Then the road climbed up onto a basalt plateau where the ground was covered in angular basalt blocks. At the next road junction we turned onto Villadale Road, which took us through the tiny settlement of Compton and back to Richmond.

Thursday 10th July

Our epic journey had almost come to an end and today we would do the drive from Richmond to Hughenden, 114 kilometres to the east along the Flinders Highway. After setting up at the Hughenden Allen Terry Caravan Park some had coffee and cake at the Windmill Inn and then explored the Flinders Discovery Centre.

Hughenden has a population of 1200 and lies at an elevation of 324m ASL. The first settlement in the area was on Hughenden Station by Ernst Henry in 1863. The property was named after the manor house of his grandfather in Buckinghamshire, England. The town was established on the banks of the Flinders River in 1876. In that same year a hotel was built to cater for travelers passing through to the Cloncurry mining region. In 1887 the town became a railhead for the Great Northern Railway.

The streets of the town are now adorned with sculptures by local artists depicting local fossils and dinosaurs. The first Cretaceous fossil, the vertebra of an Ichthyosaur, was found on the Flinders River at a property west of Hughenden in 1865. It was sent to the Museum of Victoria.

69. The Flinders River.

70. The basalt plateau northwest of Hughenden.

Later a more complete skeleton was uncovered. The head of an Ichthyosaur was found on Telemon Station west of Hughenden in 1935 and in the same year a Kronosaurus skull was found on the same property. Finds have continued right up to the present day.

The Flinders Discovery Centre has an impressive display of local and World fossils, rocks and minerals. But the greatest attraction is the life-size replica skeleton of a Muttaburrasaurus a large herbivore that lived in the Hughenden area 100ma ago. Its jaws and teeth were more suitable for cropping vegetation than for tearing flesh. Bones of dinosaurs related to Muttaburrasaurus have been found around the World but the Australian animal had enlarged nasal passages in the snout, which enabled it to honk at other members of its species. Remains were first found in a cattle yard on the Thompson River in 1963 near Muttaburra and a near-perfect skull was found west of Hughenden in 1987 in the area which then lay at the edge of the vast shallow Cretaceous Eromanga Sea. This extended from the Gulf of Carpentaria down into South Australia. Australia was then conjoined to Antarctica and there were no polar ice caps. Large marine reptiles Ichthyosaurs and Plesiosaurs swam in the sea while on land dinosaurs including *Muttaburrasaurus* and *Austrosaurus* browsed on vegetation amongst conifers, cycads and ferns.

That afternoon Barry led the group back out to the area we had explored yesterday, driving 47 kilometres back west along the Flinders Highway and right onto Dutton Downs Road just east of the Walker Creek bridge. We revisited the first moon rock site and found plenty more to photograph before moving on to the Flinders River

71. Porcupine Gorge from Hawkes Nest Lookout.

72. A huge slice through time. Porcupine Gorge from Gorge Lookout.

crossing. We drove on past the second moon rock location and continued up onto the basalt plateau. Here there were angular basalt blocks as far as the eye could see *(Photo 70)*, most strongly vesicular. But the only secondary mineral present in the vesicles was white crusts of calcite. In the road cutting adjacent to the creek at the base of the plateau we could clearly see that the flow was around 3 metres thick and lay above a thin bed of clay which rested on top of thick palaeosoil. We turned back here and returned to the second moon rock locality where some time was spent looking and photographing. The rule here was not to break any of the complete moon rocks but confine collecting to those already partly broken. Paul found the impression of part of an ammonite on a huge moon rock fragment and opted to take the whole thing home!

We returned to Hughenden via the Old Richmond Road, with the basalt plateau off to the left, its flat top broken only occasionally by young V-shaped valleys. Although dirt it was a good smooth road forming part of the 4WD Basalt Byway which traverses the 5ma Mount Sturgeon lava flow. We arrived back in camp at 5:30pm.

Friday 11th July

The last official day of the trip was spent exploring the country around Hughenden, in particular Porcupine Gorge 70 kilometres to the north. We headed out at 8:40 am along the sealed Kennedy Development Road, passing through flat woodlands of eucalypts and acacia with the occasional brolga and bustard at the roadside. In economic terms this is Brahman country, a breed of cattle well-suited to the hot dry conditions. We were waylaid partway by a large flock of black cockatoos perched in trees near the road and this kept the photographers busy for a while.

Our first stop was at Hawkes Nest Gorge Lookout 63 kilometres north of Hughenden located at the beginning of Porcupine Gorge, which extends from here for at least 100 kilometres north. The gorge here is unusual, being rimmed by rounded basalt boulders *(Photo 71)* forming the edge of the basalt tableland formed by 5ma old flows from the nearby Mount Desolation. This tableland has both red and black volcanic soils. Trees on the red soil country are mainly ironbark and bloodwood, while gidgee and boree are prevalent on the black soil. The second stop saw us climbing up to the Bottle Tree Ridge Lookout, so named because of the scattered bottle trees *(Kurrajong sp.)* along its summit. But there were too many trees for good views.

