'Geo-Log'
2023 - 2024

20th Anniversary Edition

Journal of the Amateur Geological Society of the Hunter Valley

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President's Introduction 2023-2024.

Dear Members,

It has been another exciting and interesting 12 months for the Society. This has been both in experiences to gain new insights geologically and to gather socially. Thank you to our Societies Vice President, Chris Morton, Secretary Richard Bale and Treasurer John Hyslop for their continued invaluable contributions and effort.

I would like to take the opportunity to thank all of the members who have contributed by organising and running the variety of activities that have been held. Thank you to all the members who continue to support the Society through their attendance and participation in the different activities presented.

Thank you to the social committee, ably led by Sue Rogers.

The life members have continued to add their invaluable contributions. A special thank you to Ron Evans and Brian England, for the high quality of this year's Geo-Log.

As well as our regular activities, we have had the opportunity to connect with other groups and experts in different fields to continue to promote an interest in geology in the community and in schools.

We look forward to another year of activities to stimulate the mind and connect socially.

Brian Dunn.

End of Permian Extinction,
Munmorah State Conservation Area

Leader: Chris Morton.
Date: Thursday 28th September, 2023.
Attendance: 5 members, 2 National Park Rangers.

Making the case for the End of Permian Extinction (EPE) to NPWS., in Munmorah State Conservation Area.

A proposal at our last AGM in July suggested that we form a committee to approach the National Parks and Wildlife Service (NPWS) in an attempt to have the NPWS promote and highlight the geology of the Munmorah State Conservation Area (MSCA) on their website and some signage, in particular depicting the End of Permian Extinction (EPE) and the significance it represents for the current debate on climate change. The motive behind the exercise was to try and prompt NPWS to highlight the geology within the MSCA because, over time, we have received requests from the general public regarding the geology within the park. Predominantly, these requests come from people who said they had contacted the NPWS's Park office at Munmorah for information on the geology. The reply from NPWS is to refer them to the Geological Survey at Maitland, who in turn, refer them to the AGSHV.

1. Stratigraphy, Wybung Head (according to Vajda et. al. 2020). (Chris Morton).

The hard part was to initially find the relevant person to contact at the National Parks and Wildlife Service (NPWS) at Munmorah. Fortunately, because of Barry Collier's long-standing association with the park, it was possible to obtain the phone number of the relevant ranger in charge. Consequently, after several phone calls, I eventually contacted a very busy Stacy Wilson, the ranger responsible for the management of Munmorah State Conservation Area (MSCA). After some difficulties due to her work constraints and co-ordinating a time when the tides would suit, Stacy agreed to meet our delegation and accompany us on a guided tour of the Wybung Head and Frazer Beach area, where we could present evidence regarding the 'End-Permian (252 Mya) deforestation, wildfires and flooding - an ancient biotic crisis with lessons for the present' which was the basis for the excursion at Wybung Head conducted on the 17th October 2020.

Unfortunately, the date chosen mainly to suit Stacy clashed with the annual AGSHV Safari to South West Queensland, which prevented some members who wished to attend the excursion from participating. However, we managed to assemble a very knowledgeable team, which included Brian England, Phil Gilmore, John Hyslop, Barry Collier and myself, a small but formidable team to prosecute our case.

As usual, after all the planning and having perfect weather and sea conditions, Murphy's Law intervened. Murphy's Law states if something can go wrong, it will go wrong. One hour before our agreed meeting time, I received a phone call from Stacy pleading for forgiveness, as she had to cancel our excursion due to a whale entangled in a fish net off Catherine Hill Bay. She was heading out in a boat to help rescue the whale.

Expressing my disappointment along with a great understanding of her situation, Stacy to her credit, said she would contact one of her colleagues to see if they could fill in for her. Stacy rang me back within ten minutes to tell me she had arranged for Ranger Ben McDougall to fill in for her. But there was one small problem, Ben was also co-ordinating a hazard reduction burn, which he could manage via his mobile phone. Modern technology does have its place.

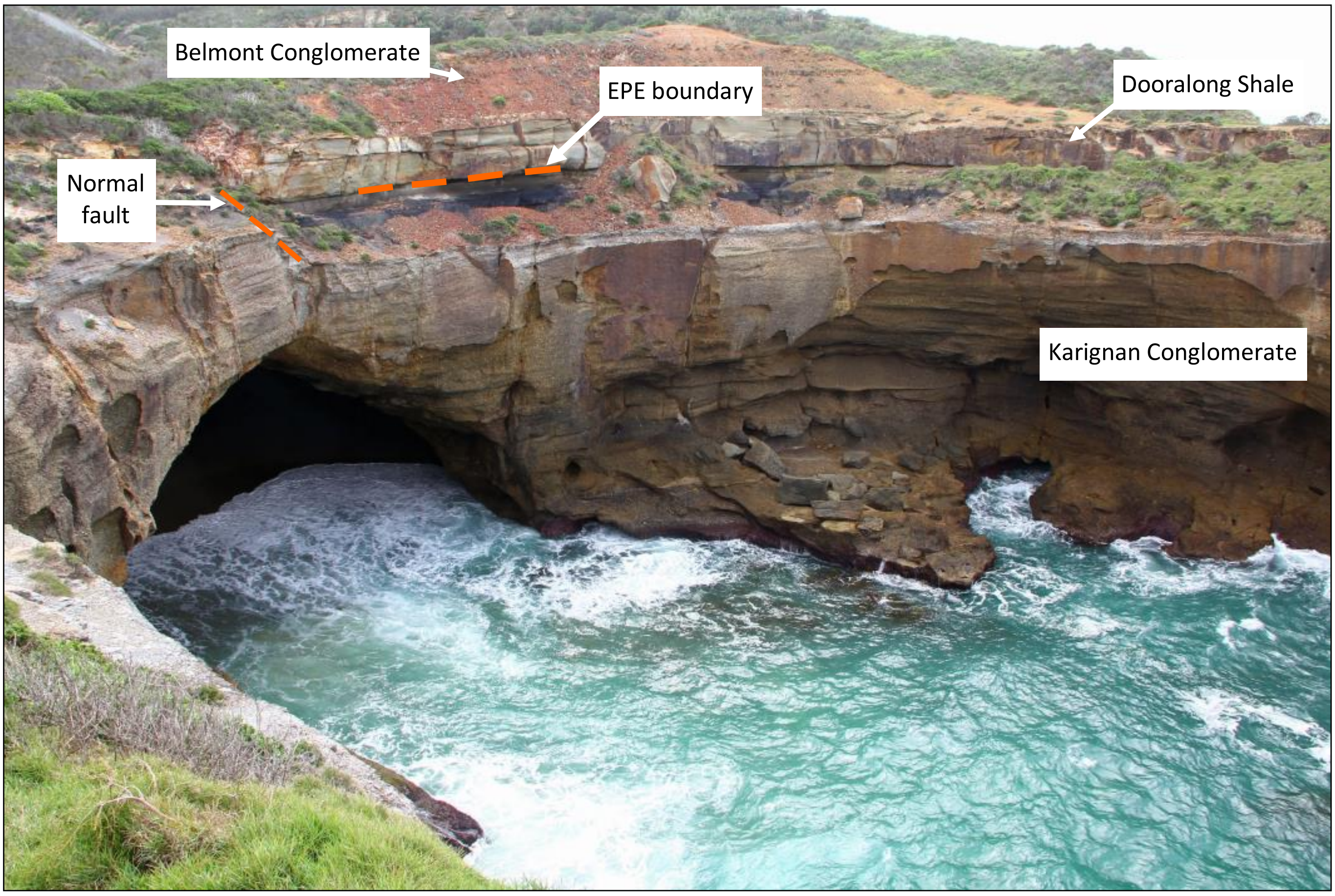
Ben turned up promptly at the 1 p.m. meeting time, and by good luck, he had a background in Earth Science and understood the information presented to him. From our meeting point at Frazer Beach car park, we walked south towards Wybung Head where you can put your hand on the EPE in the cliff face *(photos 1 & 2)*. During this, Ben's attention was divided between us and his men in the field, fulfilling his role with National Parks. As we approached Wybung Head, phone contact with his base became intermittent. Fortunately, the fire was under control, giving us enough time to present all the information regarding the EPE. Soon though, Ben was keen to resume phone reception with his base, so we returned to the car park to where there was reception.

2. Brian and Phil explaining the EPE to NPWS ranger Ben and John at Wybung Head. (Chris Morton).

3. Phil pointing out geology to NPWS rangers Ben and Elise at Snapper Point. (Chris Morton).

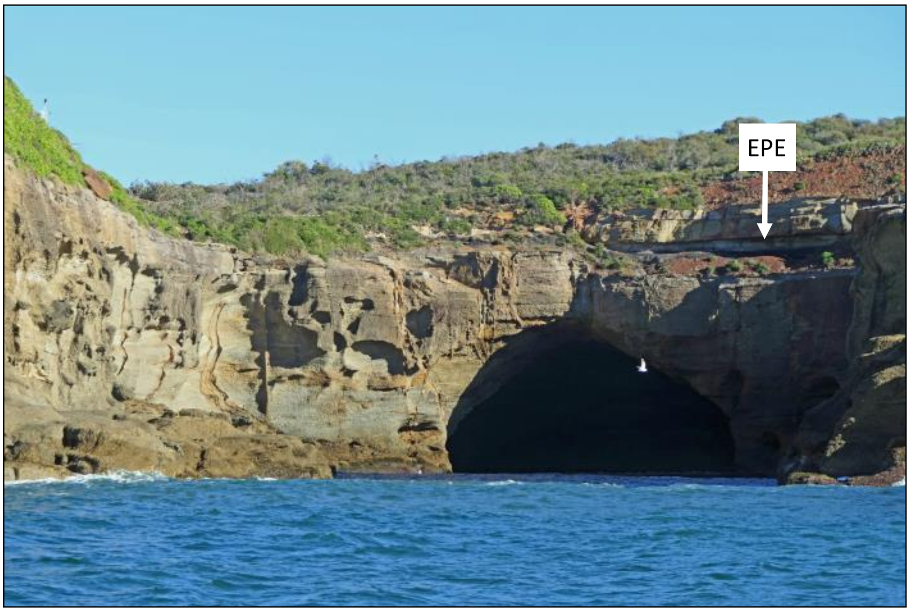
From the car park at Frazer Beach, we drove to Snapper Point, where a second ranger, Elise McCarthy was waiting. After introductions and a brief explanation, we walked to the fence overlooking the spectacular inaccessible large cavern that lies below the EPE *(photos 3, 4 & 5)* before proceeding to Snapper Point, where we could effectively stand on the EPE, before driving to a lookout over Ghosties Beach to view the EPE within the escarpment overlooking Ghosties Beach.

In conclusion, Ben told us that we presented a strong case for more exposure regarding the geology on their website within the MSCA, but it would be subject to public interest. Events from the past show unless the information is publicly available, there will be little interest generated from the public. In contrast, we believe the Wybung Head, Frazer Beach area should be recognised and promoted as an internationally significant geological site and highlighting the geology of the MSCA and the EPE will bring much more attention and increase visitation to the MSCA.



4. Snapper Point. View of the EPE boundary located just above a large sea cave that's formed by following a line of weakness caused by a normal fault. (Ron Evans).

The NPWS staff are busy with their day-to-day duties without emergencies cropping up without notice, and they could have ignored us, but to their credit, they went out of their way to accommodate and listen. On behalf of the AGSHV, our appreciation goes out to Stacy, Ben and Elise for agreeing to meet with us under difficult circumstances.



5. View of the same location from sea level. (Ron Evans).

Report by Chris Morton.

References.

MORTON, C. and ENGLAND, B. (2020) Wybung Head Excursion. Geo-Log. 2020.

VAJDA, V.; McLOUGHLIN, S.; MAYS, C.; FRANK, T.D.; FIELDING, C.R.; TEVYAW, A.; LEHSTEN, V.; BOCKING, M. and NICOLL, R.S. (2020). End Permian deforestation, wildfires and flooding - An ancient biotic crisis with lessons for the present. Earth and Planetary Science Letters. Elsevier.

Natural Science Loop

Geological Safari 2023

Sunday 27th August to Thursday 14th September

Leaders: Brian and Barbara Dunn and Sue Rogers.

Attendance: 21 members.

Introduction.

The Safari followed the Natural Science Loop in the south west region of Queensland, a 995 km circuit connecting the Paroo, Bulloo, Quilpie and Murwah Shires *(see Map 3, page 16 - the Natural Science Loop Road)*.

Participants were able to examine features of the Eromanga Basin which is part of the Great Australian Basin *(Map 1)*. The predominantly Jurassic and Cretaceous sediments of the basin give rise to a number of features such as artesian bores, mound springs, boulder opal fields, fossilized dinosaur and megafauna bones, Mitchell grass plains, jump-ups, dune systems and gorges.

Features of the Great Australian Basin.

Between 145 and 100 Ma, vast inland seas covered most of the eastern parts of the continent in what was now Queensland, N.S.W and South Australia.

Sediments deposited in these seas and on earlier river plains gradually accumulated and were hardened to rock. These rocks covered a broad area which is known generally as the Great Australian Basin (formally Great Artesian Basin).

This basin occupies one fifth of the Australian land mass and is one of the World's largest sedimentary basins and artesian systems, 1.7 million km^2 in area in Queensland from Cape York to the Simpson Desert *(Map 2)*.

Its most characteristic landscapes are flat topped "mesa" country, semi-arid rolling downs and channel and lake country to the south west.

The supply of artesian water from the Basin has allowed the development of a vast pastoral industry-at first sheep and now cattle. Resources of oil, gas, and coal have been exploited as well as the more controversial coal seam gas in recent times.

Deposits of opal, Australia's national gemstone have been extracted in several remote areas. World renowned fossils of dinosaurs and giant swimming reptiles are another feature of the area and continue to be discovered.

Map 1. Great Australian Basin (GAB). (Willmott, et al 2017)

Map 2. Extent of Great Australian Basin formally called the Great Artesian Basin. (friendsofmoundsprings.org.au)

Formation of the Great Australian Basin.

Before the most recent part of the Triassic Period (210 Ma), the eastern edge of the Australian continent was periodically compressed and heated by subduction of oceanic crust under the continental edge. After 210 Ma the subduction ceased or moved eastward.

The continental edge then relaxed, the oceanic crust sank and the continental crust cooled and contracted. The continent behind the edge sagged over a long period of time, from 200 Ma until 90 Ma.

This subsiding area became a basin for the accumulation of sediments *(Diagram 1)*.

Formation of the Sedimentary Rocks.

The earliest sediments in the basin came from rivers in the south and southwest in the early Jurassic period (205-175 Ma.) These formed extensive plains with a few low hills in the basin area. Quartz rich sand up to 150 m thick was deposited. Soon the plains filled up and the rivers became more widespread and sluggish.

In the Eromanga Basin siltstone, sandstone, shale and minor coal, the Poolowanna Formation were laid down. These are only known from oil and gas exploration wells and do not outcrop at the surface.

About 175 Ma the soft sandstone of the Hutton Sandstone was deposited. This was a continuous and thick blanket of sand. In the mid Jurassic (174-163 Ma) finer grained sediments of floodplain and swamp environments was laid down. In the Eromanga Basin this is the Birkhead Formation which has no significant coal deposits. After a break during which there was some erosion of the accumulated sediments towards the end of the Jurassic, widespread sandstones were again deposited in rivers and lakes in the Eromanga Basin.

The Adori Sandstone, Westbourne Formation and Hooray Sandstone were formed in the Eromanga Basin. This non-marine sedimentary pattern was to continue across the Jurassic-Cretaceous boundary. By the late Jurassic the Great Australian Basin was joined as a united system. The extensive sandstone units throughout the Jurassic rock sequence are the important water-bearing aquifers of the basin.

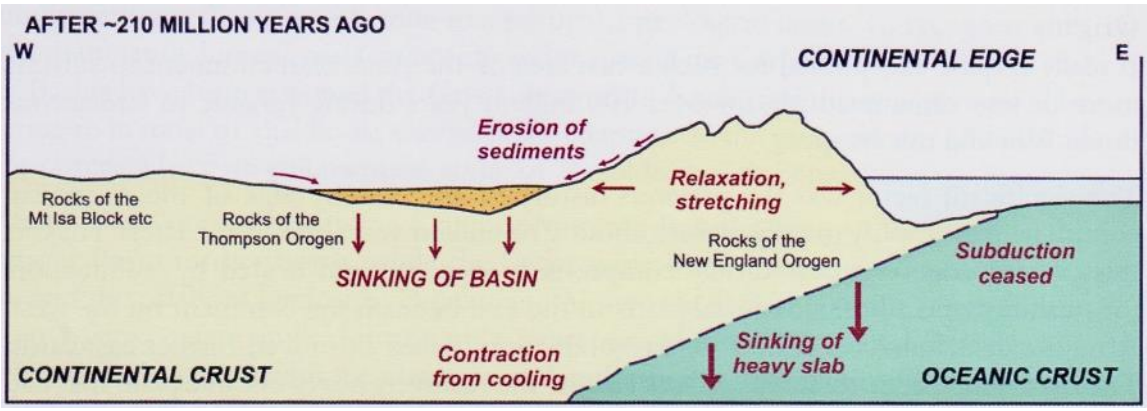


Diagram 1. Diagram illustrating conditions on the Australian Continent leading to the formation of the Great Australian Basin. (Willmott, et al 2017)

Global changes in climate and sea level and the continuing sinking of the Basin soon resulted in the first major invasion of the sea about 135 Ma. Australia at the time was located in the higher latitudes and it was a relatively warm period in the Earth's history. In the Eromanga Basin marine conditions began with the uppermost Cadna-owie Formation. There were five inundations by the sea through the Gulf of Carpentaria into the continent till about the mid-Cretaceous (90 Ma).

The third inundation of the Eromanga Sea (about 116-113 Ma) was the most extensive with mudstones deposited in the shallow seas to form the Doncaster Member of the Wallumbilla Formation. These mudstones are very fossiliferous in places. During the fourth inundation (about 108-105 Ma) deposits of siltstone and sandstone formed the Ranmoor Member of the Wallumbilla Formation.

The fifth and final inundation occurred after millions of years of erosion. The sediments from this time outcrop widely. They are from earliest to latest the Toolebuc Formation (contain organic-rich black shales and limestone concretions) formed in an oxygen-poor sea floor; Allaru Mudstone (materials derived from volcanic activity) mudstone, fossil-rich sandstone and limestone deposited in a shallow sea environment and Mackunda Formation dominated by sandstones derived from increased volcanic activity, mudstone and calcareous siltstone. The rocks of this formation contain the last marine fossils known from the Basin. They underlie the Winton Formation *(Table 1)*.

The Winton Formation.

From 100 to 93 Ma the inland sea retreated never to return. The sediments of the Winton Formation were laid down in the late Albian to early Cenomanian of the Cretaceous. Widespread freshwater lake, swamp and floodplain sediments were built up across the old sea bed. The Winton Formation rests unconformably on the older Mackunda Formation of the Eromanga Basin. The Winton Formation has maximum thickness of 1100 m and forms the uppermost part of the Rolling Downs Group (Fletcher, et. al., 2018). The Winton Formation is a heterogeneous package of sedimentary rocks that include lithic and feldspathic sandstone, mudstone, siltstone, coal, minor conglomerate and layers of volcanic deprived detrital material. These rocks are the last rock formation of the Eromanga Basin and cover much of the surface.

The Winton Formation contains many plant fossils, with rarer insects, fresh water mussels and bones and tracks of dinosaurs. Weathered sections also contain important boulder opal deposits.

The Winton Formation is part of the Rolling Downs Group which underlies the Mitchell-grass plains in the centre of the Eromanga Basin. Faults and folds have altered and interrupted these broad zones adding to the irregularities. (Willmott, et al 2017).

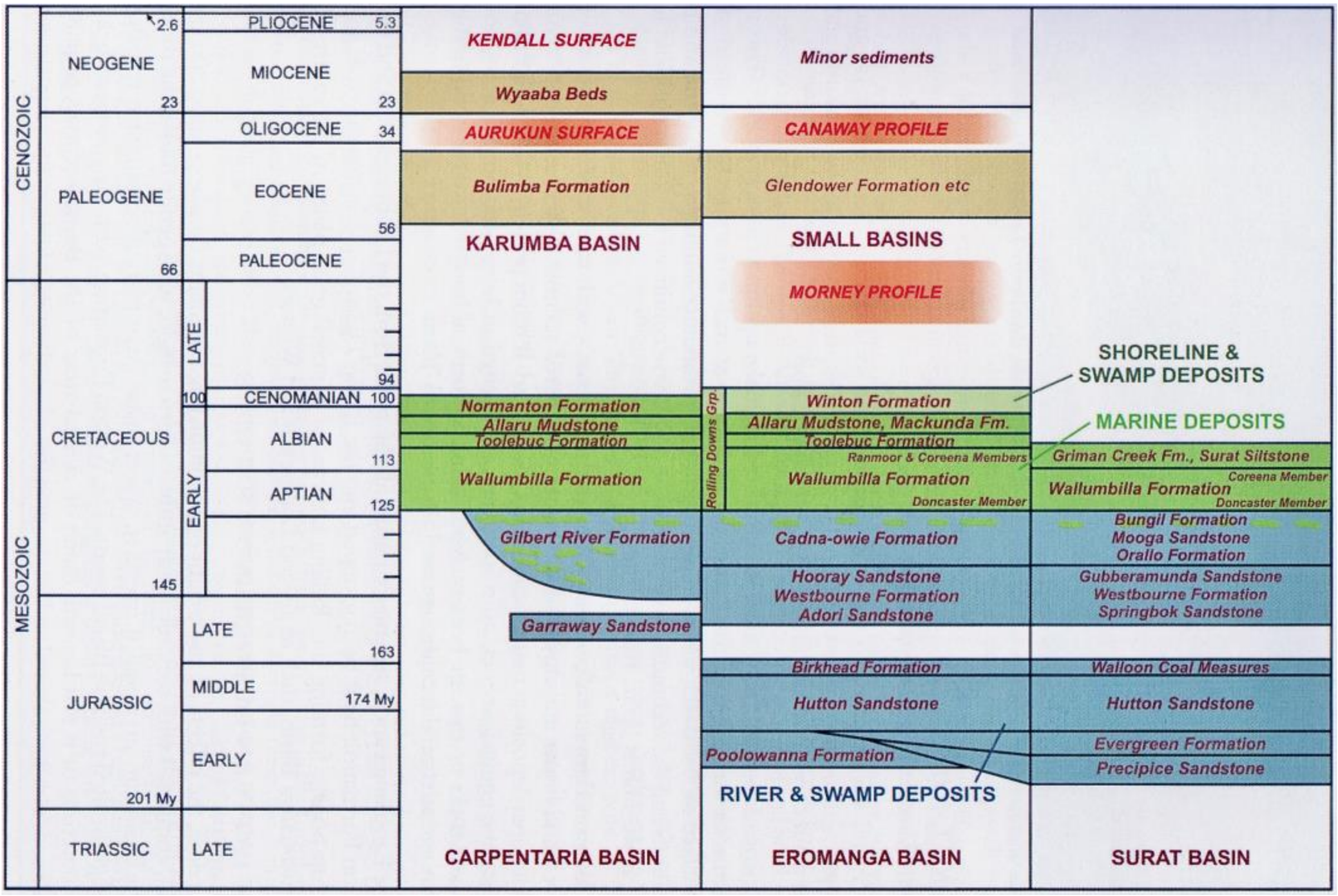


Table 1. Main rock units within the Great Australian Basin. (Willmott, et al 2017)

The Erosion Processes of the Winton Formation.

It is estimated that over 3000 m of sediment has been eroded away during a long era of weathering.

Australia broke away from Antarctica and drifted northwards to lower latitudes. Climatic conditions changed from warm moist conditions to a more arid environment. (Willmott, et al 2017).

Periods of deep weathering have been identified. During these periods hardened crusts enriched in silica and iron oxides have grown just beneath the land surface. These crusts sit above a leached mottled or white clay-rich layer. Later erosion of the surface and lowering of the landscape has resulted in these hard crusts remaining as the tops of plateaus, ridges and mesas known locally as jump-ups *(photo 1)*.

Underground Water.

The Great Artesian Basin (GAB) contains about 65 million gigalitres of water. It is one of the largest natural underground water reservoirs in the world. It consists of layers of aquifers and aquitards ranging from 65 to 250 million years old deposited in the Triassic, Jurassic and Cretaceous periods. The aquifers can be up to 3000 m deep, with water moving laterally through the Basin between 1-3 m per annum. The waters are up to two million years old.

From the perspective of the whole GAB, water from rain and some rivers enters the groundwater along elevated margins such as the Great Dividing Range.

From these areas of recharge, groundwater is driven by topographic gradient to lower-lying parts of the basin where it can discharge back to the surface. In the GAB, groundwater discharge occurs through springs, artesian bores, extraction bores and very slowly by a diffuse seepage process across broad sections of arid land.

The mechanics of groundwater flow in the GAB, or hydrodynamics, are governed by the structure and nature of the sequence of aquifers. Across much of the GAB, the Jurassic and Cretaceous beds that form aquifers are confined by nearly impervious rock layers. These confining beds and relative elevation difference with the more elevated recharge areas results in the artesian groundwater pressure *(Diagrams 2 & 3)*.

Since the 1880s, groundwater pressure has decreased, largely due to uncontrolled bores and open bore drains. Rehabilitating (capping) artesian bores and upgrading them with closed pipe systems was the focus of the GAB Sustainability Initiative (GABSI), which commenced in 1999. (gisera.csiro.au).

The most important aquifers of the Eromanga Basin are the combined strata of the Cadna-owie Formation and the Hooray Sandstone, the youngest Jurassic sandstones, as they are the highest of the artesian aquifers. (Willmott, et al 2017).

Deeper aquifers are the Adori, Springbok and Hutton Sandstones which stretch across the width of the basin. Sub-artesian aquifers are present in the Cretaceous marine sediments from the inland seas (Wallumbilla Fm, Alluri Mudstone and Mackunda Fm) and in the later swamp sediments of the Winton Fm. The bores in these units require pumping.

Artesian springs result from pressurised water breaking through thin confining layers, from water being forced up faults in the strata, or from the abutment of aquifers against impervious bedrock. (Willmott, et al 2017).

The first bores sunk in Queensland date from 1886 and by 1998 there were about 4,700 flowing bores drilled across the basin. In Queensland 74% of the bores are extinct because of the large amount of water that has been extracted.

1. Grey Range east of Thargomindah, duricrusted deeply weathered Winton Formation with a silcrete cap and talus slopes. Pediments with lag gravels overlie clay soil developed in situ. (Ron Evans 2016).

Mound or Mud Springs.

Most mound (sometimes called mud springs) occur on the margins of the GAB in the far north of South Australia, NW N.S.W. and SW Queensland. The term mound spring reflects the characteristic mounds that have developed at many but not all springs *(Diagram 4)*. In some areas the mounds have been building for thousands of years. Spring flows were stronger in the geological past.

The Eulo supergroup consists of 53 active and inactive spring complexes. This super-group of the GAB formed around the town of Eulo in SW Queensland.

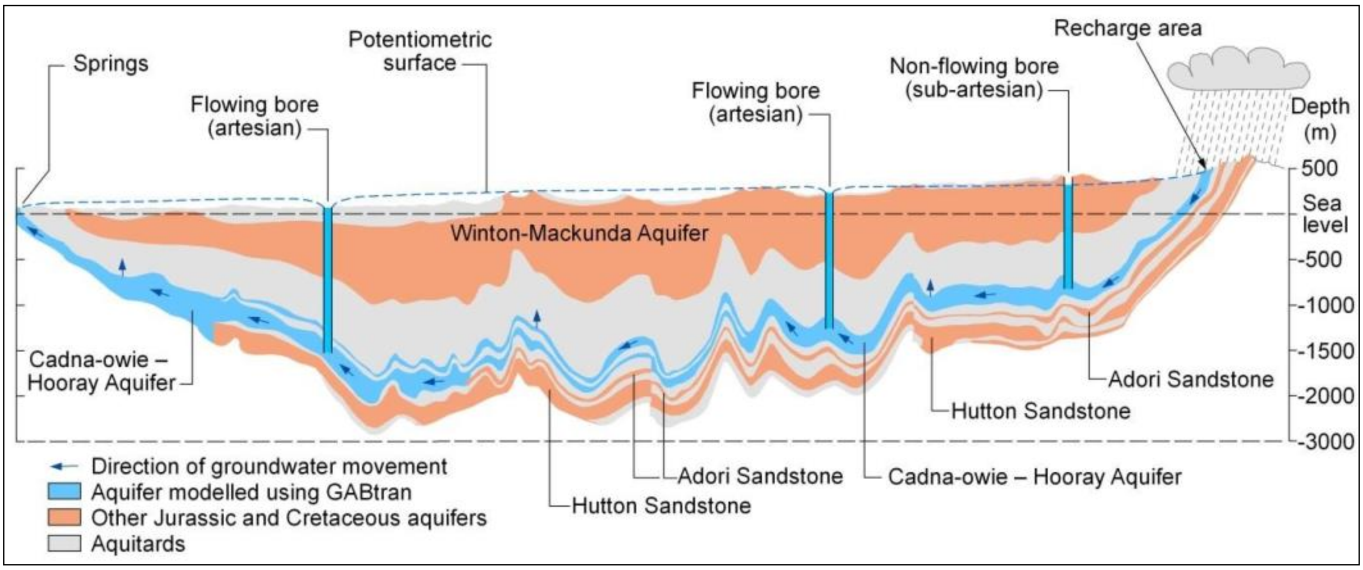


Diagram 2. Schematic slice through the Great Artesian Basin illustrating predominant aquifers in the Jurassic and Cretaceous beds in blue, confining layers in grey, and other aquifers in orange. The slice represents schematic layering from major spring zones in South Australia (left side of figure) to major recharge areas in Queensland (right side of figure) and therefore the vertical scale is exaggerated. (Radke et al., Hydrochemistry and implied hydrodynamics of the Cadna-owie – Hooray Aquifer, 2000)

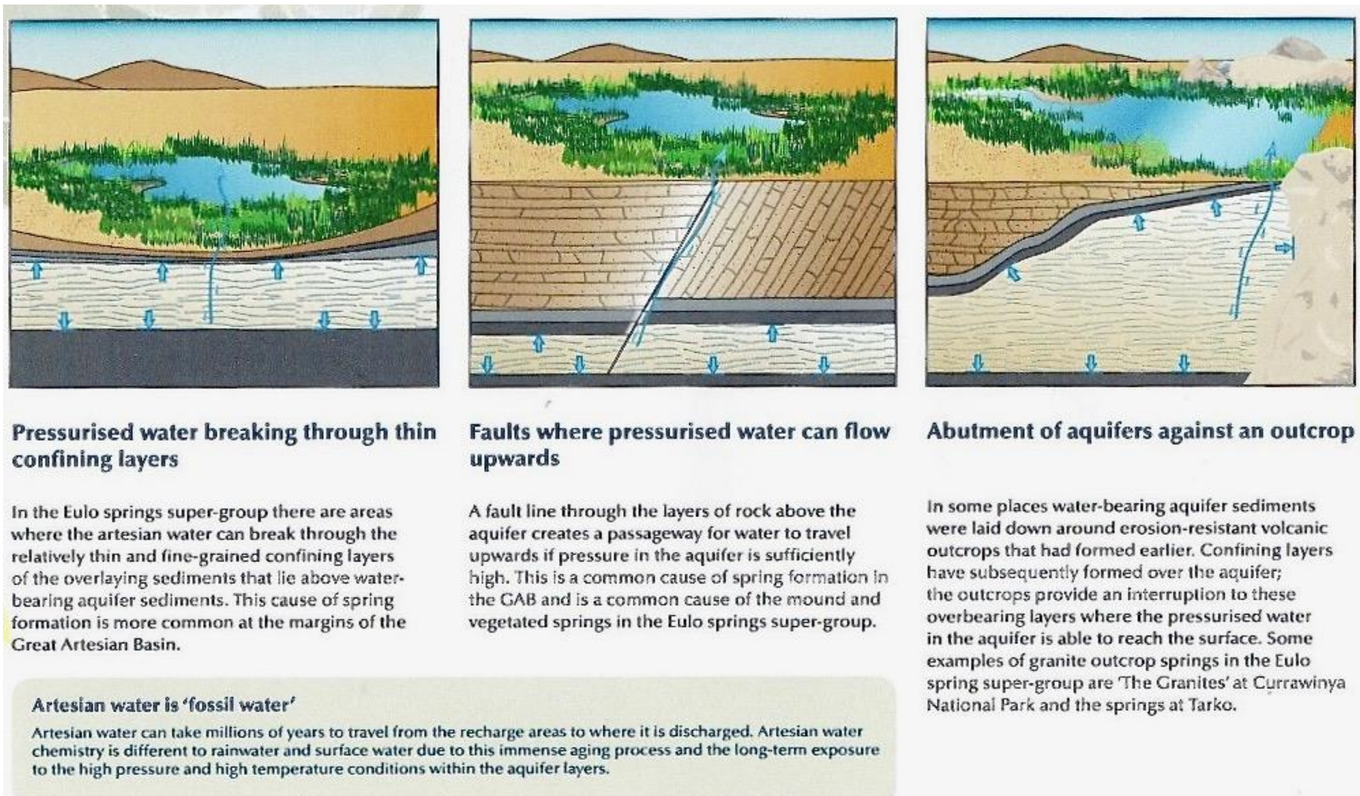


Diagram 3. Underground causes of spring flow in the Great Australian Basin.
(Conceptual Model Case Studies: Eulo springs super group)

The mud springs visited are located nine kilometres west of Eulo.

The mound springs of the Eulo region are composed of mineral-rich clay mud that has slowly been transported to the surface by the pressurised artesian water from the sandstone aquifer. The mound is quite hard on top and sounds hollow if you jump on it.

The likely source aquifers of the Eulo Springs groups are considered to be the Wyandra Sandstone Member of the Cadna-owie Fm and/or the Hooray Sandstone, although it is likely that some of these waters mix with shallower aquifers on route to the surface.

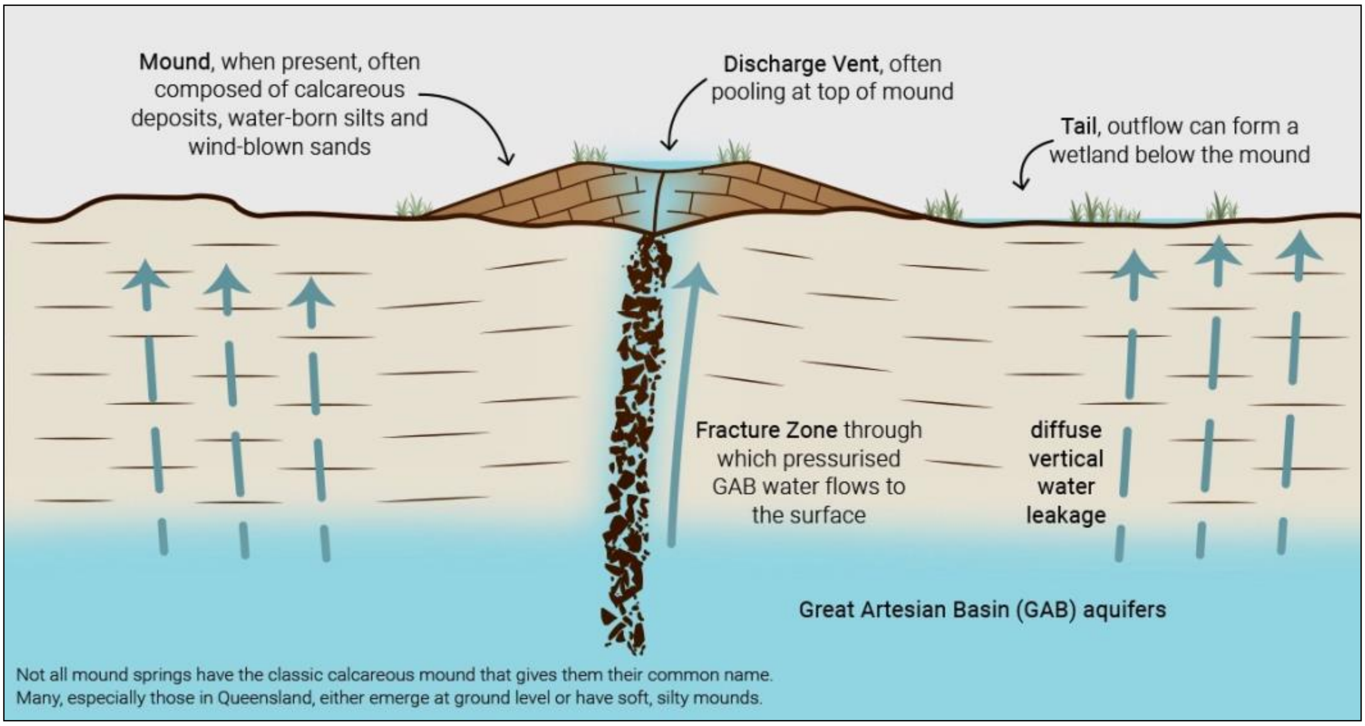


Diagram 4. Generalised structure of a mound spring. (friendsofmoundsprings.org.au)

Abutment of Aquifers Against An Outcrop.

The Eulo Springs complex, overlies the Eulo Ridge, an area of granitic bedrock exposures and regionally shallow depth to the granitic basement. The Eulo Ridge is characterised by a marked thinning of the Eromanga Basin sedimentary sequence (Senior, 1971). The Granite and Eulo Town spring complexes are situated directly adjacent to granite outcroppings, and may be considered as discharge spring complexes emanating from contact between onlapping sediments and outcropping basement structures *(Diagram 3)*.

The Yowah Opal Fields.

These formed in a syncline and have an estimated age of 35±7 Ma (late Eocene to early Oligocene), the age of the ironstone formation (Schmidt, et. al., 2017).

They were first discovered by Bryan Rossiter in the 1880's. He was an opal dealer.

2. Display of Yowah Nuts in Yowah. (Barbara Dunn 2018).

The Yowah mining area is well known for a brown opal called ironstone matrix opal and the Yowah opal nut, a siliceous ironstone nodule, an opal type only found in this part of Queensland *(photo 2)*.

These nuts range in size from about 5 mm to 200 mm across. They have a spherical or ellipsoidal shape, and show alternate concentric rings or bands of light and dark brown siliceous ironstone. There is sometimes a kernel of precious opal. Yowah opals are often cut as cabochons (round shapes without faces).

The Yowah nuts are found in layers 150-600 mm in thickness at depths of up to 20 m in a ferruginous sandstone, and are commonly associated with mudstone fragments or clay pellets.

The main layer is located near the contact between the sandstone and the underlying mudstone/ claystone, but scattered nodules, and in some cases, a second band may occur above.

In Queensland open cut mining is the norm and bulldozers and 20-40 tonne excavators are widely used.

Impact Craters.

Between Noccundra and Eromanga town a meteor crater has been detected by seismic profiling called the Tookoonooka Crater *(Diagram 5)*. It is about 66 kms across. Drilling for oil and gas in the vicinity has provided the following information.

A hole near the centre of the crater encountered quartzite and schist of presumed Ordovician age belonging to the basement beneath the basin which has been brought up at least 450 m from the elastic rebound strike. This central dome is 22 km across and is surrounded by a ring of debri and later rocks, whilst a significant thickness of eroded ejected debri extends out to a diameter of 130 km" (Willmott, et al 2017).

Scientists believe that the meteorite crashed into the first Eromanga Sea when the Cadna-owie Formation was being deposited around its shores, at about 128 Ma.

Some researchers believe that the Wyandra Sandstone Member deposited just after, is part composed of sediments from giant tsunamis generated by this huge plunge into the sea. The resulting crater is thought to have been at least hundreds of metres above the sea. The Wallumbilla Formation of marine sediments were then deposited in the Basin. Erosion of the crater rim and deposition covered over the crater so that it is no longer visible on the surface.

Cooper-Eromanga Basins, Gas and Oil Fields.

These are the largest conventional petroleum fields in Queensland and the largest onshore in Australia.

Gas was discovered in the Cooper Basin in 1963 at Gidgealpa SA and piped to Adelaide in 1969.

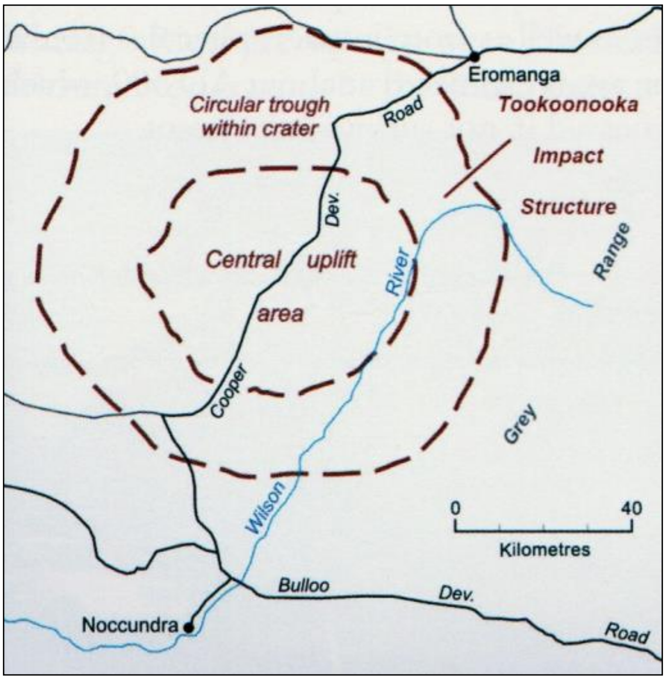


Diagram 5. Tookoonooka Crater. (Willmott, et al 2017)

Reservoirs were located in the Cooper and overlying Eromanga Basin. There are now 150 separate gas fields with 700 producing wells, and 90 oil fields with 360 producing wells.

Pipelines transmit the gas from processing hubs in Moomba, SA and Ballera, Qld. to Adelaide, Sydney, Mt Isa and Brisbane. The gas has also been used by several small gas fired power stations along the pipeline to Brisbane. Oil from the Jackson South-Naccowlah field and Kenmore field was once transported by pipeline to Moonie and then to Brisbane. Because of declining volumes the remaining oil is now taken to Moomba and then Adelaide.

Oil and gas deposits occur where a significant accumulation of organic matter in the sediments is converted under heat and pressure to hydrocarbon molecules. Light ones are gaseous, heavier ones are liquid (oil) and very heavy ones are almost solid (tar or bitumen). A permeable rock layer beneath and an impermeable cap are needed for these products to accumulate. The permeable layers are called reservoirs and the sites of accumulation are called traps.

The permeable layers are also water aquifers but the gas and oil being lighter will float to the top of the water in any trap. The traps can be structural such as where a rock layer is folded or faulted or stratigraphic where a permeable layer pinches out against an impermeable layer. *(Diagram 6)*.

A series of stacked traps may occur where more than one permeable layer is present. Initially the oil and gas will be under pressure and will gush out when a well is drilled. Eventually pumping will be required. Injection of water and fracturing of the rock by water pressure may be used to flush out the remaining oil and gas. Some oil is refined as diesel at Eromanga in a small refinery.

The source rocks are primarily Permian coal seams and mudstones of the Cooper Basin. Reservoirs are found in all sandstone layers of this basin and may be stacked above one another. The gas and oil have also migrated higher into the rocks of the Eromanga Basin in the SE. The main reservoir there is the Jurassic Hutton

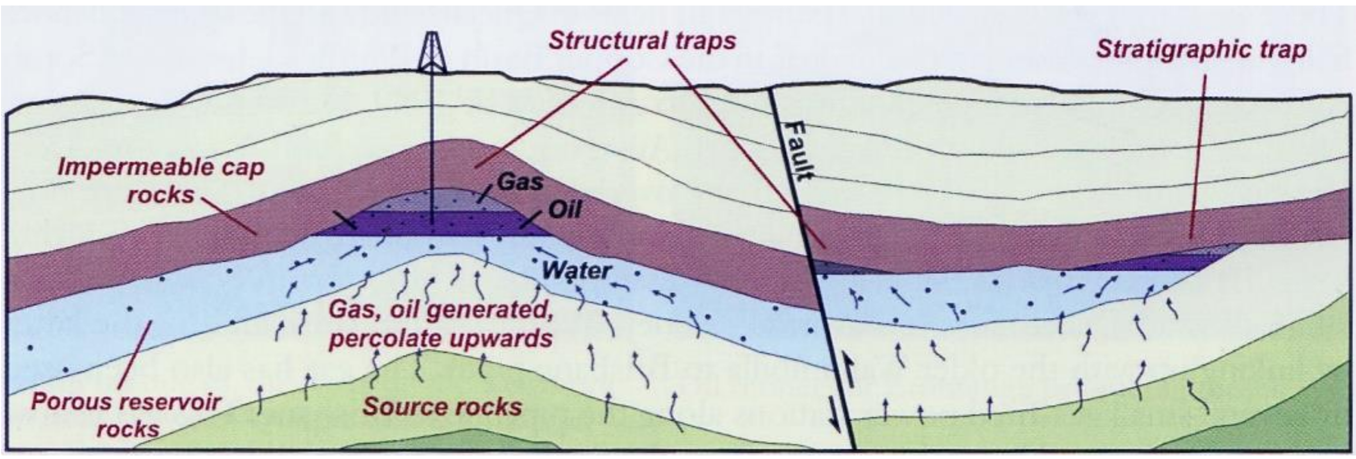


Diagram 6. Methods of generation and entrapment of oil and gas. (Willmott, et al 2017)

Sandstone beneath a seal of the Birkhead Formation rocks. There are also higher reservoirs in the Adori and Westbourne Formations, the Namur and Hooray Sandstones and the Mura and Cadna-owie Formation. Again, there may be stacked pools in the various reservoirs in any one trap.

The Channel Country.

This is situated in south-western Queensland, extending into South Australia and NSW. 280,000 km² or 70% is located in Queensland.

It is defined by having braided channels, flood and alluvial plains. In flood times the watercourses overflow into distributaries and channels sometimes reaching 80 km across. The main water courses west to east are the Georgina and Diamantina Rivers, Cooper Creek and the Bulloo River.

On the rare occasions of massive floodwaters, the watercourses discharge into Goyder's Lagoon, Lake Eyre and Coongie Lakes.

The Channel Country is found covering the Cooper and Eromanga geological basins that form part of the GAB. It is interspersed with flat-topped ridges, sand dunes and ancient floodplains. The flat basin-like expanse of land is a result of erosion over millennia, but also the 'continental sagging' that occurred between 120 -98 Ma when Australia was connected to Gondwana near the South Pole.

At this time the Channel Country was occupied by a vast inland sea populated by strange pre-historic sea life. Today it has around 770 residents and the major land use is cattle grazing.

Permanent waterholes and periodic pulses of substantial water allowed Aboriginal people to live in great numbers in Channel Country. 25 tribal groups have occupied the Channel Country for approximately 20 000 years. It was the heart of an extensive network of trade routes and dreaming pathways that linked this part of the land with the rest of the continent. Pituri, stone, ochre and pearl shell were traded.

3. Flooded channel country. (Bureau of Meteorology, Australia Helen Commens November 2020).

A succession of explorers travelling through Channel country in the middle of the 19th century were Charles Sturt (1844-45), Augustus Gregory (1858), Thomas Mitchell (1846), Burke and Wills (1860-61), John McKinley (1861) and William Hodgkinson (1861,1877). They were variously looking for an inland sea long gone, looking for pastoral lands and looking for territorial advantage for the states that had sponsored their trips.

The pastoralists followed in the 1870s, bringing sheep to the Channel Country but the ravages of the 1890s drought and attacks by dingoes saw cattle replace wool and lamb. Aboriginal people tried to resist the pastoral invasion of their lands and there were many conflicts. Eventually the Aboriginal people were reduced to roles as station hands and house-help. Leading pastoralists were John Costello, Robert Collins, Patrick Durack, Sidney Kidman and Oscar de Satge.

Birdsville and Windorah are the most prominent towns in the area while other settlements include Betoota and Bedourie. It is estimated that between 500,000 to one million head of cattle can be found in the Queensland section alone of Channel Country.

Quaternary Inland Dunefields.

In Queensland the dunes are restricted to the south-western corner of the state and form part of the Simpson and Strezlecki Dunefields. The dunes follow the direction of the prevailing south-easterly winds with the mobile crests being steeper on the eastern side due to the westerly winds in winter. That is they trend from south-east to north-west *(photo 4)*.

The sand in the dunes is derived mainly from the weathering of ancient laterites, and partly from sandstones or from alluvial deposits laid down along watercourses or in basins.

Erosion of the Tertiary landscape and quartz-rich substrates has deposited large amounts of sediments containing sand that have been reworked by wind to form sand dunes and associated sandplains. In general dunes are predominantly pale coloured on the north western side of the large alluvial plains of the Channel Country where the sand originates and becomes redder in colour to the north-west. The red colour is due to the gradual oxidation of the iron minerals coating the sand grains. Isolated semi-stable and mobile dunes are associated with many river systems in western Queensland.

4. 'Big-Red', a longitudinal sand dune near Birdsville. (Big-Red-Simpson-Desert - roadtripsaustralia.com).

5. Natural boulder opal forming the alter in St Finbarr's Catholic Church, Quilpie. (Ron Evans, 2016).

Boulder Opal.

This is found in concretionary ironstone and is mined in Queensland from numerous localities in a zone extending from Eulo to Cunnamulla district in the south and NW for a distance of 700 km to Kapuna in the north. The towns of Quilpie, Yowah and Winton are the main opal mining and wholesale centres.

The opal is found in a 300 km wide belt of sedimentary and Cretaceous rocks of the Winton Formation.

Boulder opal was first found in Quilpie around 1870. It was formed millions of years ago from a solution of silica from decomposing rocks mixed with water, which flowed into seams cracks and cavities into a type of sandstone known as ironstone. The solution hardened in underground cavities and fissures where temperature and pressure fused it into ironstone.

The ironstone matrix enhances the stones durability and vibrancy of colour, often increasing the desirable effects of play of colour and opalescence *(photo 5)*.

Boulder opals are mainly found in freeform shapes and slabs that maximize and preserve the weight of the opal strip.

The main difference between the matrix opal and the boulder opal which are very similar is the width of the veins. They are larger in the boulder opal.

Introductory Field Notes by Barbara and Brian Dunn.

References:

FLETCHER, T.L., MOSS, P.T., and SALISBURY, S,W. (2018). *The palaeoenvironment of the Upper Cretaceous (Cenomanian–Turonian) portion of the Winton Formation, Queensland, Australia.* PeerJ 6:e5513 https://doi.org/10.7717/peerj.5513

SCHMIDT, P.W. & DICKSON, B.L. (2017). *Paleomagnetic dating of ironstone nodules (nuts) from Yowah opal fields, central southern Queensland.* Australian Journal of Earth Sciences.

SENIOR, B.R. (1971). *Eulo, Queensland Sheet SH. SS.*1 International Index. Bureau of Mineral Resources, Geology and Geophysics.

WILLMOTT, W,; COOK, A. & NEVILLE, B. (2017). *Rocks, Landscapes & Resources of the Great Artesian Basin -A handbook for Travellers.* Geological Society of Australia Incorporated, Queensland Division.

WILSON, P. R and TAYLOR, P.M. (2012). *Land Zones of Queensland.* Department of Science, Information Technology, Innovation and Arts, Queensland Government.

Websites:

https://adelaideaz.com/articles/ancient-eromanga-sea

https://australianenvironmentaleducation.com.au-eromanga https://austhrutime.com/eromanga_sea.htm

https://www.bioregionassessments.gov.au>assessments

https://www.dcceew.gov.au/water/coal/-andcoal-seam-gas/resourcs/great-artesianbasin-springs-survey-voll-1

Ecological and hydrogeological survey of the Great Artesian Basin springs - Springsure, Eulo, Bourke and Bogan River supergroups - Volume 1: history, ecology and hydrogeology - DCCEEW

https:www.friendsofmoundsprings.org.au queensland.pdf Geological Framework (Compiled by I.W. Withall & L.C.Cranfield)

https://www.ga.gov.au>australia-mineral-facts>opal
htpps://odesseytraveller.com/articles/channel-country-australia https:www.opalauctions.com/learn/a-z-o-opals/boulder opals

htpps//www.opalsdownunder.com.au/learn/queensland-opal-mining-fields

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6130253/

https://www.qld.gov.au/recreation/activities/areas-facilities/fossicking/westernopal/yowah

htpps://queensland.places.com.au/channel-country

https://www.resources.qld.gov.au_data/assets/pdf_file/0007/197647/geology-of-

https://www.thefreelibrary.com/Australia https://www.uq.edu.au>Winton-Formation

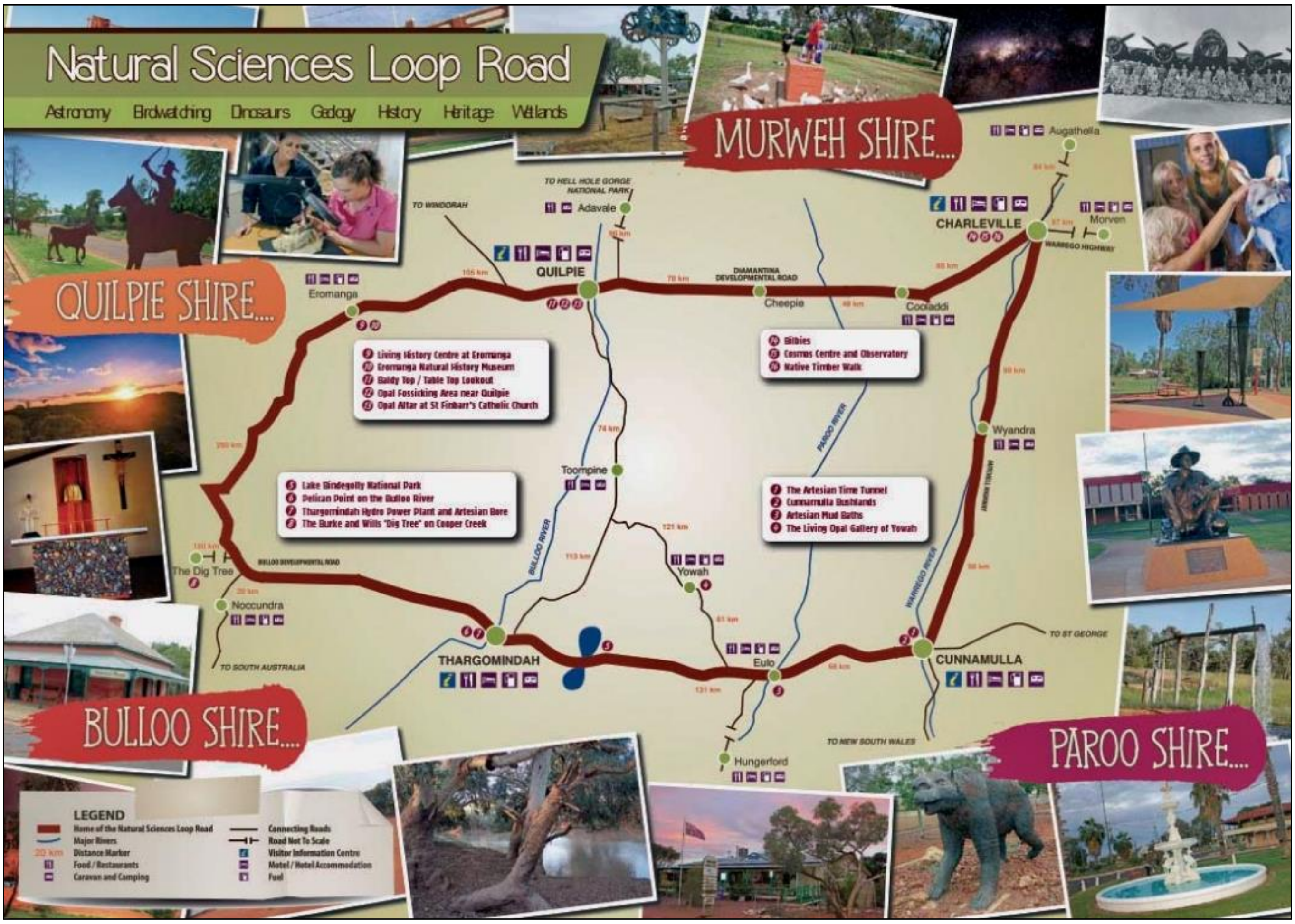
htpps://www.westernriversalliance.or.au/queensland_s_channel_country

https://www.wetlandsinfo.ehp.qld.gov.au –Conceptual Model Case Study Series Eulo Springs Super-Group (updated 2013)

https://gisera.csiro.au/resources/frequently-asked-questions/the-great-artesian-basin-and-coal-seam-gas/

https://twitter.com › BOM_au › status

Map 3: Natural Sciences Loop Road which was followed in an clockwise direction from Cunnamulla.



The 2023 Safari.

Day 1: Sunday 27th August - Arrival at Kidman's Camp, north Bourke.

17 members arrived at Kidman's Camp caravan park which is 7 km north of Bourke.

The planned activity had to change from an afternoon Jandra paddleboat cruise to a viewing of the interesting Back O' Bourke Exhibition Centre *(photo 1)*.

This world-class centre is set amongst a native garden on the banks of the Darling River and portrays the history and importance of Bourke. The centre employs a series of interactive installations *(photo 2)* and stunning visual screen displays.

We all congregated at the camp kitchen at 5pm for happy hour to meet the 4 new members and discuss the schedule for the next 3 days.

1. Dancing brolgas at the entrance to the Back O' Bourke Exhibition Centre. (Sue Rogers).

2. Sculpture in the garden at the Back O' Bourke Exhibition Centre. (Sue Rogers).

Day 2: Monday 28th August - Morning tour of Bourke.

At 8:45 am we met at the wharf to experience the beautiful Darling-Baaka River aboard the majestic Jandra Paddleboat *(photo 1)*. The original Jandra was a steam paddleboat built in Mannum, South Australia in 1894 for Arthur Senior of Bourke. Our modern paddleboat was built by Russell Mansell and his family in 2000. It is the first paddleboat to operate on the Darling River in over 60 years.

We saw a variety of bird life as we cruised down the river and under the historic span lift bridge *(photo 2)*, Australia's oldest movable span bridge. The bridge is the sole survivor of New South Wales's first two lift bridges. Opened on May 4, 1883, this lift bridge was designed by J. H. Daniels and modified in 1895 and 1903 by E. M. de Burgh, both Public Works bridge engineers. It served as a gateway structure for 114 years before being bypassed in 1997.