A little further on we turned to the right through ironbark forest to Gorge Lookout. This came as a real surprise, with no sign of this giant slice through the dead flat savanna plains until reaching its very rim *(Photo 72)*. Here lies a veritable storybook of geological history dating back 500ma. The oldest rocks lying in the northern approaches to the gorge are highly deformed Ordovician sediments (500ma) altered by heat and pressure to gneiss and schist. By around 260ma these rocks had been uplifted and exposed at the surface, where they began to erode. During the Permian (280ma), this erosion formed deposits of mudstone, siltstone and a few low quality coal beds (the Boonderoo Formation) over the top of the metamorphic rocks, forming the narrow rock platform at the bottom of the gorge in which the creek is carving a slot. At that time Australia lay close to the South Pole and its climate was cold. During the Triassic (220ma) erosion of the hinterland to the east resulted in the deposition of beds of sandstone. They now form the lower parts of the almost vertical gorge walls. However the majority of the rocks in the cliffs are made up of sediments deposited in the Jurassic and Early Cretaceous (115ma), the latter made up largely of soft sand. These were mainly fluvial sediments and now make up part of the huge aquifer known as the Great Artesian Basin. Overlying the main cliff-forming rocks is a thin layer of mudstone that represents the earliest marine deposits in the area. This rock contains scattered fossils dated at 112ma. Rocks of the Eromanga Sea do not occur at Porcupine Gorge but lie further to the south and west.

Eruptions of basalt from the Mount Sturgeon Volcanic Complex blanketed the area around 5ma. This event was critical in the formation of the gorge and its development postdates these volcanic eruptions. The gorge did not begin to form until Porcupine Creek managed to cut a narrow slot down through the 6 metre thick basalt cap into the softer underlying sandstones. Constrained by the basalt, the creek continued to cut directly downwards rather then widening to create the 120 metre deep and 300 metre wide chasm we see today. The National Park extends for 25 kilometres along Porcupine Creek, named after either the porcupine grass or the abundance of echidnas in the area.

Satisfied with our overview of the geology here we continued on to the main Pyramid Campground 11 kilometres further to the north and the start of the Gorge Walk. Here a steep rocky path led down into the widest section of the gorge where Porcupine Creek meanders between a series of rock pools carved into the white sandstone. The creek is lined with casuarinas and melaleucas, the eucalypt and acacia woodlands being confined to the cliff line.

The main landscape feature down in the gorge is the spectacular rock formation called The Pyramid *(Photo 73),* an enormous triangular cliff of bedded sandstone (a truncated ridge) forming the backdrop to a magnificent area of potholes *(Photo 74),* caves, reed-lined channels and a myriad of other shapes worn into the hummocky sandstone shelf forming the creek bed. With little rain in the past several months the water level was well down and some of the small rock pools had become isolated from the main water course. These provided spectacular reflections *(Photo 75).* The 1.2 kilometre climb back to the camping and picnic area was steep but mercifully short and most had completed their exit from the creek bed in less than 25 minutes. All were back up by 1:15pm and took advantage of the picnic shelters to have lunch before moving on.

With time to explore we drove further up the Kennedy Development Road and pulled in to the side of the road

73. The Pyramid (a truncated ridge) from the bottom of Porcupine Gorge below the Pyramid Camp Ground.

74. Potholes in the bed of Porcupine Creek.

just after crossing White Cliffs Creek, only one kilometre north of the turn into the Pyramid Campground. From the road this looked interesting but it wasn't until we had begun to walk along the creek bank that we stopped absolutely stunned at what lay under our feet. The rocks here were very strange indeed! The creek bank was a series of irregular closely-spaced pits and ridges in dense white claystone with scattered beautifully-patterned rounded masses of what at first appeared to be grey chert *(Photos 76 and 77).* Some of the pits were quite deep and one at the top of the creek bank held permanent water and had been used as a native well. At the time this site presented us with a very puzzling enigma. However later examination of samples under a stereo microscope suggest that sub-surface groundwater leaching of an originally massive grey claystone bed along intersecting joint sets of varying spacing is responsible for the patterns. Variation in erosion resistance caused by differential leaching is probably responsible for the pits and ridges, which formed as the creek cut down into and through the exposed claystone

75. Reflection of The Pyramid in a rock pool.

bed. Fissures in the clay are filled by sectile secondary silica.

Some people fossicked for belemnites further up the road, but without success. These marine animals lived for a period of 140ma and first appeared around 208ma during the Carboniferous. They became extinct at the end of the Cretaceous, the K/T boundary, which also saw the demise of the dinosaurs. Belemnites had an internal skeleton and the remains most commonly found are that part of the skeleton located in the tail.

Back in Hughenden we ended the day with coffee at the FJ Holden Café followed by a farewell dinner in Bob & Joe's Restaurant at the Great Western Hotel.

Report and photographs by Brian England
Reviewed by David Atkinson

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76. The pockmarked white banks of White Cliffs Creek.

77. Weathering patterns in the banks of White Cliffs Creek.

Burragurra and Finchley Trig

Leader: David Atkinson.

Attendance: 17 members, 1 visitor.

Date: Saturday 30th August 2014.

Seventeen members and one visitor assembled at Slack's Park in Wollombi with overcast skies, light rain showers and thoughts of the next coffee.

Around Wollombi and the valley of Wollombi Brook, the rocks belong to sediments of the Triassic Narrabeen Group, while in the country to the west sandstones of the overlying Triassic Hawkesbury Sandstone outcrop forming a series of high ridges. There only the deeper valleys penetrate into the underlying Narrabeen. Since the tracks in this area follow the ridges, most of the rocks we would see lie within the Hawkesbury Sandstone.

After a short briefing we departed for Burragurra via Yengo Creek Road and the Boree Track, stopping at the Simpson's Track junction to examine some very interesting liesegang banding in the sandstone on the rock platform 20 metres up the track. Put very simply, liesegang banding is a weathering effect caused by seasonal diffusion and periodic precipitation of iron hydroxides, in this case in porous Hawkesbury Sandstone. Where the iron concentration in the sandstone is high it is more resistant to erosion and stands proud of the zones with lower iron content to form swirling ridges *(Photo 1)*.