We then went for a drive around town. Our first stop was on the south side of the bridge for more photos and morning tea. Next was the Percy Hobson Mural which was completed in April 2021 by renowned Lightning Ridge artist John Murray, local artists Brian Smith and Bobby Barrett, Melbourne Street artist Lucas

1. Boarding the Jandra accessed by a short walk from Kidman's Camp. (Sue Rogers).

2. The historic span lift bridge crossing the Darling River. (Barbara Dunn).

Kasper, and a crew of local young Aboriginal artists. As a finishing touch, the Bourke community added their hand prints to the bottom of the mural. The mural honours Bourke's 1962 Commonwealth gold medallist and shows Percy Hobson clearing the high jump bar with red-tailed black cockatoos on the other side of the tank. Percy was the first Aboriginal athlete to win a gold medal for Australia.

Our third stop was to the historic cemetery to see Fred Hollows grave *(photo 3)* that comprises ~415 Ma Adelong Norite with sandstone blocks from Mount Oxley. A sign describes his life and his connection to Bourke. Fred first visited Bourke in 1971 when he was the Chair of the Division of Ophthalmology. Fred connected instantly with the town and the people. He provided eye care for the underprivileged and poor. He is buried with his glasses, a bottle of whisky, letters from his children, sawdust from his workshop, his pipe and a tin of tobacco. Fred was a remarkable man who contributed so much to our society before passing away from cancer in 1993.

The group was enthralled in the starting of the 1923 Crossley oil fuelled stationary engine located near Bourke's reconstructed wharf *(photo 4)*. It is an example of an early water-cooled four-stroke diesel-type engine, which followed the steam era. This particular engine was originally used from 1923 to 1938 in the Sydney Power House to generate electricity. From 1938 it was used in the Allowrie Butter Factory in Coffs Harbour until

3. Crossley Engine. (Sue Rogers).

1949, when it went to a property in Narromine to pump water for irrigation until 1964. Bourke at one stage had the largest inland wharf in the world and a maritime court house.

We then dispersed for lunch; some spent time checking out the shops while others retreated to their caravans for a rest before gathering again at 2:30pm for the drive to Mt Oxley. Another 4 members arrived today giving us 21 participants on the safari this trip.

Report day 1 and day 2 morning by Sue Rogers (activity leader).

4. Fred Hollows Grave. (Sue Rogers).

Day 2: Monday 28th August - Afternoon Geo-tour of Mt Oxley south east of Bourke.

We assembled at 2.35 pm outside Kidmans Camp. The convoy of 7 vehicles carried 19 participants for an afternoon exploration of the geology of Mt Oxley.

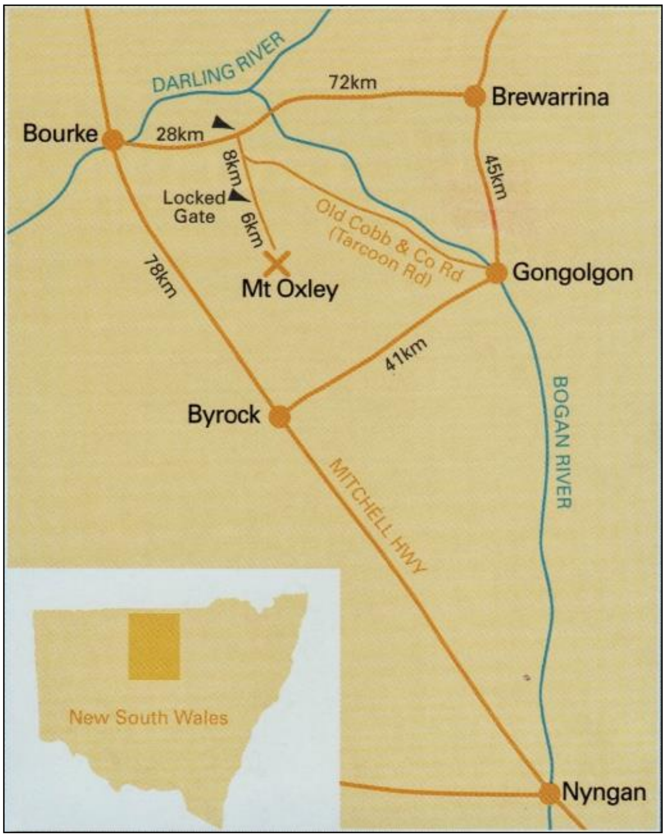
Mount Oxley and Oxley Mountain (to the north east) consists of two sandstone hills that rise out of the plains. Mt Oxley *(photo 1)* is a 307 m high mesa or jump -up having a flat plateau-like top and steep perpendicular cliffs and talus slopes. Mt Oxley is called “Oombi Oombi” by the Ngemba people. It is traditionally a men’s site and is known to have quarries where grinding stones were mined. The first recorded European to climb Mt Oxley was Captain Charles Sturt in December, 1828.

Mt Oxley is located on private property; a sheep station owned by Bill and Denise Stalley called Rossmore Station *(Map 1)*.

After organising a permit, entry lock code and payment directly with the owners, we travelled some 40 minutes east of Bourke to the locked gate and entered the property before stopping at the base of Mt Oxley.

The flat country surrounding Mt Oxley consists of mixed Quaternary colluvial, alluvial, aeolian and duricrust deposits *(Map 2)*. Remnants of Cainozoic silicified duricrust rose from this alluvium.

Our first stop was at the base of the mount where we walked to a drainage channel *(photo 2)* on the left side of the road descending from the mount to examine the Booda Formation deep marine siliclastic



Map 1. Location of Mt Oxley. (Geological Sites of NSW- Mt Oxley).

1. Mount Oxley viewed from the access road. (Barbara Dunn).

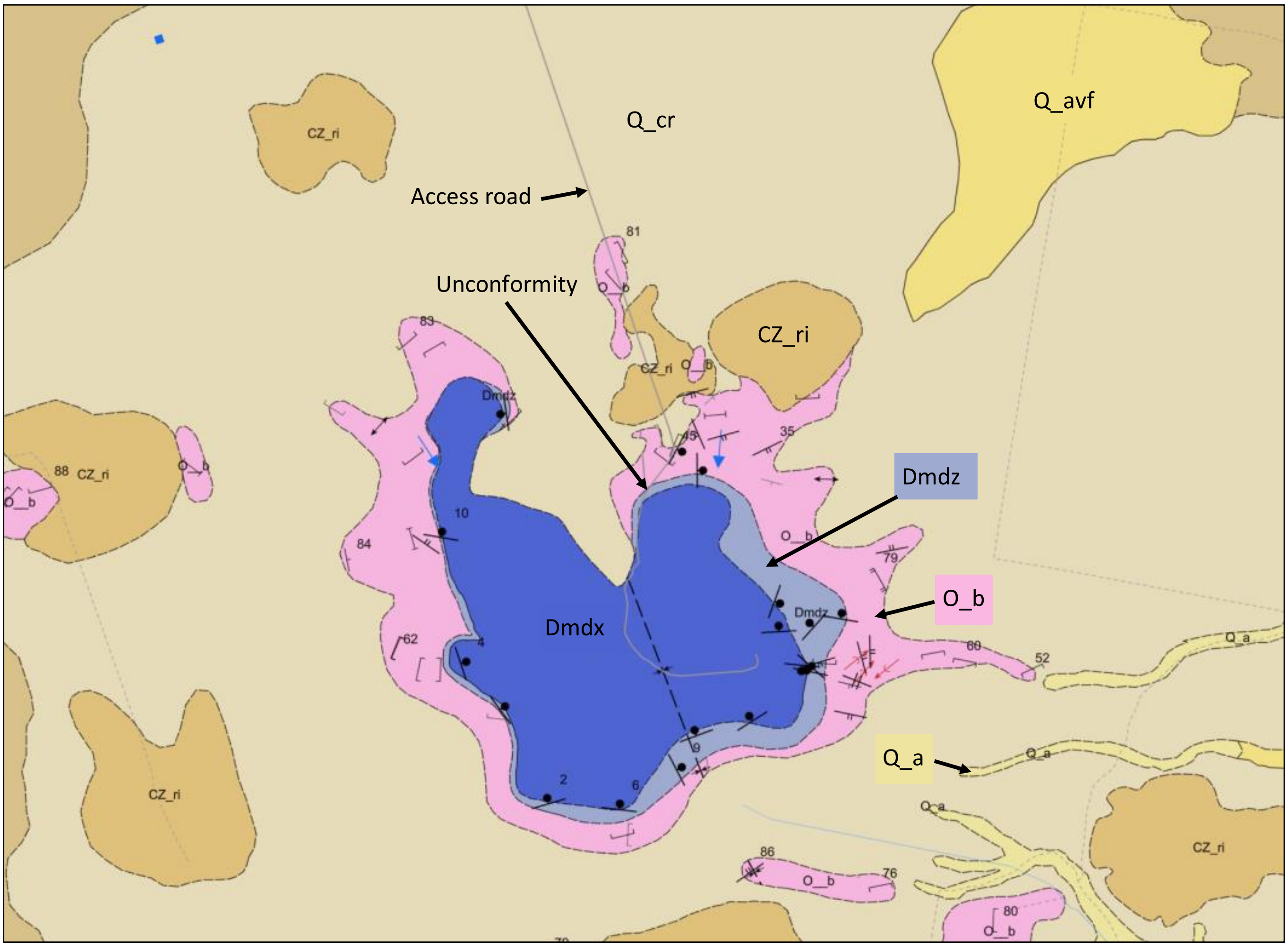
2. Participants examining an outcrop of the Booda Fm in a drainage channel at the base of Mt Oxley. (Ron Evans).

3. Booda Formation outcrop. Note fine grained metasediments separated by a fine metasandstone. Beds steeply dipping. (Barbara Dunn).

mainly metamudstone deposits 485 Ma (Ordovician) to 407.6 Ma (early Devonian) in age *(photo 3)*.

It is steeply dipping, mica rich and has quartz veins mostly in the sandstone. It is moderate to well cleaved. The Booda Fm is part of the Girilambone Group.

We then walked up the drainage channel to find an angular unconformity *(photo 4)* that separates the



Map 2. Geological map of Mt Oxley and surrounds. (Australian Geology Travel Maps).

Key:
Q_cr - Colluvial & residual deposits 2.58 to 0.01 Ma
Q_a - Alluvium 2.58 to 0.00 Ma
O_b - Booda Formation 485.4 Ma to 407.60 Ma
Dmdx - Mount Oxley Formation 407.60 to 372.20 Ma
Q_avf - Alluvial fan deposits 2.58 to 0.00 Ma
CZ_ri - Residual deposits - silcrete 2.58 to 0.01 Ma
Dmdz - Moira Formation 419.20 to 372.20 Ma

4. Inferred position of the angular unconformity between the underlying Booda Fm and the overlying Moira Fm characterized by the red beds. (Ron Evans).

5. Red beds of the Moira Formation. (Ron Evans).

Ordovician Booda Fm from the overlying Devonian Moira Fm (Dmdz). There is a 42 million year gap where the rocks of the Silurian age are missing.

The Moira Fm consists of fine to coarse grained lithic quartz sandstone and pebbly to pebble-cobble conglomerate. It is part of the Devonian Mulga Downs Group 419.2 Ma to 372.2 Ma. This formation is commonly known as the Red Beds *(photo 5)*.

6. Mount Oxley Formation beside the ascent road. Note the cross-bedding. (Ron Evans).

7. Unusual shattered rock craters on the summit of Mt Oxley. (Barbara Dunn).

8. Afternoon tea in a shelter provided by the property owners. (Barbara Dunn).

There are subangular clasts of quartz rich metasandstone and slate.

The Mt Oxley Fm (Dmdx) 407.6 Ma to 372.2 Ma was viewed from the vehicles as we ascended Mt Oxley.

This formation lies above the Moira Fm. It consists of fine, medium and course-grained white and light grey quartz arenite and variably pebbly, polymictic, conglomerate, dominated by quartz clasts, It is a medium to thick planar bedded unit with well-developed cross bedding *(photo 6).*

We reached the picnic facilities at the summit but before the group could settle in for afternoon refreshments, we guided them to the shattered quartzite rock craters *(photo 7).*

These craters are found in two distinct lines on the summit. How these craters form is still undecided by the experts but one theory is that explosions heard emanating from Mt Oxley are due to the intense heating of the rocks on calm, very hot days and the rapid cooling of the rocks at night causing them to crack open.

We returned to the picnic shelter to have afternoon tea *(photo 8)* before returning to Bourke.

Report by Barbara & Brian Dunn (trip leaders) with assistance from Ron Evans.

Reference:

CAMPBELL, L., GILMORE, P., TRIGG, S., HEGARTY, R. (2013). *"In the Footsteps of Major Mitchell update for explorers in the Bourke Region."* Geological Survey of NSW (18th June 2013).

Day 3: Tuesday 29th August - Gundabooka National Park.

The Safari participants travelled in convoy 50 km south of Bourke to Gundabooka National Park *(Map 1)*. The first stop of the day was at the Mulgowan Aboriginal Rock Art site. The road was red gravel and the traffic hazards were kangaroos, emus and feral goats thatr were very unpredictable in their behaviour.

We reached the picnic shelter at the rock art site and everyone was keen for a toilet stop and morning tea before setting off on the 1.4 km return walk to the sandstone overhang along Mulareenya Creek.

This site is of special significance as a meeting place to the Ngemba, the stone country people from the Cobar Peneplain and the Baakandjji people, the river people from along the Darling River. Many ceremonies were carried out within the region that is now the park.

The walking track led us over a sandstone hill, part of the Mulga Downs Group deposited during the Devonian period. This Group is a series of fining upward sequences of cross-bedded lithic quartzose and fine to very coarse- grained sandstone, pebbly sandstone and polymictic conglomerate with recessive units of siltstone and mudstone.

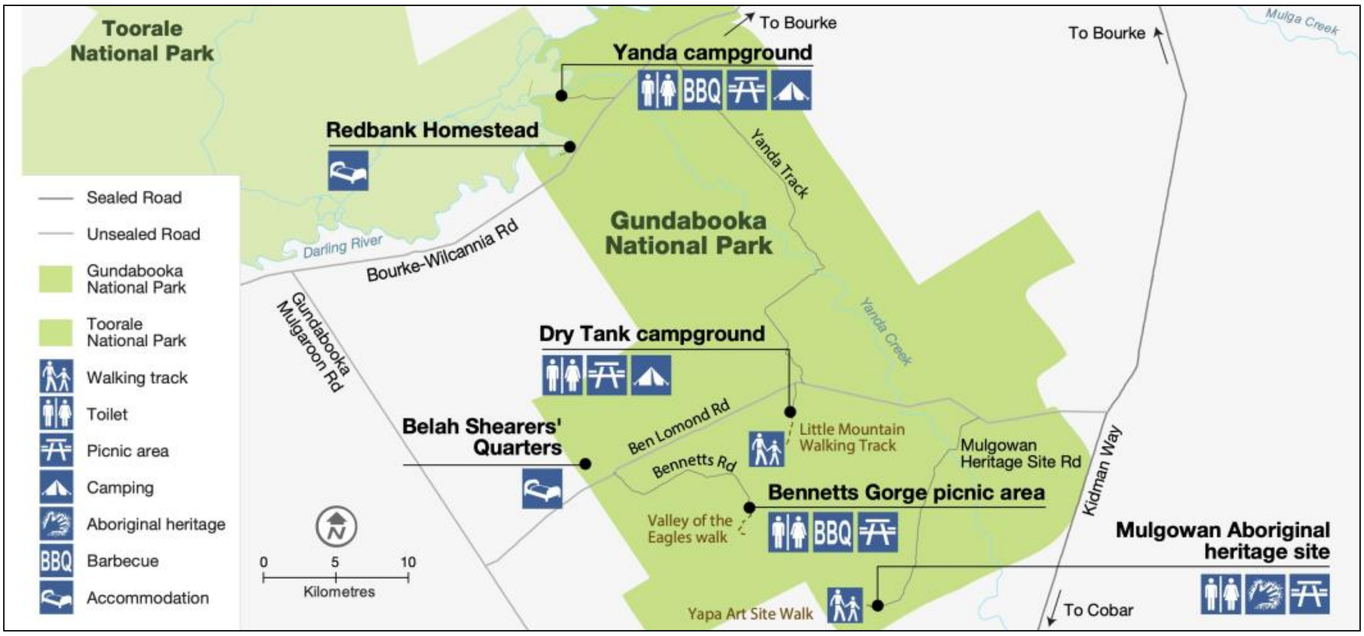
The track descended into Mulareenya Creek which only flows after rain *(photo 1)*. Under a sandstone overhang the rock art site, protected by wire caging, was found *(photo 2)*. Here we were struck by the variety of drawings. There were human figures dancing and hunting, emus, hand and tool stencilling and the layout of the Brewarrina fish traps *(photos 3 & 4)*.

Returning to the vehicles, we drove to the Dry Tank Campground to have lunch in the new picnic facilities.

While travelling through the park we crossed the Winduck Group, lower Devonian shallow marine sandstone deposits; the Girilambone Group lower Ordovician deep marine sandstone deposits and the

1. Track crossing Mulareenya Creek on the way to the Aboriginal art site (top left). (Ron Evans).

2. Yapa Art Site situated under a sandstone overhang. (Barbara Dunn).



Map 1. Gundabooka National Park and Toorale National Park. (National Parks of NSW - Visitor's guide Back o' Bourke).

Narrama Fm (part of the Girilambone group) lower Ordovician deep marine deposits of variably metamorphosed turbidites of micaceous quartzose sandstone, siltstone, claystone, phyllite and silcaeceous chert *(Map 2)*.

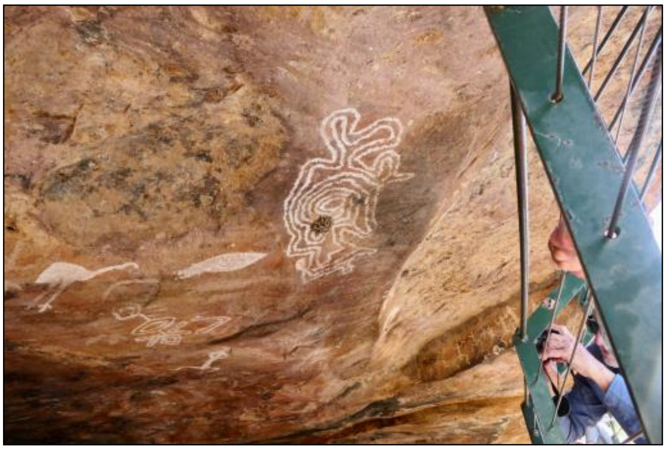
Rocks of the Girilambone Group outcrop to the north of Little Mountain. These are deep marine deposits with biochemical and siliclastic features and show some degree of metamorphism.

To get the best views of the Gundabooka Range the convoy drove to Bennett's Gorge. It was a 40 min drive on gravel to The Valley of the Eagles Walk.

The Gundabooka Range is the centerpiece of the park and rises 350 m above the plains to a height of 495 m above SL *(photo 5)* at Mt Gundabooka. Geologically, the range is a 385 Ma (Devonian) eroded syncline of quartzite sandstones of the Mulga Downs group that forms a horseshoe shape. Mulareenya Creek drains the eastern portion of this Gundabooka Range.

Mt Gundabooka and Ranges are located at the junction of two large Geological zones, the Girilambone Anticlinorial Zone and the Great Australian Basin.

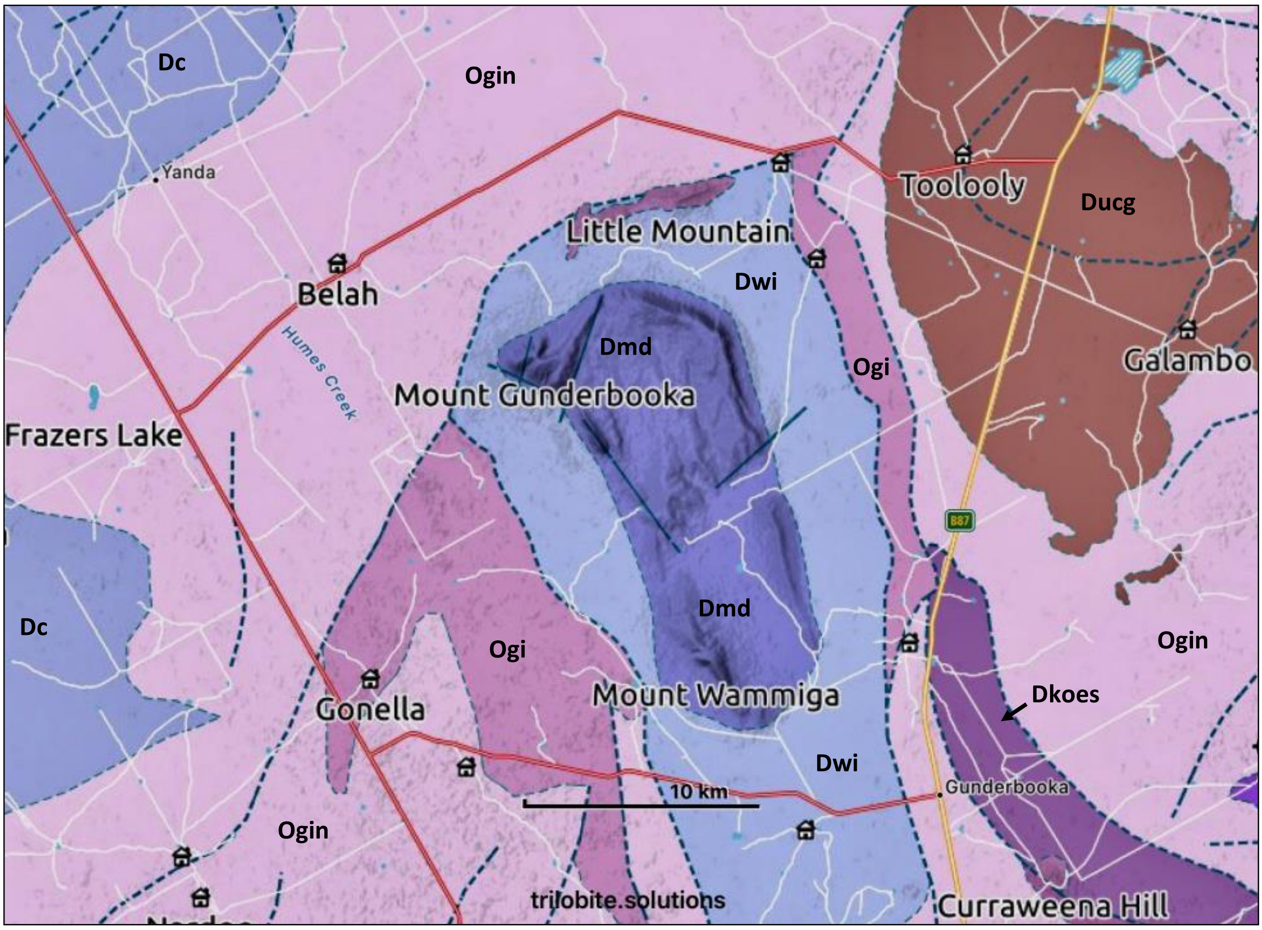
According to the Indigenous peoples, the landscape has been shaped by Baiame's travelling track across the land.



3. Examples of Aboriginal art. Keen photographers went to great lengths to get the 'best' photo. (Ron Evans).

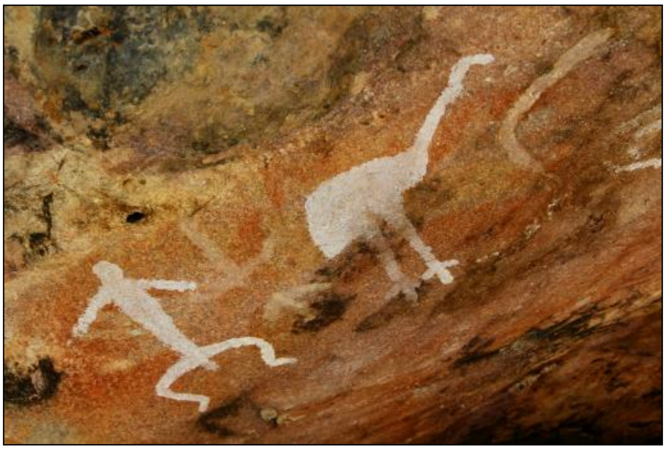
Sediments deposited mainly in the Quaternary Period (last 1.8 Ma) have blanketed the slopes and plains around the mountain range. These sediments consist generally of orange-red clay sands on grey-green clays over gypseous clays as well as arkosic gravels.

A gently sloping track led to a lookout point to the Gundabooka Ranges *(photo 6)*, the track continues to the summit of Mt Gundabooka.



Map 2. Geological map of Gundabooka National park and surrounds. (Australian Geology Travel maps).

<u>Key</u>:
- Dmd - Mulga Downs Group 407.6 Ma to 372.2 Ma
- Ogi - Girilambone Group 479.9 Ma to 458.4 Ma
- Ogin - Narrama Formation 479.9 Ma to 468.3 Ma
- Dkoes - Dederang Siltstone Member 419.2 Ma to 393.3 Ma
- Dwi - Winduck Group 419.2 Ma to 407.6 Ma
- Ducg - Galambo Granite 419.2 Ma to 358.9 Ma
- Dc - Cobar Supergroup 427.4 Ma to 407.6 Ma
- - Faults



4. Other examples of Aboriginal art at the Yapa Aboriginal Art Site. (Ron Evans).

7. Darling River at the Yanda Campground. (Ron Evans).

5. Gundabooka Range seen from the access road into Bennet's Gorge picnic area. (Barbara Dunn).

8. Old River Red Gum - note extent of erosion below horizontal roots. (Ron Evans).

6. Lookout towards the Gundabooka Range on the Valley of the Eagles walk. (Ron Evans).

9. AGSHV members beside the Darling River at Yanda Campground. (Barbara Dunn).

Leaving Bennett's Gorge we travelled out of the national park to the Louth-Bourke Road and travelled to Yanda Campground in the Gundabooka State Conservation Area to walk down to the Darling River.

The river and its features were seen from a number of viewing points along a large meander bend. *(photo 7)*. At a majestic tree on the bank whose roots were exposed through erosion *(photo 8)*, a group photo was taken *(photo 9)*.

The convoy then returned to Bourke.

Report by Barbara & Brian Dunn (trip leaders) with assistance from Ron Evans.

Day 4: Wednesday 30th August - Bourke to Cunnamulla.

We relocated to Cunnamulla with some stopping at Enngonia and/or the remnants of the border town of Barringun along the way.

At 3 pm we did a short walk along the Warrego River. The trail begins at what was once a police paddock, where police horses were kept and in which stock that had been impounded were sometimes held. The short walk option soon petered out so most of the group did the longer walk up to the lookout. Interpretive signs provided information about wildlife and local flora.

At 5 pm we had a quick meeting before listening to Robbo, a bush poet, sitting around the campfire *(photo 1)*. Many made use of the accompanying pizza van so that they could consume dinner while listening.

Day 5: Thursday 31st August - Cunnamulla.

A variety of activities were experienced today starting with a visit to the water tower to view a 3D style painting of four children intertwined through sport by Guido van Helten *(photo 2)*. The mural was funded by the Regional Arts Development Fund.

Next was a walk around Cunnamulla Conservation Bushlands *(photo 3)* through mulga lands, sand hills, gidgee stands, Mitchell grass plains, Brigalow country and wetlands. This was followed by a visit to the Cunnamulla Fella Information Visitor Centre.

2. Painted water tower, Cunnamulla. (Ron Evans).

The group split up, some went to have morning tea at one of the many cafes in town while others went to the Cunnamulla Fella Visitor Information Centre to look at the Artesian Time Tunnel, art gallery, museum and theatre with a captivating video on the Great

1. Waiting for 'Robbo' the bush poet while sitting around the campfire, Cunnamulla Tourist Park. (Sue Rogers).

Australian (formally called Artesian) Basin.

The Artesian Time Tunnel took you back 100 million years to the beginning of the Artesian Basin when dinosaurs roamed the planet prior to opal formation and the Age of Mammals. The first Queensland flow from the Great Artesian Basin was near Cunnamulla in 1887. Cunnamulla stands on the world's largest underground river.

Many took photos of the 2005 statue depicting a typical Aussie bushman *(photo 4)* with a wide-brimmed hat and a mug of tea which was created by sculptor Archie St Clair. The song, "The Cunnamulla Fella", was written by Stan Coster and recorded by Slim Dusty.

We then drove to the remains of the Robbers Tree so named as Joseph Wells hid in the tree after making an armed withdrawal from the Cunnamulla branch of the Queensland National Bank in 1880. A sheep dog followed Wells' scent and sat barking under the tree alerting police. Wells was arrested and stood trial in Toowoomba, charged with armed robbery and became the last man to be executed for armed robbery with wounding in Queensland.

It was then on to the Alan Tannock weir *(photo 5)* for photos before returning to the caravan park for lunch. After lunch some walked up the sand hills, a cultural significant site to the local indigenous community. It was originally a burial site and later was a path between the bottom camp and work /school in the town. Many elders have fond memories of walking the hills daily.

Later we drove to the Cunnamulla Railway Station which operated between 1898 and 1994. Here we were entertained by our host who explained how a small group of women fund raised and managed to build a theatre on the site and then produced a superb sound and light show. We then relaxed in our luxuary seats to listen to our holographic host, the Station Master, and watch snippets of film on the history of the railway and the importance of it to Cunnamulla. Many locals recalled their experiences of growing up in Cunnamulla and the movie gave us an insight to life in this remote town.

Day 6: Friday 1st September - Cunnamulla to Eulo.

We had a short relocation (67 km) to the village of Eulo today. At 2 pm we met outside Eulo Queen Hotel which was named after Isabel Gray, who became known as the Opal Queen of Eulo. She had arrived in Australia in 1868 and in 1871 she married Richard Robinson. The couple ran the store near Cunnamulla where the Cobb & Co. coaches stopped. With the profits from this venture they bought the hotel at Eulo. It was here that the opal miners came to drink and it was through this connection that Isabel accumulated a collection of opals which were reputedly worth over £4000 and she became known as the 'Eulo Queen'. Her complaisant husband and a stock of liquor in her bedroom helped her entertain groups of gentlemen with

3. Cunnamulla bushland garden. (Sue Rogers).

4. The 'Cunnamulla Fella" statue. (Sue Rogers).

5. Alan Tannock weir. (Sue Rogers).

conversation, gambling and more intimate entertainment.

We then crossed the road to look at the police cells, lizard lounge, the world famous lizard race track that attracted crowds of around 5,000 people, town bore, and 'Kenny' - the bronze Diprotodon sculpture *(photo 6)* that represents the many megafauna fossils that

6. 'Kenny', the bronze statue of a *Diprotodon* in Eulo. (Sue Rogers).

8. Cut slices of Yowah nut opals on display in Eulo. (Sue Rogers).

have been discovered near Eulo. A holotype specimen of a *Diprotodon* is kept in the Eromanga Natural History Museum *(Photo 7)*.

Along the main street we viewed the General Store, an Anderson design air-raid shelter, Eulo's flood truck and the rough opal, cut Yowah nut opal *(photo 8)* and unique jewellery in the old post office building.

A few then walked down to the Paroo River and viewed a few flowering Yapundah trees that bee keepers favour in the production of the dark and delicious Warrego honey. We then crossed the weir and walked through the pleasant free camping area where some of the group had set up camp close to the dry spring. Later we met at the Lizard Lounge to discuss activities for the next three days.

Report by Sue Rogers (activity leader).

7. Holotype specimen of the lower mandible of a Diprotodon in the Holotype Room at Eulo's Natural History Museum. Note how the large incisors are worn. (Ron Evans).

Day 7: Saturday 2nd September - Eulo Mud Springs & Yowah.

Leaving Eulo westward along the Adventure Highway towards Thargomindah, the first stop of the day was at the Springvale Mud Spring Nature Refuge that is part of the Eulo Springs Super Group *(photo 1)*. The mud, which may be 20,000 years old, contains silica, magnesium, potassium, calcium, iron and zinc and is believed to have therapeutic value.

Artesian springs have been critical to the survival of Aboriginal peoples of the arid interior, providing a source of water, food and other material resources, as well as having ceremonial and spiritual values. Europeans relied on the artesian springs to establish pastoralism and settlements in the semi-arid lands.

Most mound or mud springs occur on the margins of the Great Australian Basin (GAB). The Eulo Springs Complex is attributable to the shallowing of the GAB aquifers due to granitic basement structures being close to the surface.

The mound *(photo 2)* is often composed of calcareous deposits, water born salts and wind-blown sands. The discharge vent is found at the top of the mound where underground artesian pressure forces the mud and water through fissures to the surface. The outflow from the mound/mud springs can produce wetlands and soaks.

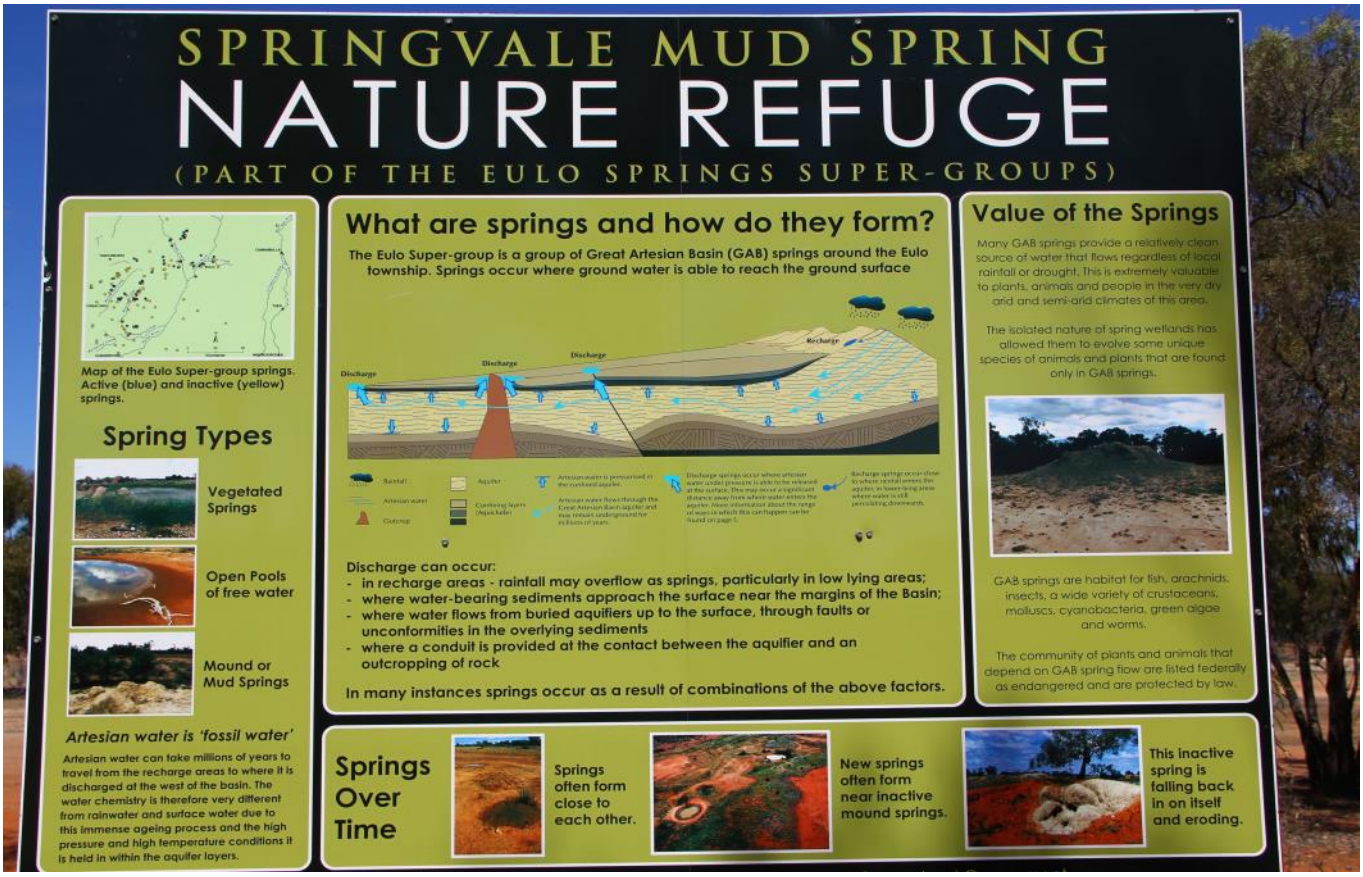
After exploring several of the mud springs which are now inactive the group departed on a single lane sealed road for Yowah about an hour's drive away north towards Toompine.

2. One of several inactive mound (mud) springs in the refuge. (Barbara Dunn).

A photo stop was made at the Yowah town sign *(photo 3)* and the plan for the rest of the day iexplained by the leaders. The town lies within the cattle station called Moolya and exists as an opal mining town with most residents being small scale opal miners who come during the winter season.

Opal is found in an ironstone matrix or in the form of the Yowah nut. Yowah's population is 126 (2021 Census) and it has an elevation of 208 m.

Yowah has a caravan park, a general store selling fuel, a Visitors Centre containing a library, a café and a craft/gift shop *(photo 4)*. There is a free camp off



1. Springvale Mud Spring Nature Refuge sign 2016. The sign is now faded and virtually unreadable. (Ron Evans).

Gemwood St. with toilets and showers. An opal fossicking area is provided on the edge of town and opals are sold from many of the miners' homes *(photo 5)* .

The group was led on a drive through of town with interesting points noted *(photo 6)*. It was near the end of the season and so Yowah was very quiet with only a few dealers at the Tailgate Markets. Some of the group talked to the miners hearing their fascinating stories, examined the opals they had on display and made modest purchases while others found the Yowah Café for coffee and scones.

For a few of hours, the group were free to look around the town, explore the opal shops, the town bore *(photo 7)*, the opal fossicking area and to utilise the artesian baths.

The town bore was sunk in 1911 to a depth of 447 m. The bore yields 1,145,600 litres/day. The temperature of the water is 57ºC.

In 2015 two artesian spa pools were built. The temperature of the pools is kept between 34º-41ºC. A donation of $5 per day entry is requested.

Later after picnic lunches were eaten, the group met again for a drive around the fossicking fields. A stop was made for the group to walk amongst the mullock heaps to see what treasures they could find *(photo 8)*. We were able to speak to a fossicker who returned most years. He showed us a bucket of ironstone nodules he and his wife had already collected. Until they were cut, he had no idea if they contained opal or not. Several modern mine sites were in evidence *(photo 9)*.

The Bluff was the last official stop of the day and the convoy drove to this 'jump-up' located 4 km out of town. It was about 60 m in elevation above the plains.

Here we had expansive views over the landscape *(photos 10, 11 & 12)*. The geological features of the jump up were examined.

Returning to town some of the group stocked up on groceries, some topped up on fuel, others went to the Artesian Baths and others returned to Eulo.

Report by Barbara & Brian Dunn (trip leaders).

4. Visitors Centre and Café, Yowah. (Barbara Dunn).

5. One of several miners homes where opals could be purchased. (Barbara Dunn).

3. Yowah town sign. (Barbara Dunn).

6. Incomplete miners house seen on town drive. (Barbara Dunn).

7. Yowah Town Bore sunk in 1911. (Barbara Dunn).

8. A local fossicker in his 'patch' while some of the AGSHV group explored the mullock heaps. (Barbara Dunn).

9. An active mine site near the fossicking area. (Barbara Dunn).

10. View south east from The Bluff. (Barbara Dunn).

11. AGSHV members on top of The Bluff, Yowah. (Ron Evans).

12. Road from The Bluff towards Yowah. (Barbara Dunn).

Day 8: Sunday 3rd September - Currawinya National Park.

Travelling from Eulo west along the Adventure Way, the convoy turned off into Hungerford Road (gravel) for an hour's drive to Currawinya National Park *(Map 1)*.

Currawinya National Park lies in the Mulga Country and overlies the Great Australian Basin.

The aim of the days trip was to examine the Currawinya Granites, as well as waterholes and historic remnants of early settlement.

The Granites are an exposure of an igneous intrusion (Devonian Hungerford Granite - 419 to 359 Ma), part of the Eulo Ridge within the Thomson Orogen which pierces the base of the Eromanga Sea within the Great Australian Basin. It is one of the few sites where the granite is exposed at the surface.

The traditional owners of the land are the Budjiti - the river people who have inhabited this landscape for over 14,000years. They gained Native Title in 2015.

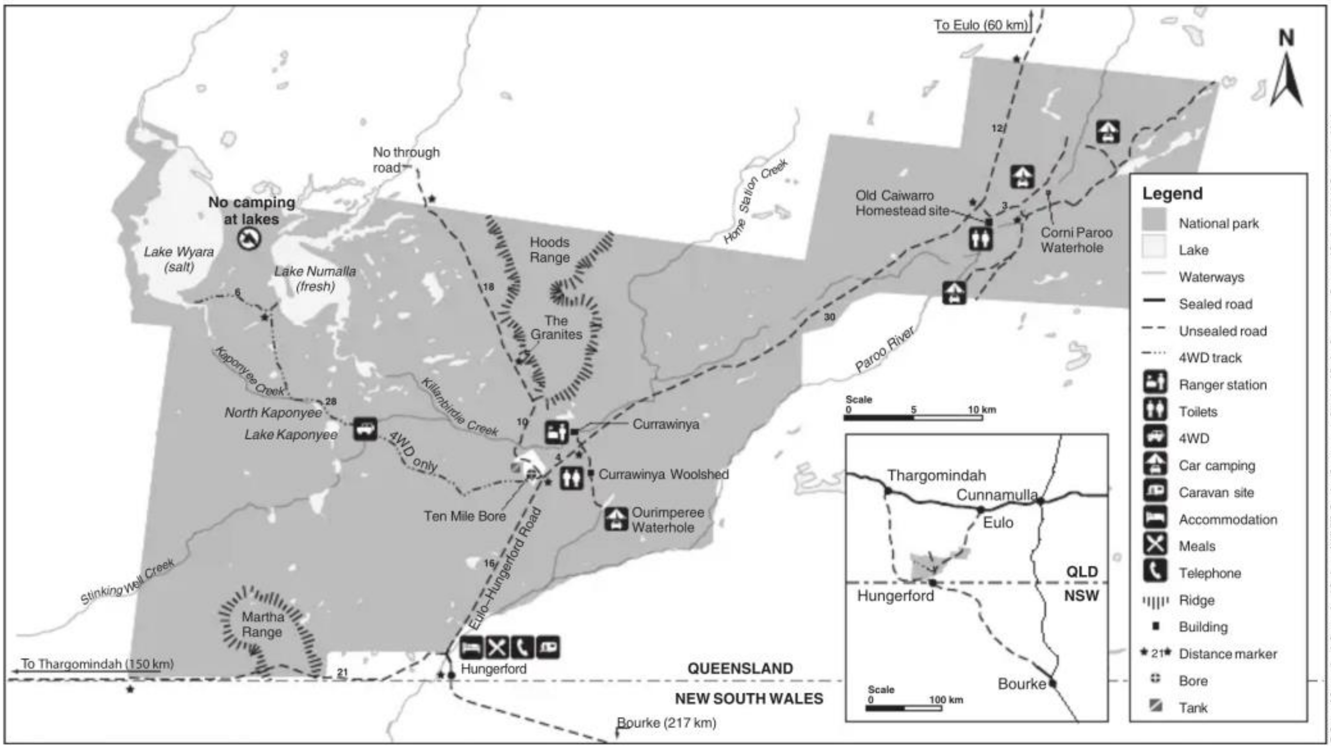
The National Park also has a great deal of European settler history from the 1860's. Early pastoralism was sheep production for wool.

The first stop of the day was at the ruins of the Caiwarro Homestead built in 1891 *(photo 1)*. The original buildings were of pisé construction (rammed earth of sand, clay and gravel). The historic buildings/ruins give a great insight into station life in an isolated semi-arid environment at the turn of the century.

Steel-framed skeletons of later year buildings complete with a wood-fired 44-gallon drum hot water system still stand stubbornly against the elements *(photo 2)*.

1. Remainder of original pisé homestead and brick chimney. (Barbara Dunn).

2. Remnant of steel-framed building with its 44 gallon hot water heater. (Barbara Dunn).



Map 1. Currawinya National Park, Queensland. (Department of Environment and Science, Queensland).

The layout of the homestead complex reflects the social stratification of station life. Aboriginal workers employed on the station had their own camp down by the Paroo River. The homestead complex included a tennis court, cricket pitch, shop and school.

Caiwarro Station was eventually shut down in 1971 after many years of severe floods and droughts.

Morning tea was taken not far from the homestead at Corni Paroo Waterhole on the Paroo River *(photo 3*. It is a very picturesque spot.

From Corni Paroo the group travelled for half an hour to the next photo stop at the sandstone sculptures that mark the entrance to the National Park *(photo 4)*.

The group then travelled a short distance to the Currawinya Woolshed built in 1951 *(photo 5)*. It replaced the original, which was demolished.

The station was established in 1865 by James and Alexander Hood and James Torrence. The massive shearing shed is remarkably well preserved and we inspected the wool bins and wool press, scales, wool classing tables, sheep pens, shearing stands (there are 10) and machine shop *(photos 6 & 7)*. A diesel engine powered the stands, a replacement for the original single steam engine. The shed was in use till 1991.

In the surrounding area were the manager's hut, sleeping quarters, meat house, kitchen, cook's quarters, shower block, wool-shed pens and chook shed *(photo 8)*.

Returning to the Hungerford Road the convoy travelled to the village of Hungerford on the NSW-Qld border. The Border Gate *(photo 9)* doubles as a Wild dog/Dingo Fence. Most of the group used the Royal Mail Hotel beer garden to have their picnic lunch. The timber framed corrugated iron clad hotel was established in 1873 and from 1875 was a Staging Post for Cobb and Co Coaches *(photo 10)*. Thomas Hungerford one of the first Europeans to travel in the area gives his name to the village which currently has a population of 19 (2021 Census).

After lunch the group travelled to The Granites passing remnants of inactive mound springs *(photo 11)* formed at the southern end of the Hood Range (deeply weathered sediments of the Cretaceous Winton Formation). The springs are part of the Eulo Artesian Springs Super Group. They appear as circular depressions often with a raised rim. However, there are more than 70 artesian springs in the National Park, providing important refuges for endemic plants and animals in this semi-arid environment.

It was an easy 1.5 km walk to two small distinct outcrops of Hungerford Granite, a coarse pink rock composed of large pink feldspar crystals in a matrix of smaller quartz and dark ferromagnesian crystals. *(photo 12)*.

Weathering along joints in the granite has resulted in distinctive granite boulder (tor) formation, these being exposed as the surrounding sedimentary rocks were eroded away *(photos 13, 14 & 15)*.

The Granites are of great cultural significance to the Budjiti Peoples. Because there are two distinct outcrops, the Budjiti people at some stage decided that one outcrop would be a sacred site for males and the other for females.

Because they are sacred sites, visitors are requested not to climb onto the outcrops.

At the end of the walk the group dispersed to return to Eulo at their own discretion.

Report by Barbara and Brian Dunn (trip leaders).

3. Cornie Paroo waterhole, a very pleasant morning tea venue. (Barbara Dunn).

4. Several sandstone sculptures marked the entrance to Currawinya National Park. (Barbara Dunn).

5. Currawinya Woolshed built in 1951. (Ron Evans).

6. Wool storage bins and wool press. Shearing stands can be seen on the left above the storage bins. (Ron Evans).

7. Shearing stands with chute through which sheared sheep were removed from the shed. (Barbara Dunn).

8. Support buildings - R to L: meat house, kitchen and dining, shearers quarters. (Ron Evans).

9. Border Gate at Hungerford on the Queensland/NSW border. (Barbara Dunn).

10. Royal Mail Hotel, Hungerford. (Barbara Dunn).

11. One of several inactive mound springs near the entrance road into The Granites. (Ron Evans).

12. Hungerford granite. Note the large pink rectangular feldspar crystals, the centre one showing a white compositional halo. (Barbara Dunn).

13. Track from the carpark towards the Granites with distinct boulder formations. (Ron Evans).

14. Exposed boulders of Hungerford Granite - note the large slab that has split off the boulder. (Ron Evans).

References:

DAWSON, N.M. and BOYLAND, D.E. (1974). *Western Arid Region Landuse Study- Part 1*. Qld Dept. of Primary Industry.

https://www.caravanworld.com.au >Destination> HeartoftheMulgalands

https://eaaflyway.net/wp-content/uploads/2017/12/SIS-EAAF090-Currawinya-Natiional-Park-v2017.pdf.

https://parks.des.qld.gov.au/currawinya

https://topwiretraveller.com/currawinya-national-park

https://www.researchgate.net

https://whichcar.com.au/explore/qld/currawinyah-national-park-queensland

15. The second more distant outcrop of The Granites. (Barbara Dunn).

Day 9: Monday 4th September - Eulo to Thargomindah.

Another relocation day as we shifted camp to the Thargomindah Caravan Park.

Many broke the two hour drive by stopping at Lake Bindegolly, a combination of salt and freshwater wetlands. These wetlands provide a welcome habitat for over 190 bird species traveling through this arid landscape.

Most then met up at the Visitors Centre for a convoy guided drive around town. We stopped at the Old Thargomindah Hospital *(photo 1)* that was opened in 1888 and is built from hand-made mud bricks, a reminder of the scarcity of materials on the edge of the desert. The bricks were made from the black soil taken from the banks of the Bulloo River. The bricks were left to dry and, amusingly, they were walked over by local dogs and cats and even emus before they set hard.

The hospital has many interesting videos which discussed the experiences doctors, nurses and townsfolk had with working and living out here. We then stopped at the Artesian Bore that was drilled to a depth of 795 m in 1893 before the water came to the surface. Once the bore started delivering hot clean water, the town attempted a unique experiment. The pressure from the bore water was used drive a generator and this, in turn, was used to supply the town's electricity. This has been claimed as Australia's first hydro-electricity scheme. The system operated until 1951.

Today the bore still provides the town's water supply. The water reaches the surface at 84°C. The bore produces around 1,300 m^3 of water a day. We watched a video on the system before the water was turned on to commence the power generation process using a Pelton wheel *(photo 2)*.

Other points of interest were Leahy House *(photo 3)* that was built in 1885 of locally made mud brick and was owned by John and Patrick Leahy. It was sold to Sir Sydney Kidman in 1912. Kidman gave it to Jack Watts who worked for him as a manager, and the purchase entitled Kidman to become a member of the Bulloo Divisional Board. The house was lived in until 1995 when the Bulloo Shire Council purchased it, restored it and gave it, in trust, to the Thargomindah Historical Society which opened it as a museum in 2001.

Opposite Leary house is the old jail that was constructed in 1930 of cypress pine with a galvanised iron roof and lined with hardwood. The tour finished with nibbles back at the air-conditioned Visitors Centre as a threatened dust storm prevented us from having them on the newly built sunset viewing deck.

Day 10: Tues 5th September - Free day.

Report by Sue Rogers (activity leader).

1. Original Thargomindah Hospital built in 1888. (Ron Evans).

2. Pelton Wheel that turns from a flow of artesian water which then drives the generator. (Sue Rogers).

3. Restored Leahy House. (Ron Evans).

Day 11: Wednesday 6th September - Eromanga.

Safari group participants travelled independently today to Eromanga having been given several options on where to spend the previous free day.

Having arrived at various times and after setting up camp, the participants were advised to tour the various places of interest in this outback town. These included the iOR Oil Refinery first established in 1985, the town bore sunk in 1909, concretions near the caravan park, the Royal Mail Hotel built in 1885, a former Cobb and Co Staging Post, Opalopolis Park with boulder opal studded memorial to opal miners, Knot-A-Saurus Park with the Sauropod Charlotte and her babies Jasper and Cory made of twisted aluminium piping *(photo 1)* sculpted by Cameron Griffen Searle and the Living History Museum which gave the history of opal and oil/gas mining, the discovery of the dinosaur Cooper and the history of the town and its characters.

In the afternoon the group met at the Natural History Museum for either the one hour or two hour tour. The two hour tour included time working at different techniques in the laboratory.

A very large concretion was on display beside the path to the Visitors Centre *(photo 2)*. The Visitors Centre is a modern attractive building with café, gift shop, theatrette and museum *(photo 3)*. A geological time line of Earth's history was an interesting display *(photo 4)*.

A video presentation of 20 minutes began the tour. This covered the Earth's geological history and the formation of Australia with the local discoveries of dinosaur and megafauna bones focused on.

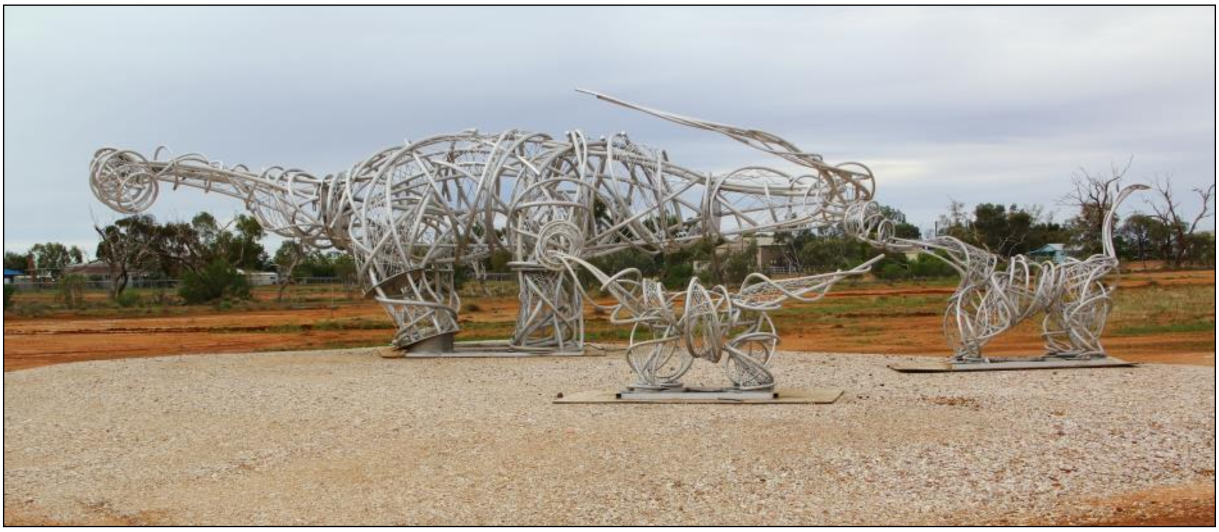
In 2004 Sandy Mckenzie, a 14 year old boy mustering cattle on his parents' (Stuart and Robyn) property on Cooper Creek came across an interesting rock which later proved to be a dinosaur bone.

Between 2006 and 2009 excavations of the site carried out by the Queensland Museum and the Eromanga Natural History Museum discovered the skeletal remains of the largest dinosaur found in Australia at the time. It was named "Cooper".

2. Display on the access path to the Visitors Centre, a large concretion discovered in the Winton Formation at Pelvna Downs in 1980. (Ron Evans).

3. Natural Science Museums Visitor Centre with the new research building behind the tree. (Ron Evans).

"Cooper" was described in 2021 as a new genus and species of Titanosauria, *Australotitan cooperensis* meaning "Southern giant". This dinosaur lived in the Cretaceous period 95 to 98 Ma when Australia would have been attached to Antarctica. "Cooper" from toes to hip is 5 to 6.5 m tall (the size of a two storey



1. Sauropod Charlotte and her babies Jasper and Cory in Knot-A-Saurus Park, Eromanga. (Ron Evans).

building), had a length of 25 to 30 m (size of a basketball court) and weighed 74 tonnes (the weight of 9 African elephants). It was a plant eater *(photo 5)*.

The group then moved to the laboratory where we were shown the fossil remains of a number of dinosaurs besides "Cooper" - Sid and Zac *(photo 6)*. A replica of Cooper's leg bones was on display *(photo 7)*.

Ten species of megafauna have also been found in the Eulo mud springs region. The best known is "Kenny" a Diprotodon meaning "two forward teeth". We saw bones of "Kenny" that had been excavated *(photo 8)*. It lived 1.6 Ma and became extinct 40 to 20,000 years ago. In Eulo we had seen a bronze sculpture of this. The megafauna evolved after the dinosaurs became extinct.

There were two people working in the laboratory. Both had done a 10 day course to work on extracting the bones from the rock matrix *(photo 9)*. They were using fine drills similar to those used by a dentist and we also saw fossils of plant species and some petrified timber.

The group then entered the Holotype Storage Room where the temperature is kept at 23ºC. Here some of the bones of "Cooper" and "Kenny" are displayed *(photo 10)*.

Those of the group doing the extra hour were called away to an annex off the main laboratory where we met Jo Pegler. Jo demonstrated the various techniques used to recover fossils. The participants then rotated through three different activities; using drills to remove the matrix from around the bones, microscopes and tweezers to locate micro fauna fish scales and vertebra from a dish of very fine sand and pebbles *(photo 11)* and to brush a solution containing acetone onto the mudstone to soften it so that it could be scrapped away from the bone. It was a challenging and interesting experience.

Participants returned to town after the tours. A short historic walking tour was conducted to a number of sites behind the Community Hall. After this many of the group retired to the pub for drinks and/or a meal.

Report by Barbara and Brian Dunn (trip leaders).

4. Geological time-line display in the Visitors Center. (Barbara Dunn).

5. Size comparison between Cooper and the Royal Mail Hotel in Eromanga. (Barbara Dunn).

6. Tail vertebrae of 'Zac'. (Ron Evans).

7. Replicas of Cooper's leg bones; hind leg closest, front leg distant. (Barbara Dunn).

8. Diprotodon jaw bones - two large incisors on the left with two rows of molars behind. Note the protective plaster casing surrounding the specimen. (Barbara Dunn).

11. Brian looking for micro fauna fish scales and vertebrae from a dish of fine sand. (Barbara Dunn).

9. One of the trained staff demonstrating how bones are separated from the surrounding rock. (Barbara Dunn).

10. Specimen of a bone from Cooper's left humerus stored in the Holotype Room. (Ron Evans).

Day 12: Thursday 7th September - Eromanga to Windorah.

Yet another relocation day as we drove north-west on a one lane road to Windorah which means "Big Fish". Windorah is some 215 km from Eromanga, the trip taking about 2.5 hours. Kyabra Waterhole made a scenic stop on the drive.

In Windorah *(photo 1)*, we had an afternoon drive via the art garden *(photo 2)* to the 12 km nature drive through the floodplain that has a number of distinctly different plant communities including coolabah woodlands, alluvial herb land, lignum shrub land, gidgee open woodland and spinifex grassland.

We stopped at the Cooper Creek crossing *(photo 3)* before returning via the highway past the Solar Power Plant *(photo 4)* to Whitula Gate Museum and Visitors Centre.

The museum contained an original slab hut built by the Rabbit Board in 1906 as a boundary riders' hut. It also displays household and station equipment as well as aboriginal artefacts *(photo 5)*.

3. Bridge over Coopers Creek 12 km from Windorah. (Ron Evans).

1. "Welcome to Windorah" signs at the entrance to the town. (Ron Evans).

4. Abandoned solar farm constructed in (Ron Evans).

2. One of several sculptures in the art garden. (Sue Rogers).

5. Grinding stones on display in the museum. (Sue Rogers).

Day 13: Friday 8th September - Welford National Park.

Travelling out of Windorah along the Diamantina Development Road the convoy turned into Hammond Downs Road which then joined onto the Jundah-Quilpie Road and led onto the causeway at the Barcoo River.

Stopping first at the southern boundary of the park marked by the Barcoo River, information panels told of the explorers Mitchell and Kennedy and how their journeys of exploration opened up the country to pastoralism *(photo 1)*.

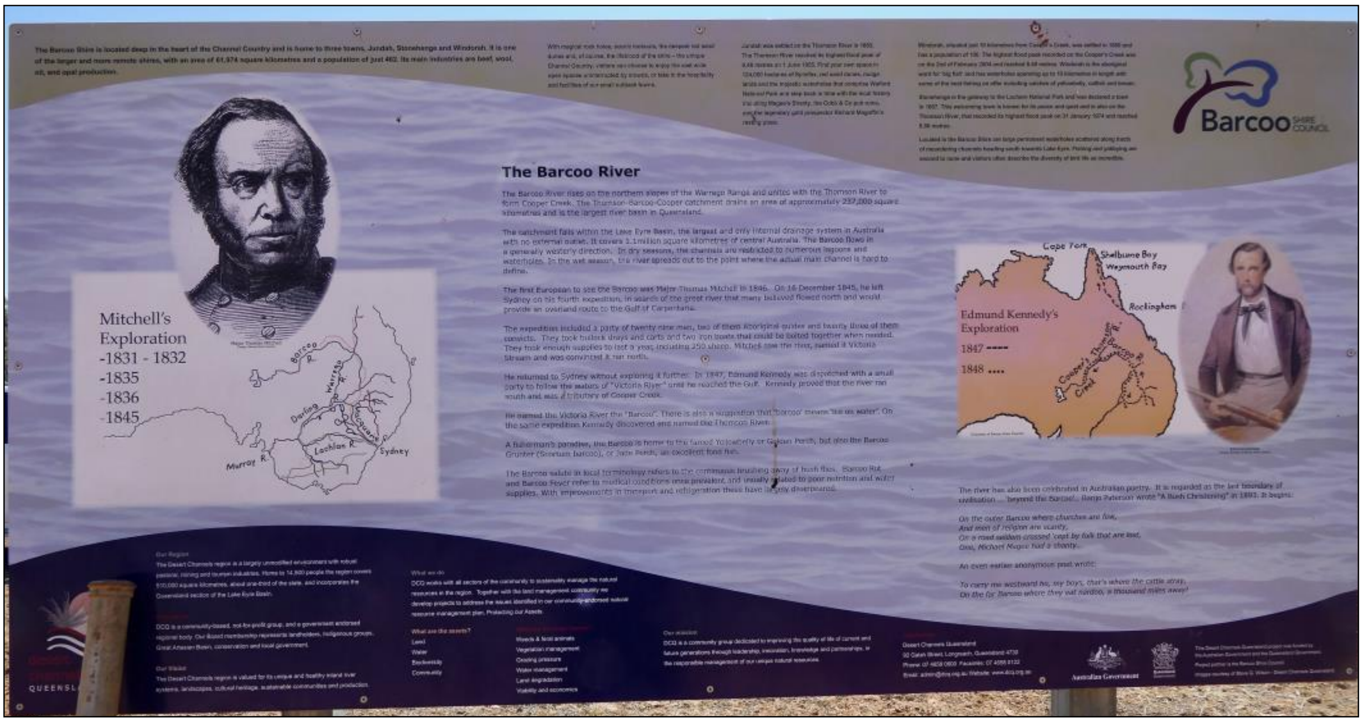
The flood levels of the Barcoo River were noted as the group walked down to the causeway *(photos 2 & 3)*. At 9 m the river is in flood and the water spreads out across the flat plains closing the park indefinitely as the clay-based soil makes the roads impassable. Banjo Paterson made the Barcoo famous in his poem "The Bush Christening".

Crossing the Barcoo River, we entered Welford National Park. Information panels explained the geological formation of the Great Australian Basin and the present-day landscape of the Channel Country, as well as more details about Welford National Park *(photo 4)*. The park was established in 1992 and gazetted in 1994 and is 124,000 ha in size. Lined by river red gums, the Barcoo River winds through Mitchell Grass plains, Mulga woodlands, and dune and channel country.

The park is named after Richard Welford who took up leases in the area in 1870. He was a lawyer who migrated to Australia from Britain in 1863. He named his property Walton Downs but it was renamed Welford Station after his death. It was one of the first pastoral stations in the region. In 1872 Richard Welford and his stockman Henry Hall were killed at Jedburgh Waterhole

2. Barcoo River crossing. (Ron Evans).

3. Barcoo River upstream from crossing. (Barbara Dunn).



1. Information board next to the Barcoo River crossing. (Ron Evans).

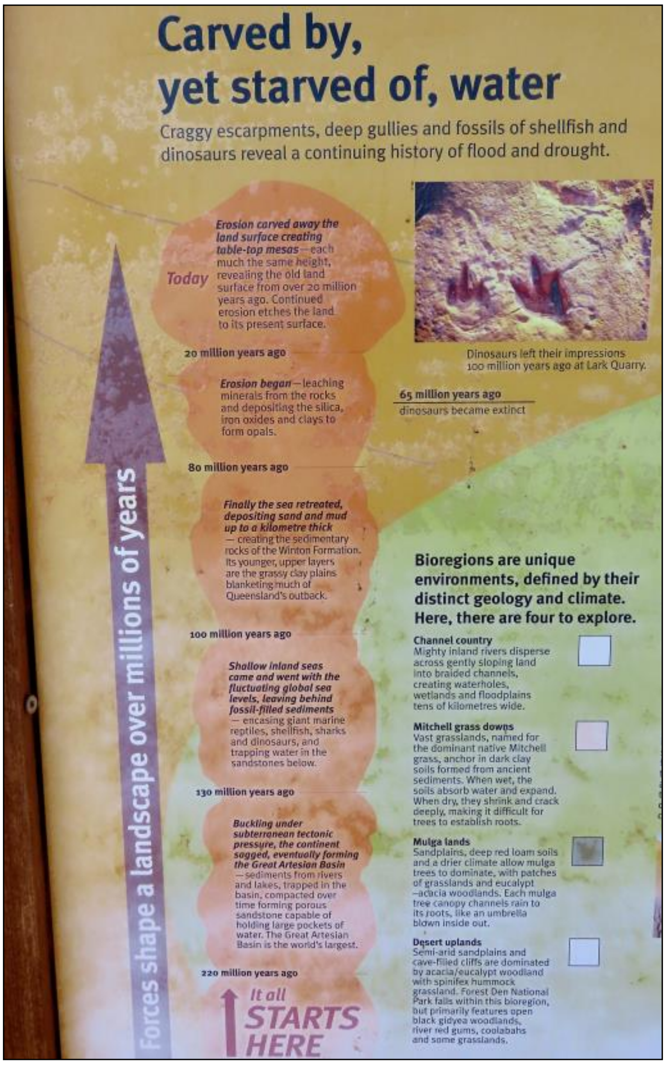
while cutting timber. The Aboriginal man held responsible was known as Kangaroo or Jiu Jiu who had deserted the Native Police. The murders led to the massacre of Aboriginal people by outraged pastoralists and the police at Battle Waterhole. The deaths were not recorded and the only survivor is said to have been a baby that fell from its mother's arms in the panic.

Once back in the vehicles we progressed to the ranger station located in the original homestead *(photo 5)*. Ranger Sophia met us and gave us a tour of the original part of the homestead that was of pisé construction (a form of rammed earth construction) built in 1882-3. A modern exterior was added in 1989 internalizing the original homestead *(photo 6)*.

There is a permanent waterhole close to the homestead. Associated historic buildings included a ringer's quarters, stone cottages, meat and poultry houses and stockyards.

The Button family lived on Welford Downs for 77 years until it became a national park. The entire park and homestead complex is listed on the Queensland Heritage Register.

Sophia told of her work as a ranger in a remote environment and the issues that had to be addressed



4. Geological history of the land on and around Welford NP over the last 200 million years. (Barbara Dunn).

5. Welford homestead. Section to the right behind the meat house is the original pisé building with new sections added to the left. (Barbara Dunn).

6. Large back verandah that's been added to the original Welford Homestead. (Barbara Dunn).

locally. The national park is surrounded by 14 pastoral properties and one of the issues they have is keeping the neighbours' cattle out of the park and maintaining the tracks after floods.

Following Mulga Drive the convoy travelled over the flat expanse of the Barcoo River floodplains seeing in the distance the stony escarpments and gullies which dissect the Mulga Country to the east. At the Trafalgar Waterhole the group settled under the shade of river red gums and coolabahs to eat a combined morning tea and lunch. Excitement rippled through the group at seeing four spinifex pigeons *(photo 7)* scavenging amongst the grasses.

Returning to the Quilpie-Jundah Road, the convoy turned onto the River Drive and crossed salt flats and claypans to Little Boomerang Waterhole and Campground. The group walked to the river and rocky outcrop on top of the raised bank and found the river water was milky brown *(photo 8)*.

The group took advantage of the only amenity in the park before leaving for the 22 km Desert Drive. At the Desert Waterhole lined with coolabahs, the waterhole foreshore was a maze of cracked mud *(photo 9)*. Sections of the mud had been flipped over to locate

7. A pair of Spinifex Pidgeons at Trafalgar Waterhole. (Ron Evans).

10. Fresh water mussel found buried in the damp mud below the cracked muddy bank. (Barbara Dunn).

8. Rocky outcrop at Barcoo River, Little Boomerang Waterhole Campground. (Ron Evans).

11. Exploring the top of Little Red Dune and admiring the plants and view. (Ron Evans).

9. Little Desert Waterhole. The drying banks shrink forming deep cracks. People have turned some of the cracked mud over looking for fresh water mussels. (Ron Evans).

12. *Grevillea juncifolia* or Honeysuckle Grevillea growing on top of sand dune. (Ron Evans).

fresh water mussels *(photo 10)*. Tiny frogs were also seen.

The Glendower Fm had been pushed up along a fault line near the Desert Waterhole. This formation is believed to have been part of an ancient river system which drained southward to link with widespread sedimentation in broad shallow tectonic basins within the central part of the Eromanga Sea. The Glendower unit comprises sandstone, conglomerate and minor siltstone and contains extensive silcrete. It unconformably overlies the Winton Fm and has a recorded thickness of 70 m.

Continuing along the Desert Drive we crossed spinifex and red sand dune country on the north western margin of the park. At "Little Red" sand dune the group made the climb to the top marvelling at the redness of the sand, the variety of flowering plants and the views over the spinifex covered sand plains *(photo 11)*. The colour is a deep red as a result of the oxidation of iron minerals coating the quartz grains. Honeysuckle grevilleas *(photo 12)* and desert Lollybush *(photo 13)* were some of the plants identified. Welford's isolated dunes are at the eastern reaches of the Lake Eyre sand dune system and to the north east of the Strzelecki-Simpson dune system. During an arid period 8 to 10,000 years ago, wind blew sand from the Eyre basin, depositing longitudinal dunes over the underlying clay soils.

Continuing on, we drove to the Oil Bore. Clay lubricated drills bored to a depth of 2,500 m for oil in 1986 then brought water from 1800 m below. This bore is now capped *(photo 14)*.

The Southern Cross Bore (also called 16 Mile Bore) was the last stop on the Desert Drive. A windmill once stood here that pumped precious sub-artesian water from only 45 m deep into stock troughs *(photo 15)*. This sub-artesian bore is now capped.

At the termination of the Desert Drive the group travelled out of the National Park to the Roadhouse in Jundah for afternoon tea. A Brown falcon and a Bustard or plains turkey were seen and photographed on the way.

The Roadhouse in Jundah was built in 2019 and is owned by the Barcoo Shire. Coffees and/or ice-creams were consumed by the group.

Jundah means "woman" in the local Aboriginal language and it is the largest of the three towns within the Barcoo Shire. The district was originally settled by the Durack and Costello pioneering families in 1880. For twenty years or so around the 1900's, Jundah was a thriving opal mining area, but lack of water caused work on the mines to cease. With the introduction of heavy machinery, the opal mining is again attracting interest. The main supporting industries around Jundah are sheep and cattle.

The convoy then headed back to Windorah, an hour's drive on a newly sealed wide road. The Thomson River was crossed just out of town. This river and the Barcoo River join together near Windorah to form Cooper Creek. Cockroach bush lined sections of the road as we travelled south.

Report by Barbara and Brian Dunn (trip leaders).

13. *Clerodendrum floribundum* or Lollybush. (Barbara Dunn).

14. Capped oil bore beside the desert road. (Ron Evans).

15. Disused stock trough. (Barbara Dunn).

16. Brown Falcon (L) and Bustard (R). (Barbara Dunn).

Day 14: Saturday 9th September - Windorah to Quilpie.

The group activity today was a pleasant walk along the Bullo River just east of Quilpie *(photos 1 & 2)*. Most enjoyed the artesian spas in the caravan park before meeting up for happy hour.

1. Road and Rail bridges cross the Bullo River at the start of the walk. (Sue Rogers).

2. Reading information on the many information signs along the Bullo River walk. (Ron Evans).

Day 15: Sunday 10th September - Free morning in Quilpie.

This was a free morning for people to explore the Airport Mini Museum, Powerhouse Museum, Visitor Information Centre & Gallery or to indulge in a coffee.

But most drove to Lake Houdraman some 7 km north east, a natural lake on the Bullo River. There were many goats grazing near the water.

Reports for days 14 & 15 by Sue Rogers (trip leader).

Day 15: Sunday 10th September - Afternoon Baldy Top Walk, Quilpie.

After travelling out of Quilpie to the west of town on the Diamantina Development Road, the convoy turned onto the Toompine Road and after a few kilometres, turned right to Baldy Top, a rocky outcrop in the Grey Range.

This range of low hills stretches across SW Queensland, from west of Blackall into Tibooburra in NW, NSW. It rises above the Great Australian Basin to an average elevation of 350 m. The range forms a watershed between the Lake Eyre catchment and the Murray-Darling catchment.

A set of steps led up the talus slope to the duricrust layer *(photo 1)* and then a track was followed *(photo 2)* to the summit. There were a number of crevices and caves eroded into the silcrete duricrust *(photo 3)* with wildflowers growing in them and stops were made on the climb for photographs of these and the scenery.

Baldy Top appeared quite small in its surroundings from the carpark but once on the top the perspective changed. Panoramic views to the horizon and to Table Top Mesa and Quilpie were amazing *(photos 4 & 5)*.

1. Steps leading up to the duricrust top of Baldy Top. (Barbara Dunn).

2. Track to the top of Baldy Top shown by the arrow. (Ron Evans).

3. A large crevice that could be scrambled through to the summit of Baldy Top. (Barbara Dunn).

6. Exploring the summit of Baldy Top. (Ron Evans).

4. View towards the Grey Range from the summit of Baldy Top. (Barbara Dunn).

7. AGSHV participants on the summit of Baldy Top. (Barbara Dunn).

5. Baldy Top carpark, access road and Quilpie in distance. (Barbara Dunn).

8. Safely descending Baldy Top. (Barbara Dunn).

During periods of deep weathering, hardened crusts enriched in silica and iron oxides have grown just below the land surface. These crusts formed above a leached and mottled white clay rich layer. Later erosion of the surface and lowering of the landscape has resulted in these hard crusts remaining as the tops of plateaus, ridges and mesas known locally as jump ups. This is what we are seeing here at Baldy Top.

The duricrust is resistant to erosion thus forming the flattened top. Undercutting into the clay rich layers helps create the talus slope as the harder rocks above collapse and form rubble and the gradual slope below the capping. Wind and rain wash weathered material down to form a pediment or outwash plain surrounding the mesa.

Walking from one end of the mesa to the other *(photo 6)* the group paused for a group photo while we were on the top *(photo 7)*.

After safely descending Baldy Top *(photo 8)*, a "cuppa" was enjoyed before returning to camp.

Dinner plans for the evening at the Imperial Hotel *(photo 9)* motivated everyone to return to Quilpie in time to change and freshen up.

Entertainment for the evening was provided by the reciting of poetry written by some members.

We farewelled one of our safari team leader couples and showed our appreciation for their wonderful contribution to the planning and execution of the safari.

Report by Barbara & Brian Dunn (trip leaders).

9. Farewell dinner in the Imperial Hotel, Quilpie.
(Sue Rogers).

Cunnamulla Bush Poetry Contribution.

The audience was ready, the fire was aglow
The poet had his stories ready for the evening show
The full moon was slowly rising. There was an expectant hush
Then poetry from the greats came out in a lyrical rush.

Banjo Paterson and local names of repute
Slipped gently off the tongue but the sound was strangely mute
Hark what do I hear a crackle and a hiss
The sound from the microphone was strangely quite remiss.

But our poet soldiered bravely on
Giving some of his best just like a song.

The audience was entranced
The words flowed like a soothing balm
Then the moment was broken
By the pizza oven parked next door
"No 31 come and get it before I do one more".

Brian Dunn.

<u>Safari Haiku – The Natural Sciences Loop</u>

Bourke's bridge stands sentry
over the Darling River –
bending but unbowed.

The Cunnamulla
Fella welcomes us to town,
where artesian rules.

Eulo's mud traps beasts,
but the honey is sweet and
leather work is fine.

Thargomindah's flies
are sticky and prolific,
but the pool is cool.

Eromanga makes,
through our imagination,
giants walk again.

Windorah

1. Cooper's Creek birdlife –
   spoonbills, egrets, heron and
   terrestrial quail.
2. Welford National Park –
   homestead oasis dazzles
   in clay pan country.

Quilpie's rodeo's
cruel but not unusual.
Church? It's opalised.

Civilisation!
Charleville - where bilbies are
shooting for the stars.

Glenda Smith.

The Ballad of the AGSHV

There's a story I could tell you about a trip I did
Up into south west Queensland, and all the wealth it hid.

It came about by chance you know, that's something I'll explain
A comment to my sister, and Brian 'Boots' Redmayne

"I'd like to see the south west, where flows the great Paroo
Where granite crops and red soils dot the vista and the view"

So off we set to Queensland, in scientific quest
Alert to rocks and outcrops, and sparrow martins' nests

We started off in Bourke town, a lively little spot
Where Kidman's camp was home and Gundabooka's 'sploding rocks

The Cunnamulla fella welcomed us so warmly to his town
We time-travelled, we steam trained, climbed sand dunes up and down

We had a special friend along to help when tough times struck
When flat tyres came, Kit hopped right to, his tool shed on his truck

At Hungerford we stopped for lunch and scanned the bill of fare
The choice – steak sandwich sitting down or steak sandwich standing there

Grace fell in love at Yowah, the charm of opals holding sway
But just one in a thousand chance could not tempt her to stay

I learnt that rocks exfoliate, at the Granites this is true
Young Terry with his walking pole helped the process start anew

Eromanga was a special place, not just for size of meat
We learnt much of megafauna and sauropod giant feet

Windorah was delightful, the pub, the Cooper too
But best of all the sand dunes, the red against the blue.

And so we come to Quilpie, a quiet sort of town
But the show's here so can't wait to see who'll win the bullride crown.

So thank you Ron and Richard for sharing what you know;
And Cooper-size thanks to Sue, Barb, Brian for showing us where to go

Before I left I knew not much about geology
But now I can distinguish between quartzite and a tree.

Graham Shaw.

Day 16: Monday 11th September - Morning Town Walk in Quilpie.

We did a town walk from the Caravan Park. Our first stop was at the powerhouse museum. Quilpie was the first remote town to have powerhouse run by a diesel generator. We then viewed St Finbarr's Church where in 1976, the Priest at the time, Father John Ryan, decided to compliment the opal mining background of the area by commissioning local miner, Des Burton to install a border of opal around the carving of Our Lady of Perpetual Succour. Instead, Des offered the Priest 'a bit on the wall'. This turned out to be almost an entire wall, which is now installed on St Finbarr's altar *(photo 1)*, lectern and baptismal font. Bill Durack who was part of a Toowoomba architectural firm who designed Quilpie's St Finbarr's Church and his sister Mary Durack, author of Kings in Grass Castles, donated the beautiful coloured glass windows in the western side of the church, in memory of their ancestors.

Next stop was morning tea before visiting the other sites in the main street such as the 45 m mural that depicts the history of Quilpie, the statues of cattle and sheep that are dotted along the medium strip, the town bore that was drilled in 1933, the opal concretion outside the library *(photo 2)*, the Visitors Centre and the old railway station.

Report by Sue Rogers (walk leader).

1. Opal Altar, St Finabarr's Church, Quilpie. (Sue Rogers).

2. Opal in the concretion outside the library. (Sue Rogers).

Day 16: Monday 11th September - Afternoon Table Top Walk, Quilpie.

The convoy formed up outside the caravan park and we drove out along the same route to Baldy Top but went beyond this to Table Top carpark and picnic shelter. The walk to the top of Table Top is less developed and not promoted to the same degree as the Baldy Top walk *(photo 1)*.

The track up the talus slope of the mesa was well defined until it got to the duricrust level *(photo 2)*. Here we were confronted with a 2 to 3 m vertical cliff. A goat track amongst the recently eroded rubble edged around the mesa cliff face to the western side where a way was found to scramble up to the top *(photo 3)*.

The track passed cliffs, crevices, caves, and fallen boulders. On the roof of one cave was a wild bee hive *(photos 4 & 5)*.

The top of the mesa was completely flat *(photo 6)* which was more defined than that of Baldy Top. There was evidence of stone ringed campfires and some camping debri since it is a wonderful location for sunrise and sunset viewing.

Lichen grew on sheltered more moist rocks. Bluebells were found. Mulga and gidgee were scattered around the perimeter of the mesa. A parasitic climbing plant called Nipan was found on the top *(photo 7)*. Its vine like growth was wrapped around the trunk of a small host tree. The flower was very attractive.

Another intriguing thing seen was delicate webs draped over boulders *(photo 8)* and sometimes up the trunks of the trees. In the end evidence was found to

1. Table Top. Note the walking track that only leads to the talus slope. (Barbara Dunn).

2. Duricrust capping on Table Top with fallen boulders below the cliff. (Barbara Dunn).

3. The group finally finding a way to scramble to the top of Table Top mesa. (Ron Evans).

4. Wild beehive on the roof of an erosion cave. (Barbara Dunn).

5. Wild hive of European bees on roof of the erosion cave. (Barbara Dunn).

6. AGSHV members exploring the flat surface of Table Top which is sparsely vegetated. (Barbara Dunn).

7. Flowers of a climbing plant called commonly called nipan (*Capparis lasiantha)*. (Barbara Dunn).

8. Very fine surface webs commonly covered rocks and tree trunks. (Barbara Dunn).

9. Small unidentified spider thought to be responsible for spinning the fine webs. (Barbara Dunn).

indicate the culprit was probably a spider *(photo 9)*.

The group traversed the top of the mesa to take in the 360º views which were breathtaking, back towards Baldy Top *(photo 10)*, towards the Grey Range *(photo 11)* and over the flat landscape to the horizon .

Finding our way back down proved to be another challenge as the pathway down was unmarked.

Eventually after a few false starts we scrambled back down over the precipice to the top of the talus slope. It was easier to walk down the rest of the talus slope via a 4WD track to the gravel road at the base rather than the track back the way we had come. This gave us an opportunity to see the chemical weathering in cracks in the rose-coloured sandstone and the local wattle in flower.

Afternoon tea was had in the picnic shelter when

10. Views of Baldy Top, carpark and picnic area, Quilpie (tip of bare branch) and surrounding plains. (Ron Evans).

11. View north from Table Top towards the Grey Range and surrounding plains. (Barbara Dunn).

all the group had returned from the walk. With the official activity over for the day the group dispersed back to Quilpie.

Report by Brian Dunn (trip leader).

Day 17: Tuesday 12th September - Charleville.

The day began with the 210 km drive to Charleville. It was yet another fine and sunny day and along the way there were emus, goats and a few kangaroos to avoid as seems to have been the case since we left Bourke.

We met at 2 pm to drive to the Graham Andrews Parklands for an informative walk amongst our Australian outback native trees *(photo 1)*. This is a very well set out park and we were able to follow a pamphlet available from the Visitors Centre. This pamphlet not only gave you the common name for the trees but also the botanical name, family name and a description along with Indigenous use and European use.

Scattered through the park were First Nations artworks and metal sculptures of a variety of birds including brolgas *(photo 2)*.

1. Reading one of several information boards Graham Andrews Parkland.
(Chris Redmayne).

2. Brolga sculptures Graham Andrews Parkland.
(Chris Redmayne).

3. Steiger Vortex rainmaking guns, Graham Andrews Parkland. (Ron Evans).

There was also a pond in the centre enjoyed not only by the ducks but also a few turtles were spotted.

On the edge of the park were the Steiger Vortex rainmaking guns *(photo 3)*. These guns, which were fired under a suitably cloudy sky in the hope of breaking the drought, were used by the Queensland Government Meteorologist Prof. Clement Wragge at Charleville on 26 September 1902. The history of the experiment is amusing. As recounted in the Queensland Historical Atlas: "The Steiger Vortex gun is a cone-shaped barrel, fabricated from sheet steel, designed as a rainmaking device. The gun was originally designed by Albert Steiger with the aim of preventing destructive hailstorms in a wine growing region of Austria. The firing of the cannon-like device caused a discharge of gas which set up vibrations in the clouds, causing rain.

While on an overseas visit, Clement Wragge, Government Meteorologist, hit upon the idea of using the gun to make rain in drought-stricken Queensland. Six guns made at Harvey and Son, at Globe Ironworks in Brisbane, to the order of Clement Wragge. It was manufactured in the hope that the technology could induce rain during the Federation Drought. Trialled in Charleville in September 1902, the six guns were set up in two rows, spaced over a kilometre apart and fired at two-minute intervals. Unfortunately, the experiment met with no success, with no sign of the desperately needed rain. Worse still, the failed experiment was seen by some as heralding the beginning of the end for Wragge's career in meteorology." It is said that Wragge addressed a group of local citizens in Aeschimann's Hall in Charleville and, so rumour has it, was greeted with considerable scepticism and derision. He left town the next day.

In the evening the group enjoyed a Spit Roast dinner at the caravan park.

Day 18: Wednesday 13th September - Charleville.

This was a day where members could choose from a variety of activities. These included Weather Balloon release, WW11 Secret Base Tour, Royal Flying Doctor Service Visitor Centre, Charleville Historic House and Museum, Mulga Lands Gallery, Bilby Experience, Big Sky Observatory.

At 9 am we drove as a group to watch the automatic release of the weather balloon at 9.15 am *(photo 4)*. The BOM release about 56 of these balloons per day from 38 locations within Australia and its offshore territories including Antarctica These balloons can reach an altitude of between 16 - 35 km in the upper atmosphere. They carry a radiosonde that provides precise measurements of temperature, pressure, humidity, wind speed and direction giving the Bureau vital information that is used in its forecasts and warnings.

We discovered a café at the Charleville Airport which gave some within the group a chance to recharge their caffeine levels before we headed over for our WW11 Secret Base tag along tour. During WW11 there were 3,500 US army Air Force personnel stationed at Charleville. The reason for this was mostly strategic as Charleville is extremely remote and eluded radar detection. It was also practical as the air strip was an existing refuelling and servicing hub. The Americans constructed 3 airstrips, 2 of which remain international standard today.

Our guide was a very enthusiastic local who as a young boy explored this area on his bicycle with his friends. The first site we visited were the bitumen baths, small dugout trenches where troops were required to bathe in a chemical solution sheep dip-style to combat ticks and lice *(photo 5)*.

We viewed the concrete foundations of the old mess and the latrine and shower blocks where soldiers used high raised shower heads in an attempt to cool the bore water. At the remains of the dance hall, we heard stories of soldier civilian fraternisation.

The tour concluded at the site listed on the blueprints as a "dental facility". It was the most

4. Weather balloon being automatically released at the Charleville Weather Station. (Graham Shaw).

5. Our guide explaining how the bitumen baths were constructed and used. (Chris Redmayne).

6. Norden Bombsight. (Chris Redmayne).

classified asset of the Charleville base - the Norden Bombsight *(photo 6)*. It was hidden in an underground concrete vault. This was Top Secret. It is a complex bomb-targeting machine used in the bombing of Hiroshima and up until the Vietnam War. This mechanical analog computer could determine the exact moment a bomb should be dropped to hit the target with great accuracy. It was developed by Carl Norden. 45,000 bombardiers were trained to use it by the end of the war and had to swear an oath of secrecy. It was placed on the plane just before takeoff and covered from view being loaded and unloaded straight after landing with an armed guard.

At the end of the tour we looked across at the aircraft hanger that was built during this time and is still being used today by The Royal Flying Doctors Service. Some of our group went into the visitor's centre to read about this service.

After lunch a few from the group went to visit the Mulga Lands Gallery where an exhibition called 'The Masters' was on display. Local artists exhibited copies of some of the masters including Van Gogh, Leonardo da Vinci and Vermeer. It was well worth the visit. Some participants crossed the road to visit the Historic House Museum where there was an extensive collection of memorabilia and artifacts reflecting the early history and development of the district.

In the afternoon we went to the "Bilby Experience" and were treated to an informative talk. Save the Bilby Fund was set up in 1999 by the late Frank Manthey and the late scientist Peter McRae. They raised money to build a fenced enclosure at Currawinya National Park in an effort to stop the steady decline of bilby numbers. In 2005 the first bilbies were released into the enclosure however in 2012 the fence was breached by feral cats and work had to start all over again. In 2019 after reconstruction of the fence 6 bilbies were released in April and a further 20 released in September. The numbers continue to grow, the aim is to have 400 bilbies at the site The centre also has a breeding facility.

After our talk we were able to look at the female bilbies in the nocturnal area *(photo 7)*.

In the evening we visited the Cosmos centre for a night viewing through 14 inch telescopes. We viewed Alpha Centauri, the Jewel Box cluster, a globular cluster and then Antares a red super giant. It was a wonderful experience sitting outside looking into the sky and trying to absorb all the information we were being given.

Day 19: Thursday 14th - Charleville.

A very well trained convoy was ready 5 minutes early today for our drive to the Outback Date Farms!

We were met at the gate by Mark Hampel, the date farmer *(photo 8)*. There was a lot to learn and he was an enthusiastic teacher. He explained how this farm had been a long term dream and it was established in 2014.

He currently growing 450 palms of eating dates using reclaimed water from the towns treatment plant. Dates love heat and water so the town water is essential for his farm.

Female date flowers are hand pollinated by

7. Female bilby in nocturnal enclosure. (Chris Redmayne).

8. Mark Hampel our enthusiastic date farmer. (Chris Redmayne).

9. Tasting of 4 different date varieties. (Chris Redmayne).

collecting pollen from the male flowers and then dusting the female flowers with the collected pollen. The bunches of dates are then covered with bird and rain resistant bags for protection.

Last year Mark lost a lot of his crop when a shower of rain came at just the wrong time and the dates burst on the vine.

After a walk around the farm looking at his water storage areas and the different date palms he grows, we were treated to a taste test of the four varieties he grows Barhee, Medjool, Khalas and Khadrawi *(photo 9)*.

After our tour we all enjoyed a coffee and delicious date loaf cooked by his wife.

We then drove to Charleville's oldest tree, a Moreton Bay Ash which is approximately 150 years old *(photo 10)*. At 31 m in height which a circumference of 4.66 m it is a beautiful tree. A walk along the Warrego River finished the mornings activities.

In the afternoon some participants visited the Hotel Corones for a guided tour. This remarkable hotel (completed in 1929) is a symbol of immigrant initiative and imagination. Harry 'Poppa' Corones, a native of the Greek island of Kythera, arrived in Australia as a penniless immigrant in the early 1900s and by 1929 had built this amazing hotel. It was in high demand for exclusive balls, parties, and banquets. Capable of seating 320 at dinner, the hall was built for coolness with a number of high- set windows and electric ceiling fans.

The tour guide, Rachel, told many tales about the hotel and Harry Corones who was obviously an amazing businessman. One example is Harry was one of the original shareholders in QANTAS and when the first QANTAS flight left Charleville and Harry supplied the first inflight catering!

Our Safari concluded with a Happy Hour at the Camp Kitchen.

Brian Dunn thanked Safari participants for supporting AGSHV's safari activities and in return the participants thanked Brian and Barbara (and Sue Rogers) for all their hard work.

Reports for days 17 to 19 by Chris Redmayne (trip leader).

10. Approximately 150 year old Morton Bay Ash, Charlevilles oldest tree. (Chris Redmayne).

Newcastle Coastal Geotrail

Leaders: Phil and Cressida Gilmore.
Date: Saturday 21st October 2023.
Attendance: 21 members and 3 Visitors.

Introduction.

A group of 24 members and visitors were led by Phil and Cressida Gilmore along the Newcastle Coastal Geotrail on Saturday 21st October 2023. Phil was the lead author for the Geotrail published by the Geological Survey of New South Wales.

Phil and Cressida operate Geotrail and Nature Tours offering guided walks along the Newcastle Coastal Geotrail and through Glenrock State Conservation Area.

The group assembled at Bar Beach car park at 8.30 am on a warm morning to arrange car-pooling into the starting point at Nobbys Surf Club. After reconvening at Nobbys Surf Club at 9 am, the group walked ~6.5 km out to Nobbys Head (Whibayganba) and back, following the Bathers Way past the Cowrie Hole, Newcastle Baths and Newcastle Beach, through Fletcher Park and King Edward Park to the Bogey Hole.

They then walked up to the old fortifications on Shepherds Hill (Khanterin) and back to Bar Beach car park via the Anzac Walk. The group returned to Bar Beach car park at 1pm, with some staying on for lunch at Swells Café.

Aim.

The aim of the field trip was to examine the geology of the Newcastle area, and explore the relationship between geology, landscape, resources, flora and fauna, and cultural history.

Newcastle is at the northern margin of the Sydney Basin, the southern part of a basin system extending south towards Ulladulla, and north through Gunnedah to Bowen in northern Queensland. The basin system opened in the early Permian as a result of the interaction of the Pacific and Australian plate margins, with sedimentation into the basin continuing to the late Permian.

The sediments deposited in the Newcastle area from the late Permian (~255 Ma or million years ago) Newcastle Coal Measures, representing river systems, forested floodplains, swamps and other environments (e.g. deltaic, shoreline) as sediment was transported from the uplands of the New England area to the coast.

Huge and frequent volcanic eruptions led to significant ashfall deposits smothering the landscape. During the final stages of the breakup of the Gondwana supercontinent, magmatic activity led to dyke emplacement through the Newcastle Coal Measures around 90 Ma. Subsequent uplift of geology and coastal processes have exposed magnificent exposures of these rocks and their features in the cliffs and platforms along the Newcastle coast.

Macquarie Pier and Nobbys Head (Whibayganba).

The tour began with an acknowledgement of the Awabakal and Worimi people as the traditional custodians of country – the Awabakal south of the Hunter River and the Worimi to the north. The river would have been shared country, and important to both groups.

In recent times, the NSW Geographic Names Board has adopted dual names for many landmarks around the city based on traditional names. This is not just a recent idea - the 1828 Sir Thomas Mitchell sketch of Nobbys included the name Whibayganba. Dual names have been used here where known.

Phil outlined the premise of a geotrail, as defined by Prof. Ross Dowling (Edith Cowan University), that a geotrail should integrate elements of the ABC - the abiotic (geology, oceans, atmosphere), the biotic (flora and fauna) and culture (indigenous and European). The Newcastle Coastal Geotrail was developed following this concept.

Nobbys Head (Whibayganba) has a long and interesting cultural history. The Awabakal story for its creation involves a kangaroo that sleeps within the headland, and occasionally thumps its tail to cause rocks to fall down the cliff face. The headland was once an island, and was ~15 m higher at ~43 m than its current height of ~28 m. It was separated from the mainland by a shallow, rocky shoal. This shoal, and variation of the wind due to the headland was hazardous to sailing ships in the early days of the settlement at Newcastle (Mulloobinba) as they entered and exited the Port of Newcastle (Yohaaba).

Macquarie Pier was built from 1818 to 1846, connecting the mainland near Flagstaff Hill (Tahlbihn) (the hill with Fort Scratchley on it) and Nobbys Head (Whibayganba). In fact, Nobbys Head (Whibayganba was going to be levelled in the early 1850s, with two tunnels excavated into the headland to place and ignite explosives. Kerr (2011) produced an excellent report on the locations and history of these tunnels and the lowering of the headland as part of the Coal River Working Group. Local residents lobbied the NSW government and a compromise of lowering the headland was reached. The first lighthouse (signal station) was constructed in 1857.

The construction of Macquarie Pier the southern breakwater and the northern breakwater have affected sand transport, deposition and erosion along this part of the coast. Sand has built up along Nobbys Beach since construction - so the extensive sand dunes and beach system have only developed in the last 170 years. Cressida showed some historic sketches *(photo 1)* of the area to illustrate the landscape pre-anthropogenic influence (e.g. Paintings by Joseph Lycett in 1818).

A viewing platform on the harbour side of the pier offers a chance to view the Port of Newcastle (Yohaaba), and discuss the origins of the Hunter River (Coquun). The river's source is at Hunter Springs, on the northern side of the high plateau of Barrington Tops. The river flows north and west, before its confluence with the Goulburn River, and then flows to the south and east to the Tasman Sea. The Hunter River catchment is the largest coastal catchment in NSW. Due to the transport of sediment down the river and by tidal movements, the harbour requires constant dredging by the always working 'David Allan' to maintain a main channel depth of >15 m for shipping. Most shipping movements are associated with coal exports, though fertiliser, grain, alumina, ore concentrates, vegetable oils and cruises are significant. The water quality of the harbour has improved markedly in the last couple of decades, with dolphins and seals now common visitors.

From the beach, the group discussed the geology of Nobbys Head (Whibayganba), which is mostly formed by sub-horizontal layers of the Nobbys Tuff *(photos 2 & 3)*. The Nobbys Tuff is interpreted to be

1. Cressida showing early illustrations of the area at Nobbys Beach. (Chris Morton).

3. "It all comes back to plate tectonics". Phil explaining geological processes that occurred at Nobbys. (Chris Morton).

2. The group on the beach at Nobbys Head. Note the horizontal layers of Nobbys Tuff forming the cliff, the thin coal seam on top and the vertical dolerite dyke. (Cressida Gilmore).

volcanic ash that was erupted from a volcano, carried by the wind, deposited on the landscape, and in some cases reworked by alluvial processes. The Nobbys Tuff consists of airfall tuff layers, and where reworked and deposited by alluvial processes is named by grainsize - i.e. tuffaceous sandstone/siltstone/claystone layers.

As an example, Geological Survey of NSW FieldObs NSWSPJG0037 from the Nobbys Tuff in King Edward Park is best described in hand sample as a tuffaceous sandstone. Under a microscope, mineral crystals and pumice fragments can be observed (as described by Dr Kate Bull), indicating that the ash has not been intensively reworked, though in outcrop cross beds are observed - indicating water-transport and deposition.

At Nobbys Head (Whibayganba), the Nobbys Tuff consists of alternating fine tuffaceous sandstone and siltstone to claystone beds, generally 30 to 50 cm thick. The coarser grained (sandy) beds are more resistant to weathering, and tend to stick out further from the cliff than the more recessive finer grained (silty and clayey) beds.

Highly siliceous 'chert-like' beds can develop a conchoidal fracture and sharp points. This rock was used by the Awabakal people for stone tools, particularly for cutting and hunting.

The age of the Nobbys Tuff has been dated at 255.02 and 255.26 Ma by high precision geochronology (chemical abrasion isotope dilution thermal ionization mass spectrometry (CA-TIMS) method) by Metcalfe et al. (2015). These samples were collected from borehole intervals west of Lake Macquarie and near Muswellbrook. The source of the volcanic activity responsible for the tuff is interpreted to be the Wandsworth Volcanic Group near Glen Innes in the New England region based on age and geochemical correlation (Blevin et al. 2014), though a more local but unknown source (e.g. now submerged under the Tasman Sea) may be possible.

The prominent sub-vertical dyke cutting through the sub-horizontal bedding in the headland has been dated at 98.79 ± 2.08 Ma (whole rock K-Ar geochronology) by Sutherland & Graham (2003) and 90.39 ± 1.94 Ma using (plagioclase K-Ar geochronology) by Offler et al. (2019). This latter paper includes new geochronology analyses and a summary of other geochronology results for dykes through the Sydney Basin and elsewhere.

4. Brian England explaining the formation of dendrites at Nobbys Head. (Phil Gilmore).

The dykes, and others in the local area (e.g. Fort Scratchley, Little Redhead, Norah Head) are interpreted to be associated with opening of the Tasman Sea. At this time, the Australian tectonic plate began to separate from Antarctica and move north. This led to the opening of the Tasman and Coral seas, including major pulses at ~80 Ma and 50 Ma, with the continent of Zealandia (New Zealand represents the emergent part of this mostly submerged continent) separating from Australia. The dykes seen along the coast are sub-parallel, broadly trending 325° to 350°. Their orientationis related to the complex rift axes related to the Tasman Sea opening (Gaina 1998).

The beach sand is predominantly made up of white to yellow quartz grains, with shell fragments and other minerals – including dark-coloured mineral grains. Waves, particularly from large swells, can winnow the lighter (less dense) quartz-dominant grains from the heavier (more dense) dark grains. The dark grains are known as 'heavy minerals' based on the density contrast – and are predominantly the minerals ilmenite ($FeTiO_3$) and rutile, (TiO_2). The heavy minerals currently found on our beaches are not concentrated enough for mining, but beach sand and dune deposits preserved from times of higher sea level in the Pleistocene ~120,000 years ago include thick deposits of heavy mineral sands along the New South Wales, Queensland and Western Australian coastal plains. They also occur in the Murray Basin and in the Eucla Basin. These heavy mineral sand deposits are interpreted to have formed in storm events. The main target minerals are ilmenite and rutile for titanium (for orthapedics, metal alloys, whitening) and zircon for zirconium, though monazite, garnet and even tin and gold are recovered in some locations.

Before leaving the beach, Brian England explained the formation of the yellow and brown dendritic patterns on some bedding and joint surfaces in the Nobbys Tuff *(photo 4)*. This location is one of the best places to see these features. Brian explained they form from a mix of iron hydroxide (goethite) and silica. The dendrites are bright yellow from finer grained goethite, and darker where coarser grained. One explanation is that iron from decomposing diagenetic pyrite in the coal and shale units, and silica from the tuff are mobilised in groundwater, and moves along joint and bedding surfaces as a gel substance before precipitating (England, 2014).

On the way back along the pier, Phil and Cressida discussed the different vegetation communities in the sand dunes – the introduced Bitou Bush, Searocket (Genus *Cakile*), Beach Evening Primrose (*Oenothera drummondii*), and native Pig Face, the coastal variant of *Acacia longifolia* and coastal spinifex (*Spinifex sericeus*). Thanks to Barry Collier for the identification of the latter two. On the harbour side, Landcare planting and rehabilitation behind Horseshoe Beach since 2004 has resulted in numerous native plants and birds (including Eastern Whip Birds and Black Cockatoos) being recorded.

This part of the pier includes some interesting weathering features in rocks used for landscaping and stability. The grey Waratah Sandstone blocks here were quarried in the hills of North Lambton/Waratah West. The sandstone was formed from lithified beach sand. Honeycomb weathering is seen in the blocks here near the coast, but not in the quarry area. This weathering is the result of chemical weakening of the rocks by separation of mineral grains via wetting and drying from salty spray, followed by wind scalloping.

The yellow-beige rectangular blocks are 'Sydney Sandstone' (Triassic Hawkesbury Sandstone) most likely quarried on the Somersby Plateau. The brown and orange-brown bands (stripes and rings) are the result of iron (goethite) precipitation from groundwater movement through the rock. The bands are commonly referred to as Liesegang rings after the similar looking rings created by German chemist Raphael E. Liesegang who formed rings by dropping silver nitrate onto a surface of potassium dichromate gel in 1896. Wilhelm Ostwald was the first to explain the phenomenon – so technically the process of precipitation is known as the catchy 'Ostwald-Liesegang supersaturation-nucleation-depletion cycle'. Vernon (2021) published a great paper on the phenomena – it's one of the surprisingly few papers on the feature.

Nobbys Surf Club to Newcastle Beach.

After a quick water and toilet stop at Nobbys Surf Club, the group proceeded to walk around Bathers Way to the Cowrie Hole. A quick stop pointed out another dyke - this one cutting across the extensive rock platform under Flagstaff Hill (Tahlbihn) to the north of the Cowrie Hole. This dyke can only be seen at low or mid tide. Although we didn't examine the dyke on this trip, the dyke has chilled margins, where the dyke cooled more quickly along its margins than in the middle - resulting in finer grained, sometimes glassy margins, and is coarser grained in the middle of the dyke. This feature tells us that there was a temperature contrast between the hot magma that crystallised to form the dyke, and the cold country rock (the Bogey Hole Formation that makes up the rock platform). The dyke here is subparallel to the dyke at Nobbys (Whibayganba).

5. Phil discussing *Dadoxylon* fossils at the Cowrie Hole. (Cressida Gilmore).

6. Exotic gneiss blocks in the retaining wall near the Canoe Pool. (Cressida Gilmore).

The rock platform between the Cowrie Hole beach and Newcastle Ocean Baths includes fossilised branches, trunks and stumps of *Dadoxylon*. The organic material is now red-brown siderite, an iron carbonate. The trees here are buried in pebbly sandstone layers here, suggesting they were carried by rivers and buried by the sediment load within those river channels.

Dadoxylon was one of the prominent plant genera in the forests that covered the landscape about 255 million years ago. At this time, Australia was much further south, closer to the south pole. The climate was colder, with temperate forests (like Alaska or Canada today). The forests grew on vast floodplains. Other genera included *Glossopteris* and *Phyllotheca*.

Phil and Cressida showed some fossils of each *(photo 5)*, and some illustrations of the forest community (from illustrations by Claus Diessel, Roz Kerr and Mary White). *Glossopteris* became extinct in the end of Permian mass extinction event - evidence of this mass extinction can be seen at Frazer Park (Vajda et al. 2020). *Phyllotheca* still grows in cold climates today - Phil and Cressida have seen it growing in Iceland, Brian England in Kamchatka. The fossilised *Phyllotheca* are evidence of cold climate in the late Permian.

On the southern side of Newcastle Ocean Baths, the group discussed the Canoe Pool. This pool was built during the 1930s, and featured a children's pool with a raised concrete map of the world. Canoes could be hired to paddle around the world. The map suffered storm damage and was constantly filled with sand, before being broken up in the 1960s. It was great to hear memories of the canoe pool from some of the members. Historic images of the Canoe Pool were published by Greg and Sylvia Ray.

Retaining walls here contain blocks of gneiss *(photo 6)*, with sub-parallel layering of black biotite and white quartz and feldspar, suggesting a granitic protolith. It is thought that these blocks were sourced near Rio de Janeiro in Brazil, and were used by ships as ballast *(photo 6)*. Shipping coming from England to the Port of Newcastle would typically travel via Rio and Cape Horn.

Newcastle Beach to the Bogey Hole.

As Bathers Way is currently closed along Newcastle South Beach for construction of sea walls and the skate park, the walk continued past Newcastle Surf Club up to Fletcher Park. James Fletcher was a Scottish coalminer and mine owner, newspaper proprietor and politician, who moved to Newcastle in 1851.

He was focused on helping miners with health, pay and rights, and he represented Newcastle in the Legislative Assembly in 1880-91.

From the top of the cliff, it is possible to look down the plane of the dyke that intruded through the sandstone of the Bogey Hole Formation and shale of the Dudley Formation, but dissipated on interaction with the Dudley Coal. It is uncertain whether this was controlled by higher water content within the coal seam, the change of permeability or a combination.

The cliff section is known as Yirannali by the Awabakal people - and known as a site to be feared. Awabakal children were not to linger or speak here due to the danger of falling rocks. One such rock fell in 2002 - a 20 ton block of sandstone documented by Kerr (2000). The block led to the closure of the road connecting Newcastle Beach with King Edward Park.

After viewing the historic surveying marker at the intersection of Watt and Ordnance streets, the group walked through King Edward Park to the Bogey Hole.

King Edward Park was dedicated in 1863 as Upper Reserve. Although dissected by roads, it includes Obelisk Hill and Arcadia Park. The park could have looked quite different, as an 1890 design for the park by Alfred Sharp included mass plantings of *Pohutukawa* (the NZ Christmas tree), and a chain of ponds in the valley where Garside Gardens is located today. His plan wasn't popular with everyone, and did not come to fruition.

7. Vertical fossilised tree at the Bogey Hole. (Phil Gilmore).

8. View of the Bogey Hole. Nobbys Tuff on top of cliff (Brian England).

Local Landcare activities have included planting of endemic vegetation and protection of *Themada australis* (Kangaroo Grass) grasslands.

The Bogey Hole was originally a convict-dug swimming hole excavated into the sandstone of the Bogey Hole Formation in 1820 for the wife of then Commandant of the Newcastle Colony, Major Morisset.

After Newcastle Council took control in 1863, the pool was enlarged to its current size in 1864.

From the platform at the base of the stairs to the Bogey Hole, a vertical fossilised tree is visible in the cliff *(photo 7)*. It appears that the tree managed to withstand sediment build up around its base and trunk, before finally succumbing to burial by sediments.

At the Bogey Hole, Phil and Cressida led discussions about the rock platforms and cliff formation *(photo 8)*. They have been developing over the last 7000 years since sea level stabilised. Around 20,000 years ago (the last glacial maximum), sea level was ~100 m lower than today due to water being contained as ice in the extensive ice sheets. Glaciation occurred around Mount Kosciusko and Tasmania at this time, with extensive glaciation in North America and Europe. Thawing of the ice sheets led to a rise in sea level. Subsequent coastal retreat through the combined forces of wind, salt, water and gravity led to collapse of the cliff sections along planes of weakness like bedding and jointing surfaces.

The rock platforms are important habitat for marine flora and fauna, and important roosting sites for seabirds, including migratory species. For example, a Ruddy Turnstone has been geotagged over several years to travel from King Island to breeding grounds in the Arctic and back, using the rock platforms around Newcastle to rest and feed mid-voyage (Gosbell et al. 2018).

These times of lower sea level were also important for Aboriginal migration and in Aboriginal history. As the shoreline was about 20 km further east when sea level was around 100 m lower, it is likely that the now submerged continental shelf was home to Awabakal people, and evidence of their lives (e.g. stone tools, middens) was washed away by the rise in sea level to current levels.

The Shepherds Hill/Khanterin cliff section to the south of the Bogey Hole provides a great view of the geology of the Newcastle Coal Measures, from the Bogey Hole Formation at the base to the Merewether Conglomerate at the top. Several coal seams can be seen - the Dudley Coal has two splits, the Nobbys Coal underlies the Nobbys Tuff towards the top of the section, and the Victoria Tunnel Seam lies between the Nobbys Tuff and the Merewether Conglomerate. Here, the Nobbys Tuff is 60-70 m above sea level in contrast to its exposure at 5 m above sea level at Nobbys/ Whibayganba and near Glenrock Lagoon. This arching or boomerang shapes indicates an anticlinal form from subsequent folding, named the Shepherds Hill Anticline by Kerr (2000).

Bogey Hole to Bar Beach.

Under the Strzelecki car park, the group examined the cliff exposure of the Merewether Conglomerate at the top of Memorial Drive. Weathering features here are the result of wind erosion, This cliff was excavated pre-1946 as part of works associated with Memorial Drive, so the weathering features here have developed over the last 77 years or so. An historic picture published by Greg and Sylvia Ray shows the cliffs with little to no weathering.

The group then returned to the Strzelecki car park, to examine the plaque commemorating the Polish geologist and explorer Sir Pawel (Paul) Edmund Strzelecki and his work in the Newcastle area, before enjoying the views over Newcastle and the coast from the Anzac Walk on the walk back to Bar Beach car park.

Report by Phil and Cressida Gilmore.

9. Up the hill to the Anzac Walk from the Bogey Hole. (Phil Gilmore).

References:

ENGLAND, B. M. (in EVANS, R), (2014). *Foreshore Geology - Nobbys Head to Newcastle South.* Geo-Log 2014, p. 7 to 8.

GAINA, C., MULLER, D. R., ROYER, J.V., STOCK, J., HARDEBECK, J., & SYMONDS, P. (1998). *The tectonic history of the Tasman Sea: A puzzle with 13 pieces*. Journal of Geophysical Research, 103(B6), 12 413–12 433. https://doi.org/10.1029/98JB00386

GOSBELL, K., LISOVSKI, S. and MINTON, C. (2018). *Geolocators track Ruddy Turnstone to Newcastle, NSW en route to King Island (Tasmania).* The Whistler, HBOC: 12, 16-21. https://www.hboc.org.au/wp-content/uploads/Turnstone-WMA-The-Whistler-Vol-12.pdf

KERR, R. (2011). *In search of Nobbys' Tunnels*. Report to Coal River Working Party, University of Newcastle. https://livinghistories.newcastle.edu.au/nodes/view/83246

KERR, R. (2000). *The bathers' way. Geology and landscape.* Report to Newcastle Tourism / City Strategy, Newcastle City Council.

METCALFE, I., CROWLEY, J.L., NICOLL, R.S. and SCHMITZ, M. (2015). *High-precision U-Pb CA-TIMS calibration of Middle Permian to Lower Triassic sequences, mass extinction and extreme climate-change in eastern Australian Gondwana*. Gondwana Research 28, 61–81. https://www.researchgate.net/publication/265730988

OFFLER, R., ZWINGMANN, H., FODEN, J., SUTHERLAND, F.L. and GRaham, I.T. (2019). *Age and composition of dykes emplaced before and during the opening of the Tasman Sea - source implications*. Australian Journal of Earth Science. https://doi.org/10.1080/08120099.2019.1614997

RAY, GREG and SYLVIA. https://www.phototimetunnel.com/

- Newcastle's lost map-of-the-world pool. Viewed online on 01/10/23: https://www.phototimetunnel.com/the-map-of-the-world-pool
- Memorial Drive, 1946. Viewed online on 01/10/23: https://www.phototimetunnel.com/product/0306-strzlecki-lookout-memorial-drive-18-8-1946-jpg-2

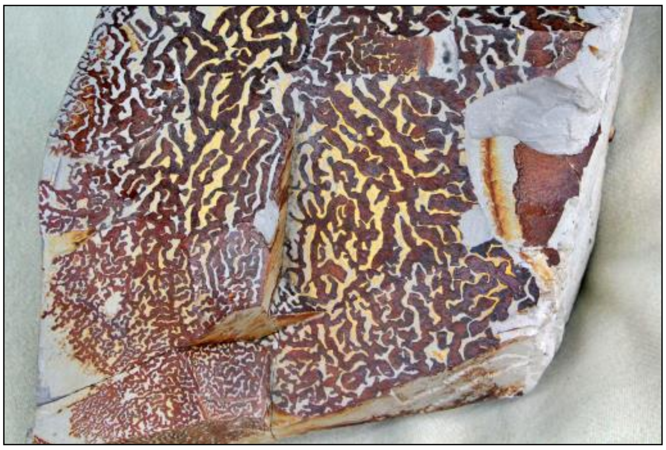
SUTHERLAND, L., and GRAHAM, I. (2003). *Geology of Barrington Tops Plateau. Sydney, NSW*. The Australian Museum Society, 56 p.

VAJDA, V., MCLOUGHLIN, S., MAYSA, C., FRANK, T.D., FIELDING, C.R., TEVYAW, A., LEHSTEN, V., BOCKING, M. and NICOLL, R.S. (2020). *End-Permian (252 Mya) deforestation, wildfires and flooding - An ancient biotic crisis with lessons for the present*. Earth and Planetary Science Letters, 529. https://doi.org/10.1016/j.epsl.2019.115875

VERNON, R.H. (2020). *Ferruginous banding in Sydney sandstone*. Australian Journal of Earth Sciences, 64 (4) 498 to 514.

Note: For more information on the Newcastle Coastal Geotrail, including the app and brochure: https://www.resourcesregulator.nsw.gov.au/meg.site/geoscience/education-and-tourism/geotrails/newcastle-coastal-geotrail

Photos by Ron Evans further illustrating information in the report.



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

Glossopteris leaf fossil preserved in tuff.

Dolerite dyke intruding rock platform and Flagstaff Hill behind it

The dolerite dyke on northern side of Flagstaff Hill (now covered), a continuation of the dyke seen on the rock platform has been kaolinized by weathering.

Petrified *Dadoxylon* stems - note branch attachment point.

Catherine Hill Bay Geology & Mining History

Leaders: Rick Miller and Brian England.
Date: Saturday 25th November, 2023.
Attendance: 25 members and 2 Visitors.

Introduction.

Catherine Hill Bay Field Trip Notes compiled by Rick Miller.

A description of the relationship between the geology in the area of Catherine Hill Bay and the coal mining and settlement there since 1873.