We then proceeded to the car park at Burragurra for morning tea before setting off for a rock platform several kilometres to the south where there is a native well which the local Aboriginals covered with flat rocks to minimize contamination. The adjacent rock platform had been

2. Native well. Note the carved drainage channel and the protective rock cover.

modified by early European settlers who added channels to lead natural runoff into the well *(Photos 2 & 3)*. Scattered across the rock platforms in this area were a number of cannon-ball concretions up to 22 cm across, one of which had been sectioned by erosion to reveal well-developed concentric banding *(Photo 4)*. Further along this rock shelf there was another spectacular example of liesegang banding *(Photo 5)* which generated further discussion about how it was formed.

On the steep rocky scramble up to this site we found two exquisite wax lipped orchids *(Glossodia major)* amongst the leaf litter.
See opposite.

We returned to Burragurra car park for lunch before making the climb to the top of Devil's Rock to examine

1. Liesegang banding in Hawkesbury Sandstone. Note the height and spacing in this location.

3. Water stored in the native well.

the deeply weathered but still spectacular Aboriginal engravings scattered over this large sandstone surface. Members were shown around the site by Chris Morton who gave details on the inferred meanings for the rock engravings. Views of Mount Yengo and Mount Wareng were limited by cloud and rain showers. There was also a spectacular display of wildflowers here.

We then drove to Finchley Camp Ground on the Yengo Track where we had afternoon tea and then examined more Aboriginal art on a rock platform approximately 100 metres further along the track. This area also held some interesting geology in the form of scattered residual boulders of well-developed pisolitic laterite. Laterite is a residual material developed by extreme weathering in tropical and sub-tropical regions where drainage is good. So the presence of laterite here is an indicator of past climate change! It is usually leached of silica and in this case contains a high concentration of iron hydroxides as well as alumina. In some regions of the world it can constitute an ore of iron, or aluminium if the alumina content is sufficiently high.

Up on the lookout at Finchley Trig there were magnificent views towards Glen Alice and the Rylstone area, although rain and low cloud obscured the view much of the time. There were also a number of woody pear trees *(Xylomelum pyriforme)* about to blossom *(Photo 6)*.

The tracks in the region had vastly improved compared to their condition on previous trips and although we had to negotiate several deep gutters and a few steep muddy hills no-one had any problems. This upgrade was largely due to the necessity to provide rapid and easy access during recent bushfires.

Finally we headed back to Wollombi for a well earned coffee at the end of a relaxing day in the bush.

Thanks to all of the participants and Chris Morton for an enjoyable outing.

Report by David Atkinson.
Geological input by Brian England.
Photography by Barry Collier.

4. 22cm canon-ball concretion.

5. Concentric banding from the differential weathering of liesegang rings.

6. A woody pear (<u>*Xylomelum pyriforme*</u>) tree with a number of flowers and a grey 'pear-shaped' fruit.

Beecroft Peninsular

Leader: Barry Collier and Brian England.

Attendance: 17 members, 1 visitor.

Date: Friday 19th to Monday 22nd September 2014.

Beecroft Peninsular is probably best described as the north head of Jervis Bay. It is a large area, approximately 10 km by 6 km wide. Most of it is owned by the Department of Defense, with the remainder consisting of the town of Currarong and a Crown Land Reserve called Abrahams Bosom. The oceanfront consists mostly of towering cliffs around 80 metres high, while the bay side consists of a series of low headlands and picturesque beaches.

The Peninsula comprises alternating beds of quartz/lithic sandstone and silty sandstone of the Late Early Permian Snapper Point Formation, the uppermost unit of the Conjola Sub-Group of the Shoulhaven Group. These sediments were deposited under marine shallow water to near-shore sub-littoral conditions (Paterson, 1974) during a marine transgression (Runnegar, 1980). The much finer sediments of the Wandrawandian Siltstone overlie these rocks conformably. However a prominent anticline (the Currarong Anticline) trending north-south along the spine of the Peninsula has raised the Snapper Point Formation rocks to such an extent that the Wandrawandian Siltstone has been eroded off the top of the Peninsula, with only a small remnant remaining on the western side around Montagu Point. The Nowra Sandstone overlies the Wandrawandian Siltstone but no outcrops of this rock were seen on this excursion. The Currarong Anticline is the most easterly of a series of sub-parallel fold structures in the Jervis Bay area.

Elaine and I decided to go a few days early and check things out. The Department of Defense land contains artillery and bombing targets as well as a firing range. Of course, no one is allowed in those areas, but whenever any are in use the whole area is closed to the public. For the week before our trip, the Peninsula was closed off, supposedly for roadwork prior to the school holidays, so we couldn't get in to check anything out.

For some reason, the management of Abrahams Bosom has decided that cliff top walks are out and we found many tracks we once knew closed off, or gone. Maybe they are worried about all those cliffs with no fences. Fishermen keep the track out to an area immediately south of Moore's Inlet open. But this was in terrible condition and the old sidetracks out to the marvelous cliff tops north of the inlet could not be found. The old 4WD trail to Beecroft Head is still there but all access between it and Coomies Walk, where the public is directed, have been closed off.

Friday was spent in Abrahams Bosom Reserve. The tracks walked on are shown on the map below. First stop was a group of viewpoints, just south of Moore's Inlet *(Photo 1)*, where fishermen have carved a track to the rock platform below. But what a track! I am an experienced bushwalker and I would want a rope ladder. The rock platform on the southern side of Moore's Inlet and another near the lighthouse are the only two places in Australia where fishermen can catch Marlin from the shoreline.