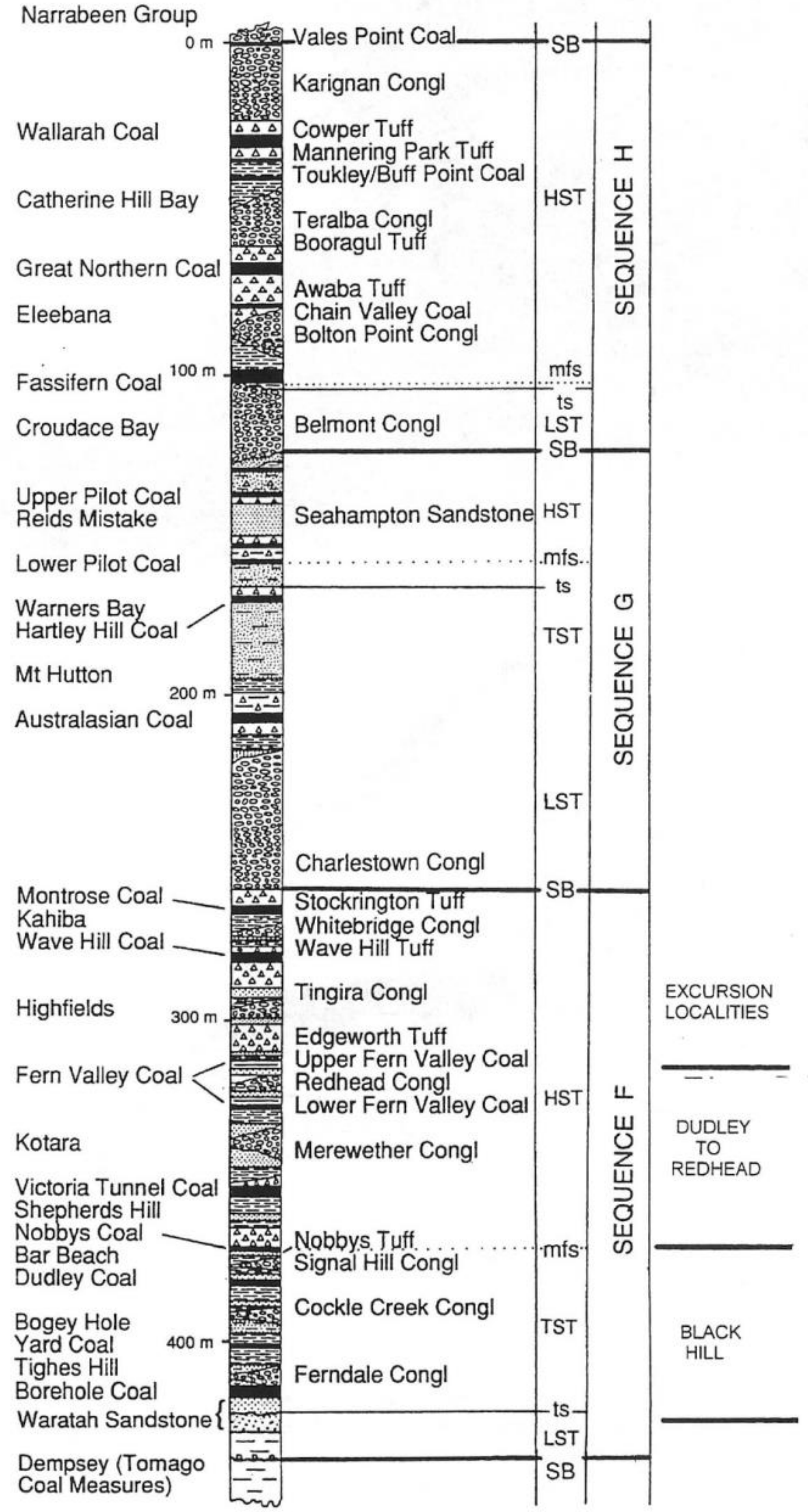


Figure 1. The Newcastle Coal Measures (Herbert 1988).

SB = Sequence Boundary,
ts = transgressive surface,
mfs = maximum flooding surface,
LST = lowstand systems tract,
TST = transgressive systems tract,
HST = highstand systems tract.

Figure 1 shows a stratigraphic column of the Newcastle Coal Measures (NCM).

In it Herbert (1988) identifies three sequences of relative sea level rise and fall during the formation of the NCM.

The coals mined in the area of Catherine Hill Bay (CHB) are in the highest of the sequences.

There are three main coal seams:

- Wallarah,
- Great Northern and
- Fassifern seams.

The Chain Valley coal is the lowest seam in the sequence but here it is uneconomic to mine. It is thought to be a split from the lower Fassifern Seam and elsewhere can be up to 3m thick.

Coal is formed when plant material accumulates in swamps faster than it can decay. When it is covered by sediments, their weight compacts the layers of organic material, increasing both the temperature and pressure in the bed. This leads to physical and chemical changes in the plant material. Water, carbon dioxide and methane are produced and escape, so the material becomes progressively enriched in carbon. With increasing time and higher heat and pressure, the plant material forms first into peat; is then converted into brown coal (lignite), then sub-bituminous coal, bituminous coal, and lastly anthracite. It takes at least 10 m of peat to create 1 m of coal. In the NCM, coal was formed on a combination of coastal marshes, floodplains and deltas.

The coal seams at CHB are bituminous and suitable for thermal and steaming coal.

The Newcastle Coal Measures shown in *Figure 1* are over 400 m thick. They formed in mostly non-marine paralic environments. These are deltas and flood plains that are formed on the landward side of a coast.

Formed between 256 Ma and 252 Ma the NCM are underlain by the marine Waratah Sandstone and Dempsey Formation (Tomago coal). As seen in *Figure 2* below, at this time a subduction zone had reformed off the present coast (Ferguson, 2019). Compression was causing the Lochinvar Anticline and Macquarie Synclines to form and a volcanic arc produced an offshore uplift *(Figure 3. Herbert 1998)*.

Movement of the Australian Continent to the north with the split from Antarctica caused it to pass over a number of "hot spots" (plumes). At about 50 Ma this produced the lava flows at the Barrington Tops and at about 30 Ma the Hornsby Plateau on which CHB sits was raised *(Figure 3)*. The NCM were in place at this time.

The coal measures in the NCM differ from those laid down in the southern part of the Basin (Illawarra Coal Measures). The NCM were formed with two sources of sediment. Erosion in the highlands of New England Orogen fed sediment into the Macquarie Syncline. This was predominantly in braided rivers and produced large deposits of conglomerate. On the eastern side a line of volcanoes *(see Figure 2)* shed sandy and muddy, dominantly volcanic, detritus into the basin via streams that fed paralic and lacustrine deltas.

Volcanic explosions deposited thick layers of ash (tuff) covering the peat beds and ending further coal formation or by providing the base on which further beds could form. The presence of these layers of tuff had serious consequences for mining at Catherine Hill Bay.

Herbert believes the coal developed in peat mires that grew during cyclical base-level rises. The mires became dormant during base-level falls and valleys were eroded into the mires. As base level rose again, fluvial gravel aggraded in the valley. When the water table rose to the top of the incised valley the dormant peat mire was reactivated. This caused another layer (ply) to be formed above the mire *(Figure 4)*.

Hutton (2009) provides the following description of the three major coal seams:

The Wallarah Seam.

The top seam of the Newcastle Coal Measures is the Wallarah seam and this is one of the most important sources of thermal coal in the Newcastle district. The

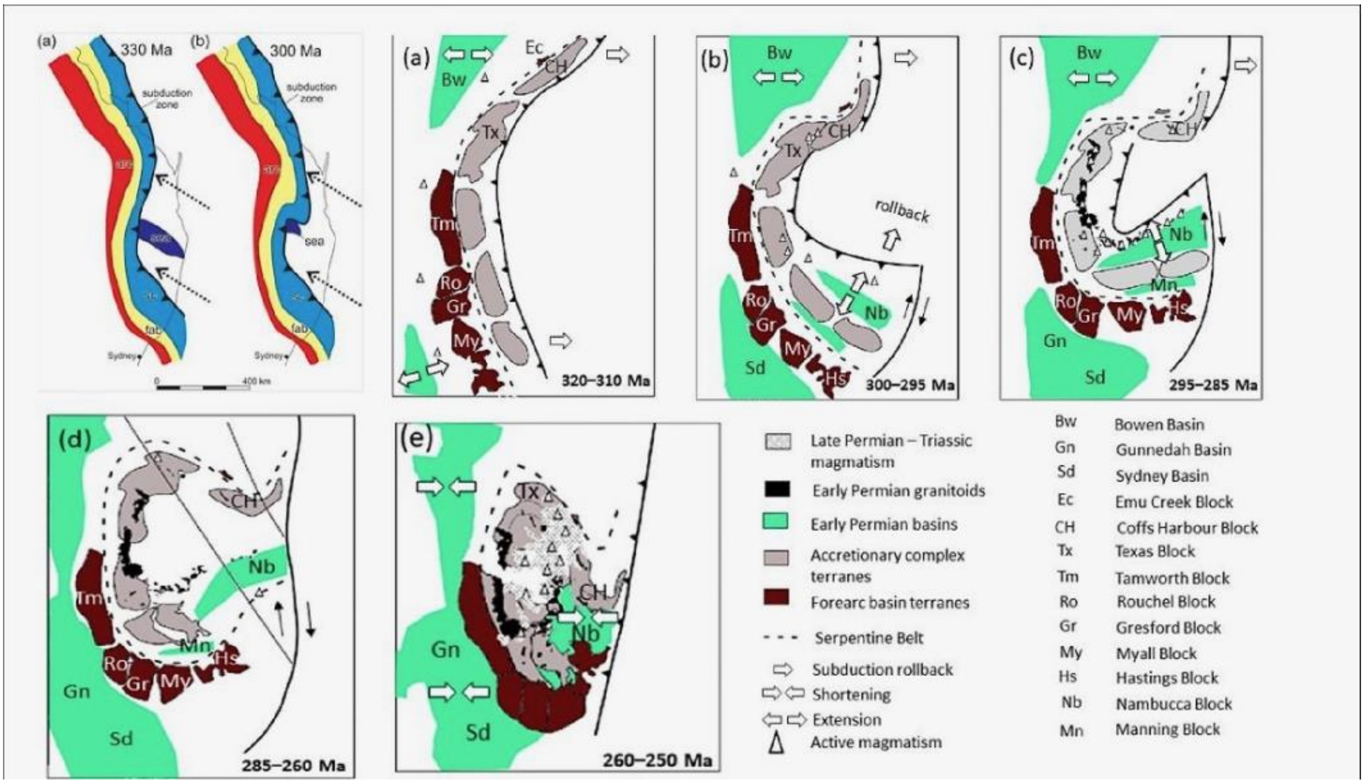


Figure 2. Stages in the formation of the Sydney Basin. (Ferguson 2019).

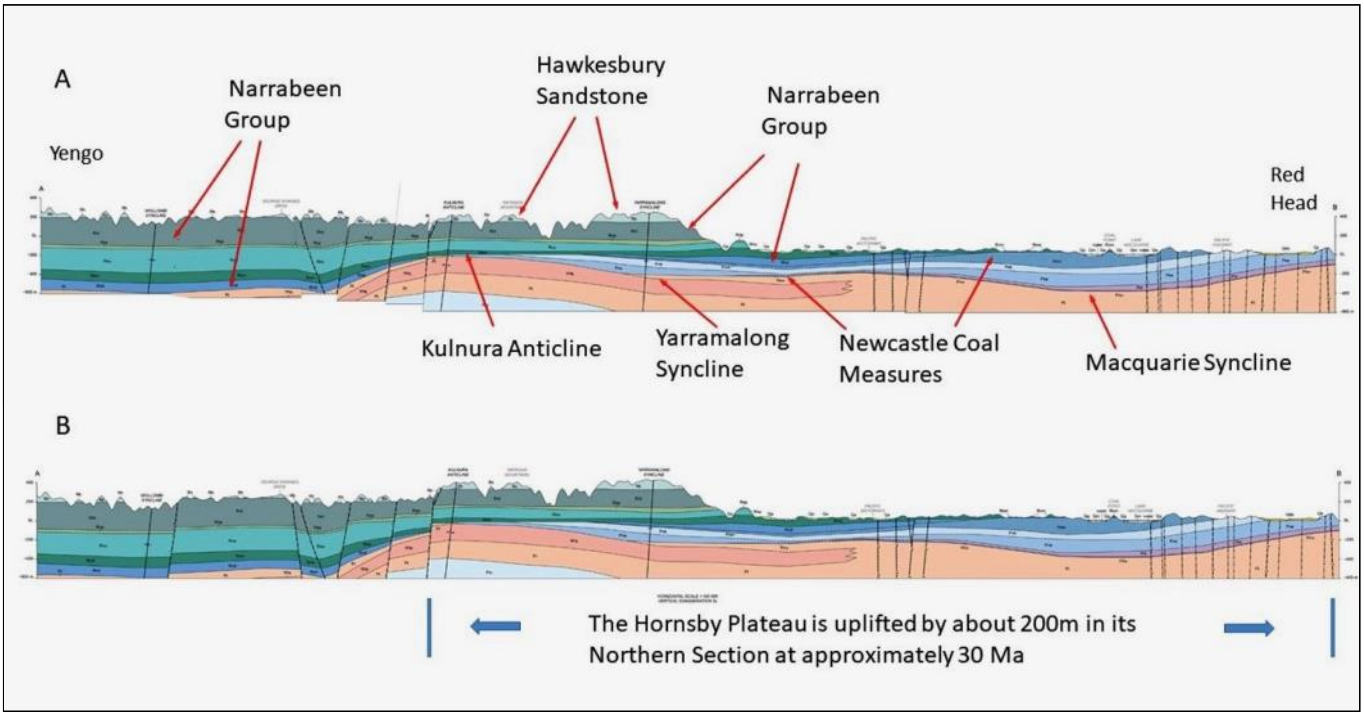


Figure 3. (A) At approximately 260 -250 Ma a subduction zone is re-established of the Australian Coast and a compression event produces the Lachlan Anticline and its southern extension the Kulnura Anticline. The Macquarie Syncline was folded on its eastern side. The Newcastle Coal Measures are deposited in the Macquarie Syncline and the Narrabeen Group is then deposited on top of this land surface. This sequence is followed by deposition of Hawkesbury Sandstone. (B) At approximately 30 Ma the Hornsby Plateau is uplifted by about 200m in its Northern Section. Compiled from the Gosford 100,000 Map.

Wallarah seam is developed from an outcrop just south of Swansea to Munmorah, and it extends to the west of and under Lake Macquarie. This goes as far west as Vales Point and possibly as far north as Wangi Wangi, The working section varies from 2 to 2.5 m and is generally free of claystone layers.

The Great Northern Seam.

The Great Northern seam, which is lower than the Wallarah seam, is also an important source of thermal coal in the area. In a large part of the area where the seam has been investigated conglomerate forms the immediate roof of the seam. There are three main centres of development: one in the in the west in the Teralba and Awaba areas; the second, a central area around Belmont and Wangi, and the third, a south-easterly zone, extending south from Catherine Hill Bay and Vales Point seam thickness in these areas varies between 1.5 and 3.5 m. A fourth, as yet undeveloped area, lies to the south and south-west of Lake Macquarie and extends to Gosford. In this area, at Vales Point, when converged with the overlying Wallarah seam, its thickness ranges up to 7 m. The Great Northern seam has been the major source of supply for thermal power stations in the Newcastle district.

The Fassifern Seam.

The Fassifern seam occurs below the Great Northern seam and is separated from it by mudstone with a thickness, ranging from less than 5 m to more than 20 m and where the interval is thickest this is replaced with some sandstone and conglomerate. The Fassifern seam has a thickness of 6 to 7 m. It generally has a characteristic seam profile and contains several claystone bands approximately 0.01 to 0.10 m thick which are persistent and can be used as marker horizons in the areas of major development. The ash yield of the whole seam is in the order of 35 to 40 per cent. Where mined, a selection is made usually from the lower ash, middle part of the seam. This has varied according to mining method and quality desired. Most mined sections involve leaving roof and floor coal. The Fassifern Seam is also a major source of supply to local thermal power stations.

Catherine Hill Bay.

In June 1867 the schooner "Catherine Hill" bound from the Richmond River to Sydney with a cargo of timber, was beached by her skipper after having begun to leak badly from damage sustained in a heavy gale. As the vessel approached the beach two crew members were washed overboard and died. The remainder were rescued the next day. The event led to eventual naming of the area.

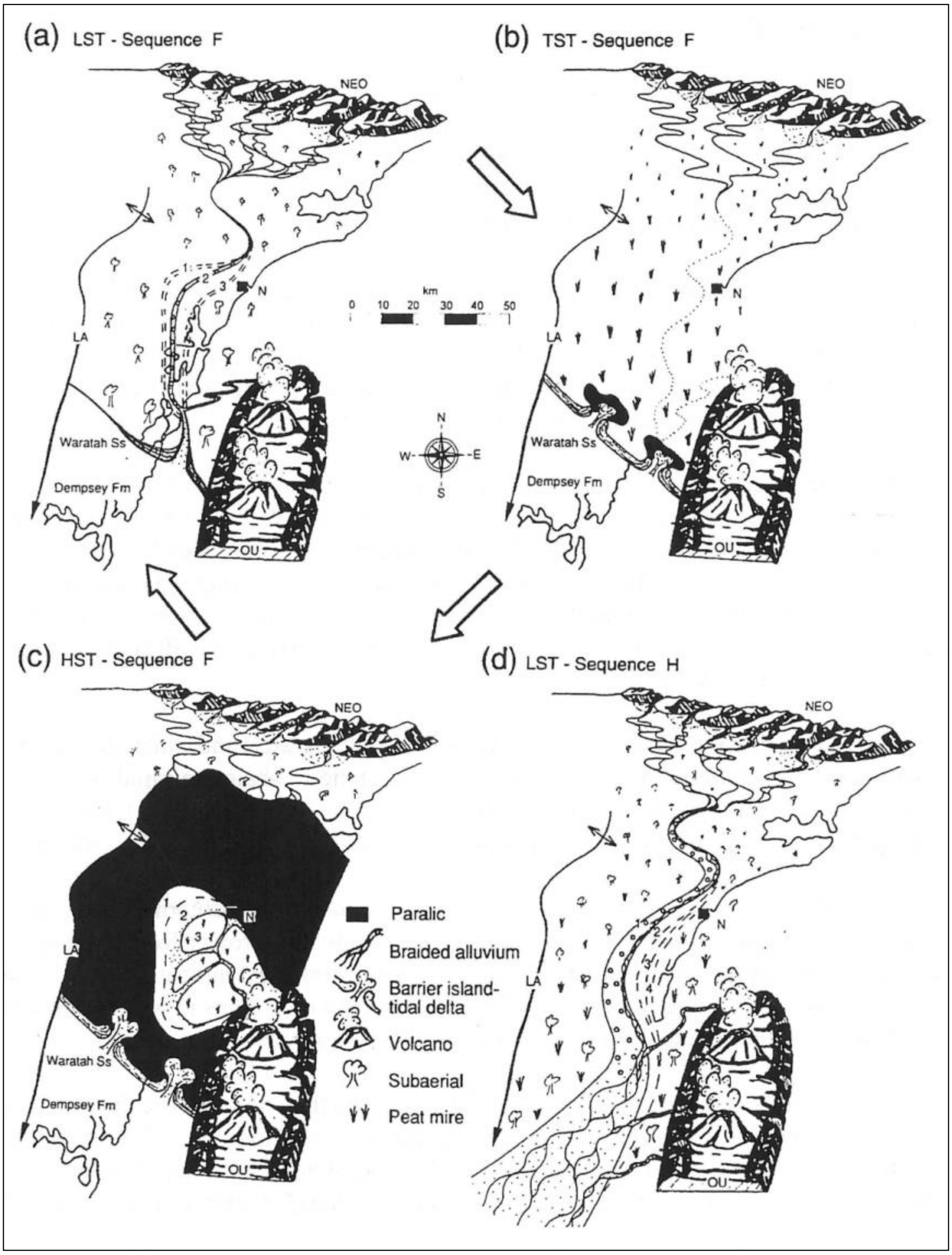
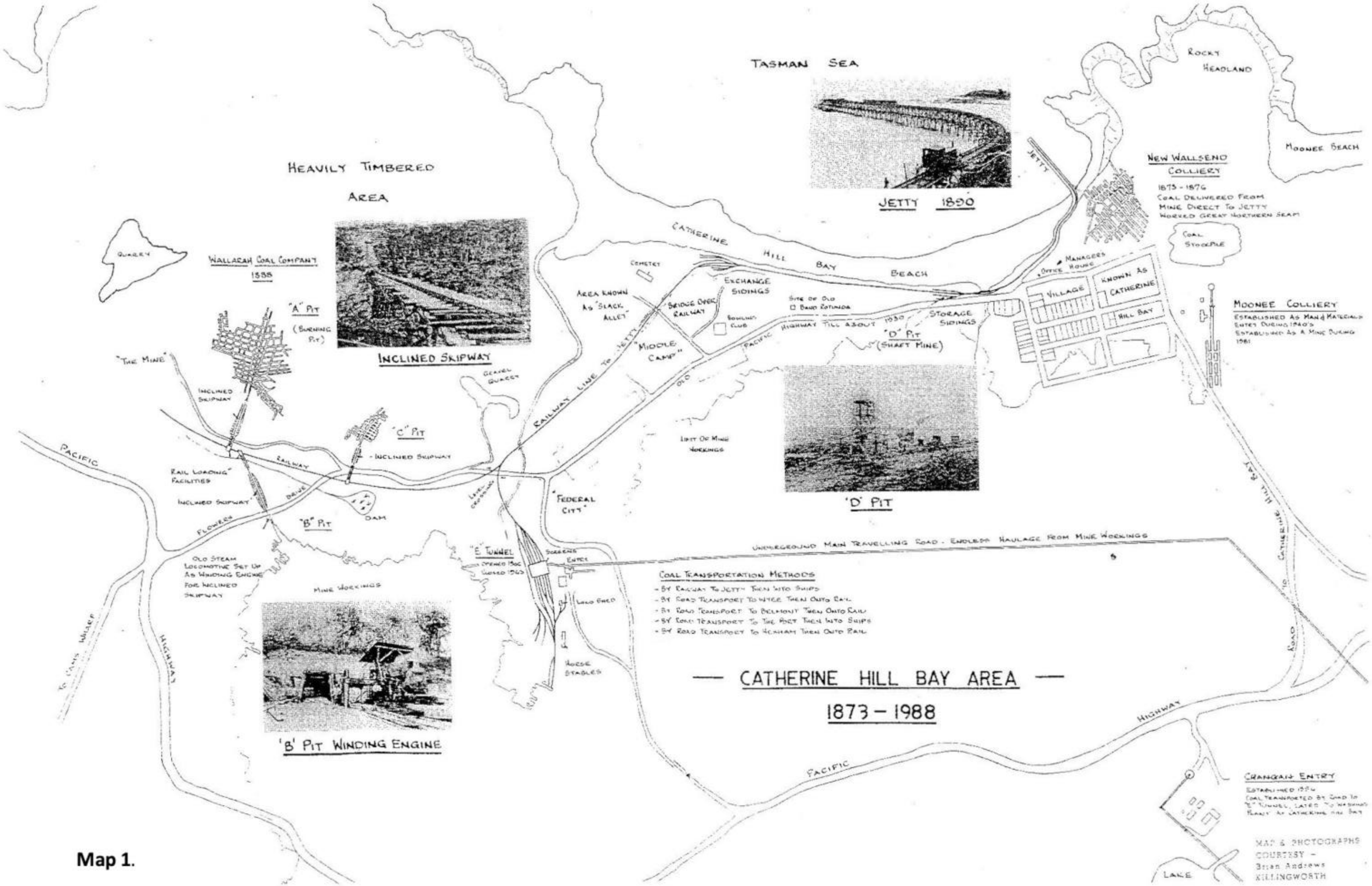


Figure 4. The large arrows show the direction from which the predominant sediment in that sequence was sourced. The marine shoreline prograded to the South during periods of LST. The Lochinvar Anticline (LA) is the western border of the Newcastle Coal Measures. The New England Orogen (NEO) supplies sediment from the North and the line of volcanoes in the East form the Offshore Uplift and the second sediment source. LST (Low Systems Tract), TST (Transgressive Systems Tract), HST (High Systems Tract). (Herbert 1998).

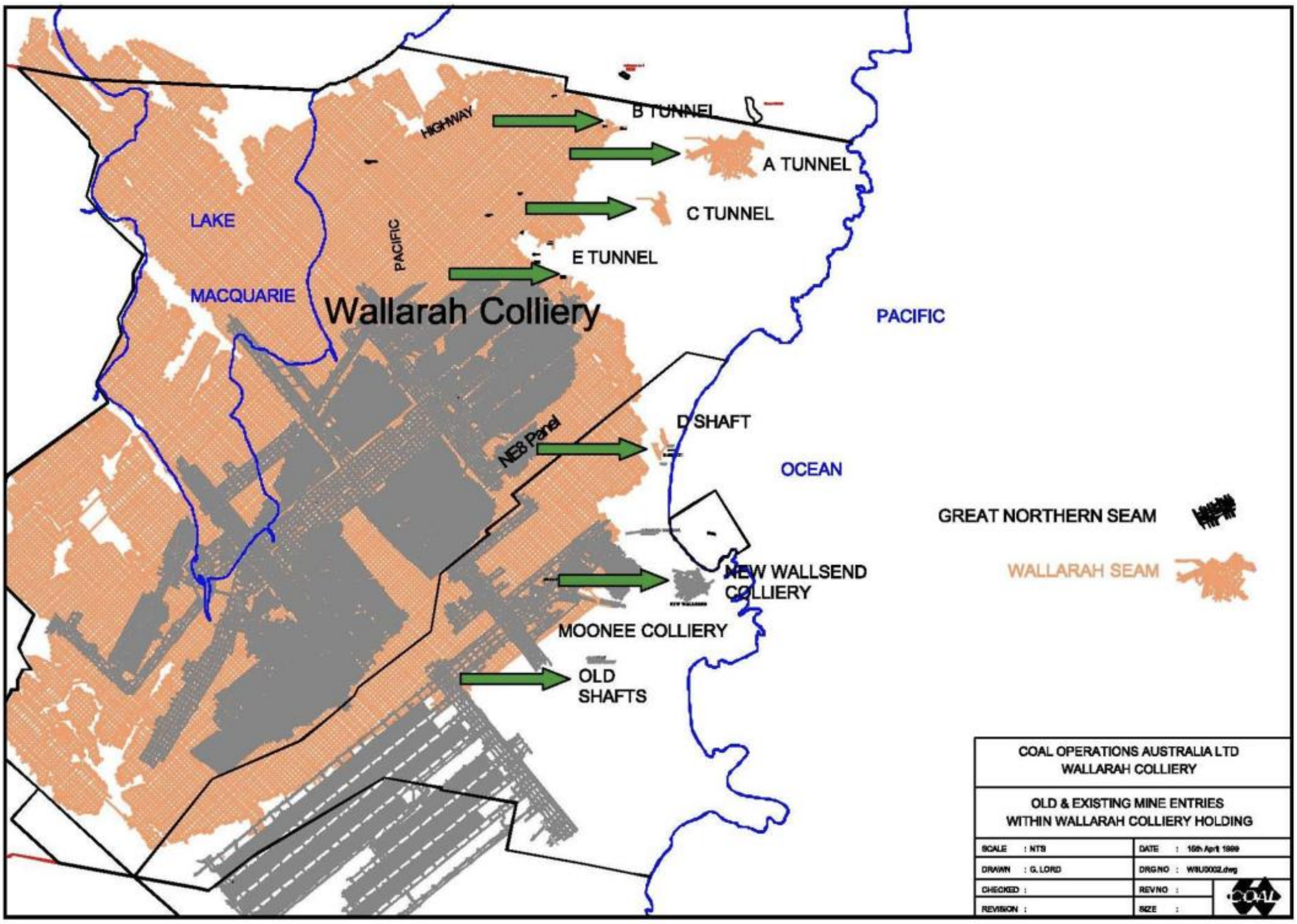
The New Wallsend Colliery.

Thomas Hale recognised the possibility of mining the Great Northern seam where it outcrops on the shore at CHB and shipping it directly by sea. He had previously begun a mine in a similar location in the Illawarra. After obtaining several partners, including Jacob Levi Montefiore, a member of the New South Wales Legislative Council and a merchant and financier, with extensive mining and pastoral interests, he began the New Wallsend Company in April 1873. The area mined can be seen in Maps 1 and 2 below. The workings covered a relatively small area of approximately 0.4 km^2.

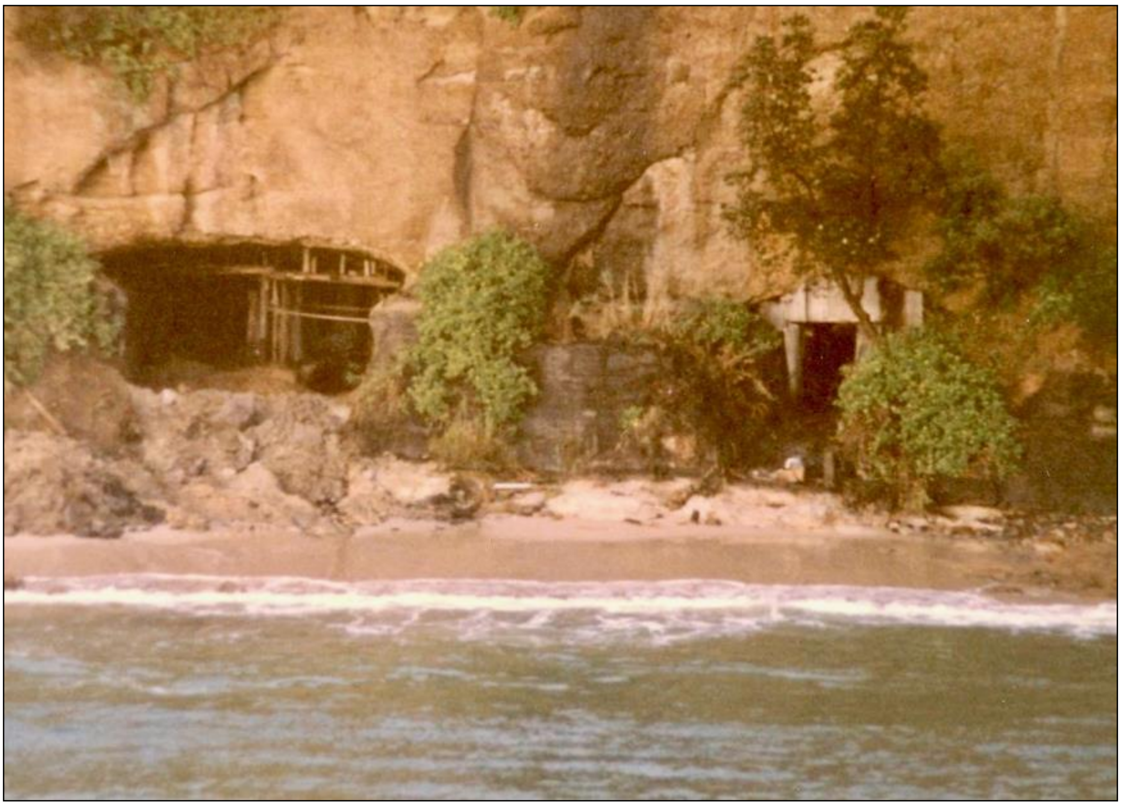


Map 1.

Map and photographs from East Lake Macquarie Historical Society Collection (ELMHS) and originally drawn by Brian Andrews



Map 2. Mine workings at Catherine Hill Bay. (Courtesy of the East Lake Macquarie Historical Society (Map from the ELMHS Collection)



1. The New Wallsend mine eventually had two openings on the beach. The Great Northern coal seam can be seen between the two shafts. (Photo from the ELMHS Collection).

2. The larger shaft remained opened after the colliery closed and at times fishermen used it to store boats. It was sealed with concrete in 2003. (Photo from the ELMHS Collection).

3. This photo shows the original wooden jetty and coal being loaded. (Photo from the ELMHS Collection).

The New Wallsend Company mined what became known as the Great Northern seam. As a profitable business it seems to have had fluctuating fortunes. About July of 1873 a tunnel had been driven on the edge of the beach *(photos 1 & 2)*, and within a further six months production reached about 300 tons per week and about 70 men were employed, 45 of whom were miners. The Newcastle Chronicle of 19th November 1874 reported that production in this mine had risen to 800 tons weekly.

Initially coal was transported by cart to Swansea but without formed roads this was difficult and a jetty was constructed out from the mine entrance *(photo 3)*. The rock platform and reef at its end stop all but the largest swells breaking here.

The New Wallsend Colliery was in existence from 1873 to 1876. Mining was suspended for three or four weeks after July 1875 following the loss of the Company's ship, the "Susannah Cuthbert". From that time the company's fortunes seem to have changed for the worse. Shipping became somewhat irregular, and maintenance of the jetty appears to have been a problem.

The Jetty had been built with inferior timber and the impact of the ships beside it caused it to develop a lean. On 4th March 1876 the shareholders met and decided to wind up their operations. No reasons appear to have been made public and the workings ceased on 15th March 1877. From this time the people living in the settlement left to seek work elsewhere.

When mining ceased in 1877 many of the people moved to Pelican Flat (Swansea). The Post Office and Postmaster were also transferred to there on 1st December 1879. Most of the houses that had been built by and for workers and for management were bought by a local developer and miner. They were transferred and apart from a few empty buildings the town was non-existent.

The Wallarah Coal Company Limited.

The Wallarah Coal Company Limited was formed in London in 1888 with the issue of 10,000 shares at £10 each, initial directions relating to the commencement of various projects was telegraphed from London to local official representatives.

Initially three hundred acres of land were purchased, presumably including the village and later the Company held 3,500 acres of freehold land for its mining purposes. The Company constructed and owned its own jetty and railway as well as having its own ships, and this, together with the quality and quantity of coal available made it successful for almost 70 years.

With the revival of work by the new company, the population began to increase again from 1889 onwards. By 1891, 164 men were employed, and in 1893 the population was reported to be 440 persons of whom 100 were attending school.

The initial pits, "A" 1888, "B" 1889 and "C" 1890 were all to the north and involved a walk of at least 3 km from the original settlement (see Map 1). As a result miners began to build huts and erect tents closer to these mines in the vicinity of Middle Camp and Mine Camp *(photo 4)*.

The entrance to "A" pit was located on the hillside above the railway and an inclined railway *(photo 5)* took coal wagons to the loading screens in the railway below. The descending loaded skips being used to haul the empty ones back up the incline and into the tunnel. "B" Pit was on the other side of the valley *(photo 6)*.

When the pits were closed the rail lines were removed and used elsewhere. The coal in "A" Pit caught

4. Miners houses at "Angels Rest" near "A" Pit. (Photo from the ELMHS Collection).

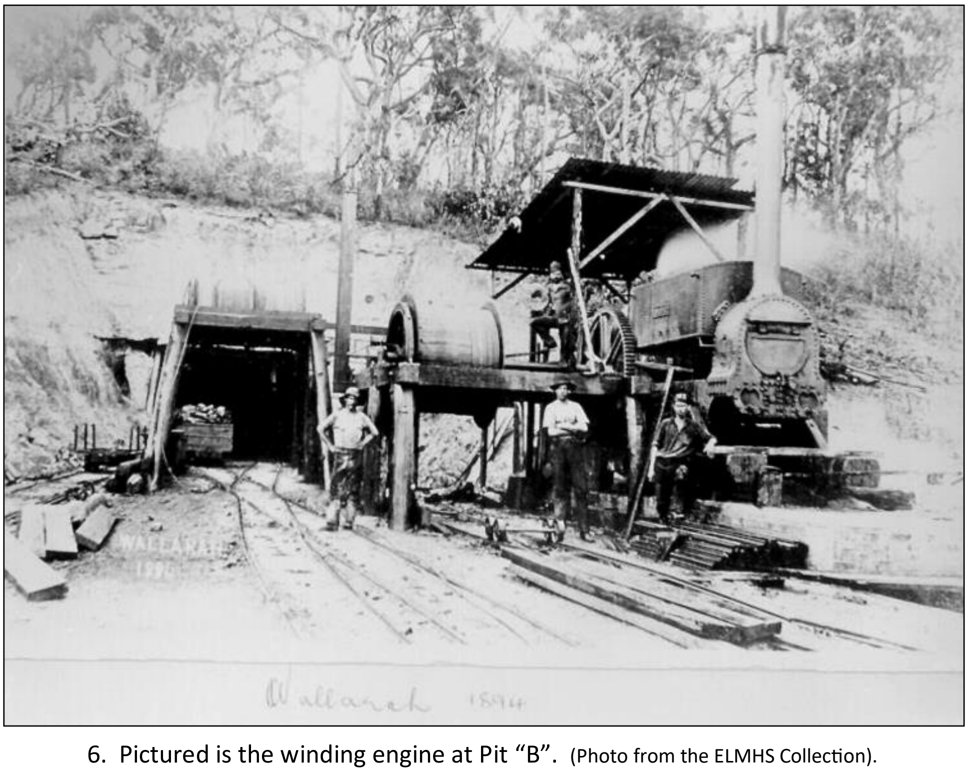
alight after the pit was closed and burnt for many years. When a radar station was built above it during the Second World War the operators could feel warm ground in places and see steam rise on cold mornings.

A rail line was built connecting the pits to the new jetty. A weigh bridge and water point were built into the line and these were located in a series of sidings near the Cemetery at Middle Camp. The sidings are labelled "Exchange Sidings" on Map 1. There were seven lines in the sidings and the weighbridge used a water balance mechanism.

In 1897 a fourth pit ("D" Pit) was developed right on the coast, beside the rail line *(photos 7 & 8)*. This, as for the other pits, mined the Wallarah seam. It only lasted a short time as it was very wet, closing in 1898.

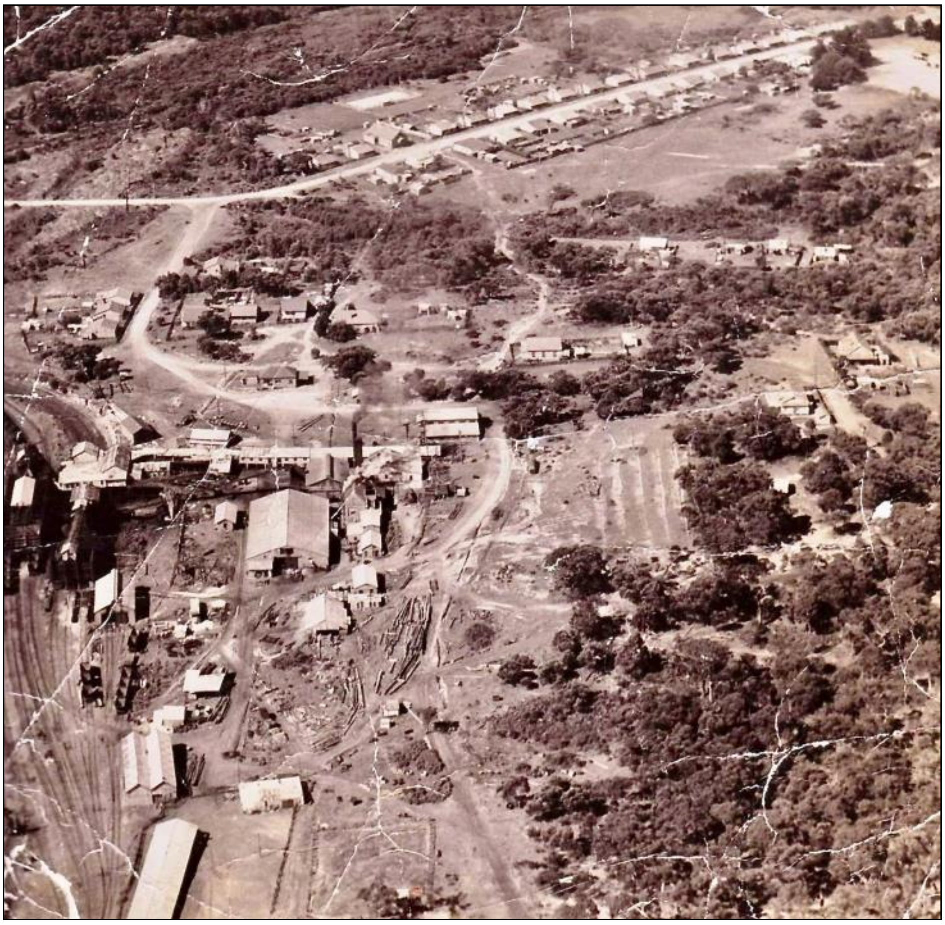
In 1906, a fifth mine known as "E" Pit was brought into operation and located near what was later to become known as "Federal City". For that year, production from "B" and "E" pits was recorded as

5. This shows the inclined railway from "B" Pit. Pit "A" is on the opposite side of the valley and the main railway at the bottom runs down to the right following the stream. (Photo from the ELMHS Collection).



6. Pictured is the winding engine at Pit "B". (Photo from the ELMHS Collection).

7 & 8. "D" Pit is shown on the left. The engine house was later converted to a home. In recent years it was known as "The Pines" and was burnt down in the 2013 wildfire. (Photo from the ELMHS Collection).



9. An aerial view of "E" Pit and the associated rail yard. (Photo from the ELMHS Collection).

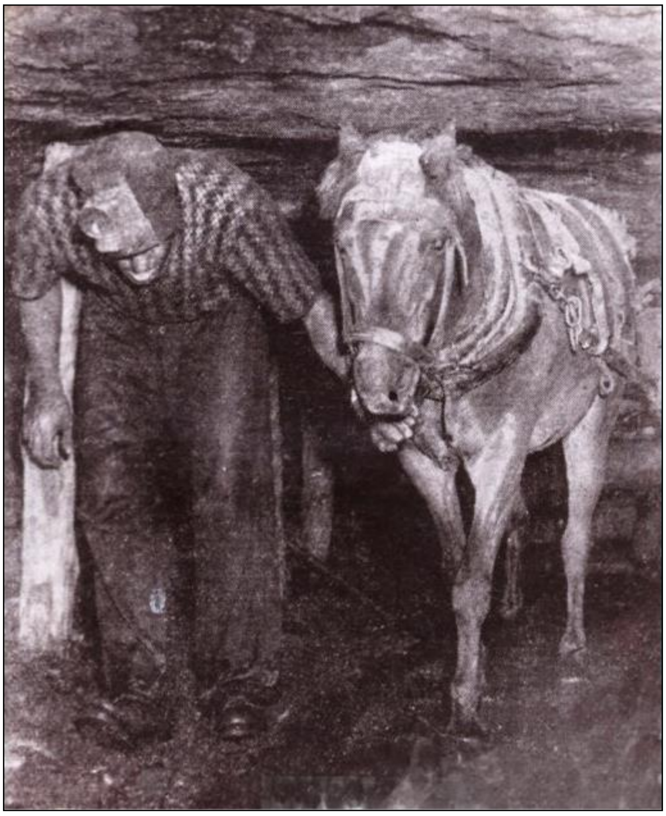
1,000 tons per day with 320 men employed. New screens for train loading operations were built at "E" Pit while those near "A" and "B" pits were removed, and the railway to them dismantled. "E" pit thus became the main coal producing location for many years. It closed in 1963.

Livestock.

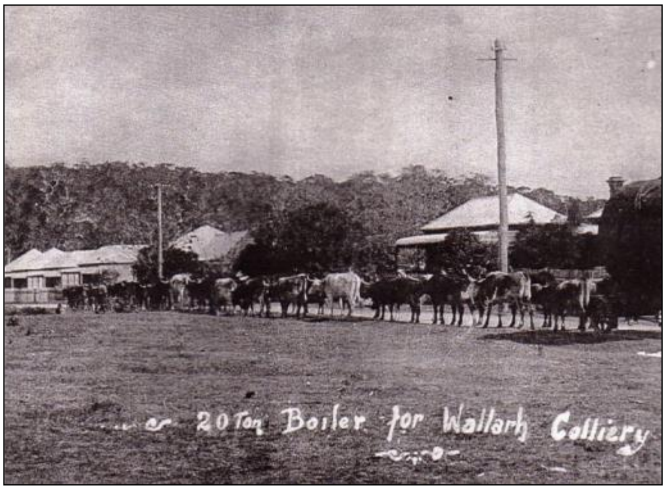
In the early years of mining horses and bullocks were used extensively *(photos 10, 11 & 12)*. The last pit horses at Wallarah were retired and slaughtered in about 1940 *(photo 13)*. Hauling heavy loads of mining machinery over unmade roads required large bullock teams.

At New Wallsend and Wallarah, unlike some areas in Europe, the ponies were brought out of the mine at the end of the day. There appears to have been a strong bond between horse and miner.

10. Bullock team operating at the Middle Camp sawmill. (Photo from the ELMHS Collection).



11. A pit pony being led through a low goaf. (Photo from the ELMHS Collection).



12. Bullock team pulling a boiler from Newcastle to Catherine Hill Bay. (Photo from the ELMHS Collection).

13. In about 1940 the use of pit ponies was discontinued. They were taken to Moonee Beach to be slaughtered. (Photo from the ELMHS Collection).

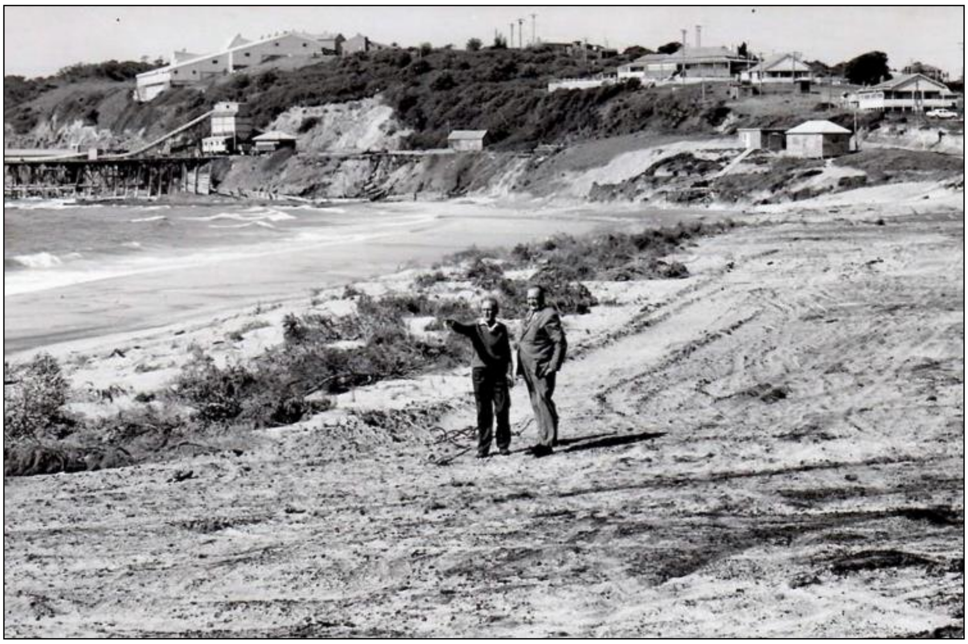
Mining post WW 2.

In 1958 a drift type mine was begun on the eastern shore of Lake Macquarie *(photo 16)*. Trucks were used to transport its output to a coal washing plant, and stock pile, on the hill overlooking the jetty.

Some coal was also transported by road to Wyee for distribution to other parts of the State. The extent of the workings are shown on Map 2.

Mining in the Wallarah and Great Northern seams continued from this entrance until 2002. It again used the Bord and Pillar method.

14. An aerial view of the Moonee Colliery The mine entrance can be seen in the top right. The ponds hold water from the Washery. Most of the land occupied by this part of the mine is now housing. (Photo from the ELMHS Collection).



15. In this photo the coastal rail line has been removed and a coal washery and loader built on the cliff top. (Photo from the ELMHS Collection).

The geology in the area, however, continued to create problems and expense. The tuff layers above and below the coal seams were very reactive and if the coal seams were mined to their full extent the roof would regularly cave in *(photos 17 & 18)*. Expansion of the tuff in the floor would cause "heave" weakening the pillars and also causing a roof fall.

The earliest instances of this occurred in 1874. In separate instances, falls of "top coal" killed two men in the New Wallsend mine.

Between 1874 and 1988 37 men were killed in mining accidents at CHB (ELMHS records).

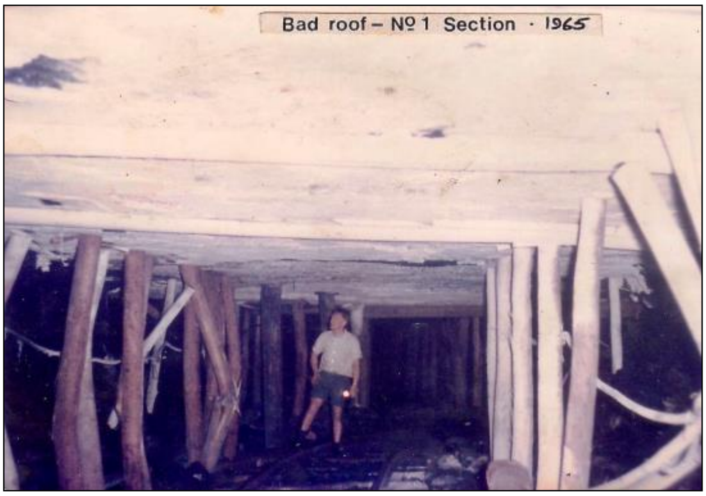
A solution to this was to leave coal on both the roof and floor and this is shown in *Figure 5*. It is shown in a Longwall setting.

An additional mine, the Moonee colliery began in the Wallarah seam in 1982. At the time the bord and pillar methods were too expensive for the market and so in 1992 when the mine was extended into the Great Northern seam Longwall Mining technics were used. The geology of the area again created significant challenges.

In the Longwall technique, as a continuous miner advances and removes coal from the face, the roof

16. The workings at Crangan Bay are shown here. Chitter from the abandoned workings were ignited in the 2013 wildfire and burnt for three months before fully extinguished. (Photo from the ELMHS Collection).

17. Expansion in a claystone roof (tuff) has warped the coal pillars. (Hayes, 2001).



18. Expansion in the claystone roof. (Photo from the ELMHS Collection).

created is supported by a jacked frame *(photo 19)*. The advancing miner leaves an open void, the roof of which begins to crumble and gently collapse *(Figure 5)*.

In many mines in the NCM massive layers of conglomerate above the coal seams do not crumble easily and large falls created "Wind Rush" or "Wind Blast". It was initially predicted that the void left in the conglomerate at Moonee would span 100 m and the roof would fall in "small lenticular shaped pods".

Instead, in the first goaf fall in the Moonee panel, an area of 20,000 m² 14 m high was involved. This created a wind in excess of 360 km per hour and damaged machinery and equipment. A second fall knocked over and injured 6 of the 19 men working in the area. Although the injuries were relatively minor the incident had a significant psychological impact.

As part of subsequent management safety scheme, miners had to wear protective suits *(photos 20, 21 & 22)*.

The most effective solution, however, was to implement hydraulic fracturing of the roof behind the continuous miner. After a 20 m advance holes were drilled into the roof and water was pumped into the holes. This produced fractures which allowed a safe collapse of the goaf. It was, however, a significant

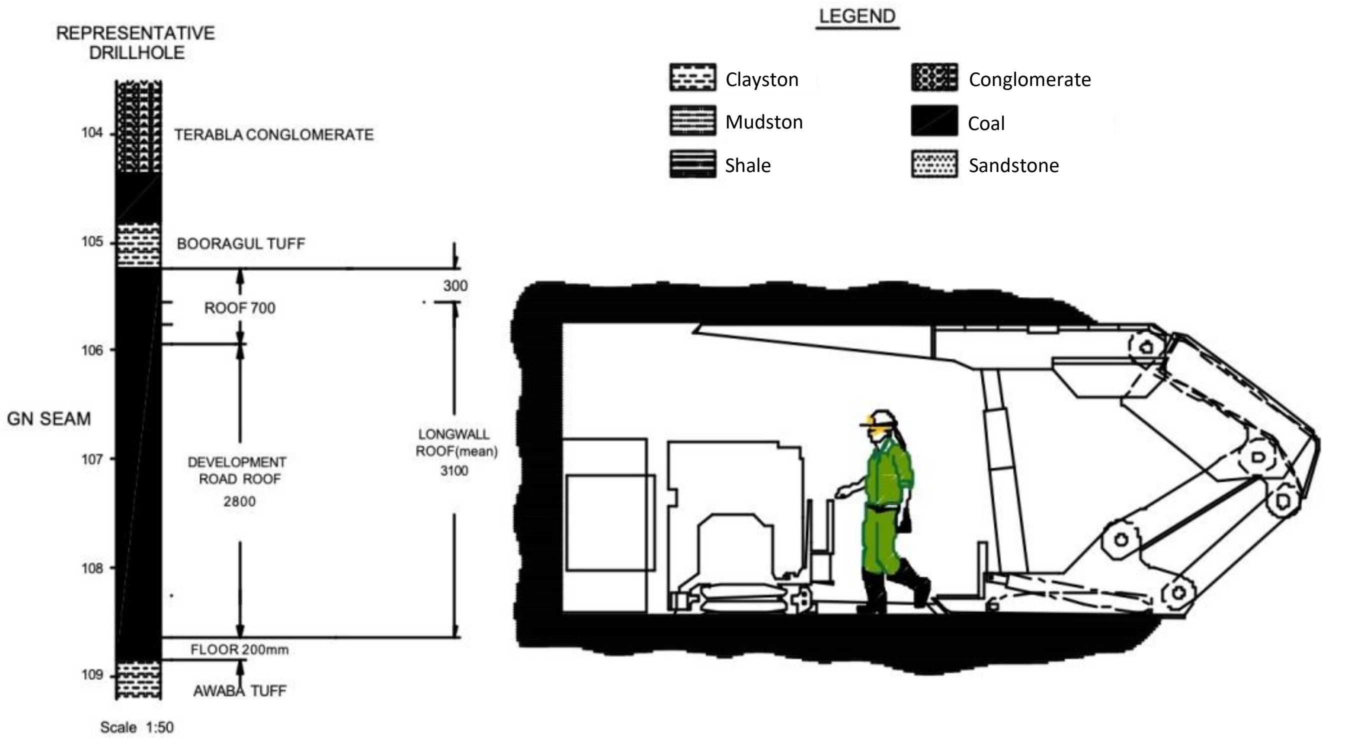
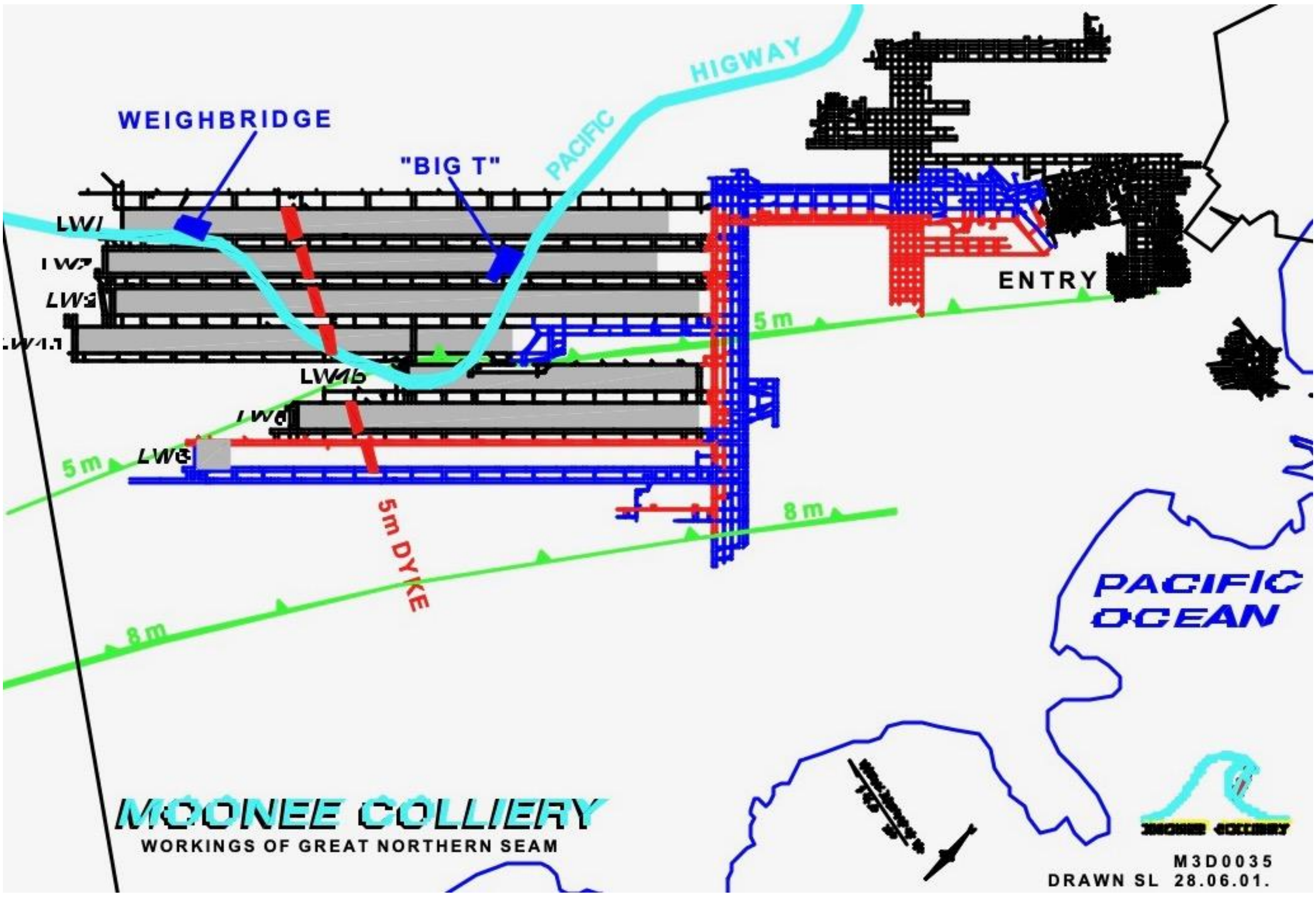


Figure 5. Sketch of a longwall miner operating in the Moonee Colliery with coal left on the floor and roof. (McDonell, 2001).



Map 3. Layout of the Moonee Colliery and major surface and geological features. (McDonell, 2001).

19. Continuous miner and roof supports used at the Moonee Colliery. (Photo from the ELMHS Collection).

additional cost.

Drilling into the roof was not without its problems as this article from the World Socialist Web Site says. "In the early hours of July 6 another name was added to the long list of deaths in Australia's mining industry. Anthony Carroll, a 39-yearold mine worker, was crushed to death in a roof collapse, at the Catherine Hill Bay Wallarah mine, near Swansea, in the Northern District coal fields of New South Wales (NSW).

Carroll and two other miners, part of a crew of five, were drilling holes for roof supports, after cutting coal within 10 m of a fault line in the coal seam. The cave-in occurred at approximately 4.45 am. Another miner, Tony Dickson, 26, of Charlestown, was pinned by the legs under tonnes of rubble for three hours before being freed. Luckily he only suffered a fractured ankle and abrasions. A third member of the crew, a mine deputy, narrowly missed being injured only because he had stepped back to get one of the 1.5 metre bolts used to secure steel straps across the mine's roof. "

20. A miner wearing protective clothing to combat the effect of Windblast. (McDonell, 2001).

Mine Subsidence.

This was an additional cost. Longwall mining can produce significant surface subsidence; falls of up to a metre were predicted and compensation/remediation was expected for three features above the mine. These were the Pacific Highway, The Big T Service Station and the 33 kv power transmission line. Modifications to the fuel lines at the Big T were undertaken and regular checks carried out on each feature.

Today there are places in the National Park with cracks in the ground from subsidence.

Fire and Explosions.

Fires and Explosions are a common problems associated with mining and transporting coal.

Firedamp is a mining term for a set of explosive gases found in mines. It's mostly made up of methane. Methane (CH4) is a colourless, odourless, highly flammable, and highly explosive noxious gas. It is found naturally in coal seams and shale deposits. Because it's much lighter than air it tends to accumulate at higher levels within enclosed spaces. Methane is only combustible at levels between 4 and 16%. Below that range there isn't enough to be ignited, and above that range the mixture is too dense (rich) to be explosive. All it takes is a naked flame or a spark from a machine to cause an explosion when these levels of methane are in


21 & 22. The scene at a longwall coal face before and after clothing was introduced. (Photos from the ELMHS Collection).

the air. Methane can also displace oxygen from the air and can cause asphyxia.

In 1898 virtually all miners used lights with naked flames for vision. To the north of CHB at Dudley a build-up of firedamp caused an explosion that killed 15 miners. From the inquiry an increased emphasis was placed on ventilation. At CHB the coal seams also produce less gas than in the Borehole seam that was mined at Dudley.

Spontaneous combustion however is a problem at all mines. When exposed to air coal oxidises and this produces heat that can cause it to ignite. When mining was discontinued in "A" Pit it caught fire. To prevent ignition it is necessary to reduce the heat e.g. flood the mine, or starve the coal of oxygen by sealing the workings. Ventilation can also cool the coal. Although "A" Pit was sealed this was not effective and the seam continued to burn into the 1950s.

Fires in stockpiles are a common problem when not managed well. In the miner's strike of 1917 a large amount of coal could not be transported and was dumped at Slack Alley *(photo 23)*. Without cooling it ignited.

23. Coal dump at Slack Alley alight during the 1917 miner's strike. (Photo from the ELMHS Collection).

Poor grade coal, termed "Chitter", could not be sold and has been dumped extensively throughout the CHB area and around the mines on the Central Coast.

Often covered with a layer of dirt many of these dumps were ignited during the 2013 wildfire. A chitter dump at the Crangan Bay mine entrance burnt for three months while it was being turned over by machinery. It could not be extinguished with water as the runoff would pollute the Lake.

The railway on the coast was regularly subject to wave attack and chitter was dumped to protect it *(photo 24)*.

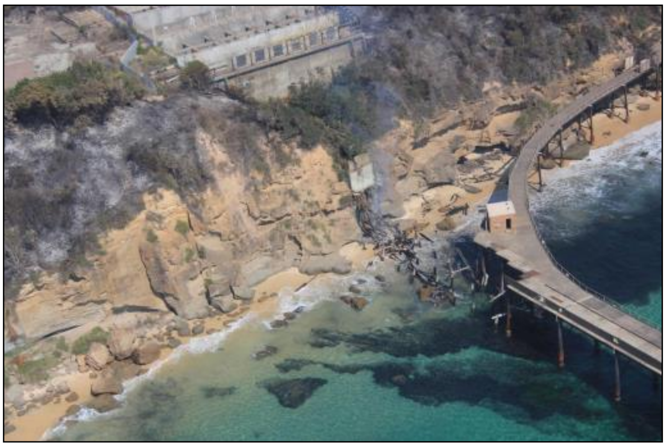
Chitter was also used as road base in various places and this resulted in loss of part of the Jetty in the 2013 fire *(photo 25)*.

The Jetties.

At CHB the rock platform and reef prevented the predominant south easterly swell from breaking beside it, in all but a gale or "black nor'easter". In June 1974 an East Coast low known as the "Sigma" storm damaged the second timber jetty and destroyed a large section at the seaward end *(photos 28 & 29*.

In Europe sites such as this, Norah Head and

24. When dumping coal onto the beach front in the 1930's a rail wagon was shunted too far and crashed onto the beach. It is being recovered by a bullock team. (Photo from the ELMHS Collection).



25. Coal from the loading chute in the cliff had been spilt onto the wooden jetty. This was ignited by falling embers during the 2013 fire. (Photo R Miller).

26. Coal chitter burning underground has collapsed the surface here. This occurred in several locations on the 2013 fireground. (Photo R Miller).

27. Temperature in the underground fire. (Photo R Miller).

Terrigal Haven would have had sea walls built to enclose a harbour.

The wooden structure was replaced with steel. A steel frame was erected first at the seaward end and a Bailey bridge was then placed to span the gap to the damaged sections *(photos 30 & 31)*. Temporary supports were used as steel legs were erected underneath. After each section was completed the Bailey would be repositioned to allow work to be carried on towards shore.

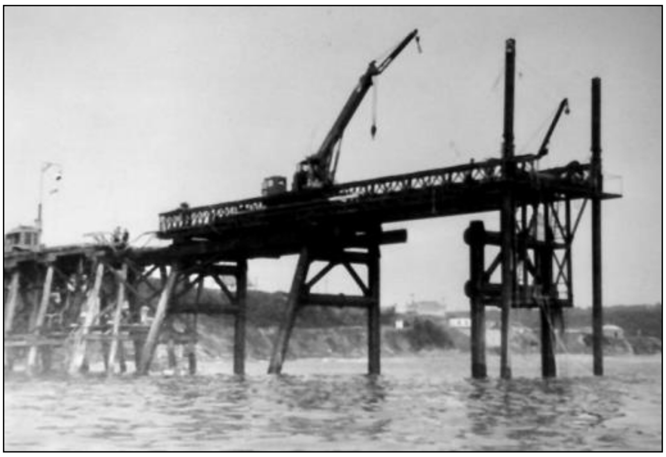
The pile frames were prefabricated on shore and floated to the jetty and then fitted into pockets that had been cut into the sea floor. The girders were then lifted into place and the process repeated shore wards. Concrete slabs for the deck were poured at Teralba and brought to site by sea and a conveyor system was installed, starting from the coal loader.

The Moonee Colliery, was opened in 1982 as a new mine in Wallarah seam. It was placed in care and maintenance in 1992. In 1996 it was re-opened as longwall in Great Northern seam. It operated until 2002. Much of the mining infrastructure has been

28 & 29. Debris from the damaged wooden original jetty strewn on the foreshore. (Photos from the ELMHS Collection).

removed and replaced by new housing developments. During the 2013 wildfire the Mine Managers House, the Jetty Masters House, "The Pines" and a former gaol cell for the Police Station were burnt.

Lake Macquarie Library has an excellent website on the Social History of the houses of Catherine Hill Bay. This details most of the buildings and the people who occupied them. It can be found at https://socialhistorychb.md1729.com/



30 & 31. A Bailey bridge was used to repair and rebuild the second jetty. The wooden frames were replaced with steel. (Photos from the ELMHS Collection).

References.

COOK, T. (1988). *World Socialist Website*. https://www.wsws.org/en/articles/1998/07/mine-j09.html.

DIESSEL, C. F. K. (1992). *Coal-bearing depositional systems*. Springer-Verlag Berlin Heidelberg.

DIVER, M. *The Coal Loading Jetty at Catherine Hill Bay*. Records held by the East Lake Macquarie Historical Society. PO Box 284 Swansea NSW 2281.

DIVER, M. *Historical Facts about Catherine Hill Bay*. Records held by the East Lake Macquarie Historical Society. PO Box 284 Swansea NSW 2281.

Historical Research at Catherine Hill Bay. Records held by the East Lake Macquarie Historical Society. PO Box 284 Swansea NSW 2281

FERGUSSON, C. L. (2019). *Subduction Accretion and Orocline Development in Modern and Ancient Settings: Implications of Japanese examples for development of the New England Orogen of eastern Australia*. Journal of Geodynamics, 129 117-130.

HAYES, P.J. (2001). *Towards High Productivity Under a "Claystone" Roof: Great Northern Seam Support, Management Experiences at Chain Valley, Moonee and Wallarah Collieries*. Proceedings of the 2001 Coal Operators' Conference, Mining Engineering, University of Wollongong, 18-20 February 2019.

HERBERT, C. (1998). *A new look at the Newcastle Coal Measures – Two contrasting approaches to their formation and sequence stratigraphy*. Notes for a Field Trip, originally held Friday April 3, 1998, for the 32nd Newcastle Symposium on Advances in the Study of the Sydney Basin.

HUTTON, A. C. (2009). *Geological Setting of Australasian Coal Deposits*. https://ro.uow.edu.au/scipapers/733

LAKE MACQUARIE LIBRARY. *A Social History of the Houses of Catherine Hill Bay and the people that lived in these houses*. https://socialhistorychb.md1729.com/

Mc DONELL, S. (2001). *Longwall Mining beneath the Pacific Highway. Moonee Colliery – An Overview*. Technical Services Coordinator Moonee Colliery. 42nd Australian Surveyors Congress - A Spatial Odyssey.

The Geology and Geomorphology of Catherine Hill Bay and its influence on mining and settlement - Morning Session.

Leader: Rick Miller.

On arrival the group heard a brief history of mining in the area. Coal was known to be in the area from 1830 but mining by Europeans did not begin at Catherine Hill Bay until 1873. In 1830 Captain Reid was sent to Newcastle to collect coal but he mistook Moon Island for Nobbys Head and landed at Swansea Heads. He found coal on the headland in exposed seams and the area initially became known as Reid's Mistake.

Mining at Lake Macquarie was initially delayed by a government monopoly given to the Australian Agricultural Company and when begun by Rev. Lancelot Threlkeld (Coal Point 1840) and the Murray Brothers (Murrays Beach 1863) it was made uneconomic by the shallow bar at Swansea Heads. This limited the size of vessels that could transport coal or meant loading them off shore from lighters.

The completion of the Sydney/Newcastle Railway in 1889 was the end of Lake Macquarie as an economic coal export port.

Coal, however, was in high demand in the latter half of the 19th Century. The increase in steam power for both manufacturing and transport and the rapid population growth initiated by the Gold Rush were the main driving factors.

From the lookout the group could see the village of Catherine Hill Bay. These and features in Catherine Hill Bay (CHB) area are named after significant people in the development of the first mine.

Thomas Hale was a successful watchmaker who was advised to move out of Sydney for a healthier country life style. He bought a dairy farm near Wollongong and, finding that his neighbour had a coal seam on his property, persuaded him to start a mine. As part of this Hale built an earth ramp and railway down to a jetty on the coast. He sent samples of coal to England, Shanghai and San Francisco and these were well received as steaming coal. Unfortunately his partner died and the business was discontinued. Seeking another opportunity, Hale began a search of the coast. He wanted a similar site, with coal situated close to a sheltered anchorage and so he came to Catherine Hill Bay.

Montefiore Street is named after Jacob Levi Montefiore, a trader, banker and owner of multiple grazing properties. His family was connected to the Rothschild banking family who financed many European Governments. Montefiore and Hale took out a mining lease on the southern end of CHB in 1873 and developed the New Wallsend Mining Company. Lindsley Street was named after one of the Company's principal shareholders, John Lindsley. Clarke Street was named after the Rev William Branwhite Clarke who was an Anglican clergyman and a geologist. He is credited with first measuring the Great Northern coal seam at Catherine Hill Bay in 1865.

Just to the north of the town the creek is named after the first mine manager Anders De Flon.

Due to under capitalisation, damage to the jetty and the loss of the steamer, the Susannah Cuthbert, this coal mining venture collapsed.

The Wallarah Coal Company followed in 1888. It was largely instigated by Charles Parbury. He was the son of a Sydney trader and wharf owner and he saw opportunity to develop business in the Lake Macquarie area. He began purchasing land and in 1865 he petitioned the government to allow expansion of the coal and timber industries by building a break wall and dredging the Swansea bar.

After the partial success of the New Wallsend mine, Parbury, who had moved to London, used the mining provisions of the Robertson Land Act 1861 to select the coastal land between CHB and Swansea.

In 1888 he raised funds, employed a manager, hired a team of English miners and sent them to begin a new mine; the company was called the Wallarah Coal Company.

Thomas Parton, the mine manager surveyed the coal seams and, rather than continue with the Great Northern seam at sea level, he chose to mine the Wallarah seam. The site chosen for A Pit was about 3 km north of the original mine. He built a second jetty, close to the first, as this still provided the most sheltered anchorage. Continued industrialisation, mechanisation and electrification made the mine a success, despite the downturn in the 1890s. For example electric light began in Sydney in 1909 and electric trams in 1930 (these were powered by the White Bay Power Station).

The geology and geomorphology of the area influenced Parton's decisions. The seam chosen was approximately 2.5 m thick, with no bands of ash and easy to hew. It outcropped on a hillside and this made transport easier.

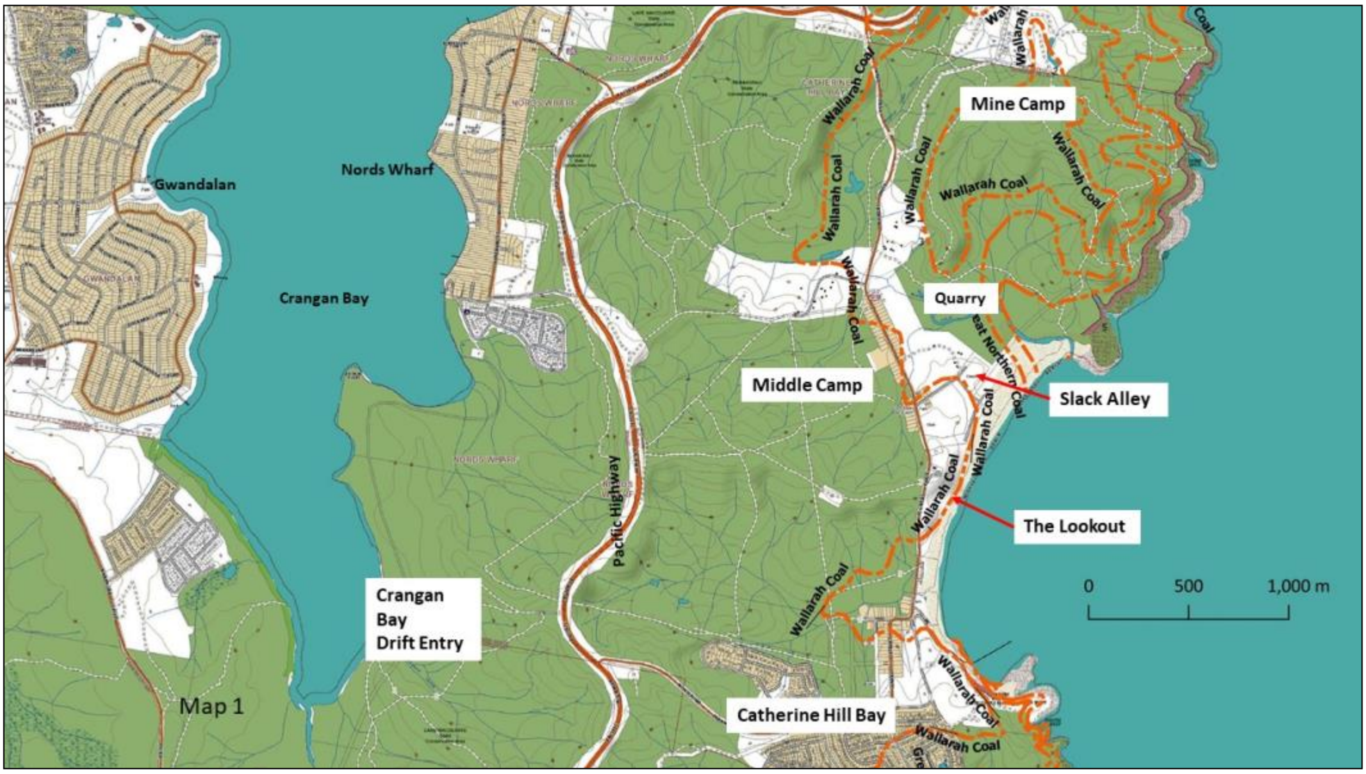
A settlement known as Mine Camp developed near the new pit *(Map 1)*.

At the lookout meeting place the group was standing in part of the Sydney Basin and on a segment of the Hornsby Plateau. Immediately below us were rocks from the Newcastle Coal Measures. The group heard a brief summary of the present landform development.

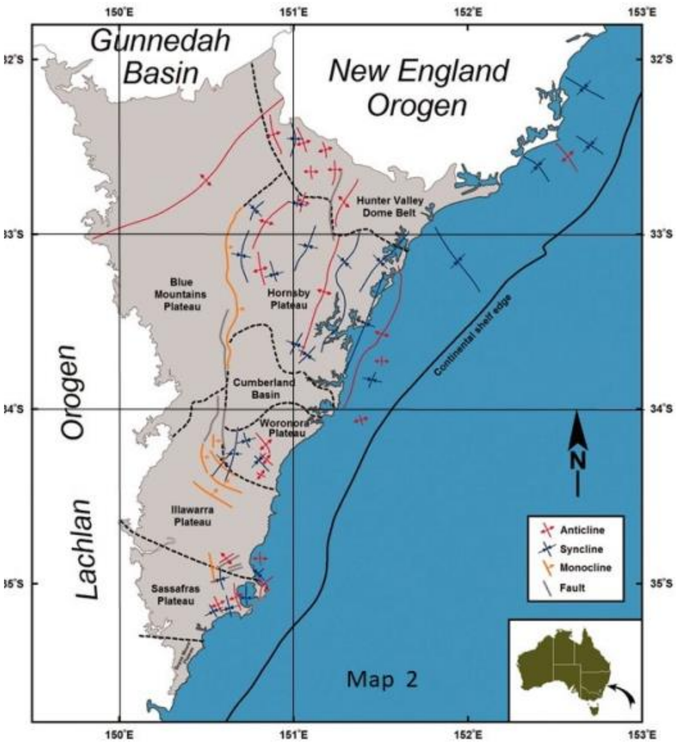
As was suggested in the pre-trip notes (Ferguson 2019) the Sydney Basin began to be formed about 300 Ma.

Between about 260-250 Ma a west dipping subduction zone was re-established off the coast and compressive force led to the formation of the Lochinvar Anticline, the Macquarie Syncline and an offshore uplift that was associated with a volcanic arc. *(Maps 2 & 3).*

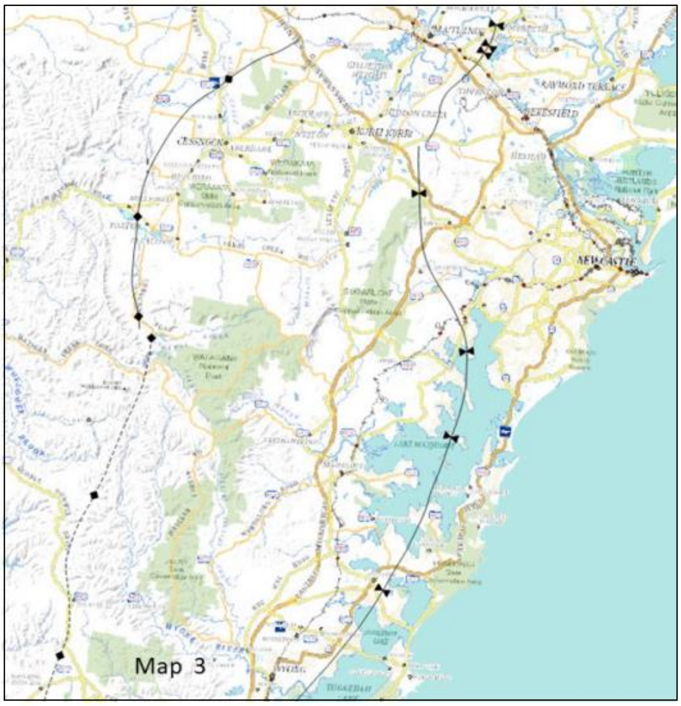
Sediment from highland of the New England Orogen and the off-shore uplift flowed into the Macquarie Syncline. The Lochinvar Anticline and its southern extension, the Kulnura Anticline separated the



Map 1. Catherine Hill Bay and Surrounds. (Prepared by R Miller).



Map 2. Structure of the Sydney Basin. (Source: Gale 2020).



Map 3. Location of the folds developed during the re-establishment of a west dipping subduction zone off the coast between 260 – 250 Ma. (Prepared by: R Miller).

flow of sediment and ultimately the Newcastle and Western Coalfields.

The Macquarie Syncline slopes down to the south and uplift in the New England Orogen (NEO) produced two large alluvial fans separated by the Lochinvar Anticline. The Newcastle Coal Measures were formed on an eastern delta and so had the same slight fall to the south.

Johnson (1974) studied the relationship between the structural evolution of the Macquarie Syncline and sedimentation in the Moon Island Beach sub-group. He says that in the lower sections of the Macquarie Syncline *(see Map 4)* and during the deposition of the sediments and coals of the Moon Island Beach Sub-group, a persistent pattern of tectonic subsidence existed. In the southern end of Lake Macquarie this produced two areas of subsidence to which he gave the names Chain Valley Bay Depression and the Wyong Slope. These were separated by a low rise that he termed the Wyee Saddle.

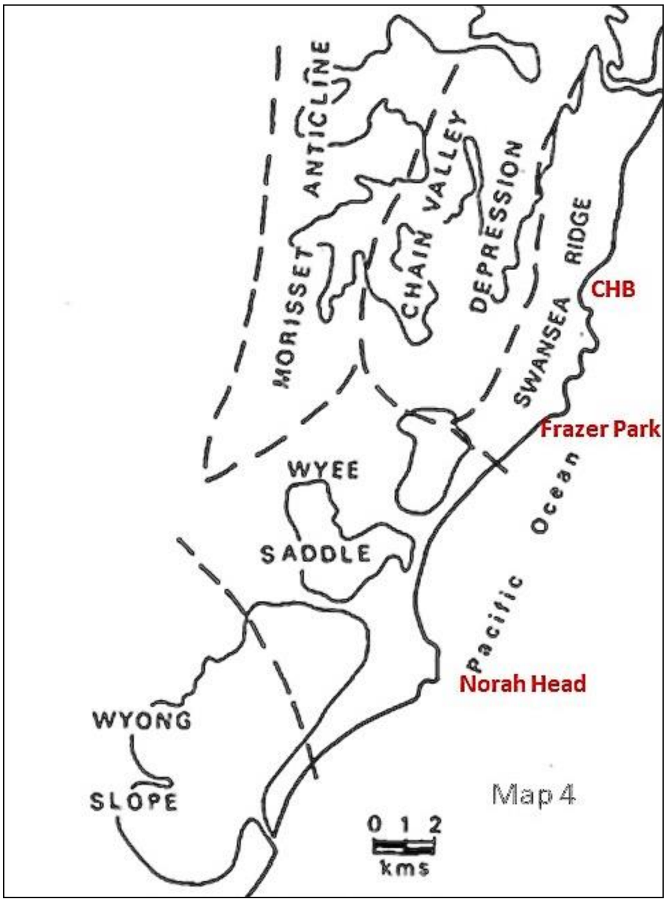
This regional tectonic subsidence pattern had two parts: one a weak planar component dipping slightly to the northeast, and the other a synclinal subsidence pattern trending to the north-northeast.

The subsidence influenced the deposition of coal seams in the Moon Island Beach Sub-group. He plotted the base and thickness of the Wallarah, Great Northern and Fassifern seams and found, for the latter two, that they dipped along the syncline and thinned towards the Wyee Saddle. The great Northern seam thickened towards the Saddle *(Map 4)*.

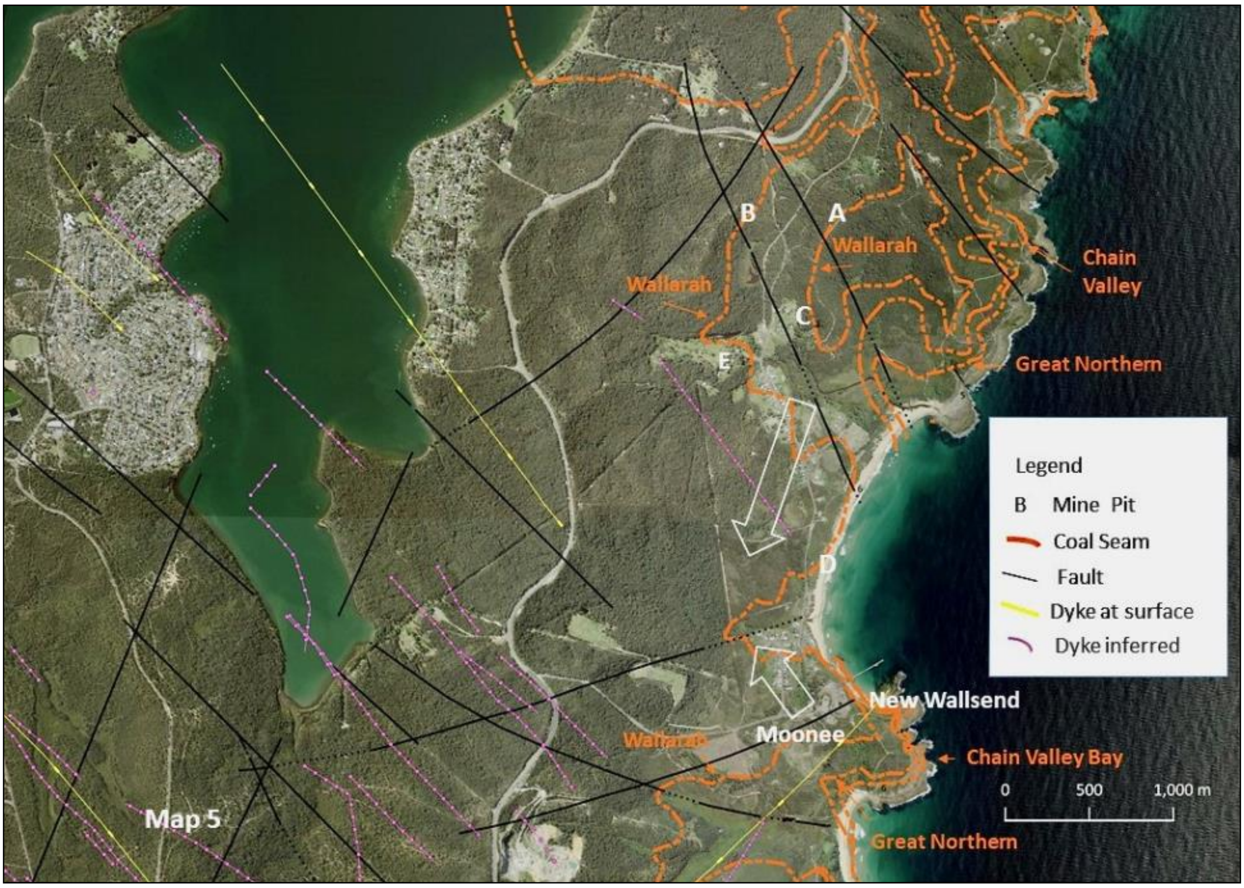
He believes that the supply of sediment from the north overcame the rate of subsidence and that, while it did not create a noticeable topographic feature, it did, however, influence the subsequent drainage pattern.

In the CHB area the coal seams also appear to have a pattern of subsidence. The Wallarah seam is under the beach below the lookout but in the vicinity of the first and second pits mined by the Wallarah Coal Company. it is approximately 50 m A.S.L. On the headland at CHB (Hales Bluff) the seam is found at approximately 40 m A.S.L.

The subsidence is associated with a number of faults. *Map 5* shows those in the area of CHB and that



Map 4. Structural elements of the lower Macquarie Syncline. (Source: Johnson (1974).



Map 5. Structural geology and coal seams at Catherine Hill Bay. The arrows show direction of dip. (Prepared by R Miller from NSW Seamless Geology and QGIS).

these trend mostly to the north west or north east. They are also associated with a large number of dykes (Ziolkowsky 1978). The large north easterly trending fault on the Hales Bluff Headland is responsible for exposing the Great Northern seam at sea level.

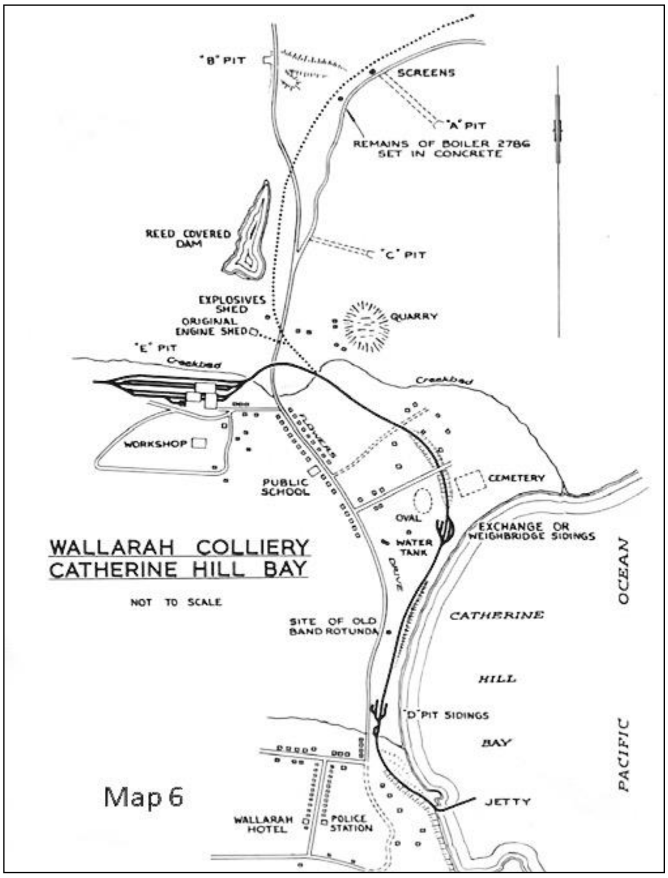
Coal is formed when plant material accumulates in swamps faster than it can decay. When it is covered by sediments, their weight compacts the layers of organic material, increasing both the temperature and pressure in the bed. This leads to physical and chemical changes in the plant material. Water, carbon dioxide and methane are produced and escape, so the material becomes progressively enriched in carbon. With increasing time and higher heat and pressure, the plant material forms first into peat; is then converted into brown coal (lignite), then sub-bituminous coal, bituminous coal, and lastly anthracite. It takes at least 10 m of peat to create 1 m of coal.

In the Newcastle Coal Measures (NCM), coal was formed on a combination of coastal marshes, floodplains and deltas.

The NCM were also formed with two sources of sediment. Erosion in the highlands of New England Orogen fed sediment into the Macquarie Syncline. This was predominantly in braided rivers and produced large deposits of conglomerate. On its eastern side a line of volcanoes shed sandy and muddy, dominantly volcanic, detritus into the basin via streams that fed paralic and lacustrine deltas. Volcanic explosions deposited thick layers of ash (tuff) that covered all or part of the peat beds and ended further coal formation or provided the base on which further beds could form.

Ash falls, over bank flooding and channel movements could remove, thin, or split coal seams. For example the Wallarah seam near Caves Beach is split into three strata and on the rock platform at CHB the Chain Valley coal is split by the Bolton Point Conglomerate.

In other places erosion has meant that coal seams have coalesced. This has occurred in the area under Chain Valley Bay where the Great Northern and Fassifern seams have joined.

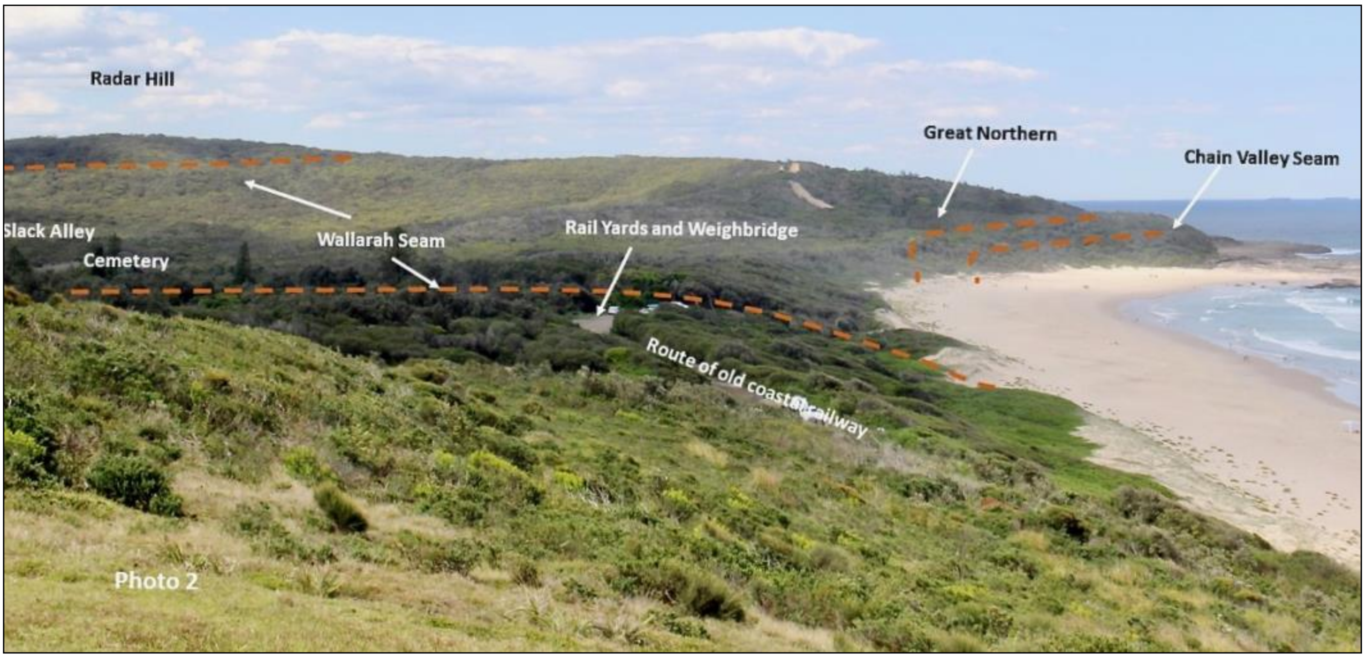


Map 6. Pre-1960s infrastructure and settlement Bay associated with the Wallarah Coal Company at Catherine Hill. Slack Alley is shown by the buildings just north of the cemetery. (Source: NSW Government Planning Portal).

Mining at CHB began near the coast with the New Wallsend mine *(see Map 5)*. The Wallarah mine began with A Pit in the north and progressed to the south and towards the Lake and Macquarie Syncline.

Map 6 gives at outline of the pre-1960s

1. Looking south from the CHB Lookout. The dotted line shows the approximate position of the Wallarah seam. (Prepared by R Miller from NSW Seamless Geology).



2. Looking to the north from the Lookout at CHB. The dotted lines show the approximate position of coal seam outcrops.
(Prepared by R Miller from NSW Seamless Geology).

3. This tank is visible from the Lookout. It was used to re-water locomotives on the line below.
(Source: The East Lake Macquarie Historical Society Collection).

infrastructure and settlement associated with the Wallarah Coal Company.

Looking to the south from the lookout the group could see the original Catherine Hill Settlement and the site of the New Wallsend mine near the 1974 jetty *(photo 1)*.

To the north the group could see the break of slope points associated with the coal seams *(photo 2)* and also part of the route occupied by the coastal railway that was built by Parton to take coal from A and B pits to the jetty *(photo 3)* .

The group then travelled north through Middle Camp to Slack Alley *(Map 1)*. "Slack" is a term for coal dust or very small coal. The area was beside the rail line and often used to store or dump coal.

Many of the houses in the three settlements were built and owned by the Company. Often they were built and rented to groups of single male miners. As families

5. One of the three remaining houses in Slack Alley. Most houses were original weatherboard and later covered with fibro sheets. (Source: R Miller).

6. Tent camp for the 400 strike breakers enlisted by the NSW Government and housed near Slack Alley. (Source: The East Lake Macquarie Historical Society Collection).

were established there were often up to 10 children in some of the houses that we see along the route.

In Slack Alley several miners built their own houses with permission on Company land. They paid rent for the sites. Most have been pulled down and the remaining can't be sold by the present owners because they don't own the land.

Mat Diver, in his pamphlet Historical Facts About Catherine Hill Bay, says "Single men gaining employment at the pit had two choices to find accommodation; to board with another family or at the middle camp boarding house *(photo 4)* opposite Wallarah

4. The photo shows the inhabitants of a boarding house for miners in the village of Catherine Hill Bay. Overcrowded housing was an issue during the management of the Wallarah Coal Company.
(Source: The East Lake Macquarie Historical Society Collection).

Hall, or to knock-up a "'batch" off the main road, built with bush timber and any other materials, brattice, cement, corrugated iron, etc., that could be scrounged from the pit.

There were many such "batches" at the bay, not owned by the company, but on company land. These were not sold in 1964 when the Wallarah Coal Company sold the houses to the tenants.

Company houses, mainly hardwood timber milled at the pit, comprised four rooms initially, about 30 feet wide, (9.2 metres) and 24 feet deep, generally having a "front room" main bedroom, second bedroom and a small kitchen with an open fire. In the 1930's a cast iron simplex or Metters stove was provided by the company. Rents would go up about 1\6d a week (forever) to cover that capital cost.

To most houses, two back rooms were added by the company in the 1920's, some being converted to a rough bathroom, and some tenants "closed–in" the front veranda to house the growing family.

The floors were of four inch wide hardwood Cooranbong timber, no tongue and groove, the walls all lined with lining boards, 3 to 4 inches wide, with a lath to seal the edges.

Looking back, it is a wonder of memory to understand how families of two or more adults and say six or seven kids were housed there-in *(photo 5)*.

Industrial action was common over the history of mining in the area and Slack Alley played a significant part. One of the first disputes was over the wages of the English miners enlisted by Parbury. They had signed contracts to work at wages set by the company and these were below what was current in NSW.

During WW1, in 1917, there was a strike by rail workers when the government introduced a time card monitoring system; they were supported by the miners at CHB. The government enlisted 400 patriotic volunteers/scabs to work the mines at CHB and housed them in tents at Slack Alley *(photo 6)*. The response of the miners was a train derailment and an attempt to blow up the jetty

There were strikes in 1933 and a nationwide strike in 1949. Much of the coal mined by the strike breakers was left in huge dumps in Slack Alley. The miners refused to touch this coal or load it onto the ships. The dumps would spontaneously catch fire emitting toxic smoke, creating a nuisance to the women whose lines of washing would suffer and occasionally leading to falls by children playing on them.

In 1924 there was strike over poor housing. Most workers houses had no bathrooms. Running water was connected to the houses of management, but not to the workers houses. The group of management houses on the hill at Mine Camp was known as "Snob Hill". If improvements such as an extra water tank or stove were made the rent would be increased.

In 1929 a State-wide lockout occurred over attempts to reduce wages and introduce mechanisation as the Depression began. Tensions increased after the Rothbury Riot and mechanisation continued to be an issue.

Full mechanisation was achieved at CHB in 1937. In 1958 after the mines were sold to Coal and Allied, the Crangan Bay entrance was developed. At this time 200 miners were sacked and a 203 hrs stay in strike was begun.

From Slack Alley the group then travelled to the intersection of Mine Camp Road and Flowers Drive. The A Pit was approximately 500 m up Mine Camp Road, on the right. Apart from the earthen ramp for the railway very little remains of this mine. The site of the village built by and for the miners is just before the gate on the National Park boundary. During WW 2 buildings were erected here to house the personnel for a radar station which was used for the defence of Newcastle. The buildings were removed at the end of the war but part of the radar instillations remain on the hill above.

At the end of WW2 the mines of NSW had been run down and, with post war growth, coal was in short supply. The NSW Government established the Joint Coal Board in 1945 to encourage improvements in mine safety and conditions. It also sought to identify areas of coal that could be quickly and cheaply mined. Flowers Drive was named after a resident of CHB who was also a Director of the Joint Coal Board.

The group visited a small open cut quarry *(Map 7 & photo 7)*. Here examples of the coal from the Wallarah seam could be examined. The characteristics of coking coal and steaming coal were also explained.

The physical and chemical properties of coal vary quite dramatically. They emit volatile substances as they are heated. These volatiles are in the form of methane (CH_4), carbon dioxide (CO_2), carbon monoxide (CO), free nitrogen (N_2) and hydrogen sulphide (H_2S). As they are emitted the carbon content of the coal increases. The coal also has the potential to become fluid with rising temperature.

Low rank coals emit their contained volatiles at low temperatures, prior to any melting, and produce a crumbly powdery residue. High rank coals emit their volatiles at high temperatures.

Medium rank coals, however, emit volatiles at the same temperatures at which they become fluid. This coincidence causes the coal to froth. The weakly resistive liquid coal material fills with bubbles to form an expanded, carbon-rich material with a large surface area and a strong resilient framework known as 'coke', which is used predominantly in the smelting of iron ore." (Beeston 1995)

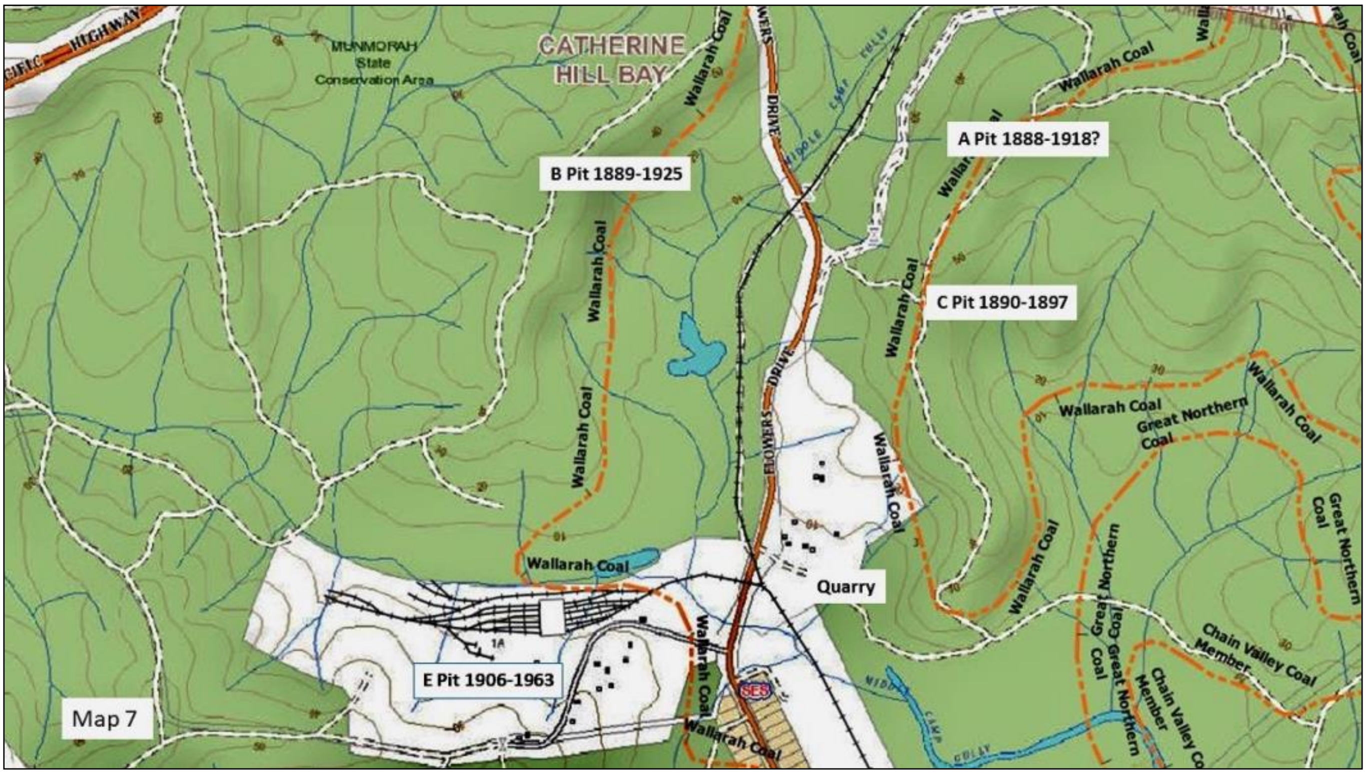
The air holes are an advantage in steel making using blast furnaces. They expose a greater surface area to the hot air as it is blasted into the furnace The hot air reacts vigorously with the coke, which is mostly carbon and produces carbon monoxide, this in turn, reacts with the iron oxide to produce carbon dioxide, metallic iron and slag.

The next stop was at E Pit, off Colliery Road. Photo 8 shows the present view seen by the group. This will be part of the next stage of housing development.

The machinery shed in the left *(photo 8)* is the one remaining building from the E Pit workings. The Pit entrance was in the left of the photo and coal was conveyed downhill to rail yards on the right. The red dot on photo 9 shows were photo 8 was taken from.

The final stop for the first session was a walk along the beach from the Surf Club to the north and passed the site of D Pit.

Photo 10 shows how the strata dip towards the south. The Wallarah seam is under the beach and it was into this that D Pit was dug. It is likely that bores were also sunk to investigate the Great Northern seam below it. The mine was short lived due to water egress.



Map 7. Situation of the northern Pits of the Wallarah Coal Company. *(Prepared by R Miller).*

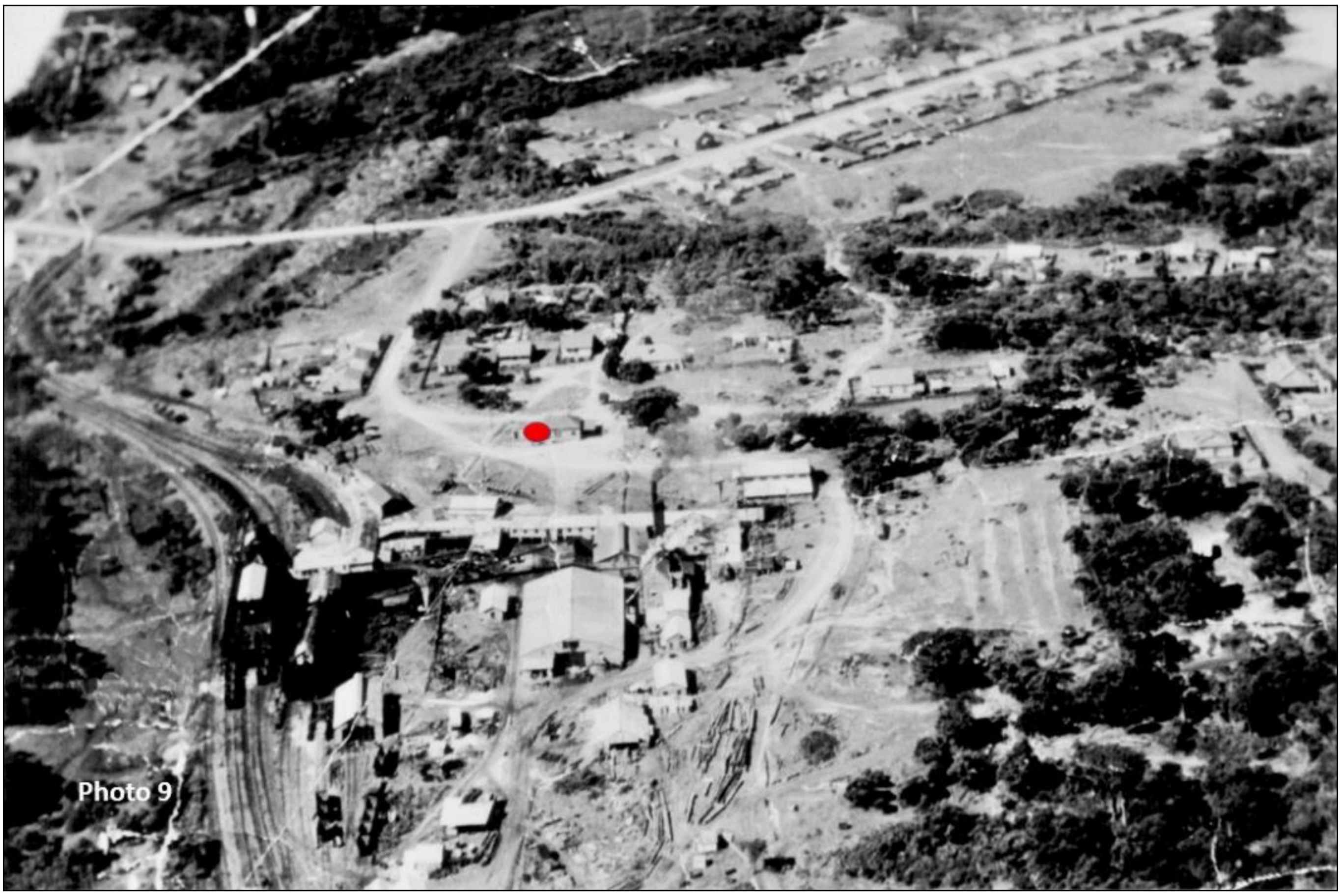
7. AGSHV Members at the 1950s quarry to examine specimens of Wallarah coal. (Photo by Chris Morton).

8. Little remains of the buildings and infrastructure from E Pit. The building is the engineers shed. (Photo: R Miller).

While walking along the beach many remains of the coastal rail tracks and sidings could be seen *(photos 11 & 12)*. Wave attack was a constant problem and meant that a timber break wall was needed in the central, exposed section, of the beach. The remains of this wall can be seen in photo 14.

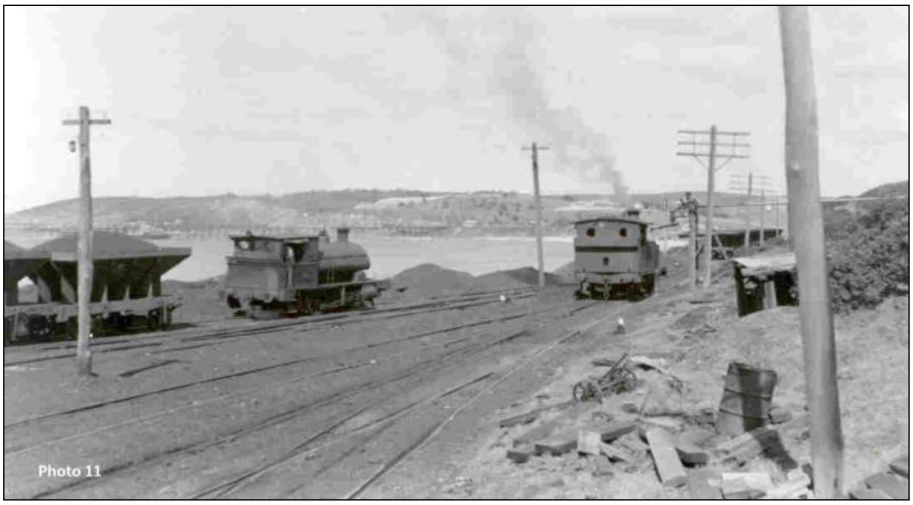
Remains of the old track can be seen on the bank above the beach and these sit on layers of coal chitter *(photo 13)*. Chitter was dumped regularly onto the beach.

After lunch the group walked to the rock platform and jetty at the southern end of the beach. The jetty is protected from the predominant south east swell by the rock platform. This extends into the sea as a result of the uplift along a north east trending fault line *(Map 5)*. Despite this several ships were wrecked or damaged by storm waves during the lifetime of the mine. *(photos 15-17)*.

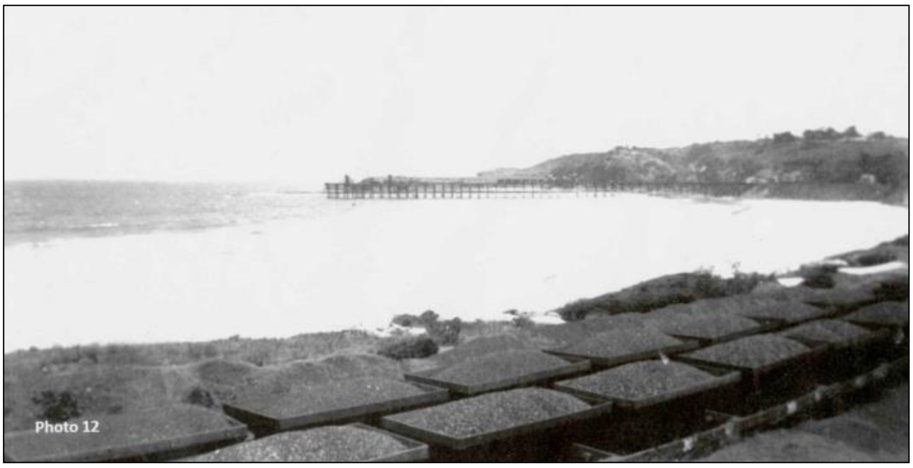


9. The red dot shows the location from which Photo 8 was taken and the observation site for the group. They were looking towards the bottom of the photo. The long narrow building housed the conveyor taking coal to the screens over the rail lines. (Source: The East Lake Macquarie Historical Society Collection).

10. View of Catherine Hill Beach just north of De Flon Creek and the Northern Car Park. The latter was once the rail siding for D Pit. (Prepared by R Miller).



11. A view of the rail sidings near the cemetery.
(Source: The East Lake Macquarie Historical Society Collection).



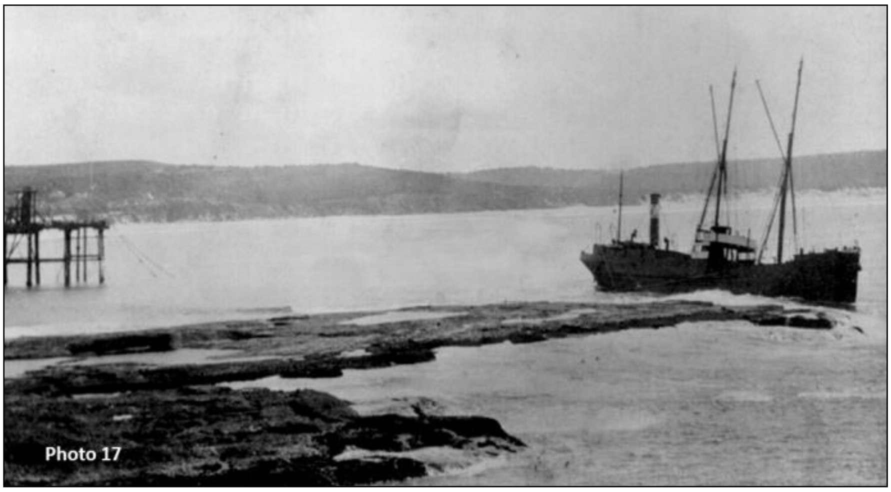
12. Rail wagons waiting at the siding.
(Source: The East Lake Macquarie Historical Society Collection).

13. Remains of the coastal railway seen from the beach. (Photo by Chris Morton).

14. Piles from a break wall created to prevent erosion on the coastal railway.
(Photo by Chris Morton).

15. Heavy seas can overcome the protection of the rock platform and reef. A scene from 1990. Part of the second jetty was destroyed in a storm in 1974.
(Source: The East Lake Macquarie Historical Society Collection).

16. Wallarah 3 has broken its mooring and is ashore.
(Source: The East Lake Macquarie Historical Society Collection).



17. Wallarah 1 was one of several ships that were totally wrecked while transporting coal from Catherine Hill Bay.
(Source: The East Lake Macquarie Historical Society Collection).

18. Only one entry of the New Wallsend mine was visible during our visit. The entry on the left has been covered by a rock fall by 1990. A further fall of a large sheet of conglomerate has covered part of the coal seam on the right of the photo. (Source: The East Lake Macquarie Historical Society Collection).

There were two entries for the New Wallsend Mine but today only one is visible. Members of the group tried to find the covered entrance without success. Photo 18 clears this up; it shows the shaft on the southern side has been covered by a rock fall. Since this photo was taken a large slab of conglomerate has fallen on the northern side and it was under this that we were searching.

19. Location of entrances to the New Wallsend mine. (Photo by Rick Miller).

Report by Rick Miller.

References.

BEESTON, J.M. (1995). *Coal rank and vitrinite reflectivity. Geology of Australian Coal Basins, Geological Society of Australia Inc*. Coal Geology Group. Special Publication No.1 ed. by CR Ward, HJ Harrington, CW Mallett & JW Beeston.

DIVER, M. (2005). *Historical Facts about Catherine Hill Bay.* East Lake Macquarie Historical Society

GALE, S. J. (2020). *Age and Origin of the Cumberland (Inner Sydney) Basin of southeast Australia*. Australian Journal of Earth Sciences.

JOHNSON, K. R. (1974). *The relation of the structural evolution of the Macquarie Syncline to sedimentation in the Moon Island Beach sub-group, New South Wales*. Journal of the Geological Society of Australia

ZIOLKOWKSKI, W. (1978). *The Geology of the Frazer Park Area.* Hons. Thesis. University of Newcastle. East Lake Macquarie Historical Society Inc. Address: Pacific Highway Swansea NSW, 2281, Australia. Email: historyeastlakemacquariesoc18@gmail.

NSW Government Planning Portal. Statement of Heritage Impact for Proposed Subdivision of Wallarah House Precinct at Catherine Hill Bay NSW Issue D 17 January 2013. https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=MP10_0204-MOD-1%T112939.556%20GMT

Catherine Hill Bay Field trip - Afternoon Activity.

Leader: Brian England.

Following lunch under shelter in the Surf Club carpark the group headed out towards the southern end of the beach to explore the geology of the rock platform, taking maximum advantage of a very low early afternoon tide. This section of the coast was first explored by the Society back in 2011 (Morton, 2011) but on this present visit we had access to much more recent information. By now the rain had stopped but the sky remained heavily overcast.

On the northern side and beneath the old coal loader and jetty the coarse conglomerate forming the roughly eroded rock platform and shoreline boulders *(photo 1)* comprises the Teralba Conglomerate in the Catherine Hill Bay Formation. This forms small arches and shallow caves near and beneath the coal loader due to its concrete-like texture.

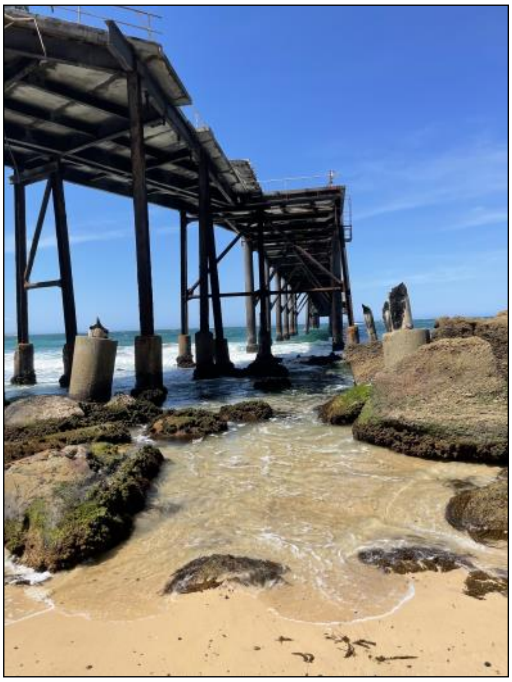
The conglomerate continues south as a high cliff line showing cross sections of structural features typical of a large braided river system, including excellent examples of sandy point bar deposits showing well-defined cross bedding *(photo 2)*. In some of the conglomerate beds the pebbles show distinct imbrication. The conglomerate is cut by major southwest-northeast joints which have led to large blocks breaking away from the cliff and falling onto the beach as marine undercutting occurs *(photo 3)*.