Next stop was the headland on the southern side of Moore's Inlet. It protrudes beyond the general cliff line and the views are magic *(Photo 2)*. Moore's Inlet is a gorge about 200 metres long, 80 metres deep and less than 20 metres wide *(Photo 3)*. There are a number of similar inlets on the peninsula, but this is the longest.

We paused for morning tea on Beecroft Head, *(Photo 4)* with more amazing views *(Photo 5)*. Then we were faced with the problem of how to find our way onto Coomies Walk without going back to the cars. Eventually we found a way after ploughing through a short patch of heathland scrub and continued on to Beecroft Lookdown *(Photo 6)*. At least that is what the sign said. It is certainly not on Beecroft Head and the map of Coomies Walk calls it Cliff Edge Lookout. Last time we were there, there was a track out onto a spectacular ledge, with a huge chasm running beside it. Since then there have been landslips and the track is broken by a 10 metre deep gorge.

1. View south towards Point Perpendicular from head of track to rock platform.

3. Moores Inlet.
Photo by Brian England.

We then headed off to Mermaid Inlet for lunch. At the head of the inlet there were warning signs about narrow track in quite a few places *(Photo 7)* and they weren't kidding, so some members gave it a miss. The cliffs on the northern side of the inlet were amazing, probably only 50 metres high, but composed of dozens of ledges, with the gaps between them going back as much as 5 metres. The underside of one of the higher sandstone ledges above the track showed spectacular honeycomb weathering *(Photo 8)*. Lunch was enjoyed in front of a huge cave, the walls of which were constructed with the same amazing ledges *(Photo 9)*.

The Snapper Point Formation rocks in the vicinity of the cave are thinly bedded and have eroded differentially, with the more resistant sandstone projecting outwards as thin ledges and the less resistant silty layers forming the deep crevices. Both rock types are heavily bioturbated with the vertical burrows of marine worms. There were many drop stones on the rock platform in front of the cave but no fossils were seen.

After lunch, we returned to the head of the inlet join the others and then followed the track up to Gossangs Tunnel. But the track became indistinct when it reached a sandstone ledge and without further signs it was fortunate that one of the group knew to head to the right along the ledge to the sinkhole marking the landward entry. The tunnel is about 40 metres long, but the first half of it can only be accessed by crawling *(Photo 10)* and the remainder by stooping. It opened out onto a platform a little to the west and 30 metres above our lunch site. The views from that platform were amazing. There were along the same cliff line we saw at lunchtime, but the slight change of angle due to its location on the east limb of the Currarong Anticline and different altitude made so much difference. Most of those who traversed the cave suffered scratches and muscle pains, but the views were worth it.

Interesting geological features seen in the sea cliffs around the cave entrance included spectacular drop stones and groups of ice-rafted pebbles *(Photo 11)*. These slowly settled to the sea floor still cemented by ice as the density of the ice/pebble mixtures exceeded the density of the seawater. The tunnel is said to have formed as a sea cave when

2. Cliffs north of Moore's Inlet.

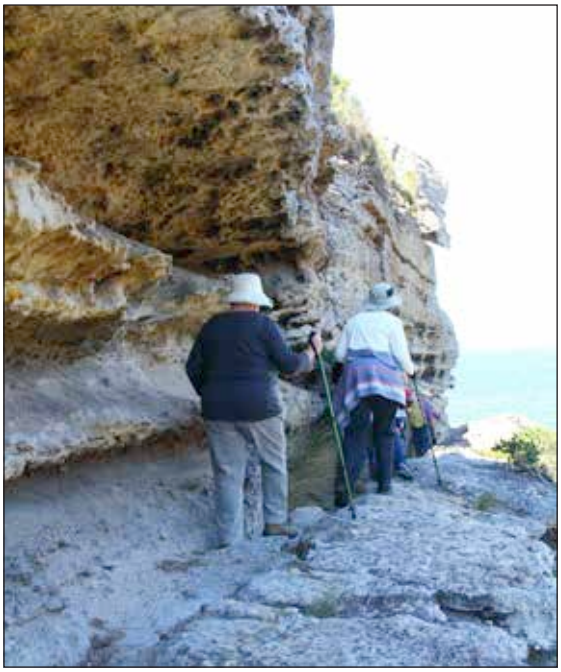
4. Morning tea, Beecroft Head.

5. Sea cliffs south of Beecroft Head.

sea level was much higher than it is today. However the presence of a narrow vertical crack that extends down to present sea level and runs the full length of the tunnel along the middle of the floor provides a clue to a more probable origin. Waves penetrating along a joint in the sandstone gradually widened and extended it until a zone of less resistant rock was encountered. Subsequent wave action was then able to blast out the rock either side of the joint to extend the opening laterally. This process is probably still active during storms.

From there it was back to the start of Coomies Walk, trying to avoid several flooded sections of the track that had turned into muddy quagmires *(Photo 12)*. There was a brief detour to Lobster Bay. Very nice, but not a patch on what we had seen and, believe it or not, we then all went for coffee at Zac's in Currarong.

On Saturday our first stop was Crookhaven Head, which looks like an island from a distance, but is actually joined to the mainland by a low sandy saddle. We walked down stairs to the saddle and then headed off southwards across the rock platform to some amazing folds associated with dolerite dykes within the Wandrawandian Siltstone. The larger of the dykes appears to have penetrated a zone of weakness along the axial plane of an anticline. On land the



7. Track down to rock platform at Mermaid's Inlet.

crest of this anticline is marked by a deep heavily vegetated trench while below high water, marine erosion has carved out a shallow inlet along the path of the dyke *(Photo 13)*. Just to the north another much smaller dyke lies along the axial plane of a small syncline. There were also a few fossils and quite a number of drop stones in the rock platform.