Beneath the coal loader the contact between the eroded top of the Great Northern seam and the overlying Teralba Conglomerate can sometimes be seen at the base of the cliff *(photo 4)*. This erosion is indicated by the presence of occasional tabular clasts of coal up to 20 cm across enclosed in the Teralba Conglomerate just above the coal.

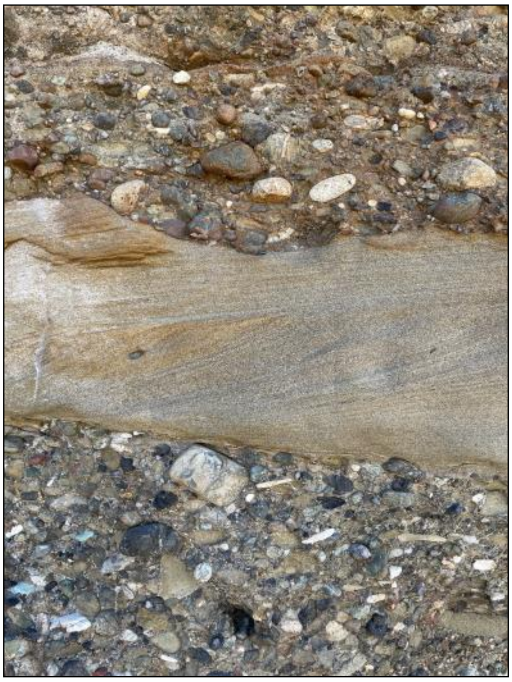
A few metres to the south the Great Northern coal seam outcrops on the beach as a series of benches and steps caused by two major joint sets intersecting at right angles *(photo 5)*. Just beyond lies the sealed 1873 portal of the original New Wallsend Coal Company mine which was bored directly into the Great Northern seam at its thickest point just above the beach. This seam is composed of dull coal *(photo 6)*, formed when the peat bog became inactive due to a fall in the water table associated with sea level fall (Lindsay & Herbert, 2002) which led to the oxidation of the vegetable matter in the presence of air. The seam reaches 7 metres in thickness and is not subject to splitting, although it does contain several thin clay bands which extend over a wide area (Herbert and Helby, 1980).

Looking at the cliff section either side of the coal loader there is an anomalous northerly dip in the coal, not to the south as would be expected. This is due to the proximity of the Macquarie Syncline to the west.

The Awaba Tuff and Chain Valley coal seam, normally seen between the Bolton Point Conglomerate and the Great Northern coal were no visible.



1. Boulders of Teralba Conglomerate scattered beneath the disused jetty in front of the Catherine Hill Bay Coal Loader and shoreline.



2. Cross bedding in sandy point bar bed in the Teralba Conglomerate.

Between the coal loader and Hales Bluff to the south is a wide rock platform exposed at low tide. This platform consists entirely of Bolton Point Conglomerate which underlies the Great Northern seam. This conglomerate comprises well-rounded pebbles of chert, red, green and black jasper, rhyolite, andesite, silicified shale, hornfels, sandstone, rare granodiorite, white vein quartz and clay ironstone set in a fine sandy matrix.

3. Large blocks of Teralba Conglomerate fallen from the adjacent cliff.

5. Great Northern coal seam exposed on the beach under the coal loader.

4. The eroded top of the Great Northern seam overlain by the Teralba Conglomerate.

6. The Great Northern seam exposed above the beach.

(Herbert and Helby, 1980). Its pebble lithology is identical to that of the Teralba Conglomerate (Herbert and Helby, 1980).

As in the Teralba Conglomerate, small to large scale interbedding of sandy point bars and gravel beds is common and trough cross bedding is also present in places where washouts occurred in the stream bed. The Bolton Point Conglomerate is less extensive than the Teralba Conglomerate but shows a wider clast range (up to 0.2 m).

Many of the softer sandstone pebbles in both the Bolton Point and Teralba Conglomerates have been case hardened by silica induration from groundwater percolation and where this hardened surface has been breached by marine erosion the soft centre has been eaten away by honeycomb weathering aided by burrowing marine molluscs *(photo 7)*.

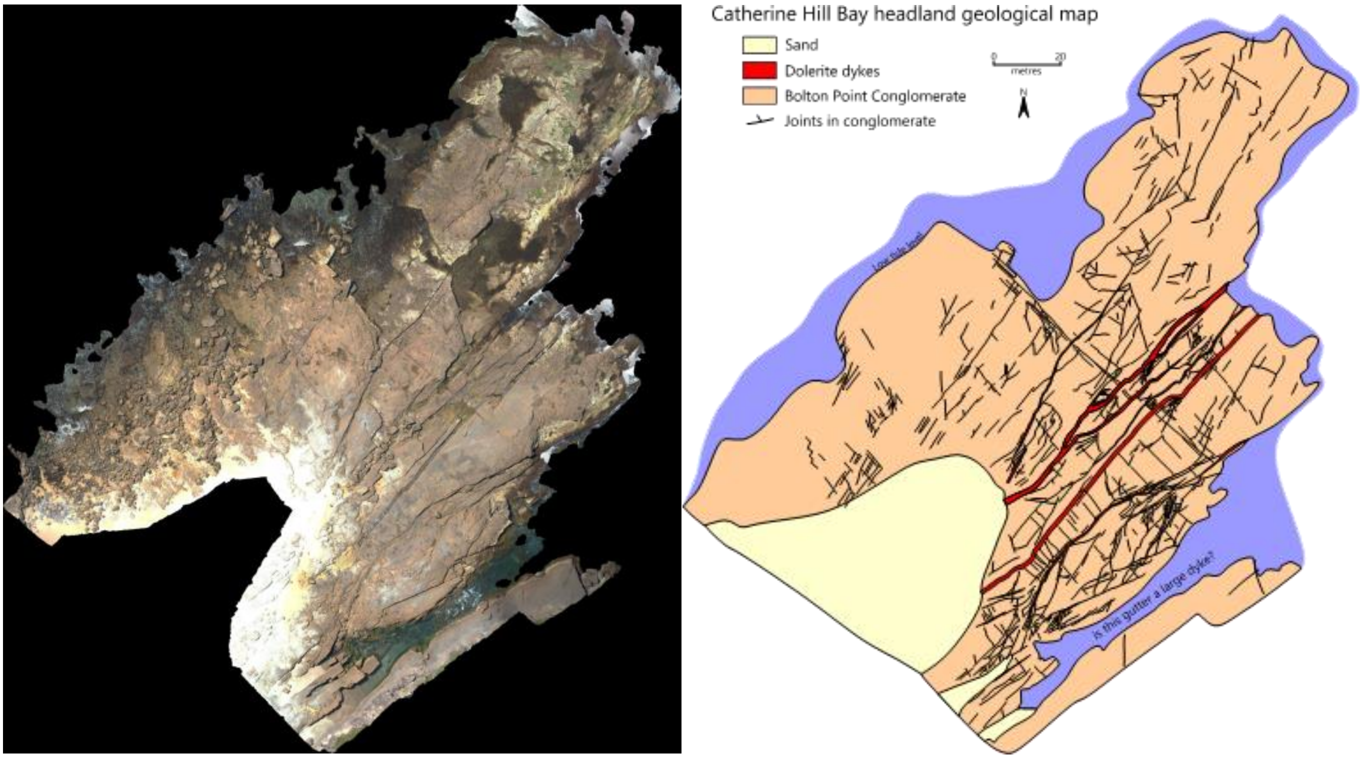


Figure 1: Photogrammetry survey of Catherine Hill Bay rock platform produced a digital elevation map and a high resolution orthophoto 3D model. (From Langanberger, 2023 - see Geo-Log 2023, page 65).

7. Sandstone pebble showing honeycomb weathering. Pebble is 8 cm.

8. One of the dolerite dykes exposed on the rock platform.

The mean dip azimuth of 50 foreset beds in the Bolton Point Conglomerate indicate a paleocurrent direction from the northeast, suggesting that in addition to a New England Fold Belt source there was an additional eastern source (Herbert and Helby, 1980).

However, this may be an artefact of the anastomosing nature of the braided river which laid down the gravels.

The Bolton Point Conglomerate on the rock platform is dissected by what is probably the greatest concentration of dolerite dykes anywhere along the New South Wales coastline, filling a complex network of intersecting joints and fractures *(Figure 1)*.

The dykes have been dated at 53 Ma (Eocene) (Offler, et.al., 2019) and are the youngest of a series of dykes between Norah Head and Nobbys. This date places the dykes at a time much later than the opening of the Tasman Sea at around 85-90 Ma in the Cretaceous. Unlike the northeast trend of most of the dykes in the Newcastle Coal Measures these lie roughly parallel with a strike of N30E. They range in size up to 1.5 metres (Herbert and Helby, 1980) *(photo 8)*. Some of the narrower dykes pinch out to the southwest while a few jump between joints and fill complex fracture systems exposed towards the beach *(photo 9)*.

Longitudinal sheet-like structures parallel to the dyke walls are sometimes present, indicating periodic pulsed injection of magma as the joint slowly widened (sheeted dykes). Well defined columnar jointing normal to the dyke walls is common *(photo 10)*, and these joints penetrate the chill margins in most dykes. Unfortunately, some of the features were partly obscured by seaweed and/or a light covering of sand but enough was exposed to give a good idea of the geological importance of this site.

An unusual and unpleasant sight during the excursion was the presence of an unusually large number of dead birds along the foreshore. These short-tailed shearwaters (muttonbirds) normally travel over 10,000 kilometres from Alaska to our coast each year to breed. But increasing water temperature this year made fishing for the birds more difficult and they died of starvation and exhaustion, falling into the sea and washing up on the beach and into the back of small caves under the coal loader (Sunday Telegraph 12/11/23).

Just as the group began to amble back to the carpark at around 2:30 pm the rain returned.

Report and photos by Brian England.

References.

HERBERT, C. and HELBY, R. (1980). *A guide to the Sydney Basin.* Department of Mineral Resources. Geological Survey of New South Wales. Bulletin 26.

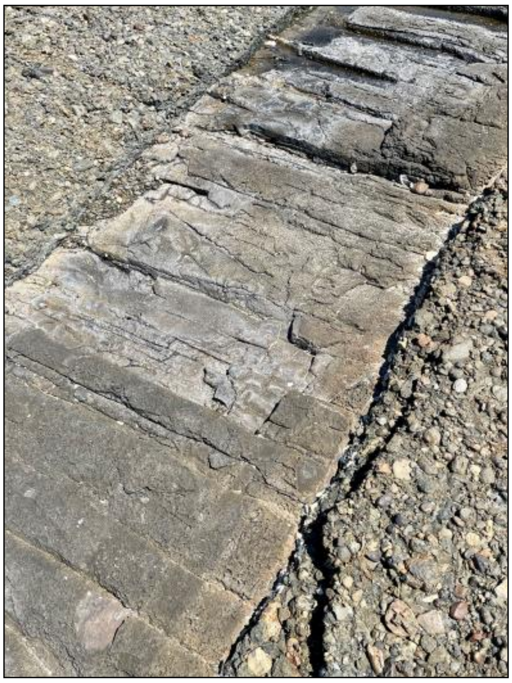
LANGENBERGER, B. (2023). *Application of Photogrammetry and other Visualisation Techniques in STEM.* Geo-Log 2022-2023.

LINDSAY, G. and HERBERT, C. (2002). *Coal and conglomerate in the Newcastle Coal Measures. Coeval or temporally unrelated?* International Journal of Coal Geology, 51, 169-184.

MORTON, C. (2011). *Catherine Hill Bay walk*. Geo-Log 2011, 3-4.

OFFLER, R.; ZWINGMANN, H.; FODEN, J.; SUTHERLAND, F.L. and GRAHAM, I.T. (2019). *Age and composition of dykes emplaced before and during the opening of the Tasman Sea – source implications.* Australian Journal of Earth Sciences, 66(8), 1129-1144.

9. Dolerite infilling complex fracture system in Bolton Point Conglomerate. Note longitudinal banding. (Ron Evans).



10. Pronounced columnar jointing in one of the dolerite dykes. Note also the prominent chill margin.

Proposed Great Extinctions Geotrail and Ornamental Corundum

Presenters: Peter Mitchell, Lesley Mountford and Robert Coenraads.
Date: Thursday 18th January, 2024.
Attendance: 28 members.

Session 1. Proposed Great Extinctions Geotrail. Presented by Dr Peter Mitchell OAM.

At the January meeting in Club Macquarie Peter Mitchell outlined progress and some of the history concerning the proposed Ku-ring-gai GeoRegion and opened discussion on the possibility of AGSHV doing similar work along the coast from Newcastle to the Hawkesbury.

Following is an outline of the proposal presented by Peter Mitchell.

Proposal: A Great Extinctions Geotrail.

In April 2021, the Australian Geoscience Council launched a National Geotourism Strategy to support the development of geotourism projects comparable to those overseas and to improve communication with the broader Australian community about the values of geoscience.

A key part of the strategy is the identification of Geosites and Geotrails that can offer educational and tourism experiences through the interpretation of their geology, landscape, biota, and cultural heritage.

Geotrails are increasingly popular overseas and are an integral part of UNESCO Geoparks of which there are now more than 200 across the globe, but none in Australia. The coast of central NSW from Newcastle to Ulladulla has a number of superb geological sections of the sedimentary sequence in the Permian and Triassic that are of international significance and there are opportunities to label and interpret these for their educational value.

At this stage identifying a Geopark is a long way down the track and depends on State and Commonwealth support. But getting to first base is easier using the idea of a GeoRegion with established sites and trails. There are two active proposals for GeoRegions in NSW; one in the New England Tablelands and another centered on Ku-ring-gai Chase National Park extending from Berowra Creek to the Northern Beaches. Both proposals have been in train for some time and are close to being recognised by the State Government. The proponents of these schemes have adopted a strategy endorsed by a working group of the National Geotourism Strategy that proposes GeoRegions as the precursor to nomination as a UNESCO Geopark by the Commonwealth Government.

Until recently the Commonwealth has not been supportive of any Geopark proposal but the Minister for the Environment and Water, the Hon Tanya Plibersek, has recently expressed support for the concept and the first term of the Labor Government may be an opportune time to advance it.

The Ku-ring-gai GeoRegion is very close to being formally established. Within the nominal boundaries some 55 geosites have been identified and six geotrails documented and presented to local governments and NSW National Parks for signposting and promotion.

The first signage was recently installed by Ku-ring-gai Council and it is hoped that the first fully functional Geotrail will be operational at Long Reef in early 2024.

Linking the Long Reef Geotrail to the Newcastle Coastal Geotrail would be a major step forward and that can be done by recognising about 10 or 12 geosites between Glenrock and the Hawkesbury River.

What is a geosite?

A geosite is any location where geological or geomorphological features can be interpreted to improve public awareness of the environment and where those features can be properly managed and conserved. Geotrails are a logical sequence of accessible and linked geosites which can be a cost-effective means of enhancing regional natural history marketing and tourism.

The technical establishment of a geotrail is neither difficult nor costly. There are several options for the presentation of information. Conventional signboards are expensive, non-portable and subject to vandalism. Folded brochures as used on the Newcastle Coastal Geotrail are convenient, appreciated by users, and provide good publicity for managers but are somewhat expensive and slow to update. The latest approach however using small signs at points of interest with QR codes linked to a phone app are becoming 'best practice'. Users are familiar with the code approach, they can carry the message on their device from place to place, the information can be linked to an organisation's web page and produced and updated at minimal cost.

Economically, geotrails make sense as Australia has over five million international visitors annually, about two-thirds of whom engage in some form of nature-based tourism. The domestic market for nature-based tourism is estimated to be 20 million overnights and 20-25 million day trips. Any local geotrail that can attract a share of such numbers will contribute to local economies.

The very big picture - A geotrail proposal.

With careful selection and interpretation, coastal geosites between Glenrock and the Hawkesbury River can be linked to form a car-based geotrail that tells the story of the geological periods either side of the end of Permian mass-extinction event (EPE) when coal swamps were destroyed and an entirely new biota recolonised the world. The event was global and involved the loss of 80% of marine invertebrates and perhaps 70% of terrestrial vertebrates. The cause is still debated but major changes in temperature of both land and oceans linked to the carbon cycle is usually invoked. The potential lessons for our present situation with climate change are obvious.

The Great Extinction of the EPE is not the only geological phenomenon which can be explained along this section of coast. The most recent major geological changes which began in the Pleistocene and are continuing in the present Anthropocene are also well exhibited. This is the geology of yesterday and on this coast, it is most evident in the effects of sea level changing through 120 m at the end of the Pleistocene Ice Ages and in particular during the last 30,000 years – a time well within the period of Aboriginal occupation. The modern geography of the coastal cliffs, shore platforms, beaches, and estuarine lakes can all be attributed to this event, and there is a detailed record of just how the biota changed derived from pollen cores taken in Redhead Lagoon.

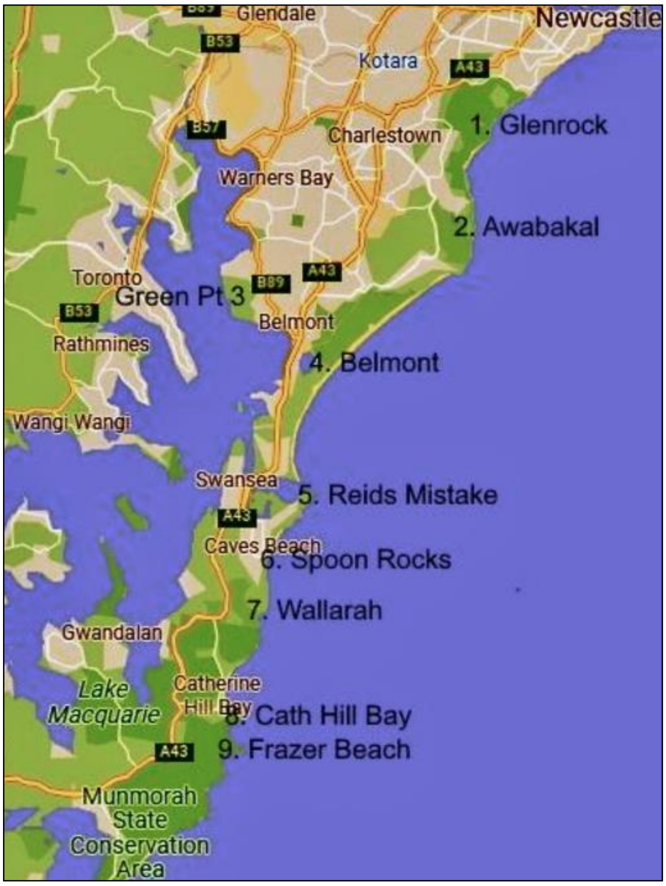
Aboriginal people would have lived along this coast through most of the time recorded by this pollen core but their dated archaeological trace is more limited. However, we do have details of Aboriginal sites in Glenrock and some of the creation stories were recorded by Rev Lancelot Threlkeld (1788-1859) at the Bahtabah mission (Belmont). Inclusion of such stories using an Aboriginal perspective and understanding of the landscape is very desirable in the recognition of geosites and may be obtained if managers work collaboratively with Awabakal Local Aboriginal Land Council (LALC) and Bahtabah LALC.

Site ownership and therefore management responsibility is variously held between three local governments, National Parks and Wildlife Service, and two or three LALCs.

Map 1 identifies nine Geosites that are suggested as the initial basis of a Great Extinction Geotrail. The necessary geological data is available in recent scientific publications and the knowledge of members of the Amateur Geological Society of the Hunter Valley (AGSHV). Most sites are already documented in plain English in the Society's Journal, 'Geo-Log'.

Suggested geosites and points of interest.

Note that not all the locations suggested here have been field checked, and other sites further south to the Hawkesbury River are yet to be included. The project should start on a single interpretive trail in Glenrock State Conservation Area where protocols can be established that can be later applied to other sites.



Map 1. Suggested geosites along a Great Extinction Geotrail.

Glenrock State Conservation Area.

Themes: Geological and ecological background, Aboriginal history, industrial legacy of mining and smelting, natural recovery of disturbed land.

Develop interpretive sites along the existing tracks: Yuelarbar (part of the Great North Walk) and Bombala walking tracks. Including:

- ◊ The lagoon, beach, natural vegetation and recovered lands.
- ◊ Stories include: Aboriginal Bora Grounds and other Aboriginal sites.
- ◊ Discovery of coal in 1791 by escaped convicts Mary and William Bryant who went on to reach Timor.
- ◊ Visit by Ludwig Leichhardt in 1842 and his sketch of the local geology.
- ◊ Burwood and Glenrock Collieries operated by James Mitchell who has a long list of engineering 'firsts' as he set out to break the monopoly held by the Australian Agricultural Company.
- ◊ Extension of mining under the sea.
- ◊ Operation of coke ovens and an unsuccessful copper smelter drawing ore from South Australia, Goulburn and elsewhere.

◊ Overmans house <1887 – formerly the home of the Burwood Colliery undermanager.

◊ Property owned by BHP in 1932 who provided a 99 year lease of 40 ha to Scouts.

◊ Relics of WWII operations by Defence (if any).

Some of these operations have left a physical trace that can be interpreted and there are a number of early photographs that could be site matched.

Burwood Coal mine 1885 adjacent to the lagoon.

Awabakal Nature Reserve.

Themes: Geological and ecological background, Aboriginal history, specifics of Pleistocene vegetation change.

Develop sites along the existing tracks; Redhead Lagoon Trail and Awabakal Coastal Walk.

Present day vegetation is quite varied and probably related to presence/absence of cliff top dunes and drainage.

Redhead Lagoon has a comprehensive story of local vegetation change over 75,000 years obtained by analyses of pollen from sediment cores taken in the bed of the lagoon.

At the southern end of Awabakal Coastal Walk on Redhead Point the shore platform has a good section through the Kotara Formation, Victoria Tunnel Coal seam, Shepherds Hill Formation down to the Nobbys Tuff member. The Kotara Formation (lacustrine) includes a good example of soft sediment slumping, numerous examples of siderite lenses and boxwork, and fossils logs all lying horizontally in the sediment with younger beds draped over them. The Fern Valley coal seam exhibits a couple of splits and the Redhead Conglomerate is exposed in the cliff. Numerous examples of strong jointing and honeycomb weathering.

Green Point foreshore reserve Lake Macquarie.

Themes: Geological and ecological background, specifics of Pleistocene landscape change and formation of the lake, Aboriginal history, first contact with a white missionary, modern day management issues such as sediment contamination, and Operation Posidonia.

This reserve already has a number of easy walking/cycling tracks with existing interpretation signs and viewpoints across the lake. It is a good site for telling the Quaternary history of the lake, Aboriginal stories, and of interaction between Aboriginal people with Rev Threkeld whose original mission station 'Bahtabah' was located in the vicinity of the primary school in Victoria St.

Belmont Lagoon Wetlands and Nine Mile Beach.

Themes: Geological and ecological background, Aboriginal history, more recent industrial legacy of mining, dredging and quarrying, changed lake hydrology, weed invasion, dune destabilisation, and managed recovery of disturbed land.

This is an intriguing area on a very modified Pleistocene/Holocene coastal barrier where land use and land restoration stories can be interpreted.

Originally a broad- leafed paperbark and swamp she oak wetland lagoon complex. Extensively used by Aboriginal people then largely ignored and abused

Belmont Lagoon and Nine Mile Beach.

during the C20 when BHP operated the John Darling Colliery. A ventilation shaft was sunk in the middle of the lagoon, numerous tracks and dumps constructed, and surface drainage was changed so that the freshwater lagoon was connected to Lake Macquarie and has since become a brackish system. Heavy mineral dredging and sand quarrying was conducted in the dunes in 1950/70s.

The colliery closed in 1987, recreational 4WDs and trail bikes created numerous trails and increased instability in the coastal dunes but subsequent land management has included site rehabilitation.

Reids Mistake Head.

Themes: Geological background of fossil forest, Aboriginal history, and European history.

Swansea Heads and the entrance to Lake Macquarie has a long history of Aboriginal occupation.

The shore platform at the headland has a cliff section first described and drawn by TWE David in 1907. It includes the Lower Pilot Coal seam in the rock platform, Reid's Mistake Formation in the cliff fronting the coast and the Upper Pilot seam in the higher part of the cliff. Further south massive conglomerates with sandstone layers belonging to the Belmont Conglomerate Member are found.

Glossopterris trees (*Dadoxylon*? - the nomenclature is unclear) growing in the Lower Pilot coal were thrown, killed and buried by a dense volcanic ash cloud 250 million years ago. The stumps are now preserved as fossil logs and fallen trunks aligned to the west indicating that the ash cloud came from the east. It may have been similar to the eruption of Mt St Helens in 1980. This site is recognised as an NSW Geological site.

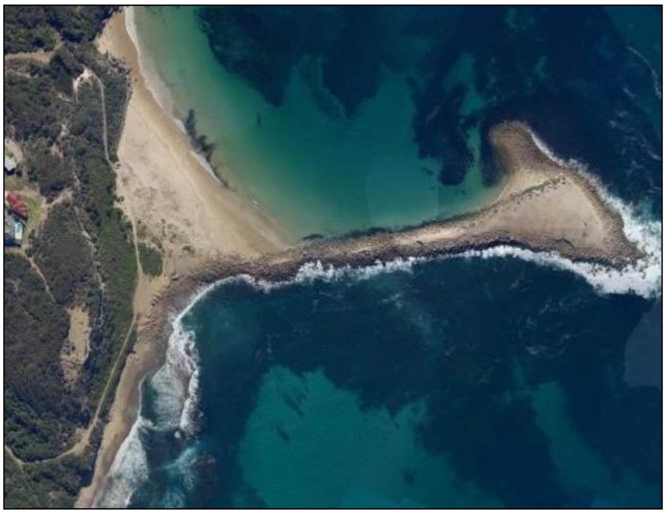
One of many *Dadoxylon* stumps to be found at Reeds Mistake.

Spoon Rocks, Quarries Head.

Themes: Geological and geomorphic background, Aboriginal history, and industrial legacy of attempted mining.

There are several potential geosites along this section of coast which is an extension of the sequence exposed at Reids Mistake Head. These include an excellent exposure of base surge in a crystal tuff, numerous in situ stumps, examples of fossil tree roots (*Vertebraria*) and some very unusual siderite log-like formations which have yet to be explained.

Spoon Rocks was the location of an aborted (illegal?) coal mining operation in the 1970s started by Mr A Mawson, a Swansea hotel keeper and businessman who provided the impetus to develop Caves Beach. He involved a Japanese consortium in a mining venture called Silver Valley Minerals to mine and export coal from the Wallarah seam at the top of the Moon Island Beach Subgroup. This eroding breakwater was one result.



Spoon Rocks.

Quarries Head presents high sea cliffs in Belmont Conglomerate and limits coastal access. Joints are wide spaced and as they slowly open huge blocks of conglomerate separate from the cliff line and eventually tumble into the sea. Split Rock is in the process of doing this and has been accessible in the past via a ladderway/ ramp which is no longer functional.

On the south side of Quarries Head, in a sandy

Quarries Head.

variant of the Belmont Conglomerate, there are some excellent examples of honeycomb weathering and a great collection of spherical concretions exposed on the benches of an accessible cliff face.

Rock platform on southern side of Quarries Head showing a collection of spherical concretions.

Wallarah National Park.

Themes: Geologic geomorphic and ecological background, Aboriginal history, industrial legacy of WWII, gravel extraction, natural recovery of disturbed land.

On Pinny Beach (south of Quarries Head) gravel was mined from the surf zone using a cable stayed dragline (foundations still exist). The gravel was used in decorative concrete.

Inland from Pinny Beach on Radar Hill Fire trail are the remains of bunkers belonging to 208 Radar Station Swansea (RAAF) established as one of the main NSW defence stations in 1943.

Remains of 208 Radar Station.

At the end of Shark Hole Trail is Shark Hole Bay. The head of the bay has one of the most spectacular gorges on the NSW coast, probably eroded on a volcanic dyke.

An eroded dyke, Shark Hole Bay.

Catherine Hill Bay.

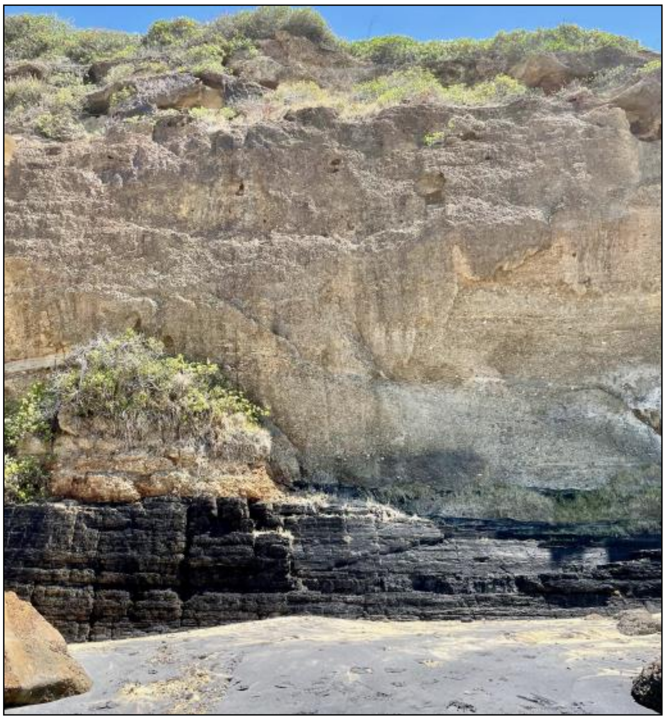
Themes: Geological and ecological background, Aboriginal history, industrial legacy of mining and heritage issues.

Coal was mined here by the New Wallsend Company and shipped from a jetty as early as 1873. The first jetty was wrecked in 1875 but the mines reopened under the Wallarah Coal Co in 1889.

The jetty and miner's cottages still exist along with foundations of the colliery, but a number of heritage buildings were destroyed by bushfires in 2013.

In the cliff face the sequence of the Great Northern coal seam, the underlying Bolton Point

Remnant of chain at the base of the now disused jetty at Catherine Hill Bay.



Cliff face south of Catherine Hill Bay jetty showing the Great Northern coal seam overlain by the Teralba Conglomerate. The underlying Bolton Point Conglomerate is not visible at this location as its covered by the beach. (Brian England).

One of several dolerite dykes intruding the Bolton Point Conglomerate on the rock platform.

Conglomerate and the overlying Teralba Conglomerate are visible.

Further south from the cliff section shown in the top photo, dolerite dykes intruding the Bolton Point Conglomerate are clearly seen and the current marine flora and fauna can be readily examined.

Frazer Blowhole, Frazer Beach in Munmorah SRA.

Themes: Critical exposure of the EPE and other geological features.

Includes sections through the Moon Island Beach Sub-group in the Newcastle Coal Measures. Strata include the Karignan Conglomerate overlain by the Vales Point Coal Member, the uppermost Permian unit. Munmorah Conglomerate, the lowest unit in the Triassic Narrabeen Group, overlies the Coal Member, usually with an eroded contact

Sea caves exist at Timber Beach which can only be entered at low tide and calm seas.

In the 1950's, a Mr Frisby operated a gravel extraction operation in a sea cave at Frazer Blowhole by lowering a bobcat and skip into the cave from an aerial rope at low tide. The gravel was used as aggregate for decorative concrete at Bankstown Civic Centre, the fascia of Wynyard Station and as far away as Broken Hill. This operation continued until the land became part of conservation area in 1977.

Large sea cave at Snapper Point from which Mt Frisby extracted gravel at low tide by lowering a bob cat from the cliff just to the right of the car park. The EPE boundary can be seen in the cliff at the top of the blowhole.

Behind Frazer Beach one of the best exposures of the EPE can be examined where the Vales Point Coal Seam is abruptly cut off by a thin layer of micro-breccia (dead zone) and overlain by the Dooralong Shale then conglomerates of the Coal Cliff Sandstone, Munmorah Conglomerate and laterally equivalent lowest Triassic units.

Very detailed lithological descriptions and analyses of the pollen and spore content are available along with recent descriptions of fossil vertebrate burrows which are interpreted as the first signs of returning life forms after the extinction event.

There are other potential geosites in Munmorah SCA but this is a good place to finish this initial proposal as it marks the end of the Permian and happens to be just beyond the boundary of Lake Macquarie City.

Where do we begin and what needs to be done?

Step back from the big picture and start with small steps in Glenrock State Conservation Area where there are existing tracks, known sites and a single management authority. We should not attempt to expand to other sites until Glenrock is established and a model for future development has been established.

Establish a small working group to work up site details and estimate budgets with the following suggested membership:

◊ NPWS - Kate Harrison
◊ AGSHV - Peter Mitchell, Phil Gilmore, Chris Morton, and Brian England. Awabakal LALC ?
◊ Convene an on-site meeting to kick it all around.

Budget guess.

The required budget is presently a guess but we should aim to keep costs as low as possible, web page and app design should be done in house, using wording that is available at no cost.

Peter Mitchell with John Illingsworth can produce a short video at minimal cost (travel expenses from Sydney) if this is seen as desirable.

QR codes and a phone App may already be available within NPWS otherwise they are likely to be about $25-30 per month. This needs investigation and there are ongoing access negotiations between NPWS and NSW Geological Survey for Ku-ring-gai moment that might be extended to include Glenrock.

Printed brochures may also be involved but I have no idea of likely costs.

A colour printed metal sign like the one illustrated is probably the most expensive outlay if required as this one cost was $8,000 installed in 2023.

In total stablishing a Glenrock trail might be about $20,000.

The possibility of grant funding should be investigated once a firm proposal is established.

The big picture view is that the whole Permian/ Triassic coast sequence has geodiversity values at an international level that could make it a candidate for a UNESCO Global Geopark. To get to that position will take considerable time but it is now possible because political attitudes are shifting and key players in governments are recognising that Australia should be involved in that programme.

UNESCO has a target of 500 Geoparks around the world and now has 211 in 48 countries but none in Australia. New Zealand got its first last year centred around Oamaru on the South Island.

Geoparks are attracting more than 80 million visitors a year so promoting them as an educational tourism activity can add real economic value to local

communities. Unlike more conventional National Parks, they can incorporate all sorts of land uses and land ownership patterns, and their declaration does not need to impinge on any existing form of management. In fact, several Geoparks even include active mining operations. GeoRegions and Geoparks are based on geology and landscape, but are integrative in also displaying and interpreting all other natural and cultural values of the place.

In April 2021 the Australian Geoscience Council launched a National Geotourism Strategy to support the development of geotourism projects. A key part of the strategy is the identification of Geosites and Geotrails that can offer comprehensive educational tourism experiences. This is where the idea of a GeoRegion comes from as a first step toward eventual recognition as a UNESCO Global Geopark, which has to be done by the Federal Government.

The Ku-ring-gai GeoRegion is close to being formally established by the State. The boundary is nominal and we have identified 55 geosites and documented six geotrails in collaboration with three local governments and NSW National Parks. Our first signage has been installed and we are hoping that the first fully developed geotrail will be open at Long Reef in the next few months.

It has taken quite some time to get to this point and a major barrier has been funding for signage. But we think we have overcome this with a new approach using small QR coded 'totem posts' that are cheaper than the usual printed metal information boards.

The following is an example of the design we putting forward for Long Reef. It will be only about 400 x 150mm made of a vinyl/aluminium composite and attached to walkway handrails or a short post. We estimate this can be done for under $200.

Scan the code with your phone and it takes you to a website with a couple of pictures and 200-500 words of description. The Sun is too bright to read it? Tap a button and a friendly voice will read it for you.

Depending on budgets the same information can be printed in a fold-out brochure and backed up with more detail and reference material perhaps published by a group like NSW Linnean Society. That is yet to be negotiated!

As you are all aware there are some fabulous geological stories to be told between Newcastle and the Hawkesbury River. The first and perhaps the easiest opportunity is to develop an interpretive geotrail in Glenrock State Conservation Area. AGSHV has the knowledge and most of it is already in a form that can be easily edited to meet the needs of QR coding. Kate Harrison, the Glenrock ranger, is keen and she tells me that her budget is currently fairly healthy. As I see it, our role in such a venture would be to provide the information and assist with site selection, NPWS can pick up sign manufacture and web site hosting.

This idea of the Society's involvement was discussed and agreement reached to explore it further with a day visit to Glenrock with Kate to be arranged asap. A small group declared interest in being involved; Brian Dunn, Richard Bale, Brian England, Phil Gilmore, Chris Morton and Peter Mitchell.

It was also pointed out that new urban developments along the coast such as at Catherine Hill Bay and Pinney Beach are currently developing coastal walks for Lake Macquarie City as part of their community contributions. Perhaps we could offer some timely assistance with information along those. We will follow this up, and see how we might get involved.

Watch this space, you will hear more.

Presented by Dr Peter Mitchell, OAM.
Photographs and maps by Peter Mitchell.

Session 2. Ornamental Corundum from Western Australia.
Presented by Dr. Robert Coenraads FGAA and Lesley Mountford FGAA.

Lesley Mountford commencing the presentation by explaining methods used to non-destructively identify minerals present in collected samples.
(Brian England).

Approximately 3,500 kg of opaque blue corundum was recovered from exploration licence E 09/1256 and mining lease M 09/34 located approximately 90 km of north Gascoyne Junction in Western Australia.

Abundant corundum was found littering the ground surface of a 125 Ha area within Williambury Station. The corundum occurs as individual crystals or crystal fragments; short hexagonal prisms with flat crystal terminations or hexagonal pyramids tapering to a point ("dogs teeth") varying in length from 1 to 20 cm.

Groups of intergrown crystals are most common with many of these masses being nodular in shape.

Some of the largest masses of blue corundum found to date weigh up to 40 kilograms. The corundum is opaque and varies in colour from a dark blue to a medium blue, often with a slightly violet hue reminiscent of sodalite or lapis lazuli. In some specimens hexagonal growth zones of blue and white corundum are visible.

Prospectors traced their corundum finds upslope to outcropping veins of a coarse pegmatite composed of silvery muscovite, pink andalusite and blue corundum. The veins vary from 20 cm to 2 m in thickness and run in an east-west direction within schists of the Proterozoic Morrissey Formation. The pegmatite is soft and friable and, as a result, is easy to mine.

Heavy machinery (a bulldozer and 20 tonne excavator) was used to extensively bulk sample the outcropping corundum source rock in two places within M 09/34

X-ray diffraction analysis carried out by the Australian Museum, Sydney, confirmed the material to be corundum with some minor alteration to diaspore (hydrated aluminium oxide). Petrologic thin sections indicate that alteration is localized along fractures and sets of parting planes within the corundum crystals. This dense gridwork of fractures and parting planes also explains the corundum's opacity. X-ray diffraction work by Peter Williams at the University of Western Sydney identified the principal pink mineral present in the pegmatite as andalusite.

The recovered corundum was sent to Thailand for evaluation of its gemstone or ornamental potential--the finished product demonstrating that the corundum carves well and takes an excellent polish; however heat treatment experiments were unable to convert the opaque blue corundum into transparent faceting grade sapphire.

In conclusion, the surface corundum on Williambury Station was collected relatively quickly, and the bulk sampling exercise demonstrated that corundum does not exist in sufficient quantity or quality within the pegmatite veins to economically mine.

Large sapphire crystal 7cm diameter.
(Brian England).

Dr Robert Coenraads illustrating his presentation with field investigation and mineral specimen photographs.
(Brian England).

Sawn and polished sapphire nodule.
(Brian England).

Presented by Lesley Mountford and Dr. Robert Coenraads .

Australian Museum Tour of the Minerals Gallery and Earth Sciences Collection, Sydney

Leader: Joan Henley.
Date: Wednesday 21st February, 2024.
Attendance: 28 members.

Preamble.

Joan Henley (nee Hingley) worked at the Australian Museum from 1972-1989 starting as Technical Officer and progressing through the grades to Collection Manager with a short stint as Joint Divisional Head of Department. On her departure, she was made Senior Fellow in recognition of her 'above and beyond' contributions to the Museum. She and Ross Pogson were fellow students and she hired Ross on Museum grants as temporary assistant in 1979. She supported him in his application for the position of Technical Assistant in 1980 and for the Collection Manager's position after Joan left the Museum in 1989.

Brian England is a Research Associate with the Australian Museum and is quite familiar with the Earth Science collections. He has published with Dr Lin Sutherland (Museum Senior Research Scientist Earth Sciences 1973-2001) on several research projects. In 1988, they won the Mineralogical Record award for best article (England and Sutherland, 1988). Joan met Brian in the early 1970s when he visited the Museum and they have been friends since. Brian introduced Joan to the AGSHV.

Introduction.

The visit to Earth Sciences at the Australian Museum combined a tour of the new Minerals Gallery installed in 2022, with visits to the mineral and fossil collections held in the non-public areas of the lower ground and basement levels of the Museum. The Museum began collecting earth science specimens in 1827 and collections now comprise 60,475 minerals 19,270 rocks including 755 meteorites and 164,315 fossils. These are stored mainly at the Australian Museum but also at the Castle Hill Discovery Centre, the Bathurst Fossil and Mineral Museum and the Age of Fishes Museum at Canowindra in central west NSW.

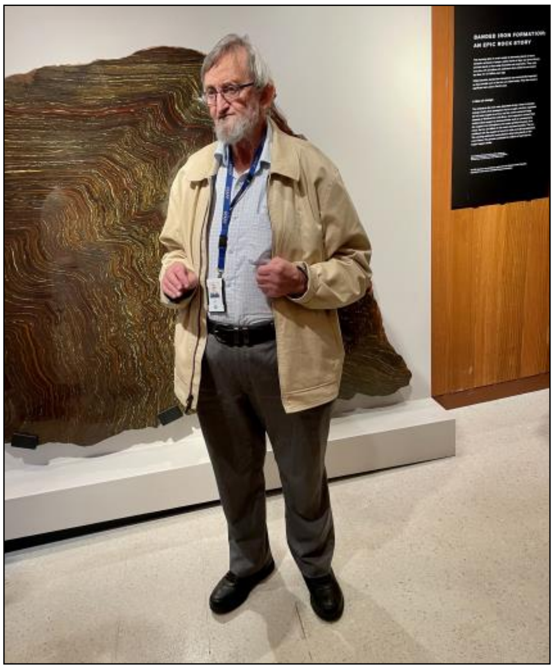
Museum curators are a lively, enthusiastic lot. In the 1840s, the Rev. W. B. Clarke, Australia's first exploration geologist, traversed the Australian countryside before there were road maps or even roads. He travelled by horseback while attending to his flock, keeping an eye on the ground for likely specimens. Others went to the Antarctic, crossed the Simpson Desert on camels, wound their way across the interior searching for meteorites, trekked through Papua-New Guinea and climbed live volcanoes.

In the same spirit of adventure, twenty-eight AGSHV members braved country and city travel to meet at the Australian Museum Gift Store by 10.30 am. There, Joan Henley introduced our guides, Ross Pogson, Manager of Earth Sciences and Archaeology and overall collection manager of minerals, rocks, meteorites and tektites; and Dayna McGeeney, technical officer and gemmologist. Ross started with the Museum 1979, conducts research into cave minerals and publishes prolifically.

The Minerals Gallery.

Members climbed the stairs to the hallway on Level 1 to inspect a very large polished slab of banded iron formation (BIF) on open display. People were encouraged to run their hands over its beautifully polished surface while Ross explained its significance to the Earth's history. This dramatic and colourful, 2.5 billion years old specimen signifies the beginning of a process that led to the formation of the earth's oxygen-rich atmosphere which resulted in the world we now enjoy. The slab is composed of alternating bands of greyish iron ores, reddish cherts and golden tiger-eye, making it a very colourful, awe-inspiring introduction to the Minerals Gallery *(photo 1)*.

Moving into the corridor leading to the Minerals Gallery, members were distracted by a display of the Museum's precious opal specimens many of which Dayna told us, were donations. However, everyone's attention was soon riveted on the large display case of intensely coloured shapes and forms spilling across the entrance to the Minerals Gallery like a giant open treasure chest. It was an epicurean display of almost all the Museum's most attractive and valuable crystallized mineral specimens, designed simply to awe and please *(photos 2 & 3)*.



1. Ross Pogson describing the polished slab of banded iron formation behind him. (Brian England).

2 & 3. The splendid displays of minerals at the entrance to the Minerals Gallery. (Joan Henley).

Many of these specimens came from overseas and were expensive purchases due to worldwide competition for such items. Australian minerals also compete in this arena. A uniquely large and beautifully crystallized molybdenite from the Allies mine (Deepwater) on the New England Tableland is the best in the whole world and was headhunted in the 1970s by Mineral Curator, Paul Desautels from the Smithsonian Institute in Washington DC. He used to get on his knees and bow down before it whenever he visited the Museum. Its large, malleable, silver-coloured, hexagonal crystals form rosettes which are as soft as silver foil and are easily buckled out of shape, losing the crystal sharpness that gives this specimen its value. For over 80 years, this specimen has been carefully handled and protected to preserve its heritage and monetary value. *(photo 4).*

After this spectacular introduction to the Minerals Gallery, Ross and Dayna divided the group into two and took them in separate directions around the interior of the gallery. They explained how the Gallery is designed to educate the public about both the scientific nature of minerals and the rocks they are found in, as well as show the mining heritage of Australia where these specimens are often the only remaining artefacts of some very famous mines. The Broken Hill mines, in particular, are world famous for their outstanding specimens formed in its unusual lead and manganese rich gossan and fissures within the orebody. The gossan is that part of the ore body which has been weathered and leached to form a boxwork of cavities. A wide range of new minerals can form in these spaces when mineralised solutions combine with the metals from the ore body resulting in carbonates, sulphates, chlorides, phosphates, oxides and hydroxides. At Broken Hill in particular, these minerals developed in conditions which allowed the varied and perfect crystal growth sought after by collectors. The Museum was fortunate to receive donations from the Broken Hill Proprietary Company in 1895 and in 1933 of some of the most prized specimens to come from these mines.

Much of the gallery is organised to show specimens from the prominent mines and mineral sites which characterised each state or territory. Anecdotes were told about collecting trips to some of the mineral sites in the 1970s when many of the roads to the outback were unsealed and facilities were few and far between.

A section devoted to notable Australian collectors featured Albert Chapman who sold his world-famous collection to the NSW government in 1988 for $1 million dollars. Early on, he befriended Broken Hill miners and was able to obtain specimens in a time before mineral collecting became a big hobby. This enabled him to preserve some of the early specimens from this locality. He collected widely and traded overseas, establishing an international reputation as fine-specimen collector and mineralogist. He opened Australia to international collectors and encouraged Australian collectors to travel overseas *(photo 5)*.

Other notable mineral collectors and their collections were: Douglas Mawson who collected Antarctic rocks and meteorites during the period of heroic Antarctic exploration; George Smith and his collection of exquisite and rare specimens from the late 1800s to early 1900s and; Warren Somerville who purchased fabulous, blockbuster specimens from all around the world.

Some people spent a lot of time at the gemstone case possibly deciding which one of the stones they would purloin if they could breach the subtle but effective security. Would it be the perfect 33.39ct Thai sapphire in the donated ring or the charmingly roughcut, pale blue 60ct Indian sapphire whose facets had been slapped asymmetrically over the natural shape of the stone *(photo 6)*. A preference might be for one of the less familiar 'collector' gems cut from any mineral that happens to be transparent and colourful such as crocoite and fluorite. A large 179ct pink spodumene sits centre stage flaunting its value as a gemstone as well as a critical mineral harbouring the much-desired element, lithium. Other gemstones such as garnet and tourmaline are lined up in strands demonstrating the colour ranges

4. Priceless specimen of molybdenite crystals with quartz from Deepwater Mine, NSW. (Brian England).

5. Display of mineral collector, Albert Chapman, with some of his collection. (Brian England).

6. The 60ct Indian sapphire, retaining its original field cut. (John Fields).

for each mineral.

If looking at all the glittery minerals became too much, members were able to use the interactive displays that taught how minerals are used in our society; or star gaze at the meteorites and explore the concavities of the free standing 617 kg mass of the Western Australian Mundrabilla meteorite. After almost 2 hours spent in the gallery people were ready to rest their eyes and feet to have lunch in one of the Museum's two cafes. Half an hour later, rested and reinvigorated, people mustered at the cloak room on the Lower Ground floor for the behind-the-scenes tours to the earth sciences collections.

The Earth Science Collections - Minerals.

The storage areas in the bowels of the old museum building, are intersected by narrow corridors and small spaces. Our large group of people represented an organizational challenge to Joan and the museum staff when it came to touring the collections. This was overcome by dividing the members into groups of 9, labelling them A, B and C and scheduling to rotate them through the different areas.

Dayna and Ross led groups A and B through a locked doorway into a long narrow corridor and up a set of old stairs into the mineral storeroom which was part of the basement of the original 1849 museum building.

The mineral collection occupies two separate rooms flanking a corridor. One group entered each room and squeezed between the cabinets and around their guide as shelves were rolled out. The specimens are organised alphabetically except for family groupings such as quartzes and feldspars. Each specimen is numbered, registered and photographed in the database. It is then placed in a cardboard tray with a description label and placed on the appropriate shelf in a cabinet *(photo 7)*.

Ross and Dayna hosted a room each and explained that the collections served to preserve the mining heritage of Australia and were also safe repositories for the valuable display specimens. However, the wider collection is used by researchers who describe the range of species (chemical variations) and habits (different outward shapes but the same internal symmetry) of the same mineral. Having a large representation of habits can help geologists to recognise minerals in the field when searching for resources. The collection also needs to represent minerals from each of its localities. This allows researchers to understand the environments of mineral formation which leads to developing criteria for their discovery and utilisation.

7. A shelf of stored azurites inside a cabinet in the mineral collection storage area. (Sue Rogers).

The Museum actively encourages researchers to access the collections for their work. For example, when asbestos became a domestic health hazard researchers used the collections to try to find a substitute material.

The two groups got to visit both sides of the corridor and view shelf after shelf of colourful and vivid minerals. Fortunately, no one suffered from claustrophobia.

Earth Science collections - Fossils.

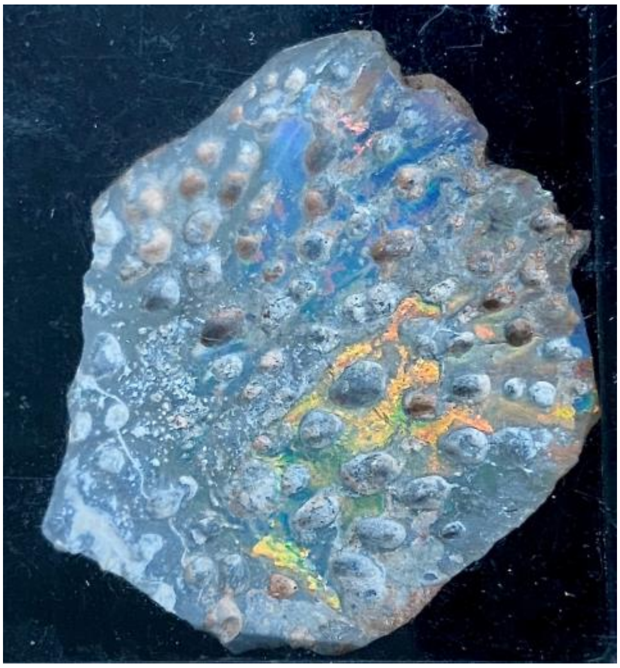
Group C followed Joan down to the fossil collection in the basement area of the Museum's relatively newer William Street extension. AGSHV members soon learned about a recent architectural oversight resulting in the idiosyncratic lack of a staircase which should have linked the Lower Ground level to the basement below. Not wanting to wait for the extremely small and slow lift, members opted to follow Joan out of the Museum, down the steps from the William Street doorway and around the corner to a staff entrance into the basement. Here, banks of modern compactus units which house the fossil collection, occupy most of the central area flanked by offices and work stations on either side.

The fossil collection is organised into the 'type' collection, which also holds published specimens, and the general collections. Specimens are organised taxonomically according to class, order, family, genus and then locality. Its content has grown out of curators' research interests in the past. However, modern practices aim for broader representation and certainly, rare specimen acquisition.

Dr Patrick Smith from Palaeontology was waiting behind an array of fossil specimens which demonstrated a range of fossils from NSW throughout time. He is a fluent and expressive speaker and immediately engaged the attention of our members. He began by holding up the weighty skull of a labyrinthodont; a salamander-like amphibian that lived in lakes in the Sydney Basin during the Triassic period *(photo 8)*. This specimen is unique in that it is the only example of a complete, 3-dimensionally preserved skull from this area and the only vertebrate fossil of the Triassic in the collection.

He moved on to his favourite subject, trilobites, comparing a trilobite from Gunningbland, near Parkes, NSW to a Moroccan trilobite to demonstrate the proximity of the continents during the Ordovician.

8. Dr Patrick Smith displaying the perfection of this rare labyrinthodont skull from the Sydney Basin. (Joan Henley).



10. Opalised specimen of a crocodile scute. (Ron Evans).

Moving onto the Jurassic, Patrick pointed to a clearly defined fish and a conifer fossil on siltstone from Talbragar *(photo 9)*. This locality is one of the most significant terrestrial fossil deposits in Australia and the only Jurassic fish site in NSW. The conifer is closely related to the Wollemi Pine.

We finished up with a tour through an opalised specimen of a crocodile scute (a scale which is part of the animal's armour) from Lightning Ridge *(photo 10)*, a *Meiolania* skull (Cainozoic horned tortoise) from Lord Howe Island and a very rare 15my *Megamonodontian* (a big trap door spider) from McGrath's Flat, NSW. Members made good use of question time and Patrick later stated that he was impressed at the extent of knowledge about Australian fossils within the 'amateur' group.

Members then mustered at the Cloak Room again to swap around. Group A went to the fossil collection with Dayna, Group C to the mineral collection with Ross and Group B followed Joan to the 200 Treasures Gallery which displays the Museum's extra special specimens. Joan led members to the 10.7 kg Maitland Bar gold nugget *(photo 11)* which is the only remaining documented example of a large gold nugget discovered during the late gold-rush years of New South Wales. It was discovered in 1887, purchased by the NSW colonial government and placed in the care of Treasury. It was stored in a large Wells Fargo box and over time it was forgotten. The box was used each year as stumps for the Treasury office Christmas cricket game because it was just about the right height. One year, curiosity made a treasury staff member look inside and the nugget was rediscovered. It resided with the Geological and Mining Museum for some time and then became the responsibility of the Geological Survey of NSW (GSNSW). It was placed in a safe in Newcastle

9. Perfectly preserved leaves of *Podozamites* and a fossil fish from the Talbragar fossil site. (Abram Powell. https://australian.museum).

11. Maitland Bar gold nugget. (Ron Evans).

and each year it was audited by Brian England and GSNSW officials to ensure that it was still there and that no one had removed any part of it. It was loaned to the Australian Museum in 2017 and its display under secure conditions means the auditing process is no longer necessary.

Joan pointed out some of the Museum's other valuables such as the beautifully complex, brass, antique goniometer which was used to measure the angles between crystal faces to establish the crystal shape of a mineral before more modern methods were developed; 'Eric', the 110my old opalised Plesiosaur from Lightning Ridge; the Broken Hill cerussite with sword-like crystal blades up to 28.7 cm long; one of Mawson's sleds used in his Antarctic explorations; the 17th century Japanese sword presented to famous geologist and Antarctic explorer, Edgeworth-David, who aided the Japanese Antarctic expedition team in 1911; the Canowindra rock slab which contains four significant fish species including NSW's state fossil emblem, *Mandageria fairfaxi* and; the magnificent, fragile crocoite specimen with terminated crystals up to 7 cm long. The tour continued up the old curved red cedar staircase to Level 1 to see further earth science specimens and artefacts.

One last muster allowed Group B to go to the fossil collection and Groups A and C to indulge in the Museum Treasures gallery and further storytelling. Then it was time to regroup, applaud our guides, say our thankyous and goodbyes and prepare for our return journeys home. Most members eyes, ears and feet welcomed the rest. The Museum is a big place and there was a lot of stair-climbing, walking, listening and looking testifying to the continued stamina of the AGSHV members.

Brian Dunn purchased a copy of Ross Pogson's book, 'Mineral Icons of the Australian Museum' which can be borrowed from the AGSHV library.

Report by Joan Henley.

References:

POGSON, R. (2022). *Mineral Icons of the Australian Museum.* Australian Museum, Sydney

POGSON, R. (2023). *The new Minerals exhibition at the Australian Museum, Sydney.* Australian Journal of Mineralogy 24,1, 46-55.

HINGLEY, J. (1977). *A Candid Look at Crystals.* Australian Natural History 19,3, 90-95

ENGLAND, B. M. and SUTHERLAND F. L. (1988). *Volcanic Zeolites and Associated Minerals from New South Wales.* Mineralogical Record 19:6, 389-406.

SUTHERLAND, F.L. (1911). *Gemstones of the Southern Continents.* Reed Books Pty Ltd, Sydney

https://australian.museum/learn/australia-over-time/fossils/sites/talbragar/

View of the mineral display area, Australian Museum, Sydney. (Ron Evans).

Dungog to East Gresford

Leaders: Brian England, Chris Morton & Ron Evans.
Date: Saturday 23rd March 2034.
Attendance: 19 members.

Background Information.

The region lies at the southern end of the New England Fold Belt* between the Peel Fault in the east and the Hunter Fault/Thrust in the west *(Figure 2)* and forms a southwestern extension of the Tamworth Trough, which preceded the Werrie Trough. This is a region comprising a shallow (in the west) to relatively deep water (in the east) marine shelf bordered in the west by a dacitic volcanic chain and in the east by a deep -water slope and forearc basin province. Hence during the Devonian and Carboniferous the eastern edge of the Australian craton represented and Andean-style convergent continental margin with a west-dipping subduction zone. Sediments deposited in the basin range from continental volcanic sandstones in the west, through shallow marine sandstones, oolitic limestones on shallow carbonate banks and mudstones, to relatively deep-water mudstone with interbedded turbidites in the east adjacent to the Peel Fault, which may have controlled the position of the shelf edge during the Devonian and Carboniferous (Roberts, et.al.,1991). The geology of eastern Australia is considered to be a type example of a subduction-related accretionary orogen referred to as The Tasmanides (Rosenbaum, 2012).

The region comprises three distinct provinces now regarded as three distinct blocks – the Rouchel, Gresford and Myall Blocks *(Figure 3)* separated by major faults. This excursion covers the geology of the central Gresford Block that covers the central shallow marine shelf environment and comprises part of the Gilmore Volcanic Group along Sugarloaf and Bingleburra Roads between Dungog and East Gresford *(Figure 1)*. A previous excursion (Evans and England, 2020) covered the geology of the adjacent Myall Block to the east which comprises deeper water sediments, including turbidites.

Stops have been selected to illustrate the different rock types and depositional environments present from east to west *(Figures 5 and 6)*. With most of the sediment source from the Andean volcanic chain in the west, the various depositional environments gradually migrated towards the east as the basin filled so that the earlier environments were sequentially overlain by later ones, building up the vertical stratigraphy we see today *(Tables 1 and 2)*. Note that because of faulting, outcrops may not be seen in the correct stratigraphic sequence.

Tectonics.

While the Triassic Sydney Basin sediments to the west of the Hunter Thrust are relatively undisturbed, the area to the east has been strongly affected by at least six deformation episodes extending from the Early Permian through into the Triassic (Roberts, et.al., 1991).

Episode 1.

In the Early Permian, east-west compression directed from the east caused folding and some faulting due to subduction along the east coast and collision of an outboard island arc. Collapse of the pre-existing sediment-filled geosynclinal forearc basin and emergence of the sea floor occurred during this episode.

However, the relative ages of individual faults cannot be ascertained.

Episode 2.

In the Late Early Permian, southwest-northeast tension produced a series of subparallel northwest to southeast-striking normal faults. This event allowed the intrusion of the Barrington Tops Granodiorite (269Ma) to the north of the excursion area.

Episode 3.

In the Late Permian, southwest-northeast compression originating from the east or northeast resulted in major folding. However, in the Gresford Block folds have become difficult to recognise as major features. This dramatic change in fold style between adjacent structural blocks may be due to basement control.

Episode 4.

In the Late Permian, east-west tension resulted in major north to north-northwest trending vertical to high angle normal faulting caused by stress relief during uplift. This produced a series of horsts, grabens and step faults within the Gilmore Volcanic Group, resulting in the same stratigraphic sequences being repeated several times in sections across the Block geology (Figure 4).

Episodes 5 and 6.

In the Triassic these episodes involved the detachment of sheets of Devonian and Carboniferous rocks from uplifted area in the south end of the fold belt, gravity sliding for short distances south-westwards and over thrusting the Permian sediments of the Sydney Basin. However, this event did not affect the Gresford Block sediments.

In the Gresford Block the overlying Permian rocks affected by these tectonics have been removed by erosion.

The above deformation episodes may have been complicated by the development of the New England Oroclines to the north around 310-260Ma, caused by subduction rollback (Rosenbaum, 2012).

- The New England Fold Belt represents the remnants of the Hunter-Bowen Orogeny, the last significant deformation episode in the Tasman Geosyncline that occurred between 265 and 230 Ma (Permian to Triassic). It involved the tectonic accretion of metamorphic terranes and mid-crustal granitoid intrusions, with the region also affected by intense folding and faulting (Wikipedia).

Background Information by Brian England.

References.

EVANS, R. and ENGLAND, B.M. (2020). *Booral to Bulahdelah.* Geo-Log 2020, 30-39.

ROBERTS, J.; ENGEL, B. and CHAPMAN, J. (1991). *Geology of the Camberwell, Dungog and Bulahdelah 1:100,000 sheets 9133, 9233, 9333.* Geological Survey of New South Wales. Department of Mineral Resources.

ROSENBAUM, G. (2012). *Oroclinal bending in the southern New England Orogen (eastern Australia):* a geological field excursion from Brisbane to Sydney.

Journal of the Virtual Explorer, 43, paper 6.

Undulating country some 5 km west of Dungog viewed from Bingleburra Road. (Ron Evans).

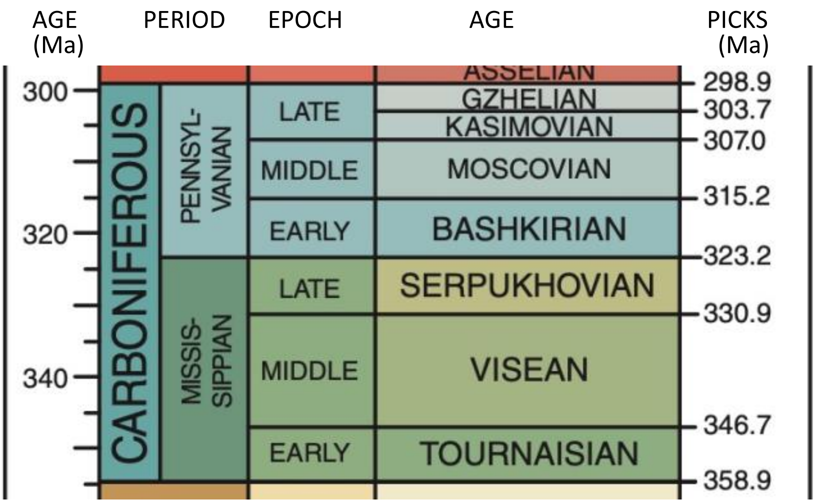
Dungog to East Gresford Excursion Information.

On the Dungog Geological Series Sheet 9233 1:100,000 Map (Edition 1) 1991 *(Table 1)*, strata observed are classified as follows:

Table 1: Summary of strata observed during the trip from Dungog to East Gresford.

Formation	Member	Age (Ma)	Main Lithology	Relationship
Wallaringa Formation.		346.9 to 330.9. Visean (Middle Carboniferous).	Sandstone. Terrestrial - fluvial.	Overlies Flagstaff Formation.
Flagstaff Formation.		346.7 to 330.9. Visean (Middle Carboniferous).	Sandstone. Shallow marine - outer shelf.	Basal sandstones conformably overlie Bonnington Fm mudstones.
	Allyn River		Sandstone. Shallow marine - outer shelf.	Strata reflect changing depositional conditions within the broad depositional environment of the Flagstaff Fm.
	Flagstaff Fm conglomerate		Conglomerate. Possibly Feeder channel deposits.	
Bonnington Siltstone.		346.7 to 330.9. Visean (Middle Carboniferous).	Siltstone. Shallow marine - outer shelf.	Conformably overlain by Flagstaff Fm strata.
Ararat Formation.		358.9 to 330.9. Tournaisian (Early Carboniferous) to Visean (Middle Carboniferous).	Siltstone. Shallow marine – volcaniclastic.	Conformably overlie mudstones of the Binglebura Fm which is overlain by the Bonnington Siltstone
	Ararat Fm limestone member.		Limestone. Shallow marine - probably a carbonate bank.	
Binglebura Formation.		358.9 to 346.7. Tournaisian (Early Carboniferous)	Limestone. Shallow marine - outer shelf.	Conformably overlain by the Ararat Fm.

Note: Carboniferous Period classification is as follows:



(GSA Geologic Time Scale v.5.0)

PICKS refers to the radioisotopic dates for the boundaries between the ages.

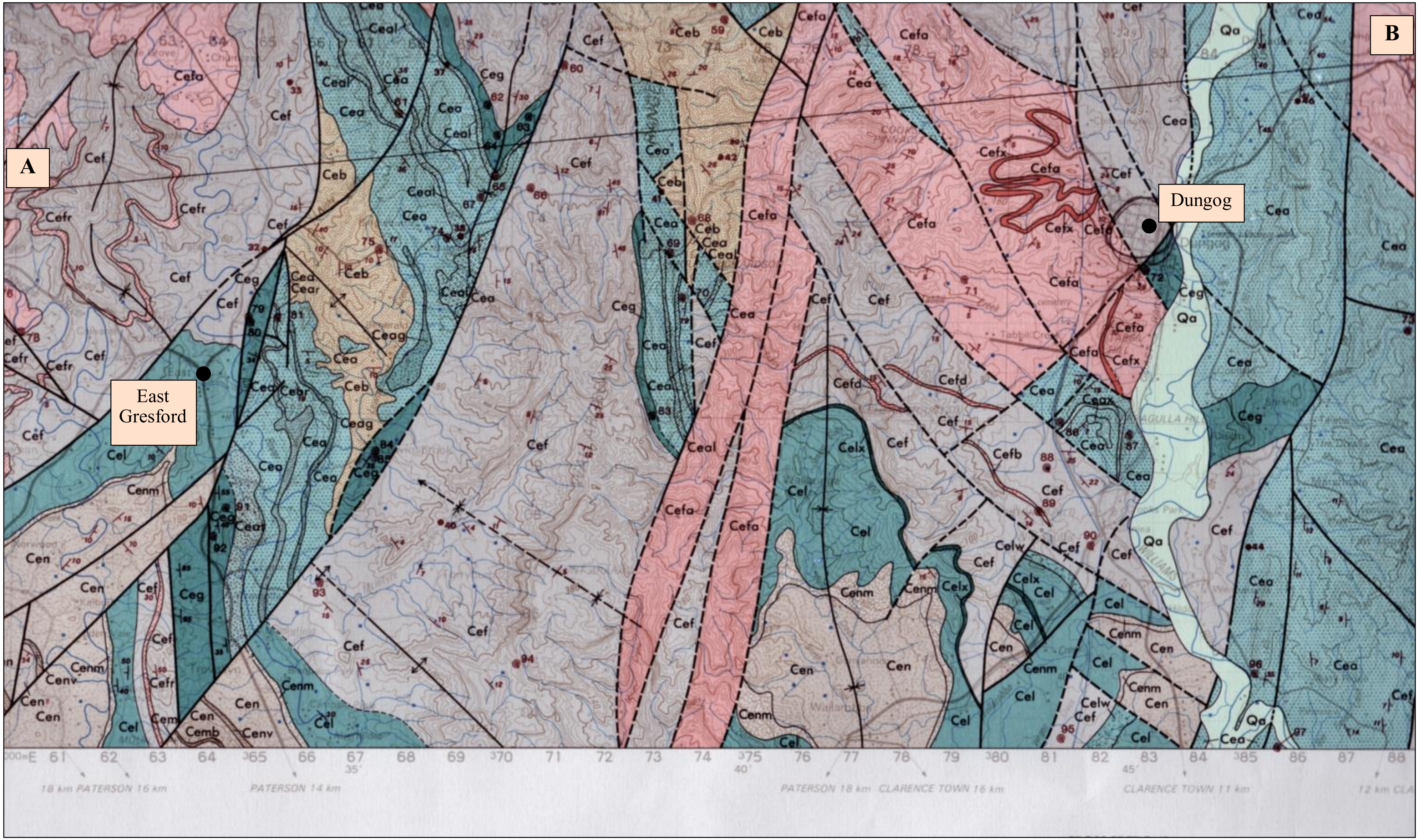


Figure 1. Geological map showing strata between East Gresford and Dungog. See page 2 for key.
(DUNGOG. Geological Series Sheet 9233 (Edition 1) 1991)

Key to Strata shown on *Figure 1.*

GILMORE VOLCANIC GROUP.

Cel WALLARINGA FORMATION - **Cugw** on GSNSW Seamless Geology of NSW map.
Pink to brown, thickly bedded lithic sandstone, conglomerate and minor siltstone.

Cef FLAGSTAFF FORMATION - **Cugf** on GSNSW Seamless Geology of NSW map.
Thickly bedded green lithic sandstone with varying proportions of brown mudstone and conglomerate, and minor oolitic, skeletal and coralline limestone.

Cefa Allyn River Member - **Cugfa** on GSNSW Seamless Geology of NSW map.
Green to brown, medium to thickly bedded lithic sandstone and turbidic sedimentary structures and interbeds of brown thinly bedded mudstone.

Cefx Unnamed conglomerate members - **Cugf_c** (Flagstaff Formation conglomerate) on GSNSW Seamless Geology of NSW map.

Ceg BONNINGTON SILTSTONE - **Cugo** on GSNSW Seamless Geology of NSW map.
Grey, thinly bedded siliceous siltstone, cherty mudstone and chert.

Cea ARARAT FORMATION - Cgia on GSNSW Seamless Geology of NSW map.
Green to brown, thick to medium-bedded lithic sandstone, lensoidal units of grey, cross bedded oolitic and crinoidal limestone, cobble conglomerate, minor mudstone and occasional ignimbrite.

Ceal Unnamed limestone members - **Cgia_l** (Ararat Formation – Limestone) on GSNSW Seamless Geology of NSW map.

Ceb BINGLEBURRA FORMATION - **Cugb** on GSNSW Seamless Geology of NSW map.
Brown and grey, thinly bedded mudstone and siltstone with thin interbeds of lithic sandstone, oolitic and crinoidal limestone.

Note: See page 117 for an explanation of Group, Formation and Member.

A Reminder.

During late Devonian and Carboniferous, the Hunter Region was part of a shallow to deep water shelf area *(Figure 2)* bordered to the West by a dacitic volcanic chain and to the East by a deep-water (marine) slope and basin province.

Parts of the latter have been interpreted as a subduction complex suggesting that at the time the eastern edge of the subduction craton represented an Andean type continental margin with a westerly dipping subduction zone.

Faulting was active during the Carboniferous and continued into the early Permian when it was most intense meaning today the strata observed in the region is greatly disrupted by faults and folds *(Figure 4)*.

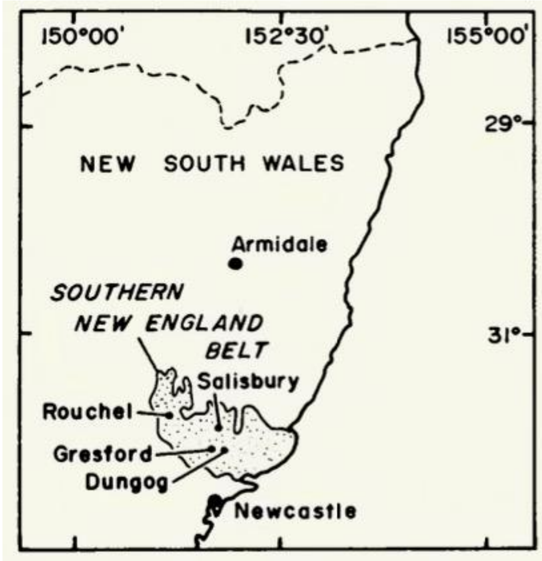


Figure 2. Location of the Southern New England Belt. (Lindley, I.D., 1984).

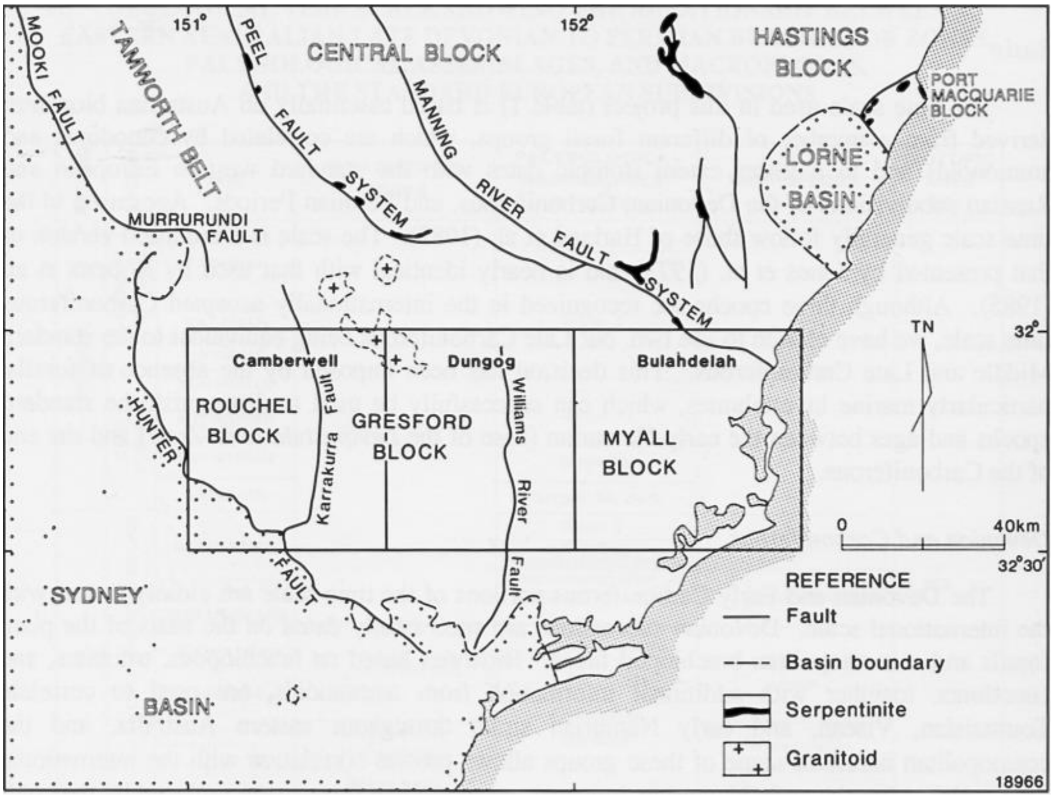


Figure 3. Location of Rouchel, Gresford and Myall Blocks and the major faults bordering the Tamworth belt. (Roberts et. al., 1991).

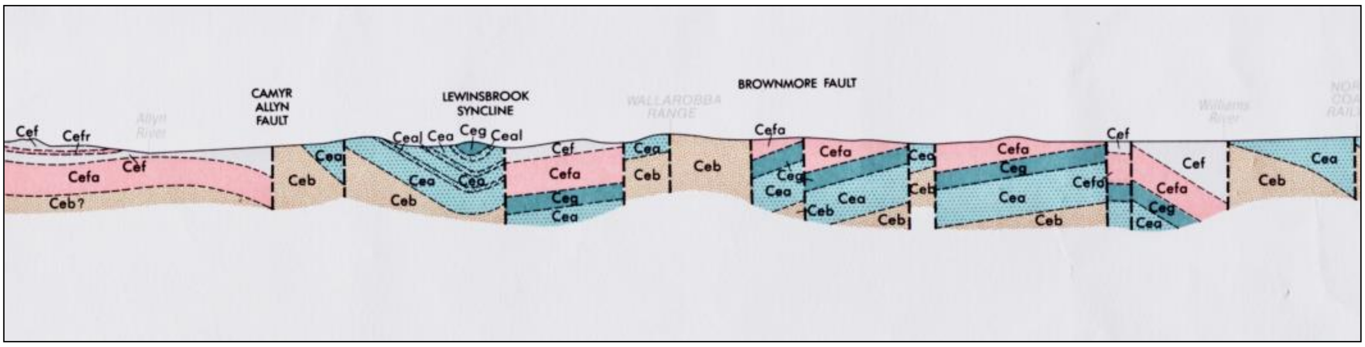


Figure 4. Cross-section of Carboniferous strata *(A to B on Figure 5)* between East Gresford (left) and Dungog (right). (DUNGOG. Geological Series Sheet 9233 (Edition 1) 1991)

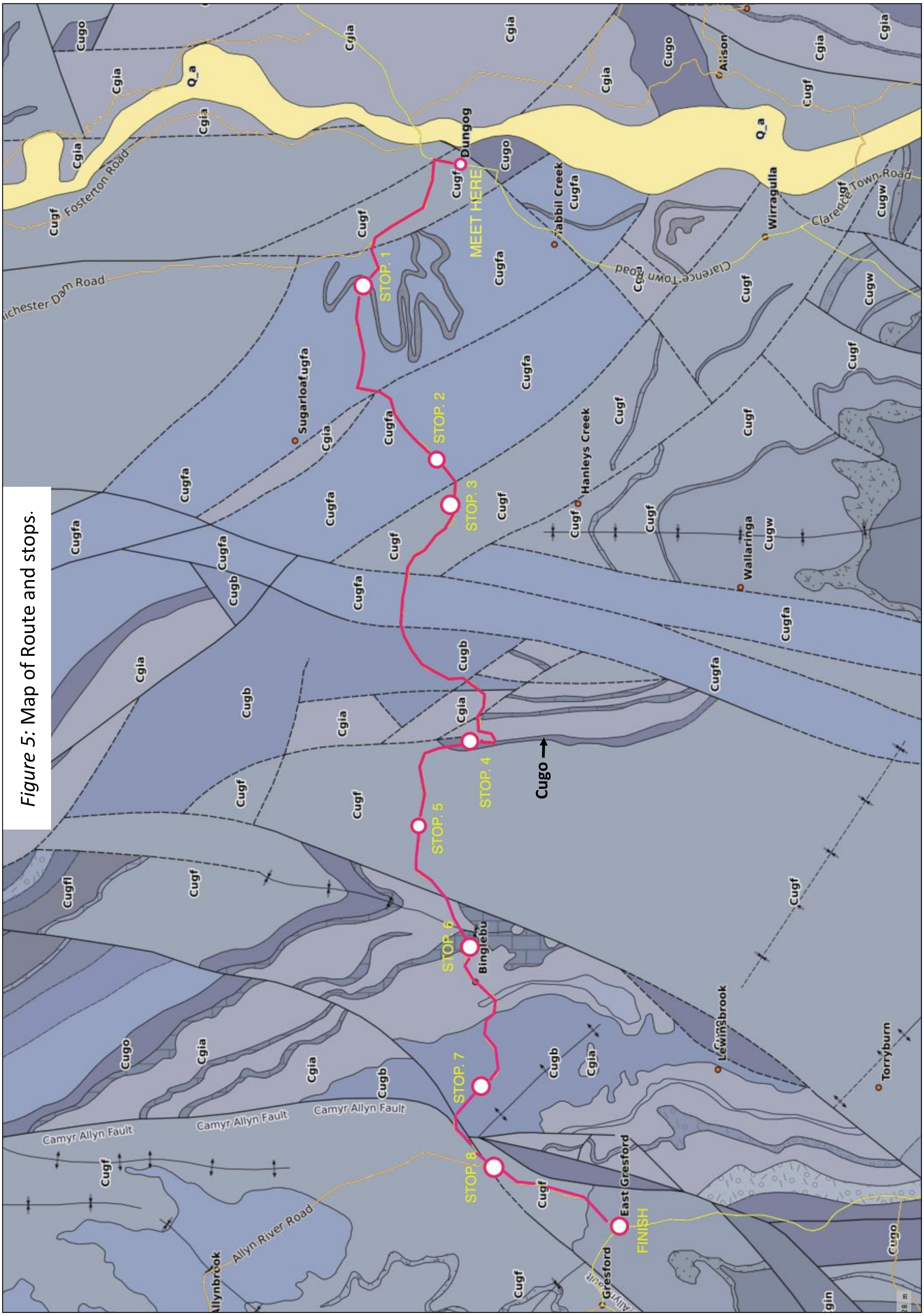


Figure 5: Map of Route and stops.

Points of Interest.

As well as the stratigraphy examined at the indicated stops, there are also other geological points of interest to be noted an the drive.

These are indicated on Figure 6 below.

A Outcrop of sandstone within Allyn River Member.

B Narrow outcrop of Ararat Formation limestone - located within steeply dipping beds interbedded with other rocks located on the left side of the road.

C Axis of a syncline in the valley.

D Camyr Allen Fault, one of the major faults in the Gresford Block.

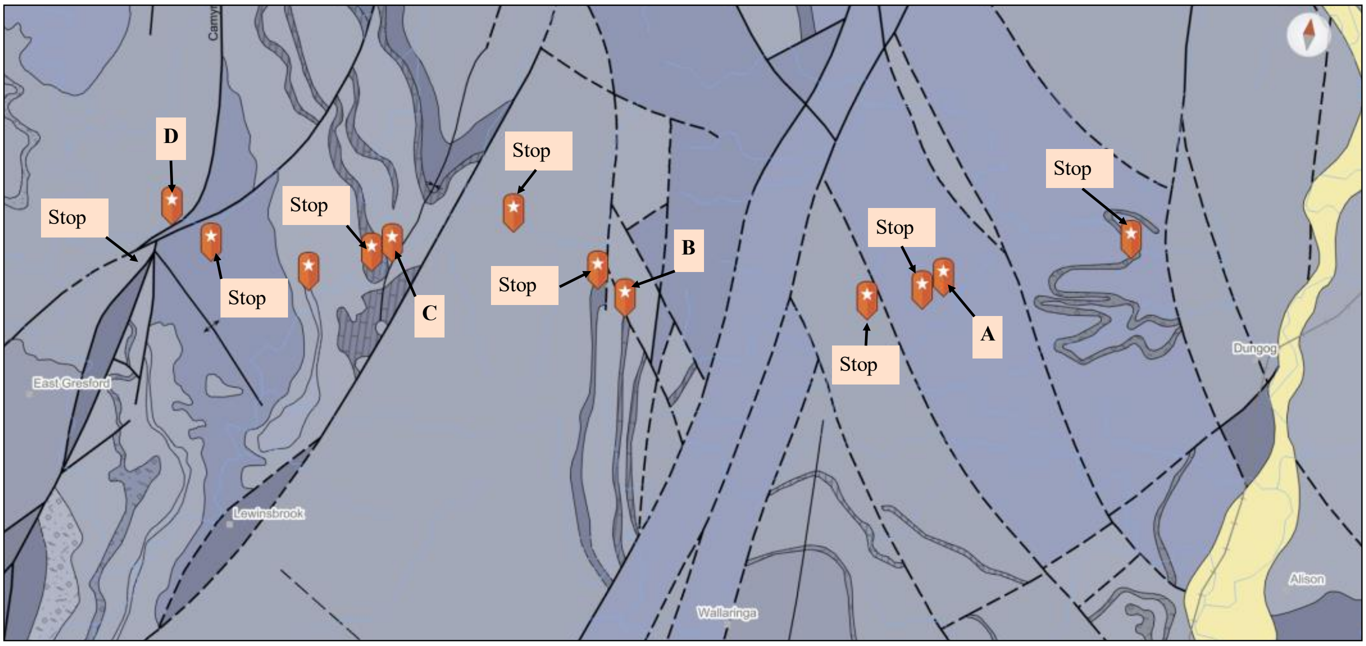


Figure 6. Points of interest.

Table 2. Details of stratigraphy along the route between Dungog and East Gresford.

Formation/Age	Lithology	Depositional Environment	Distance from start of Sugarloaf Road.	Outcrop Lithology	Geomorphology
Flagstaff Formation – Cugf 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cef - Dungog map**.	Volcaniclastic, lithic sandstone, mudstone, conglomerate, volcanic breccia, dacitic ignimbrite, chert & limestone. ***Dominant Lithology is sandstone***.	Shallow marine - outer shelf.	Note: Most of the NW part of Dungog township is situated on the Flagstaff Fm.	No outcrop.	Undulating low hills.
Allyn River Member – Cugfa 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cefa - Dungog map**.	Green to brown, medium-thickly bedded lithic sandstone with turbidic sedimentary structures and interbeds of brown thinly bedded mudstone. ***Dominant Lithology is sandstone***.	Shallow marine - outer shelf.	*Boundary at 0.1 km* - immediately after the start of Sugarloaf Road at 80 km/h sign.	No outcrop.	Undulating low hills.
Flagstaff Formation - Conglomerate Cugf_c 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cefx - Dungog map**.	Conglomerate. ***Dominant Lithology is conglomerate***.	Shallow marine - outer shelf.	*Boundary at 0.7 km.* **STOP 1** Outcrop middle of small road cutting on the left hand side (LHS) of Sugarloaf Road. Note: The road turns south onto Bingleburra Road soon after Stop 1.	The conglomerate outcrop is only small and very weathered. It appears to follow the hill contours.	Undulating country - small creek on the right with hills behind.
Allyn River Member – Cugfa 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cefa - Dungog map**.	As above.	Shallow marine - outer shelf.	Fault within the Allyn River Member crossed at 3.2 km – note change in dip. **STOP 2** Outcrop on right at 4.8 km.	Thickly bedded massive sandstone showing spheroidal weathering seen at 4.4 km and 4.8 km on top of ridge. Well jointed massive immature sandstone (rock fragments, fresh feldspar) showing spheroidal weathering present.	Country becoming very hilly.
Flagstaff Formation – Cugf 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cef - Dungog map**.	As above.	Shallow marine - outer shelf.	*Boundary at 5.5* km. **STOP 3** Outcrop LHS of cutting on a ridge at 5.8 km.	Strata dips towards road. Lenticular bedding present.	Very hilly.
Allyn River Formation – Cugfa 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cefa - Dungog map**.	As above.	Shallow marine - outer shelf.	*Boundary at 7.6* km just through road cutting.	Sandstone in road cutting.	Very hilly.

Formation/Age	Lithology	Depositional Environment	Distance from start of Sugarloaf Road.	Outcrop Lithology	Geomorphology
Bingleburra Formation – Cugb 358.9 to 346.7 Ma (Tournaisian - Early Carboniferous) **Ceb - Dungog map**.	Brown and grey, thinly bedded mudstone with thin interbeds of lithic sandstone, oolitic and crinoidal limestone. ***Dominant Lithology is mudstone***.	Shallow marine - outer shelf.	*Boundary at 8.6 km.*	Mudstone outcrops form road cutting walls.	Very hilly.
Ararat Formation – Cgia 358.9 to 330.9 Ma (Early and Middle Carboniferous) **Cea - Dungog map**.	Green to brown, thick to medium-bedded lithic sandstone, lensoidal units of grey cross-bedded oolitic and crinoidal limestone, cobble conglomerate, minor mudstone and occasional ignimbrite. ***Dominant Lithology is sandstone***.	Shallow marine – volcaniclastic.	*Boundary at 10.6 km.*	Fine sandstone in beds steeply dipping towards road, hence recent landslips (water lubricated bedding planes). Sandstone and siltstone in lower sections of formation burrowed and bioturbated.	Very steep and hilly. At 11.1 to 11.2 km at a left bend, Ararat Formation Limestone is present, but not obvious.
Bonnington Formation – Cugo 346.7 to 330.9 Ma (Middle Carboniferous) **Ceg - Dungog map**.	Grey, thinly bedded siliceous siltstone, cherty mudstone and minor lithic sandstone. ***Dominant Lithology is siltstone***.	Shallow marine - outer shelf. Much of the deposited sediment derived from nearby volcanoes as ash.	*Boundary at 12 km.* **STOP 4** Mudstone outcrop in road cutting.	Siltstone outcrops in steeply dipping beds within the road cutting. Note the dip of the beds away from the road (southwards) whereas beds (landslip location) appear to steeply dip towards the road. This appears to be the result of fault planes as the bedding still appears to dip southwards.	Very hilly. Creek on the right probably follows the fault that's present.
Flagstaff Formation – Cugf 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cef - Dungog map**.	As Above.	Shallow marine - outer shelf, turbidic in parts.	*Boundary at 12.6 km.* **STOP 5** Sandstone and mudstone beds in road cutting.	Flagstaff Formation strata conformably overlies the Bonnington Siltstone. Beds form a shallow trough downfold on LHS of road. Small thrust fault present at 14.5 km.	Undulating and hilly. Hills lessen at 13.5 km.
Ararat Formation – Cgia 358.9 to 330.9 Ma (Tournaisian and Visean - Early and Middle Carboniferous) **Cea - Dungog map**.	As above.	Shallow marine - volcaniclastic.	*Boundary at 16.1 km on a major fault next to "The Burra" sin.* Dipping beds of sandstone - axis of N-S trending syncline crossed at 16.6 km.	Fine sandstone in road cutting.	Top of ridge in undulating hilly country.

Formation/Age	Lithology	Depositional Environment	Distance from start of Sugarloaf Road.	Outcrop Lithology	Geomorphology
Ararat Formation – limestone - Cgia_l 358.9 to 330.9 Ma (Tournaisian and Visean - Early and Middle Carboniferous) **Ceal - Dungog map**.	Grey oolitic limestone. ***Dominant Lithology is limestone***	Shallow marine. - a carbonate bank in the Dungog Embayment.	Boundary at 16.7 km. **STOP 6** Limestone outcrops, both weathered and unweathered.	Limestone outcrops on both sides of road.	Limestone forms a small ridge through which the road cutting traverses.
Glencoy Conglomerate Member – Cgiag 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Ceag - Dungog map**.	Medium to fine-grained lithic sandstone and conglomerate. Volcanic clasts predominate (85%) with 8% sedimentary clasts and 6% plutonic clasts. Sandstone also contains ignimbrite clasts.	Terrestrial - fluvial.	*Boundary at 18.3 to 18.4 km.* A small outcrop of conglomerate in road cutting on RHS of road.	Conglomerate outcrops in a small area in the middle of the road cutting. Once past the outcrop, the Ararat Formation is present.	Forms a small ridge.
Bingleburra Formation – Cugb 358.9 to 346.7 Ma (Tournaisian - Early Carboniferous) **Ceb - Dungog map**.	As above. Note: the mudstone weathers by fretting – this can be seen in small outcrops beside the road.	Shallow marine - outer shelf.	*Boundary at 18.7 km. Camyr Allan Fault crossed.* **STOP 7** Mudstone outcrops in the road cutting.	Thinly bedded mudstone dipping approximately 20° on a small crest through the which the road cuts. Park at 20.2 km – outcrop LHS cutting.	Hilly.
Flagstaff Formation - Conglomerate Cugf_c 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cef - Dungog map**.	As above.	Shallow marine - outer shelf.	*Boundary at 21.2 km.* At the junction of Bingleburra Road with the Allyn River Road poorly sorted lithic sandstones can be examined in the road cutting. **OPTIONAL STOP 8**	Small road cutting on the southern side of the road junctions at 22.2 km. Immature sandstone outcrops in road cutting on LHS of road junctions.	Undulating landscape.
Wallaringa Formation – Cugw 346.7 – 330.9 Ma (Visean - Middle Carboniferous) **Cel - Dungog map**.	Pink to brown, thickly bedded lithic sandstone, conglomerate and granitoids, minor sandstone.	Terrestrial – fluvial.	*Boundary at 24.2 km at the 50 km Ahead sign.* East Gresford village is located on the Wallaringa Formation.	No outcrops observed.	Undulating landscape.

Rock-Stratigraphic Classification.

To assist in the understanding of the names of rock units examined, the Classification of Rocks Based on Stratigraphy is outlined below;

A rock-stratigraphic unit is a subdivision of rocks that is delimited on the basis of lithologic characteristics (American Comm. Strat. Nomenclature, 1961).

Classification of Rocks Based on Stratigraphy.

Rock-stratigraphic units are divided into:
- ◊ Groups – may be part of a Supergroup
- ◊ Formations
- ◊ Members
- ◊ Beds

Supergroup.
- A supergroup is a set of two or more associated groups and/or formations that share certain lithological characteristics.
- A supergroup may be made up of different groups in different geographical areas.

Group.
- A group is a set of two or more formations that share certain lithological characteristics.
- A group may be made up of different formations in different geographical areas and individual formations may appear in more than one group.

Formation.
- A formation is the most fundamental and useful unit in this division.
- They are the primary units used in the subdivision of a sequence and may vary in scale from tens of centimetres to kilometres.
- They should be distinct lithologically from other formations, although the boundaries do not need to be sharp.
- To be formally recognised, a formation must have sufficient extent to be useful in mapping an area.

Member.
- A member is a named lithologically distinct part of a formation.
- Not all formations are subdivided in this way and even where they are recognized, they may only form part of the formation.

Bed.
- A bed is a lithologically distinct layer within a member or formation and is the smallest recognisable stratigraphic unit.
- Beds are the layers of sedimentary rocks that are distinctly different from overlying and underlying subsequent beds and is the smallest recognisable stratigraphic unit.
- Beds are not normally named, but may be in the case of a marker horizon.

Example:

GROUP	FORMATION	LITHOLOGY
Dalwood	Farley	Siltstone Shallow marine – siliclastic
	Rutherford	Siltstone Transitional – deltaic
	Allandale	Conglomerate Shallow marine – siliclastic
	Lochinvar	Basalt Shallow marine – extrusive volcanic

Table 2. Example of Group/Formation strata classification.

The Day's Excursion.

Participating AGSHV Members met in Paterson at John Tucker Park at 8:30 am where car pooling was organised before Brian and Ron outlined the days activity and provided information on geological processes involved along the excursion route. Participants were reminded to wear safety vests.

The convoy departed ay 9:30 to Dungog with a quick comfort stop before turning off Chichester Road onto Sugarloaf Road. Vehicle odometers were set to 0.00 km at this intersection.

Stop 1 at 0.7 km: Flagstaff Formation Conglomerate.

Vehicles parked in a cleared gravel area on the right of the bend.

A bed of conglomerate was seen exposed in the first part of the road cutting on the left *(photos 1 to 3)*. This was underlain by sandstone. The conglomerate is probably a stream channel deposit.

On the geology map *(figures 1, 5 & 6)* the outcrop appears to follow the slope contours. Pebbles are up to 12 cm in diameter. Most are volcanic in origin, mainly rhyodacitic ignimbrite. Their source was probably the volcanic arc to the west.

1. Small outcrop of Flagstaff Formation conglomerate on the southern side of the road.

2. Participants listening to an explanation of probable processes involved in the formation of the conglomerate.

3. Rounded volcanic pebbles and cobbles form most of the conglomerate.

Stop 2 at 4.8 km: Allyn River Member, Flagstaff Formation.

The cutting exposes a fine grained thickly bedded sandstone with spheroidal weathering evident *(photo 4)* as well as small bands of shale.

This is the same rock as exposed in the cuttings leading up to the stop.

The relationship between the joint and bedding planes was pointed out. At first glance the joint planes appear to represent highly tilted bedding but the presence of shale bands indicates the true bedding *(photos 5 & 6)*.

4. Spheroidal weathered sandstone.

5. Well developed joint planes can be mistaken for true bedding but the presence of shale bands indicates true bedding.

8. Plant fragments within a siliceous-rich band.

6. Indicators of true bedding - small shale bands.

9. Rock sample clearly illustrating the clay-rich (light) and quartz-rich (dark) bands present. (Brian England).

Stop 3 at 5.8 km: Flagstaff Formation - Varved sandstone/shale.

Outcrops in the cutting on the left displayed a spectacular varved shale/sandstone bed *(photo 7)* which contains rare plant fragments *(photo 8)*.

This probably indicates a lake bed deposit showing seasonal deposition.

Grey bands are clay-rich while light coloured bands are quartz-rich *(photo 9)*.

Stop 4 at 12.2 km: Ararat and Bonnington Formations.

This is an area in which major land slips occurred after the heavy rains which hit the region in February 2021, closing the road for an extended period until remedial rock bolting and meshing could be completed to stabilise the cutting *(photo 10)*. Although the road is now fully open, roadside concrete barriers are still in place to deal with any future minor slippages that might occur.

7. Varved bedding was evident in the outcrops.

10. Stabilised section of Bingleburra Road.

The geological structures in the vicinity of this large cutting are still poorly understood and potentially complex. Further investigation is needed but may be thwarted by the very limited access available to key sections.

The rocks exposed before and at the sharp right hand bend comprise thickly bedded sandstones of the Ararat Formation in which the bedding planes dip to the west towards the road. Hence the inherent instability after heavy rain events, with increased groundwater flow lubricating the clay-rich bedding and joint planes, resulting in catastrophic failure.

At the bend the road swings sharply at 90 degrees to the bedding in the sandstones and major jointing takes over as the principal structural feature. Coincidentally these joint planes also dip towards the road at this point *(photo 11)* increasing the probability of slope failure in this area and providing a significant challenge to the road engineers.

On geological maps of the area a major fault is inferred somewhere in the cutting *(see Figure 5)*, with Stop 4 (at the pullout) actually located in the overlying Bonnington Siltstone (Cugo) according to seamless geology. But recent remedial work has made the critical area of interest either inaccessible or at best extremely dangerous, so this was not explored. It is probable that the juxtapositioning of the Ararat and Bonnington sequences is due to the fact that here the rocks dip to the west on the western limb of a large anticline *(see figure 4)* and is NOT due to faulting. However, further down the road this enigma has been solved!

A few hundred metres up the road from the pullout at Stop 4 where our vehicles were parked, apparent bedding planes in the Bonnington Siltstone also dip towards the road *(photo 12)*. BUT from the geological map *(Figures 1 and 5)* the bedding should still dip to the west, not the north, and close examination shows these apparent dip slopes are actually joints and the bedding does indeed dip to the west back into the hillside as shown by the presence of pale-coloured thin shale bands and conglomerate beds *(photos 13 & 14)* in which the pebbles are again volcanic in origin (andesitic Ignimbrite).

11. Joint planes dip towards the road while bedding dips away from the road.

12. Outcrops of Bonnington Siltstone near Stop 4 appear to dip towards the road. However, they actually dip away from the road.

13. Bed of conglomerate clearly dipping down away from the road.

14. Conglomerate bands (sheared by jointing) indicating true bedding away from the road.

Further up there road (just beyond the start of the concrete barriers) these joints show a very abrupt change in orientation *(photo 15)*. The adjacent surfaces still dip towards the road, but at different angles, the boundary between them marked by an obvious shear or crush zone, indicating the presence of a significant fault which terminates near the top of the cutting like a giant

15. Shear zone on the left behind the post. This is indicated by change in the dip of joint surfaces. (Brian England).

16. Fossil brachiopod *(Productid)*. Note remnant shell on top of the internal mould, and the external mould above.

17. Mould of a rugose coral above the card.

vertical tear. This conforms precisely with the position and extent of the inferred fault shown in Figure 6. Enigma solved!

Remnant scree from the Bonnington Siltstone at the roadside contains fossil brachiopods *(photo 16)*, crinoid fragments and rugose corals *(photos 17 & 18)* supporting its shallow marine origin.

Site 4 interpretation by Brian England.

18. Rugose coral fossils, a mould on the left and some original calcareous skeleton (corallum) in the center. (Brian England).

Stop 5 at 14.5 km: Flagstaff Formation - Thrust fault.

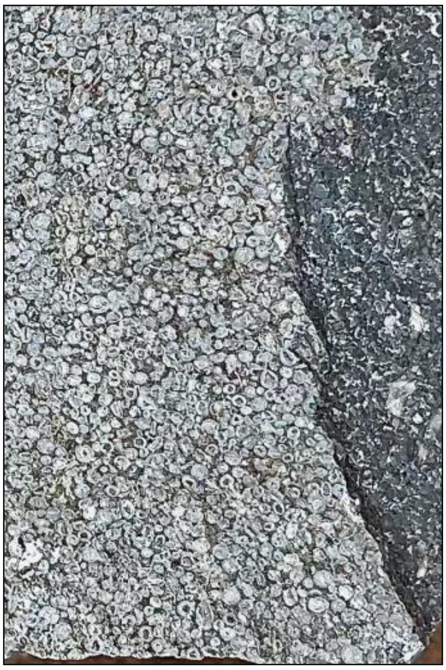
Here a small thrust fault is present in thinly bedded shale/sandstone *(photo 19)*. Note the change in dip near the fault and the presence of a fault crush zone within the fault plane.

19. Small thrust fault on the southern side of the road Cutting.

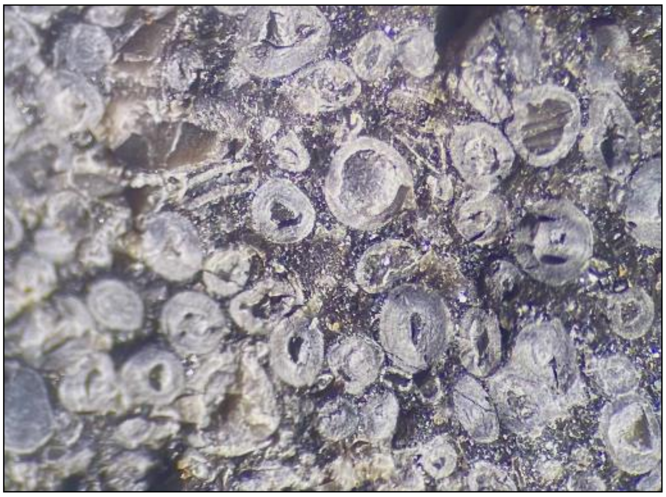
Stop 6 at 16.7 km: Ararat Formation - Limestone.

The cuttings on the left and right exposed a fine grained oolitic limestone deposited on a shallow marine carbonate bank in the Dungog Embayment.

The individual ooliths were small and a hand lens was needed to see them clearly. It was noted that these could only be seen on weathered surfaces of the rock (photos 20 & 21). Also present were rare corals and crinoid ossicles.



20. Weathered surface of the limestone revealing small ooliths (left) compared to fresh rock surface (right). (Brian England).



21. Magnified view of ooliths that formed when calcite precipitated around a small nucleus in supersaturated water. (Brian England).

One boulder displays stylolites *(photo 22)*. These appeared as dark wavy lines. Stylolites form when pressure causes calcite to dissolve leaving behind insoluble material along planes of calcite dissolution (clays, organic matter etc) making the styolite visible.

At 18.7 km the Camyr Allan Fault is crossed *(see figure 6)* but there is no obvious surface expression. This is one of the major faults in the Gresford Block.

22. The dark wavy bands are stylolites. Note also the presence of fossilised crinoid stems.

Stop 7 at 20.2 km: Bingleburra Formation - Mudstone.

A brief stop was made to view an exposure of a thinly bedded mudstone with a dip of around 20 degrees that outcrops on the left (west) side of the road *(photo 23)*.

Two geological features were clearly seen. Firstly flat joint planes protected with a chemical veneer that prevents weathering by fretting until it breaks down. The presence of a veneer along the joint surfaces also hides the bedding underneath *(photo 24)*.

23. Bingleburra mudstone beds dipping south-west.

23. Flat joint planes protected by a chemical veneer. Note how the mudstone is weathering by fretting on the top left where the veneer has broken down.

Stop 8 at 21.2 km: Flagstaff Formation - Sandstone.

This stop was bypassed due to time constraints.

At the 50 kph sign in East Gresford the road crosses into the Wallaringa Formation, but there is no outcrop, just surface regolith.

After parking in East Gresford, we adjourned to the Beatty Hotel for an enjoyable lunch *(photo 24)*.

24. AGSHV members enjoying lunch at the Betty Hotel East Gresford.

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

References.

LINDLEY, I.D. (1984). *Stratigraphic Revision of the Early Carboniferous Flagstaff Formation, Southern New England Belt, N.S.W*. Journal and Proceedings, Royal Society of New South Wales, Vol. 7-14

ROBERTS, J.; ENGEL, B. and CHAPMAN, J. (1991). *Geology of the Camberwell, Dungog and Buladelah 1:100 O00 sheets*. Geological Survey of New South Wales.

Arc GIS Explorer. Geological Survey of New South Wales. Seamless geology of New South Wales. App for smartphone and tablet.

DUNGOG. Geological Series Sheet 9233 (Edition 1) 1991.

Geological Timescale. Australian Journal of Earth Sciences bookmark 2012.

Geomorphology of the Lower Blue Mountains near the Grose River

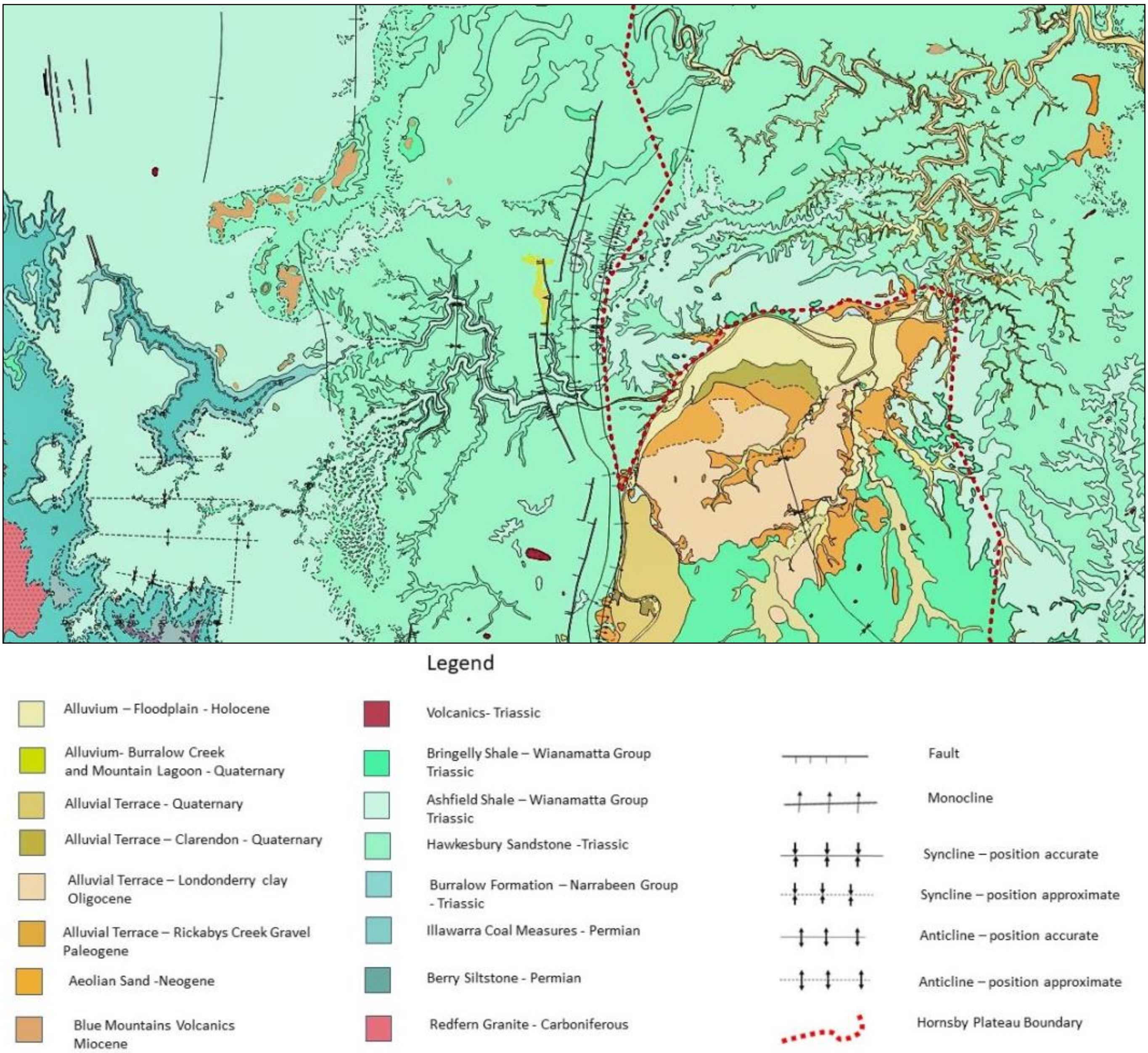
Leader: Rick Miller.
Date: Tuesday 9th to Wednesday 10th April, 2024.
Attendance: 11 members.

The **aim of the trip** was to examine the geology/ geomorphology of the Blue Mountains in the area to the west of the Hawkesbury, and assess its effects on human settlement *(Map 1)*. This continues many of the themes that were examined on the 2021 trip.

An east coast low caused minor flooding in the days prior to the trip and some members were unable to attend. An examination of the recent Burralow Uplift was not possible as the area was closed by NPWS staff and heavy rain in the late afternoon caused us to cancel the scheduled walk at the Mount Wilson waterfall. This flows over a layer of columnar basalt. Instead, we were able to examine an example basalt at Mt Tomah.

An outline of the Geology/Geomorphology of the study area.

The Sydney Basin was formed from about 300 Ma when the subduction zone off the coast was congested and a large orocline formed. The deformation opened an extensive basin on the sides of the orocline. In the south this became the Sydney Basin and it began to be filled by material eroded from the highlands in the orocline.



Map 1. The Study Area - Lower Blue Mountains, the Hornsby Plateau and the Hawkesbury Floodplain and Terraces.

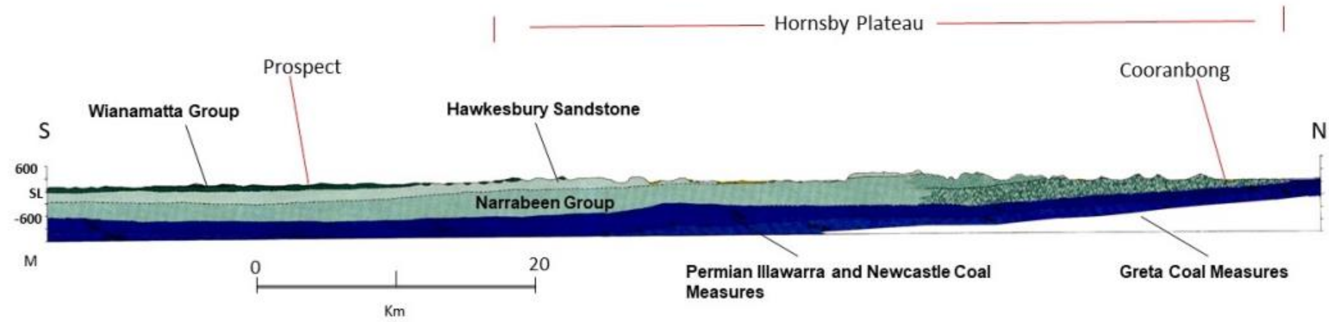


Figure 1. North – south cross-section of the Hornsby Plateau. (From the 1:1000,000 Gosford Mapsheet).

At approximately 260-250 Ma a subduction zone re-established off the coast and a compression event began to fold it. This produced the Lachlan Anticline and its southern extension, the Kulnura Anticline. Beside it, on the coastal side, the Macquarie Syncline was also formed. The Newcastle Coal Measures were then deposited in the Macquarie Syncline and the Narrabeen Group was deposited on top of this land surface *(Figure 1)*.

Deposition in what was termed the Narrabeen Episode occurred in three stages, between 251-247 Ma. (Herbert, et. al., 1980). In the first, alluvial fans and outwash plains spread from the Hunter-Mooki Thrust into a shallow marine environment. The sediments here vary; pebbly conglomerate was initially brought by braided streams and deposited in alluvial fans. During the regressive sea levels of the period, they were then overlain by finer sediments that were deposited on the floodplains of the meandering rivers and in estuaries. (Herbert et. Al., 1980).

The middle period was almost entirely of alluvial deposition on floodplains. Rivers flowing into the Sydney Basin from the north west were the major source. But in the southern areas, streams from the west brought sediment with a higher quartz content. There were also streams bringing sediment from the Volcanics of the Broughton Formation in the south east.

In the northern part of the basin on the extensive floodplains, there were deposits of fine-grained red, green and grey material. Some of this produced the Patonga Claystone.

For the third phase, the sediment supply from the north decreased and the area became a semi-marine environment. In the south and west deposition was mainly quartz sandstones, shales and red-brown clay stones. We saw some of these on our field trip.

The Hawkesbury Depositional Episode (246-236 Ma) was then initiated by uplift in the area to the south-west, the Lachlan Fold Belt (Herbert, et. al., 1980).

This produced large braided rivers that flowed into the deltaic Narrabeen environment and overwhelmed it with a sand sheet up to 250 m thick.

This depositional source ceased towards the end of the Triassic and the Wianamatta Series were then deposited (235-201 Ma). Meandering streams flowed down the Basin, mainly from the north west and a period of infilling with large deltas occurred. Sea level fluctuated during this period.

Initially, Ashfield Shale was deposited in low energy marine environments on the coast and this consisted of laminated silty sediments, often grey in colour. In places Minchinbury Sandstone was deposited above the shale and this was in sandy barrier islands and coastal lagoons located at the shoreline.

A continuing marine regression meant that swampy alluvial plains formed behind the barriers and these were filled by meandering streams flowing from the west. The beds of Bringelly Shale, the last formation in the Wianamatta Group, were formed in this period of deposition.

The sediments forming the Ashfield Shales are relatively high in phosphorous compared to those making up the Hawkesbury Sandstone. Soils formed on these shales were sought by both the Aboriginal inhabitants and Europeans and have had a profound effect on the settlement pattern and land use of the area.

The Ashfield Shale has a phosphorus content of between 0.1 and 0.9% P_2O_5 and this is significantly higher than levels in the Bringelly Shale. It is contained in thin beds rich in phosphatic siderite nodules. Unweathered it is dark grey to black in colour. It generally grades up from sideritic claystone and siltstone into fine layers of sandstone and siltstone (Step Inc.) It is readily weathered and mass movement on raised areas produces rolling topography and deep soils.

In the past Ashfield Shale was the major source of raw material for the Sydney brick making industry. Because of its high siderite content, the unweathered material fires to a dark red colour and gave the tile roofs and bricks of inner Sydney their red colour. It is rarely used today, with black tiles being the fashion.

The Bringelly Shale was re-defined in the late 1970s to include all Wianamatta sediments above the Minchinbury Sandstone. This means sandstone units which may be up to 30 m thick but which were probably channel or point bar deposits are now considered as members of the Bringelly Shale. Some of these are the Potts Hill Sandstone, the Razorback Sandstone and the Mt Hercules Sandstone

The Bringelly Shale had a maximum thickness of about 257 m near Razorback in the Southern Highlands but it has weathered and eroded significantly post-Triassic in the Parramatta-Sydney area. In the Hawkesbury and Lower Blue Mountains, it mostly remains as caps on isolated outcrops. We inspected one at Kurrajong.

Little deposition occurred in the Jurassic but there was widespread volcanic activity with at least 130 diatremes formed in the Basin.

At approximately 130 Ma India and South America begin to split from Australia and Antarctica and the latter two began to move to the north. The Kosciusko Uplift began in the north and by about 120 Ma extended to Southern Australia. This produced uplift of approximately 400-600 m.

As a result of the uplift a large braided river flowed from the south west into the area of the present Hawkesbury Valley and deposited layers of sand and gravel along its course. This continued into the Paleogene and the deposits are named the Rickabys Creek Gravels *(photo 1)*. Today deposits of these gravels are found over a wide area, from Berkshire Park to the edges of the Blue Mountains Plateau and parts of the Hornsby Plateau.

Tributary rivers also flowed out of the high land to the west and overtime they developed concave longitudinal profiles. These included the Grose and Colo Rivers and the profiles were significant in dating later uplifts.

During this and in a later period, sand deposited by these rivers was reworked and blown into dunes. There are three main areas; Agnes Banks has the largest and there are minor areas at Pitt Town and Maroota.

As the Basin continued to move north it passed over plumes in the asthenosphere and widespread volcanic activity occurred. In some areas, such as the Barrington Tops, this produced basalt flows, in others it led to uplift by underplating. Carter (2011) believes that from about 55-45 Ma and by approximately 30 Ma, the land along the present coast between Belmont and northern Sydney had been raised by about 200 m to form the Hornsby Plateau. This dammed the river and produced a large lake that extended back to the area of Penrith *(Figure 2)*.

The clay is so fine and impermeable that it has also had a significant impact on settlement. It was not valued for agriculture and so was largely left forested as part of Sydney's green belt. The NSW Government has located several facilities in it. These include prisons, fire research facilities for both NSWFB and RFS, munitions factories and storage, RAAF and international radio transmitters, and the bore core library at Londenberry. It has also been used for storing much of Sydney's liquid waste.

Water flowing into the lake eventually overtopped it and eroded a channel to the sea. The incised valleys of the Hawkesbury are incapable of transporting the volume of water that flows during periods of heavy rains, especially in times of East Coast Lows. The lake then partially reappears. It can take several days for the water to recede and layers of silt and clay are still deposited over the lowlands.

The source of the river has changed over time and now has a meandering pattern with cut-offs and billabongs on its floodplain. Natural levee banks line many sections.

Clark and Rawson (2005) produced a model (*Figure 3)* to explain the next stages in the area's development.