We then followed the footpath up onto the headland where there are the remains of an old lighthouse and a new, tiny one on top of a tall spire. There are two lookout platforms here. One is hardly more than decoration, but the other gives a great view over large, as yet unexplained circular patterns on the rock platform below. While puzzling over their origin, we saw a group of seals feeding and a large pod of dolphins swimming past.

After that it was back to the cars and off to Tilbury Cove picnic area at Culburra for morning tea. We then headed down to the rock platform, which provided more fascinating geology within the Wandrawandian Siltstone.

6. Beecroft lookdown.

8. Honeycomb weathering, Mermaid Inlet rock platform.

Photo by Brian England.

9. Rock platform, Mermaids Inlet, our lunch stop.

11. A group of ice-rafted pebbles in Snapper Point Formation.

The first of these features was a fantastic section of heavily dimpled sandstone extending several metres across the rock platform *(Photo 14)*. Then, after walking a couple of hundred metres further south we came across the most fascinating collection of siderite/limonite concretions and plenty of fossils. The concretions were up to a metre across and many had been sectioned by marine erosion to expose soft centers, which had been hollowed out, leaving just the thin external shell *(Photo 15)*. Most were spherical; although more complex shapes had formed where adjacent concretions had coalesced. A variety of marine flora and fauna had gained a foothold in these unusual niches, including a small octopus that I delighted in teasing! In some parts of the rock platform the concretions were completely spherical and about the size of cannon balls, giving the impression of an ancient civil war site! Fossils were sparse but included a superb example of the Permian gastropod *Keenia ocula (Photo 16)*. Drop stones were again abundant and up to half a metre across.

Eventually, we got back to the cars for a late lunch and then headed back to the start of Coomies Walk at Currarong. Brian said there were some photogenic rock formations at the mouth of Abrahams Bosom Creek. As usual, he wasn't wrong, so some time was spent there photographing spectacular honeycomb weathering under a sandstone overhang. There were also some unbelievable reflections in the creek at the pedestrian bridge on Coomies Walk *(Photo 17)*.

10. Terry negotiating Gossang's Tunnel.

We then walked out to what was left of the wreck of the S.S. Merimbula and pottered about there for a while taking photographs. After just managing to return to the beach before the incoming tide cut access, most headed back to Currarong for coffee. A few decided to do the loop past Honeymoon Point, which turned out to be quite pleasant.

Sunday was expected to be the highlight of the trip. Up till then, we were enjoying beautiful sunshine, but I wanted total cloud cover for our first activity. Someone up there likes us. We woke to total cloud cover and as soon as the first activity was over, the clouds began to rapidly disappear.

The topographic map showed a 4WD trail about halfway between the bombing range and the lighthouse leading out to a series of sea cliffs, which on satellite photographs looked absolutely superb. But when we got there we found that the 4WD track had morphed into a narrow walking trail through the dense heathland scrub. Then about 100 metres from the cliffs it abruptly petered out! But rock climbers had pushed a sidetrack off to the left through a perched boggy swamp and this led to the first section of cliffs.

From there we could walk about 500 metres to the north, using sections of bare cliff top interspersed with walking tracks. All along, the views were simply amazing *(Photo 18)* and there were so many metal bolts in the rock for abseilers to attach their ropes. At one point there was a cave a quarter of the way down the cliff that appeared to have a dwelling constructed in it *(Photo 19)*. Access could only be by rope and while abseiling could be used to get into it, the only way out would be to prussic back up the rope.

12. Group at one of the many flooded sections on Coomies Walk.
Photo by Brian England.

Next stop was the Perpendicular Point Lighthouse for morning tea and after a rather drawn out tea break and some wandering, we headed off to Honeymoon Bay *(Photo 20)* for lunch. Being school holidays this delightful small enclosed bay was packed with holidaymakers. After lunch and some more wandering around, we headed off to the Long Beach South car park from where we could access the north end of Long Beach.

Once down on the beach we strolled northwards towards the rock platforms around Montagu Point to examine a number of features in the only outcrop of Wandrawandian Siltstone on the Peninsula. This section of shoreline exposes the upper part of the siltstone immediately beneath the Nowra Sandstone. Montague Point is composed of lenticular silty sandstones deposited in channels well out on the Permian marine shelf (Herbert and Helby, 1980). We would be walking up sequence, oldest to youngest.

13. Weathered dyke on an anticlinal fold, Crookhaven Head.

14. Dimpled sandstone rock platform, Culburra.

The first small platform displayed amazing arcuate bioturbation patterns *(Photo 21)* formed by feeding mollusks. Then came an amazing dolerite dyke 26 metres wide *(Photo 22)* containing abundant disc-like plagioclase (feldspar) crystals to over one centimetre, all aligned parallel to the dyke walls *(Photo 23)*. The siltstone on either side of this dyke had been baked to a hard resistant hornfels suggesting that the sediments were still wet when the dyke intruded. Further north we came to a wide section of rock platform crowded with calcareous concretions rich in well-preserved fossils of a variety of brachiopods and other species. Particularly evident were superb examples of a branching form of the bryozoan *Stenopora (Photo 24)*. The concretions themselves stood out in bold relief, making for some excellent photography. Further up the shoreline a bed of dense mudstone contained scattered perfectly preserved examples of the horn-shaped simple coral *Zaphrentis (Photo 25)*.

Further north the nature of the concretions changed dramatically, closely resembling those seen on Saturday at Culburra. Just before returning to our vehicles we came to a section of rock platform containing the most amazing fossils, in fact the best we had seen over the entire weekend. Included were fragments of crinoid stems to 2cm thick, superb examples of the bryozoan *Fenestella (Photo 26),* spiriferid brachiopods, and branching bryzoan *Stenopora*. There was also an abundance of drop stones here and some interesting fold structures.

It was then back to camp to get ready for dinner at Zac's in Currarong. Great food, coffee and a marvelous evening was had by all.

Apart from the geology, we saw some very interesting plants that are mostly confined to Jervis Bay. *Prostanthera densa* is only known from Nelson Bay and Beecroft Peninsula. It is widespread on the peninsula but only known from one site at Nelson Bay. It is listed as vulnerable. *Dracophyllum oceanicum* is only known from the coastal cliff faces on the

15. Concretions in rock platform, Culburra.

17. Reflections in the tannin-stained water of Abraham Bosoms Creek.

Photo by Brian England.

headlands of Jervis Bay. *Grevillea macleayana* occurs between Jervis Bay and Ulladulla, but mostly on Beecroft Peninsula. *Philotheca buxifolia subsp falcata* is confined to Jervis Bay.

Monday was Brian's activity and he took us out to Huskisson on the other side of Jervis Bay to view some world famous geology and one of the best exposures of glendonite-rich horizons in the State. The original plan was to drive up to Kiama and do part of the Kiama Coastal Walk towards Gerringong, but the impossible logistics of getting even one van close to the track head made this impractical.

Huskisson proved to be one of the highlights of the weekend. After assembling for coffee in one of the many cafes, we strolled down to the shoreline at Tapalla Point. The first thing that took our eye was the great abundance of Port Jackson shark egg casings washing up on the beach. The kids were having great fun building castles of them in the sand! Low tide was to be at 12:40pm, but even though we had arrived a little early the water was low enough to expose the rock platforms, again composed of Wandrawandian Siltstone. Initially what we saw was disappointing, with only a few scattered and badly corroded glendonite crystals. Some were quite large, up to 25cm long, and either single sigmoidal monoclinic crystals or arrowhead twins. But just as we were about to turn back we came to an isolated section of rock platform that simply blew our minds! The tide had just cleared a large section of siltstone crowded with dark brown stellate groups of sharp glendonite crystals to 10cm across enclosed in light grey calcareous concretions *(Photo 27)*. The photographers simply went mad and it was difficult to tear ourselves away from this magical sight. Amazingly it was completely pristine and unvandalised.

Glendonite is not a mineral but the name given to pseudomorphs of impure fine granular calcite after

16. *Keenia ocula* in Wandrawandian Siltstone at Culburra.

18. Sea cliffs near Point Perpendicular.

IKAITE, a calcium carbonate hexahydrate [$CaCO_3.6H_2O$], which crystallised displacively within the sediment pile from very cold seawater. This mineral is unstable under normal atmospheric conditions and above 5°C decomposes very rapidly to a mush of water and calcium carbonate, the latter providing the replacing material in the pseudomorphs. James Dwight Dana described the original type locality at Glendon on the banks of the Hunter River east of Singleton in 1849 in his geological report for the United States Exploring Expedition for the years 1838 to 1842 under the command of Charles Wilkes USN. The name glendonite was proposed by Edgeworth David and colleagues in 1905 in a paper submitted to the Records of the Geological Survey of New South Wales after extensive studies had been carried out on the Glendon locality. Since these early reports, many other localities have been found in the Hunter Valley, on the South Coast of New South Wales, and around the World. David et. al. had proposed glauberite [$Na_2Ca(SO_4)_2$] as the precursor mineral and this precipitated much scientific debate. In fact the actual precursor was not discovered in nature until ikaite was found in the Ika Fjord in southern Greenland in 1963. Even then it was not until 1979 that the connection between ikaite and glendonites was finally made. Interestingly, the Wandrawandian Siltstone is the stratigraphic equivalent of the Branxton Formation in the northern Sydney Basin in which several of the Hunter Valley glendonite sites are located (Carr et. al., 1989). Glendonites and similar pseudomorphs are now being used around the World as palaeoclimate indicators.

Report by Barry Collier and Brian England (Monday).
Geological input by Brian England.
Photography by Ron Evans and Brian England.

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19. Sea cliffs north of Point Perpendicular. Note the dwelling built into a small cave.

20. Honeymoon Bay.

21. Bioturbation in Wandrawandian Siltstone at Montague Point.

22. Large dyke (26m wide) between chilled margins A-B at Montague Point.

25. The simple coral *Zaphrentis* in Wandrawandian Siltstone at Montague Point. Photo by Brian England.

23. Weathered plagioclase crystals in dyke rock, Montague Point.

26. *Fenestella* Species. Photo by Brian England.

24. Branching bryozoan *Stenopora* at montague Point.

27. Overlooking a patch of glendonites in concretions, Tapalla Point. Photo by Brian England.

The Great Numbat Mystery Reconnaissance Tour

Leaders: David Atkinson & Terry Kingdon.

Attendance: 15 members.

Date: Saturday 18th October 2014.

Saturday dawned with a little sun and some early cloud when a motley crew of 15 members assembled under the fallen glory of the Millfield RSL Club (a hit and miss affair including members near misses or overshoots).

The days objective was to challenge members navigation, interpretive, geological and historical skills drawn from their interpretation of a series of tasks while following the Great North Road from Millfield through Wollombi, Laguna and St. Albans to the finalé at Wiseman's Ferry.

Members were issued with one questionnaire per car which was worded in a suitably obtuse way to sort out which members were or were not paying attention.

The trail started at The House Of The Rising Sun in Millfield *(Photo 1)* where odometers were zeroed and the questionnaire started.

The first stop along the road to Wollombi was to find Thomas Budd's roadside grave. He was an early soldier who returned to England to resign before returning to farm land near Sweetmans Creek. He died in 1833 at the age of 42 and his wife died a few years later.

The second stop was at a conservation area where signage did not explain what it was or why it existed. This was the bushranger Yellow Billy's cave entrance, information on which may have been available in Wollombi but remained unknown to most until the answers were given out at Wisemans Ferry.

2. Murrays Run Culvert.

After passing through Wollombi to ponder a question on their dance hall, it was on to Laguna and the school which was built in 1873.

The next section involved stopping at two significant convict built crossings. The first, Thompsons Bridge was built by the No 7 Chain Gang between July and September 1830. The second was Fernances Crossing Culvert built in 1831. The occupants of one vehicle realised too late that their odometer was out by two kilometers and stopped at Murrays Culveret by mistake. Several other members, in Lemming-like fashion followes suit. *(Photos 2 & 3).*

This explains why the occupants of said vehicle were unable to locate the fabled "Third Rock From The Road" *(Photo 4).*

Our next stop was to examine the convict rock wall and the convict road cutting adjacent to the intersection of the St. Albans Rd. and the Wollombi-Kulnura Rd *(Photo 5).* Heneage Finch was the assistant surveyor in charge of the Great North Road construction. He was the grandson

1. House of the Rising Sun, Millfield.

3. Our 'leader' recording those who made the wrong stop.

4. Fernances Culvert, the 'correct stop'!
But which is the 'third rock from the road?'

of the Earl of Winchilsea and his work was excellent but he had issues with head office. There was an interesting geological feature here which Brian described as a pebble lag-deposit along the bottom of a stream channel filled by later cross-beds. This is a feature of the fluvial environment that deposited the Hawkesbury sandstones.

The best bird picture of the day was Elaine's photo of a leatherhead/noisy friarbird on a *Xanthorrhoea* flower at stop 8 *(Photo 6)*, where a late morning tea was enjoyed more by some than others. As can be seen by a certain party's apple-turnover 'n' cream grin *(Photo 7),* Terry & David will have to pick up their act somewhat!!

Some participants' answers to the questions posed at this stop may well have been copied from the bark of a nearby Scribbly Gum *(Photo 8).*

The St. Alban's Road, previously known as Dennis's Dog Kennel was then followed to St. Albans.

The first stop on this leg was on a ramp built by convict Iron Gang No 9 under the direction of Mr Percy Simpson. We then wended our way down to St. Albans Common which is a working common with an employed resident shepherd. Queen Victoria assented to the Common in 1853

5. Convict built rock wall near road junction.

6. Noisy friabird (leatherhead).
Photo by Elaine Collier

and it has remained an active common since that time.

Unfortunately the white cedar trees along the creek had lost a lot of their flowers between the trip survey and the trip.

The next stop was at Francisville Retreat which was/is a Chinese-Catholic Franciscan retreat established by the late Fr. Chang *(Photo 9).*

From here we travelled to St. Albans and lunched in/at the Settlers Arms Inn after which we drove to the start of the locked section of the Great North Road (Devine's Hill). On our walk we noted the wall degradation and

7. Yum, Yum, Yum!

Hangman's Rock (*Photos 10 & 11).*

We then crossed the Hawkesbury River at Wisemans Ferry for afternoon tea and to tally up the scores for the day. This activity was a first for the Society and proved extremely successful.

The Winners:

The winner was Laurel Kingdon who scored 27.5 points and received the rather expensive and well travelled first prize.

Ellen and Ron scored 27 points and were second with Chris, Brian and Winston a close third with 26 points.

Well done to all for making the activity such fun.

NUMBAT AWARDS were given to the following participants:

Leonie, ably assisted by Vic, for *'WATERING THE GRAVE'* (you just had to be there!)

Chris for *'NOT PAYING ATTENTION'* and leading others astray.

Ron & Ellen gained the *'LEMMING'* award.

Richard and Maree gained the esteemed *'FOLLOWERS'* award.

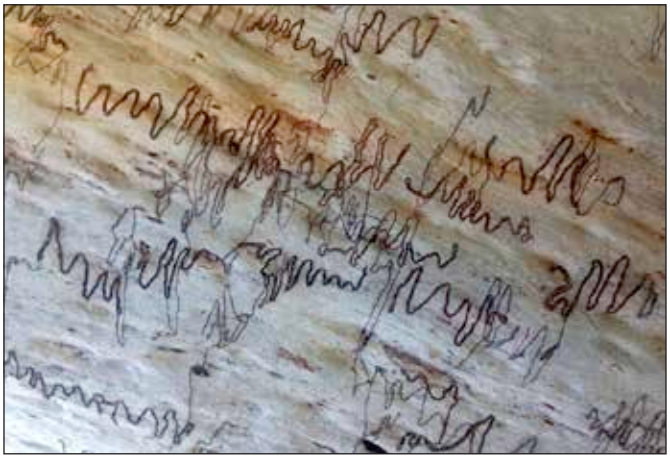
David achieved the supreme *'FORGETFULNESS'* award.

A fun day was had by all and we all returned safely home.

Report by David Atkinson.
Photographs by Ron Evans and others.

9. Gate posts and statue near the Francisville Retreat.

10. Great North Road, Devine's Hill.



8. Scribbly Gum bark.
Photo by Brian England

11. Hangmans Rock on Devine's Hill.

Geological Mapping Workshop

Leader: Ron Evans.

Attendance: 15 members.

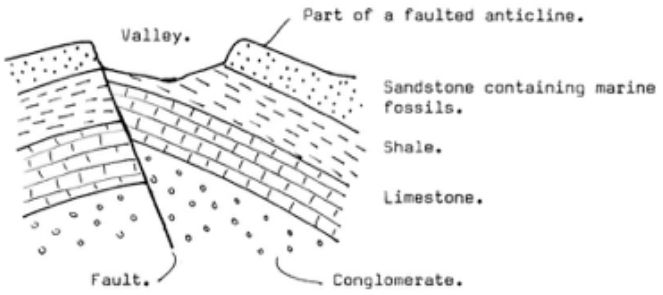
Date: Saturday 18th November 2014.

During several outings where geological maps were used to illustrate geological and topographical features, it became obvious that most members had little understanding of how to use a geological map to interpret the geological features and history of an area. With this in mind, a workshop on geological maps and their use was offered to members with a set of notes and exercises provided to participants.

The workshop was divided into different sections.

1. Maps. Purpose, types , map scales and symbols commonly used on maps were discussed and illustrated using maps kindly supplied by President Brian.
2. Geological History of a Section. Ron explained that in order to deduce the geological history of a region or section, one must consider:
a) The *geological structures present:* these indicate processes and changes that have taken place in the crust since rock formation (lithification).
b) The *rock types present:* these indicate conditions and processes that existed during lithification.
c) *Relative ages of the above:* this enables one to deduce the order of geological events that have occurred.

The following example of a cross-section was then worked through with group input:



What became apparent to participants was that in order to compile a geological history, one needs to be familiar with rocks types and how each forms as well as recognising geological structures (anticlines, reverse faults, unconformities etc) and the processes leading to their formation.

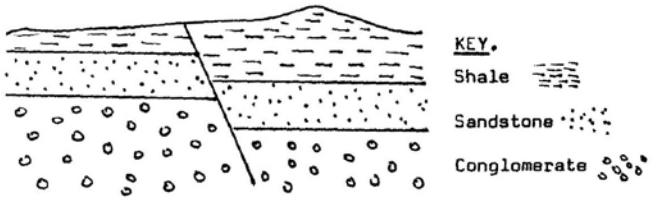
Participants were then asked to make a simple diagram of various geological structures, namely *folds* (anticlines and synclines, both symmetrical and asymmetrical and overfolds), *faults* (normal, reverse or thrust and strike-slip, as well as horsts and grabens). Ron provided diagrams that explained the formation of *unconformities* (angular, nonconformities and disconformities).

Next followed a discussion of *intrusive structures* that invade older country rock. These included dykes, sills, batholiths, stocks, laccoliths and lopoliths. When diagrams were asked for, many blank looks resulted.

After an explanation and diagrams of these structures, the group moved onto the task of compiling geological histories from cross-sections.

Simple exercises were provided with Ron guiding the process of writing down a geological history. It soon became apparent to participants that they had to have a knowledge of the processes involved in rock formation, and the environment in which different rocks formed.

One such exercise worked through follows:



Geological History of above:

- Gravels deposited in moderately high energy moving water.
- Energy lessens and sands deposited.
- Conditions become still in the water and muds deposited.
- Lithification occurs and the sediments are changed into rock.
- Earth movement occurs with tension forces causing a normal fault to form.
- Uplift and erosion forming the present land surface.

The group were then given time to attempt several more geological histories before each was discusses and questions answered.

After such an intense session, morning tea was called.

3. Constructing geological cross-sections.

Following morning tea, the last 2 hour session was dedicated to drawing a geological cross-section from a geological map and then deducing the geological history of the cross-section.

The session commenced with Ron working through the provided notes on the processes involved in constructing a geological cross-section, both on a flat land surface and on a topographic profile. It was then onto practical exercises.

Exercise 1 involved using an *Apparent Dip Table* to work out the apparent dip of strata from a geological map using true dip from the map, and direction angles read off the map using a protractor. This was a useful exercise in using a ruler and protractor accurately, important skills in constucting a geological cross-section.

Exercises 2 and 3 were to draw geological cross-sections on a flat land surface of:

- a symmetrical anticline and syncline with a 40° dip, and
- strata with a 30° dip east cut by a vertical fault.

Geological histories had to be compiled for each cross-section.

To complete the workshop, a more difficult cross-section had to be compiled. This involved:

- drawing a topographic profile for the section.
- transferring geological strata and structures onto the topographic profile and then
- compiling the cross-section with included both intrusive and extrusive structures as well as sedimentary strata.

In reviewing the geological history of the cross-section, Ron pointed out that both the geological map and the drawn cross-section had to be used to compile the geological history of the area because the cross-section did not provide sufficient information to deduce the order of geological events.

It was very pleasing to note how the skill level and understanding of geological processes within the group developed throughout the workshop. Thanks to President Brian for his assistance.

Report by Ron Evans.

Social Activities 2013

Once again, our wonderful Social Committee organised and conducted our two main social events, Soup and Slides and our Christmas Party.

Both events were held in the home of Ian and Sue Rogers. As usual, they were a great success. A very big thanks to all involved and to members for supporting these activities.

A special thanks also to all members involved in planning the activities for 2104, and to all trip leaders.

Publication Acknowledgements.

As in 2013, 'Geo-Log' 2014 was compiled and produced by Life Member Ron Evans using reports compiled and submitted by trip leaders. Well done to all involved.

Once again, Lakemac Print, Speers Point produced the final publication.

President Brian once again offered and then edited 'Geo-Log' 2014 before printing making sure that the journal was geologically and grammatically accurate.

If you wish to quickly log onto The Amateur Geological Society of the Hunter Valley Inc. website, quickly scan the QR Code below. You may need to install a QR Code Reader (free on the web) on your tablet or smart phone.

Ron Evans.