Between 30 and 20 Ma what is now the Lower Blue Mountains were lifted by approximately 250 m, with a slight tilt to the north east (Hatherly, 2020 & van der Beek et al., 2001). Between 20 and 15 Ma extensive flows of basalt covered much of this area. Many of these have since been eroded. From the uplift, knick points developed in the streams flowing into the proto-Hawkesbury/Nepean and these erded back into the highland.

The proto-Hawkesbury/Nepean had deposits of gravel over the lower reaches of the area of uplift *(C in Figure 3)*. What the diagram does not show is that small areas of what became the present scarp were also covered by the lake prior to the uplift. Carter (2011) found deposits of this Londonderry Clay *(photo 2)* on

1. Rickabys Creek Gravels. Deposits of these are found over a wide area from the lower slopes of the Blue Mountains to Shanes Park in the east and on the southern edge of the Hornsby Plateau. (Photo: R. Miller).

2. Londonderry Clay at Windsor. The deposit has been later subjected to laterisation. (Photo: R. Miller).

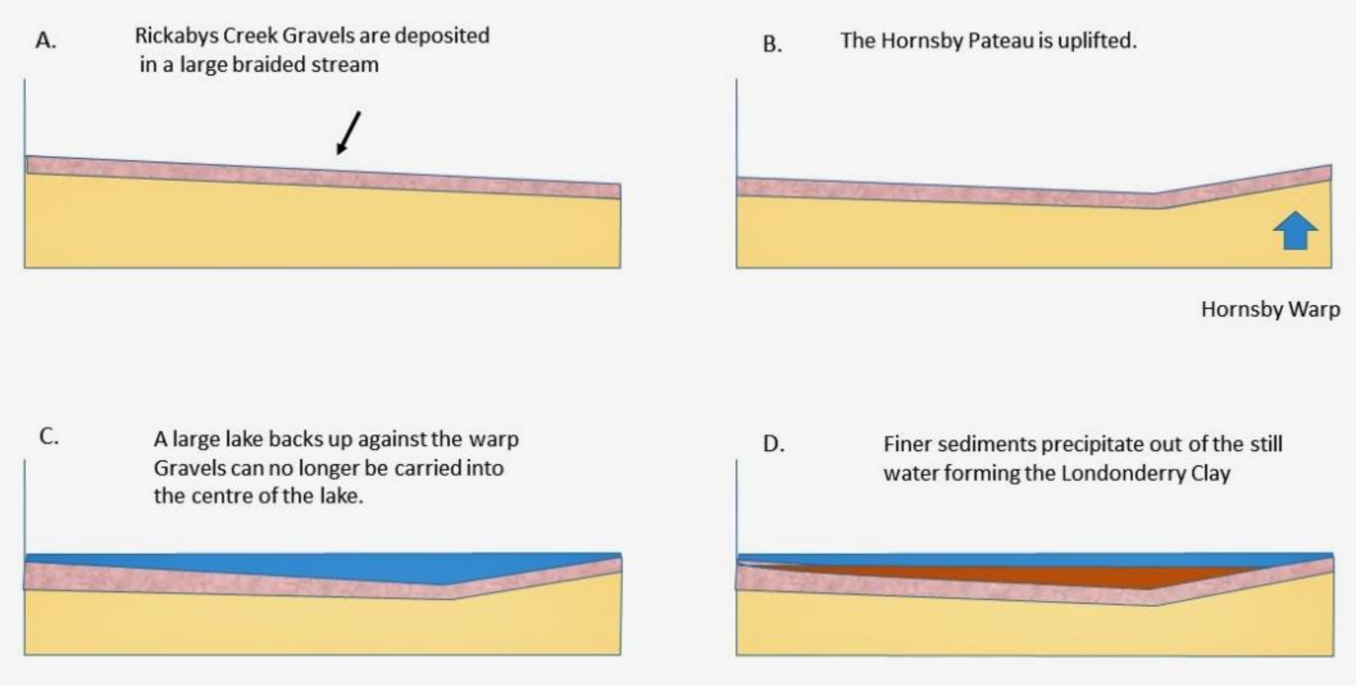


Figure 2. Stages in the formation of the Londonderry Clay that covers much of the river terraces associated with the Hawkesbury River.

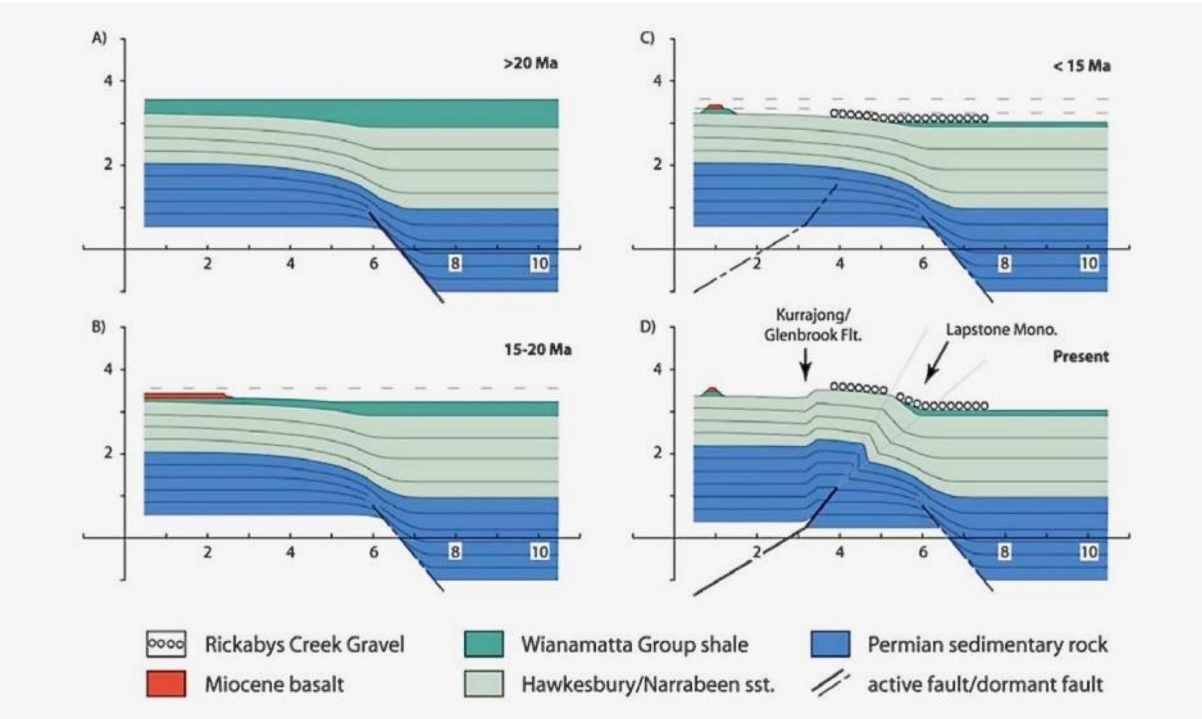


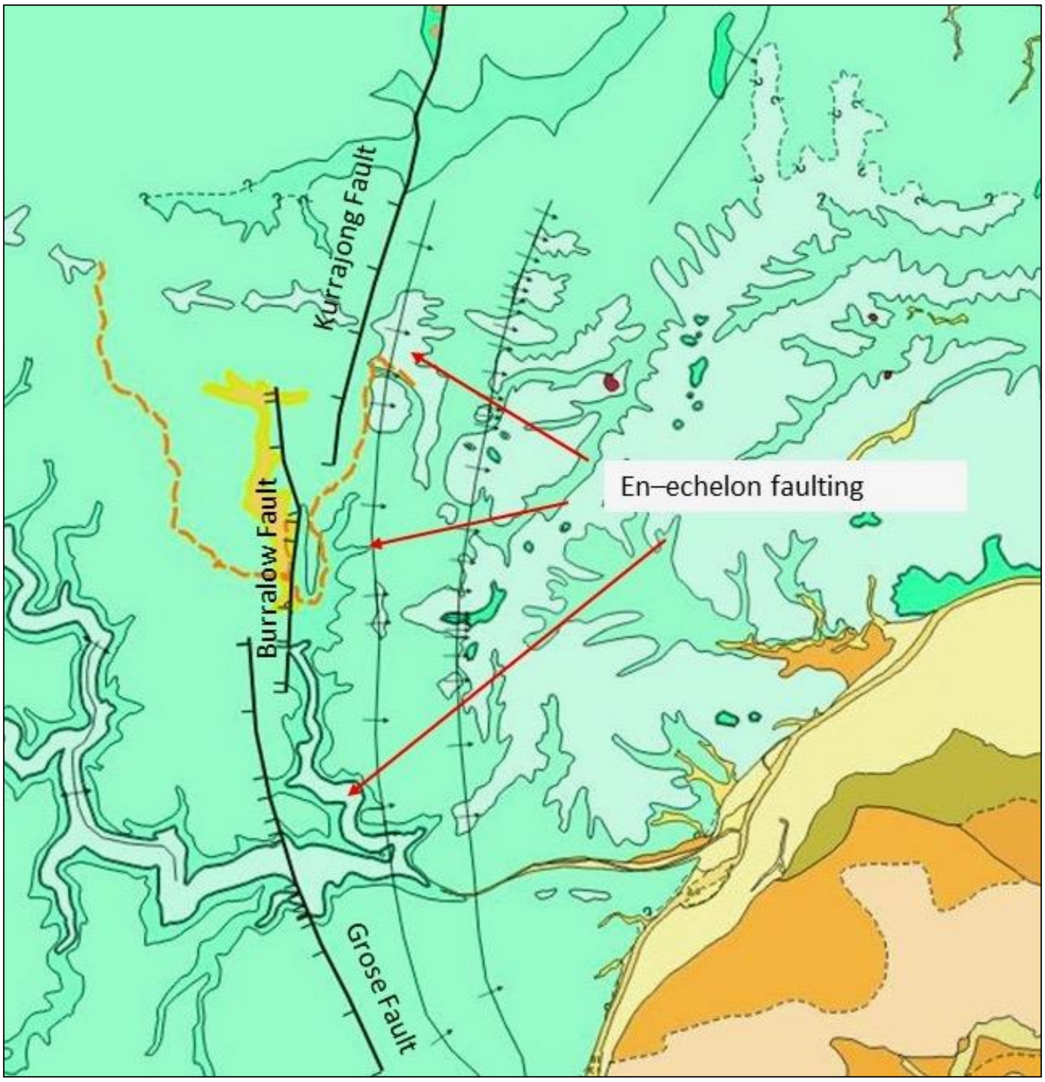
Figure 3. Stages in the formation of the Lapstone Structural Complex. (Clark and Rawson 2005).

what became the Lapstone Structural Complex (LSC). They were, however, absent on the Hornsby Plateau consistent with it having been uplifted first.

Between 15 and 10 Ma another uplift raised what is now the Lower Blue Mountains. This produced the Lapstone Structural Complex (LSC) of which the Monocline is a major feature. The uplift caused more knick points to form on the rivers flowing out of the newly raised plateau. These have been identified by several geologists and using estimated rates of erosion, they have confirmed the timing of the uplift.

The en-echelon faulting in the LSC *(Map 2)* suggests that some strike slip movement has occurred in this uplift. Clark and Rawson (2005) found a previously unknown fault to the east of the Kurrajong Fault. They suggest that the area around Kurrajong Heights is a Flower Fault *(Map 2 and Figure 4)*.

At our meeting point, The Richmond Club, we had a view over the Richmond Lowlands to the edge of the Hornsby Plateau. Locally this is called "The



Map 2. The En-echelon pattern of faulting is shown here. The Wheeny Gap Fault discovered by Clark and Rawson(2005) is not shown.

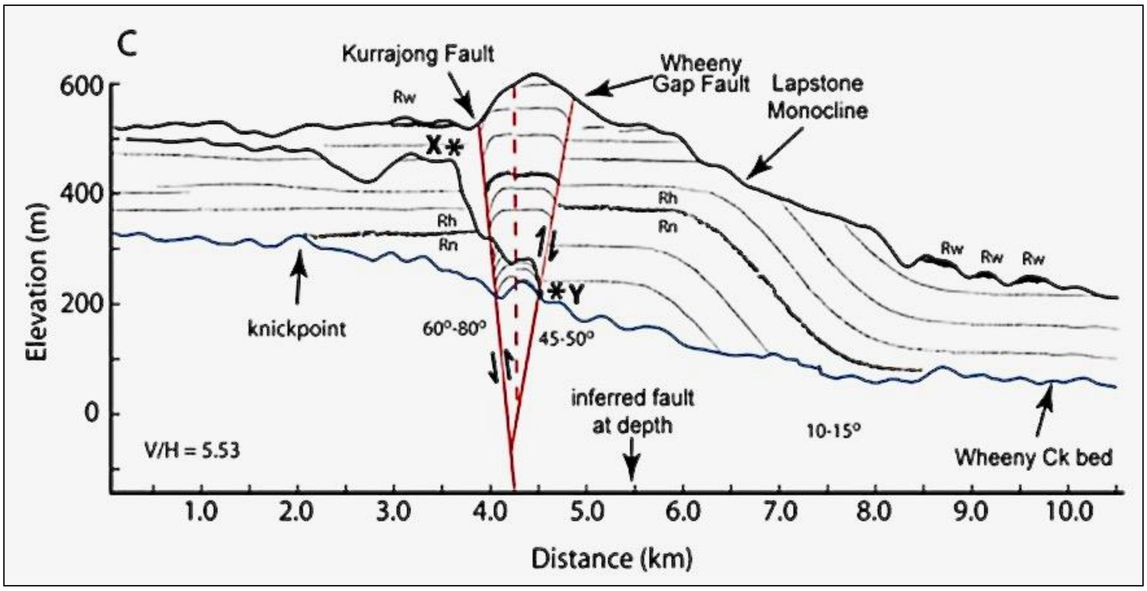


Figure 4. Cross-section at Wheeny Gap. Rh = Hawkesbury Sandstone Rn = Narrabeen Group Sandstone. The Wheeny Gap Fault is not shown on the mapping by Geoscience (Map 2). (Clark and Rawson 2005).

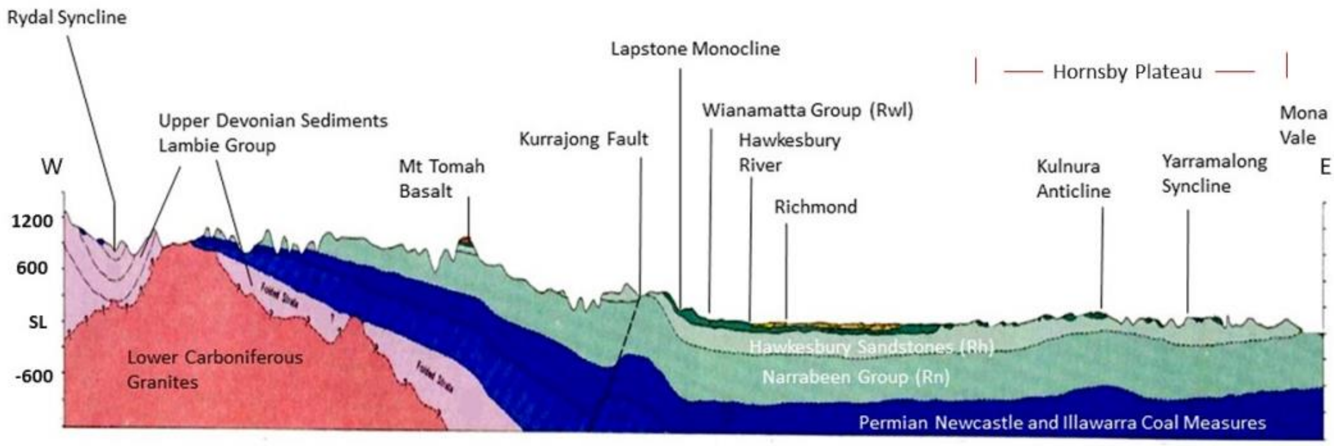


Figure 5. Cross-section of the current landforms.

Terrace" and we discussed the formation of the area's landforms.

Stop 1: Richmond Hill and Belmont.

Our first stop was at the St John of God Hospital site at Richmond Hill on Grose Vale Road. This is located on the south western end of the Hornsby Plateau and is the site of numerous conflicts in the frontier wars that occurred during British occupation although the initial contacts between the Boorooberongal Clan of the Dharug Tribe were positive. This included Aboriginal people assisting early European explorers to take their gear across the river in canoes like those in *photo 3*.

Geology and geomorphology were at the heart of the conflict. Governor Phillip needed to find fertile soils in sufficient quantity to grow crops and feed the settlement. He soon recognised that most fertile soils were those developed on Ashfield Shale. The first successful farm was at Parramatta, but was not sufficient to meet the needs of the colony. Philip then found another area of Ashfield Shale to the west, beside a permanent creek. This became the Toongabbie Farm and Westmead Hospitals are now on part of this site. Originally the area was covered by thick rainforest which the convicts had to clear.

On his trip to Richmond Hill with Watkin Tench in 1791, Phillip was partly looking for more areas of Ashfield Shale, especially beside streams. The alluvial soils of the Hawkesbury were however a major find.

The native Dharug people in the Hawkesbury based their economy largely on the flood plains. They had partially cleared the levee banks to grow tuber crops and snare quails in the surrounding undergrowth. In the forests they climbed trees for possums, koalas, and goannas. In the lagoons they caught ducks and swans. The rapids at Blacks Falls were used for fish traps and in the smaller creeks fish and eels were trapped. Fresh water mussels were plentiful in the shallow gravel beds of the Hawkesbury/Nepean and in the foothills. Pools in the mountain streams contained fish, eels and crustaceans. These were stunned with branches of white cedar and wattle and then collected. The ridges of the LSC provided seasonal crops of Burrawang Seeds and other edible plants. In places the bush was burnt and short grass was maintained to attract Kangaroos and emus. The Kangaroo Grounds at nearby Shaws Creek were maintained on a small area of Ashfield Shale.

The gravel beds in the river provided cores for stone axes and these were sharpened on outcrops of Hawkesbury Sandstone.

In other areas Aboriginal people used the soils developed on the numerous diatremes. The ground at Rooty Hill, for example, was cleared and burnt to attract kangaroos. It was appropriated by Governor King for a Government Stock farm in 1802.

Europeans rapidly occupied the levee banks between Windsor and

3. Aboriginal boys paddling canoes at Agnes Bank in the 1920s. These would have been of similar construction to those use at the time of first contact.
(Photo courtesy of Susan Kentwell).

Yarramundi. They used the sandy loam soils to grow corn and wheat. Aboriginal people visited the farms and collected the corn. The response was mostly violent and led to a cycle of reprisals from both communities. This is detailed in Chapter 5 of Grace Karskens's book People of the River (Karskens, 2020).

The rapids at Yarramundi and the mouth of the Grose River provided the major route for large groups of people and animals to cross the rivers. This made Richmond Hill a very significant site.

When hostilities escalated the response of the Europeans was to organise reprisal parties. The first was ordered by Acting Governor Paterson in 1795. He sent 62 soldiers to the Hawkesbury with orders to kill as many Aboriginal people as they could find and drive the rest as far away as possible. Those killed were to be hung in trees as a warning.

A group of soldiers crossed the river and near Richmond Hill they came across a large party of natives in the dark. These people were probably gathering for a "maize raid". They opened fire and killed an unknown number, probably seven or eight. They captured five women and an old man. These were taken to Sydney. A memorial to this massacre is located in the grounds of St John of God Hospital that our group visited *(photo 4)*.

Aboriginal trails led from the rapids up the LSC to the south, towards Springwood and along the ridge beside the Grose and then to the north along Comleroy Road to the Hunter Valley. Others led through Kurrajong and over the mountains to the west, via what was to become Bells Line of Road. They were not defined and crossing the mountains and Hornsby Plateau was difficult.

As a result, the site of Richmond Hill was significant in the British exploration of the mountains and the search for grazing lands to the west and north. Both Archibold Bell Jr and John Howe had land grants here. The former pioneered the northern road over the mountains and the latter, the first European route to the Hunter Valley.

The name Comleroy Road is a corruption of Kamilaroi, an Aboriginal tribe with connections to the upper Hunter Valley *(see Map 6)*. Europeans wanted to access the Hunter overland and John Howe eventually did this in 1820. Given the need to move cattle and sheep while avoiding deep river crossings the track along Comleroy Road skirts both the deeper sections of Wheeny Creek and the Colo River and then follows the approximately route of the present Putty Road. We travelled past the start of this road.

4. Participants at the memorial site for the 1795 Massacre Site in the Hawkesbury Frontier Wars. (Photo: Pam Miller).

The area of the Blue Mountains which we visited *(Map 3)* was inhabited by people from the Dharug tribe. They would also have interacted with the Gundungurra to the south, the Burra tribe, a smaller group inhabiting the nearby Jenolan Caves (Burra is eel in the Dharug language), the Wiradjuri in the west and the Darkinjung to the north. Interactions may have been for social/ cultural and trade activities but also on occasions they involved capturing brides (Attenbrow, 2023).

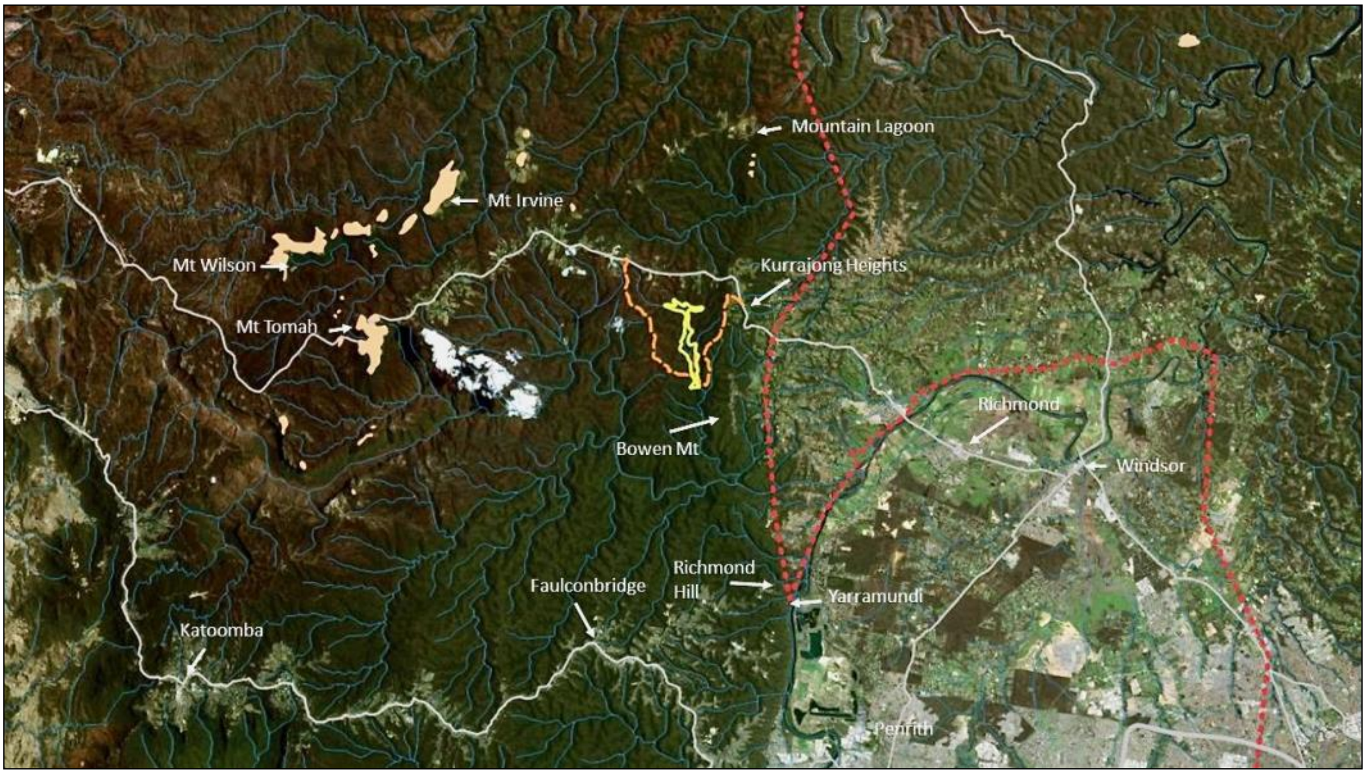
Both Aboriginal and settler communities mined for the minerals that were exposed in the sedimentary layers of the cliffs. They extracted chert for toolmaking and lumps of sandstone for the portable grindstones which they used to sharpen basalt axes.

In the grounds of St John of God Hospital, we visited the site of "Belmont", the home of Archibald Bell and his son. This was a land grant given to William Bowman and later purchased by Archbold Bell. He was granted further acres and was the officer to whom Governor Bligh complained when his daughter was insulted at the Barrack Church. The dress she was wearing, made of very fine material, was probably sent from England by her mother. This became semi-transparent in the light from the church windows. She was not wearing petticoats and many of the soldiers in the congregation sniggered when they could see the outline of the long lacy pantaloons she had on her lower body. Naturally, as a woman of her time and class, she fainted when realising what was happening and this further enlarged the scandal. She was carried from the church and later demanded apologies from the soldiers involved. This added to the growing hostility between the NSW Corp and the Governor.

The sensibilities of the time are amazing considering that the Aboriginal women in the settlement would be naked in warm weather.

Bell was also in charge of the guard at Government House when Governor Bligh was arrested on 26 January 1808, in what became the Rum Rebellion. Both Major Johnson, the leader, and later Lt Governor Paterson gave him land grants. Surprisingly Governor Macquarie later confirmed these and also appointed him as the Magistrate for the Hawkesbury.

Bell built a house, "Belmont", on the land that he was given on Richmond Hill. The house and the majority of the property were on Ashfield Shale. The Wianamatta shales were, at the time of European occupation, often covered by rain or wet sclerophyll forests. When this was removed, the weathered shales were eroded leaving undulating country; often with steep ridges between the streams that ran off the LSC. Most of the Bringelly Shale and Minchinbury Sandstone



Map 3. Study area topography. The dashed orange line shows our intended route from Kurrajong Heights through Burralow Swamp.

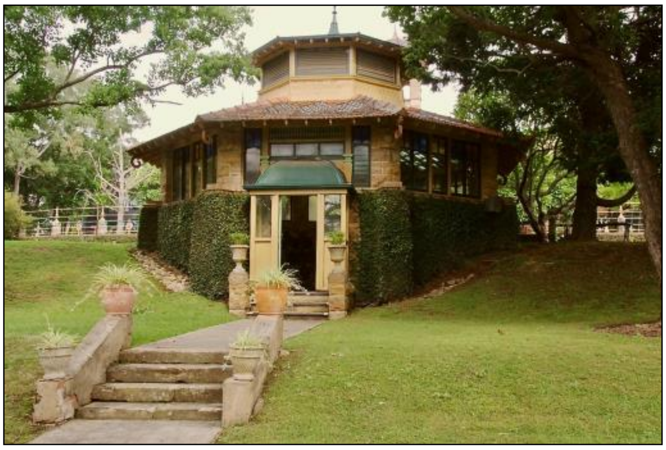
5. Sir Phillip Charley, one of the original seven founders of BHP built this mansion at Richmond Hill. It is named Belmont, as was the original house built by Archibold Bell.
(Photo from the Heritage Impact Statement).

in the Hawkesbury and Lower Blue Mountains have been eroded leaving the more fertile Ashfield Shale.

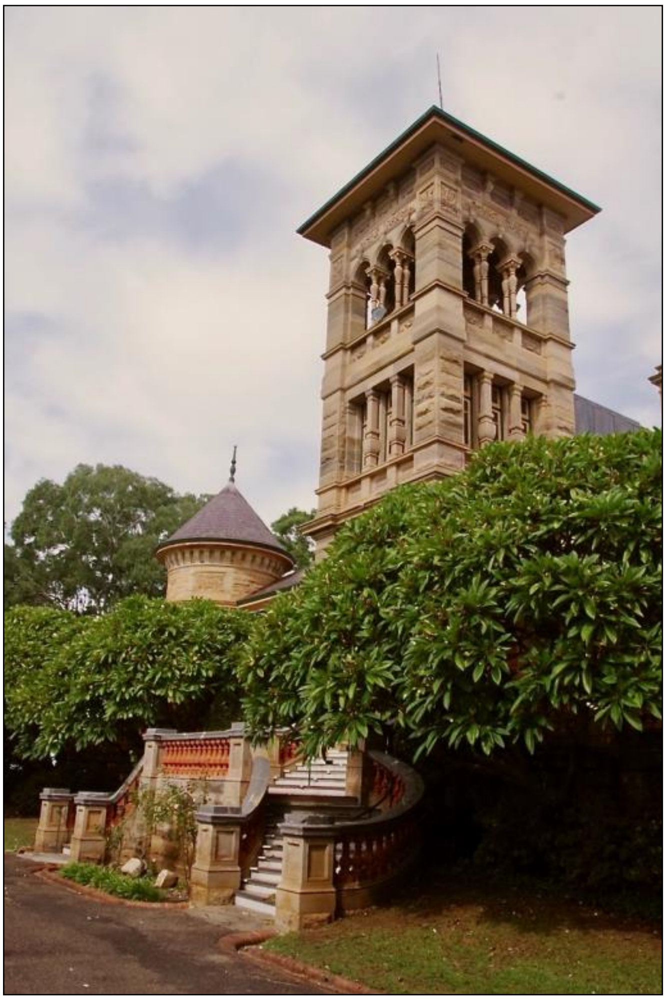
Bell's property was sold to the Newcomen family and when they had financial difficulties it was bought by Sir Phillip Charley. He was one of the seven original founders of BHP. He bought the land, knocked down the original house and built a much grander Italianate house *(photo 5)*. The group were able to visit the grounds and inspect "Belmont" *(photos 6, 7 & 8)*.

The building was later bought by the Catholic Church and became a mental hospital called St John of God.

The site was significant in the British exploration of the mountains and the search for grazing lands to the



6 & 7. Fernery at Belmont, external and internal view.
(Photos: B. Collier).



8. The tower and grand entrance at Belmont.
(Photo: B. Collier).

west and north.

Stop 2: Grose Vale/Grose River Road – Yobarnie (Keyline Farming) & Ashfield Shale.

Our next stop was on the corner of Grose Vale and Grose River Roads. This is on a ridge which, to the north, overlooks the valley of Redbank Creek. The ridges here are on the Hornsby Plateau and are mostly Ashfield Shale. There are several isolated hilltops of Bringelly Shale and these are underlain by thin deposits of Minchinbury Sandstone.

The area has been extensively farmed. Initially used by graziers, much of the land on the higher slopes was used for orchards in the late 20th Century.

During the 1950s the valleys of Redbank Creek were cleared for firewood and became subject to gully erosion and loss of topsoil. In response P.A. Yeomans developed a system called Keyline Farming and this gained world-wide attention. Field studies here were attended by people from the Middle East, China and the Americas. It was adopted in many parts of Australia. Yeomans was a geologist and mining engineer and he and his wife, Rita, bought two properties as a business investment. They were to be managed by Rita's brother. Unfortunately, he was killed in a major bush fire that swept down from the mountains in 1944.

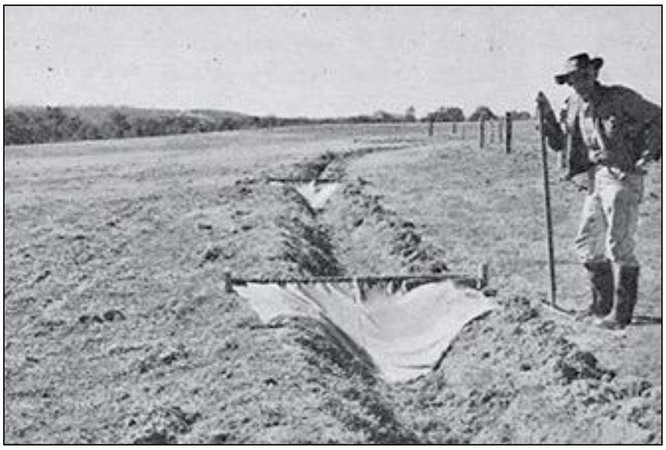
Yeomans's system restored and maintained the fertility of the land by limiting runoff and collecting water in dams that were constructed in the gullies of the first order streams. These dams were constructed at the keypoint of the stream. When rain falls on a ridge it flows overland and begins to erode the surface. The point at which this overland flow creates a channel is the keypoint. On a contour map this is usually seen as the point at which the contours begin to widen.

As each small stream enters the valley its keypoint is lower than the one before. Yeomans constructed a dam on each of the keypoints. He then linked the dams by a channel. This gently sloped from the highest dam, down valley and into the next.

Yeomans then could flood irrigate the valley sides. Initially he siphoned water from a dam into the channel and then used canvas cloths and soil to halt the movement of water in the channel. This then flowed over the side and down to the area of the hill side that he watered to irrigate *(photos 9 & 10).*

Yeomans also developed a plough to rip narrow groves in the land surface and these were constructed along the contour line. The purpose was to slow down the movement of the water and increase absorption.

He also recognised the importance of trees in



9. An example of the irrigation channels that Yeomans dug to link keypoints. Canvas sheets were used to block water flowing in the channels. (From Yeomans Keyline Farming Explained).

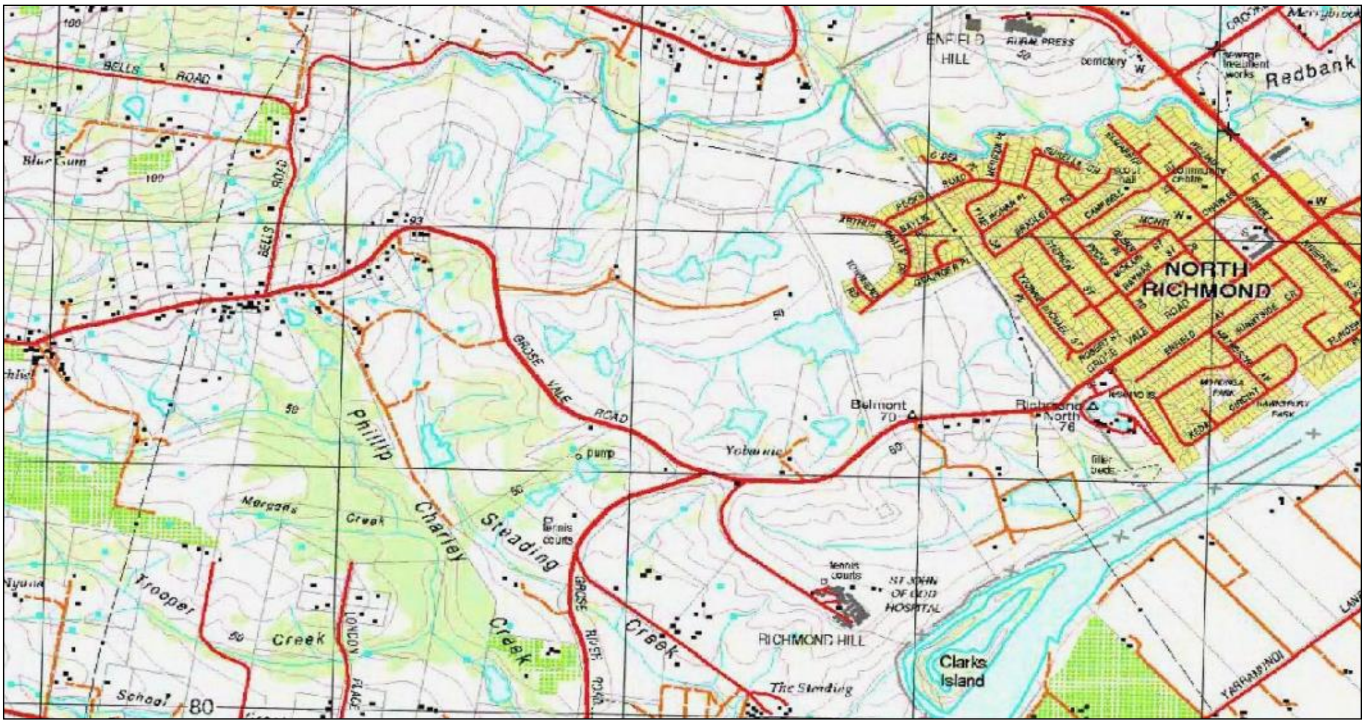
10. Blocking the channels at various points allowed Yeomans to determine which parts of the valley side would be irrigated. *(From Yeomans Keyline Farming Explained).*

11. An aerial view of the lines of trees planted along the contours. *(From Yeomans Keyline Farming Explained).*

providing shelter for grazing animals and reducing evaporation from wind. The trees could also be harvested and sold, providing another income stream *(photo 11)*.

Later he developed a system to put valves at the base of the dams and water pressure could be used in the spray irrigation systems that became more available in the 1970s. Today the farms developed by Yeomans are being covered by urban sprawl *(Map 4)*.

Walking down Grose River Road we were able to inspect some of the Ashfield Shale in a roadside cutting. It weathers readily and we were unable to find an unweathered section. The shale has a high iron content from its siderite component. This is formed in hydrothermal vents and the iron when entering the shallow seas of the time reacted with the alkaline materials to form sheets of siderite. As a result, the weathered shale has a platy texture and the soils formed from it have a bright red colour. We were able to see examples of these red podsolic soils.



Map 4. Topographic map from 2006 showing the dams constructed on Yobarnie, one of the two Yeomans properties.

12. Ashfield Shale. (Photo from Step Inc. https://www.step.org.au/index.php/item/214-wianamatta-group).

Photo 12 shows an example of the unweathered shale. When quarried and fired it produced the red tiles common on Sydney rooves.

Stop 3: 953 Grose Vale Road – Red Podsolic Soils and Wind Gap.

As the Ashfield Shale weathers and the high iron content oxidises it produces red podsolic/red chromosol soils. The vibrant red C Horizon gave its name to the valley below this location, Redbank Creek.

In 1791 Watkin Tench, Lt Dawes and Sgt. Knight followed this Creek up from North Richmond and over the ridge that we stopped on. They then followed Little Wheeny Creek up the scarp to Kurrajong Heights. They were unprepared to continue but had a great view of the Cumberland Plain. In cuttings on properties here we could see examples of the vibrant red soil *(photos 13 & 14)*.

Little Wheeny Creek has a tributary called Devils Hole Creek. The headwaters of this have captured part of Tabaraga Rill to produce the wind gap visible on the ridge line to the west of the site *(Map 5)*. We visited this gap this on Day 2.

Stop 4: 1005 Grose Vale Road. A remnant knoll of Bringelly Shale and-Minchinbury Sandstone.

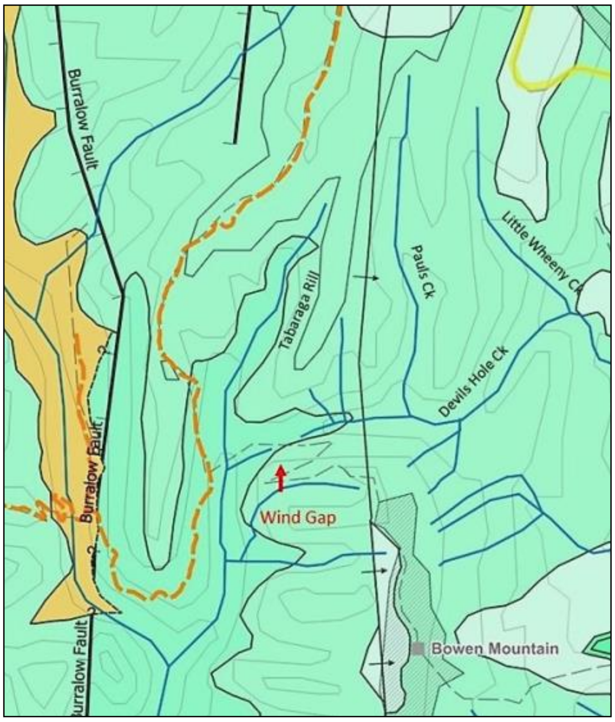
The Church in photo 15 is sited on one of many residuals in which the Bringelly Shale outcrops. In the roadside cutting we examined an outcrop of the Bringelly Shale and an underlayer of Minchinbury Sandstone *(photo 16)*.

Stop 5: 20 Old Bells Line of Road – Water Tower Kurrajong -Bringelly Shale.

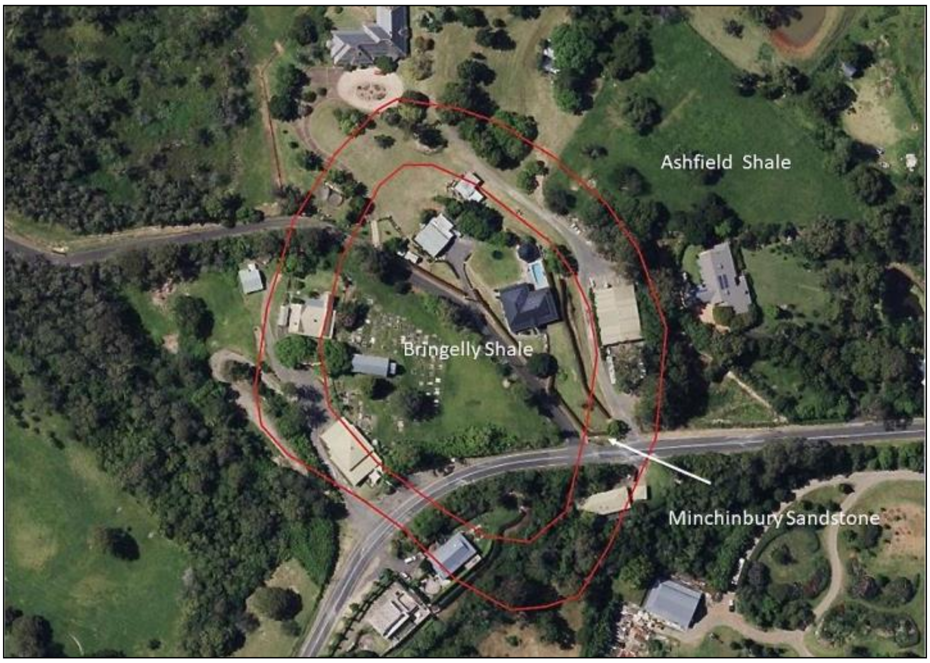
This is another of the remnant knolls capped by Bringelly Shale. The shale *(photo 17)* is highly weathered. There is a significant contrast in colour between it and the Ashfield Shale as it has a much lower iron content.

13. The LSC is seen here from 953 Grose Vale Road. Lt Paterson climbed to this location along Redbank Creek in 1791. A Lane joining Grose Vale Rd nearby is named after him. The red soil developed on the Ashfield Shale is seen here near the shed on the left. The Wind Gap was developed by stream capture. (Photo: R .Miller).

14. The bright red soils formed on Ashfield Shale can be seen here. (Photo: B. Collier).



Map 5. Devils Hole Creek, a tributary of Little Wheeny Creek, has eroded into the scarp of the LSC and captured the valley of a first order stream that feeds Tabaraga Rill. This has created a wind gap.



15. St Gregory's Kurrajong Anglican Church and associated geology.

16. *Minchinbury Sandstone underlying Bringelly Shale near the Anglican Church at Kurrajong. (R. Miller).*

17. Bringelly Shale at 20 Old Bells Line of Road, Kurrajong. (Photo: R. Miller).

The Northern Crossing and Bells Line of Road.

The pattern of roads that we travelled on has been heavily influenced by the geomorphology and the reaction of the British explorers to it. In many instances they ignored the knowledge of the Aboriginal people they were in contact with and in others, they used this knowledge successfully.

Figure 7 shows how the deeply incised valleys typical of the Blue Mountains were developed in relatively resistant and horizontal strata, underlain by relatively weak coal seams.

The mountain rivers were relatively shallow and attempts to navigate the streams proved difficult. Upstream the valleys narrowed and had steep sides with unstable scree slopes. Progress to the headwaters was often made difficult by the nick points created during the formation of the mountains. Travel by water was a familiar and regular feature of European culture, but difficult and mostly impractical here.

In 1793 Lt William Paterson explored the Grose River in two small boats. The variable water level and rapids made travel difficult and after heavy rain threatened flooding and one of his boats was damaged on the river gravels, he turned back at the junction of the Grose and Wentworth Creek junction *(Map 6)*.

Botanist George Caley learnt from this but in 1804, after climbing onto the ridge above Kurrajong Heights, near where Tench had been in 1791, he chose to travel to the west as straight as possible. This, however, involved crossing valleys with steep cliffs and unstable scree slopes. The names he gave to parts of his

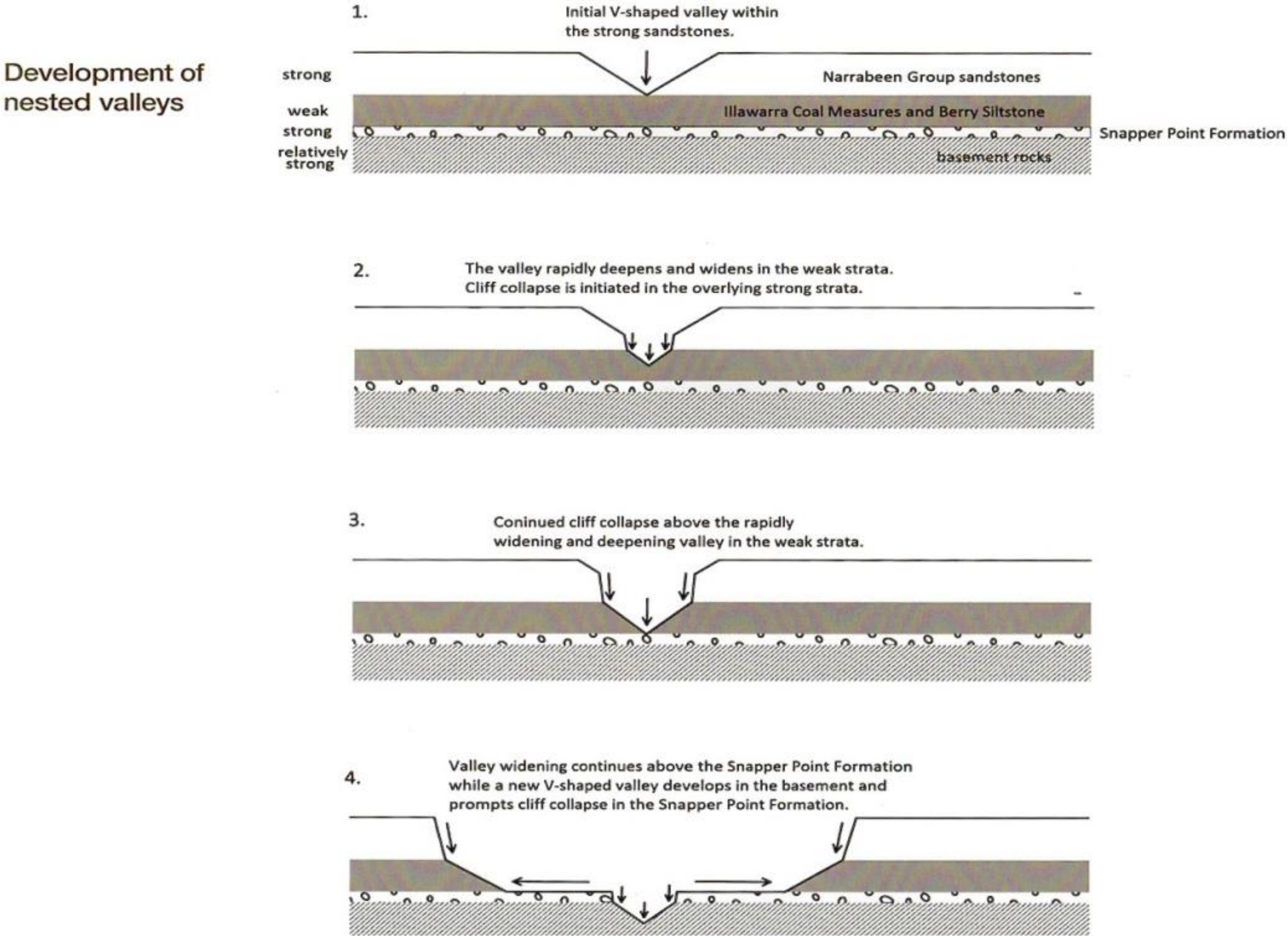
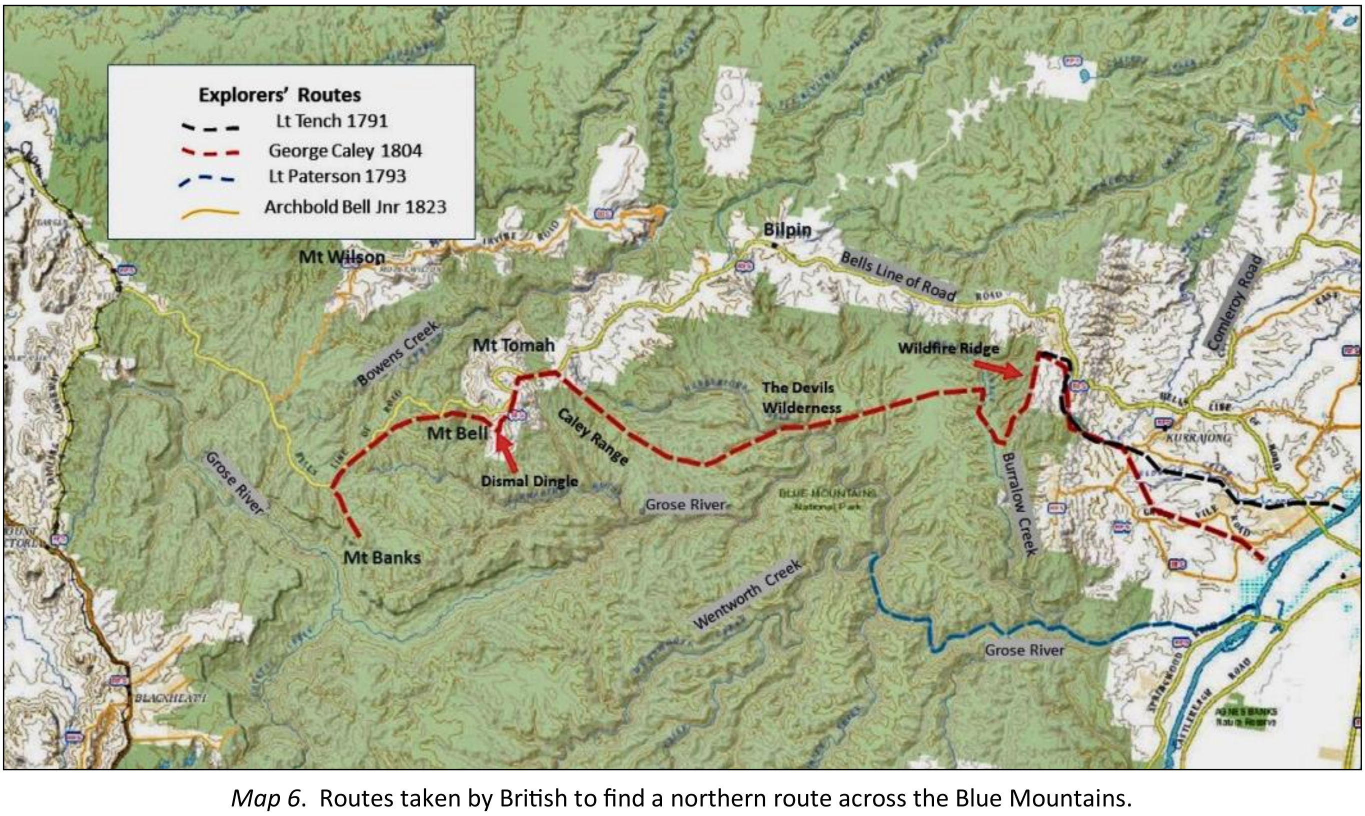
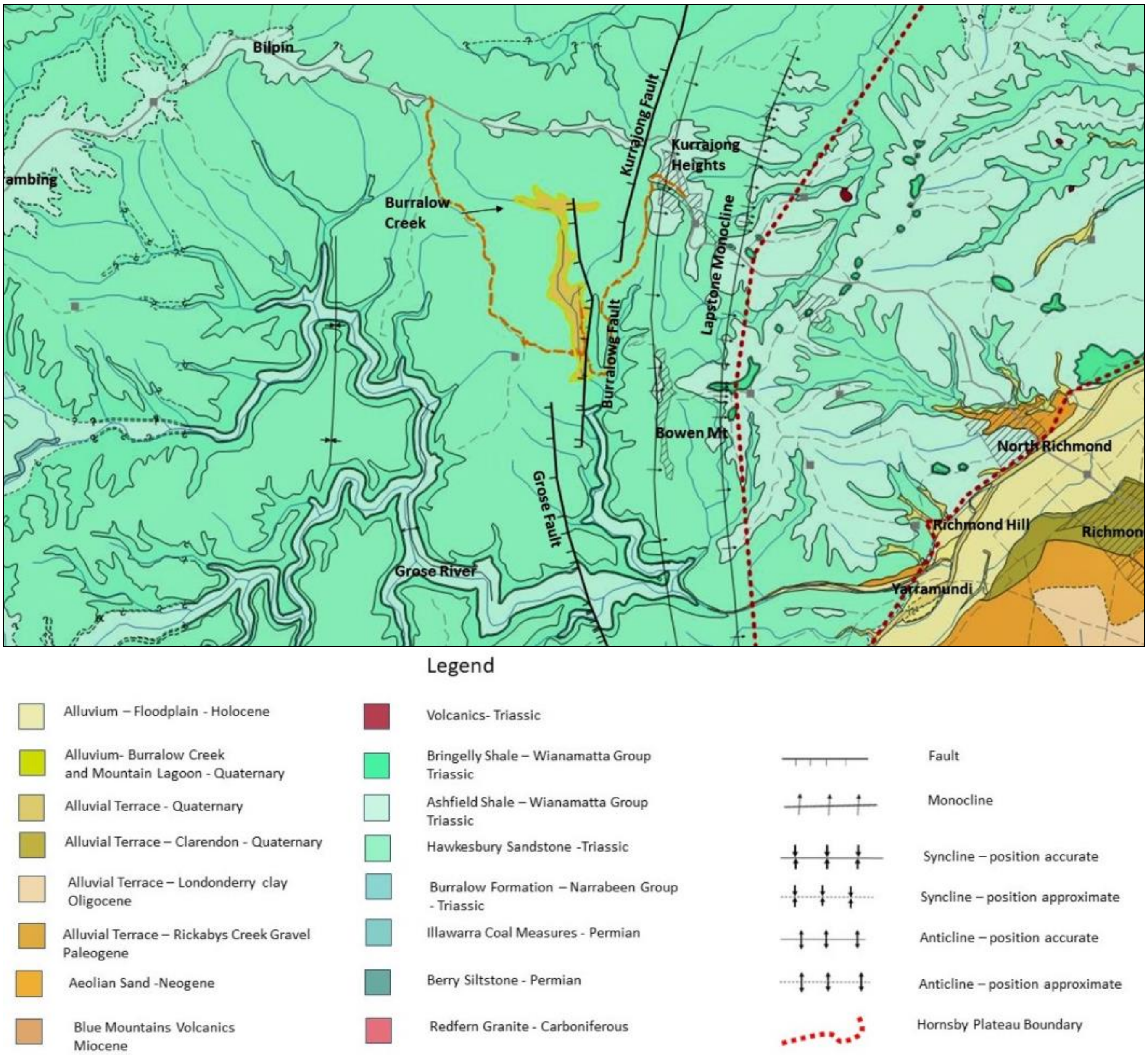


Figure 7. Formation of incised valleys in the Blue Mountains. (Hatherly and Brown 2022).



Map 6. Routes taken by British to find a northern route across the Blue Mountains.



Map 7. Geology of the Kurrajong Heights/Burralow Creek area with the proposed route. (Hatherly, 2020).

route, The Dark Valley, The Devils Wilderness and Dismal Dingle reflect his experience. He did have a lasting experience in Luminous Creek when he awoke to a display of glow worms on the rock shelf above him. Primarily a botanist he also discovered and named many new botanical specimens for his patron Joseph Banks *(Map 6 for his approximate route)*.

Caley's party initially camped in Burralow Creek and lit a camp fire that escaped giving name to Wildfire Ridge. He visited Mt Tomah and climbed Mt Banks but exhausted and seeing no end in sight, he returned to Sydney.

In the early 1800s there was great interest in finding alternative ways to cross the Blue Mountains in addition to that developed by Blaxland, Lawson and Wentworth and to also to find a way to the Hunter Valley. This desire was intensified in 1819 after years of drought. Shortages of available grazing land had also developed as a result of the ever continuing process of giving land grants.

Bell's son, also called Archibald (1804-1883), discovered a second route across the Mountains. He heard that an Aboriginal woman, captured near Belmont by a tribe from the west of the Blue Mountains, escaped and returned by a route different from that taken by the tribe. He followed her directions from Richmond to Mount Tomah on 1-5 August 1823. While he was at first unable to find a safe way to descend to the west, he returned and found a way into the Hartley Valley.

Lt. George Bowen who worked as a government surveyor and Land Commissioner had property grants on Bowen Mountain and initially Bulgamatta (Berambing), near Mt Tomah. He also claimed that while working as a Land Commissioner he had previously crossed the mountains on the same route that Bell followed.

He was a strong willed and argumentative person, very unpopular with the Church of England. After seeking and being suggested for ordination, Bowen published The Language of Theology Interpreted, in a Series of Short and Easy Lectures (Sydney, 1836). In this he argued that the Bible was entirely allegorical, made up of stories to convey moral and political values.

A road was then surveyed by Robert Hoddle and built along Bell's route by convict labour. This is largey today's Bells Line of Road. There was initially competition for the section up the LSC. An alternative through Bowen's property had lower grades but because it travelled down into Burralow Swamp and back up Patersons Ridge, it required more changes of horses for travelers using drays and coaches and so the route up Bellbird Hill to Kurrajong Heights was chosen.

Bell's route was initially little used. Its advantage was in avoiding the steep route down Mount York and it also gave more resting places for stock. We visited one of these places at the Emu Cave. The township Bell, Mount Bell and the route itself were named after the explorer.

Although the Ashfield Shale provided relatively fertile soil compared to the Hawkesbury Sandstone, the variable rainfall and the undulating topography meant that the hillslopes in the surrounding area could not support pasture growth throughout the year.

This successful crossing used Aboriginal knowledge and followed the ridges. Previous explorers relied unsuccessfully on routes via river valleys and water transport.

Attempts to use the river valleys continued and there have even been recent proposals associated with a new motorway to the west.

When considering a railway crossing in 1858 a group of Royal Engineers built a bridle trail up the Grose River Gorge from Agnes Banks. The Grose Gorge was being considered as a possible route for the railway. This involved a tunnel under the Darling Causeway.

The route was investigated by a Surveyor, Thomas Barton, and he was assisted by local man Thomas Sherwood. The latter was also involved with the Cave Hotel/Emu Cave that we visited.

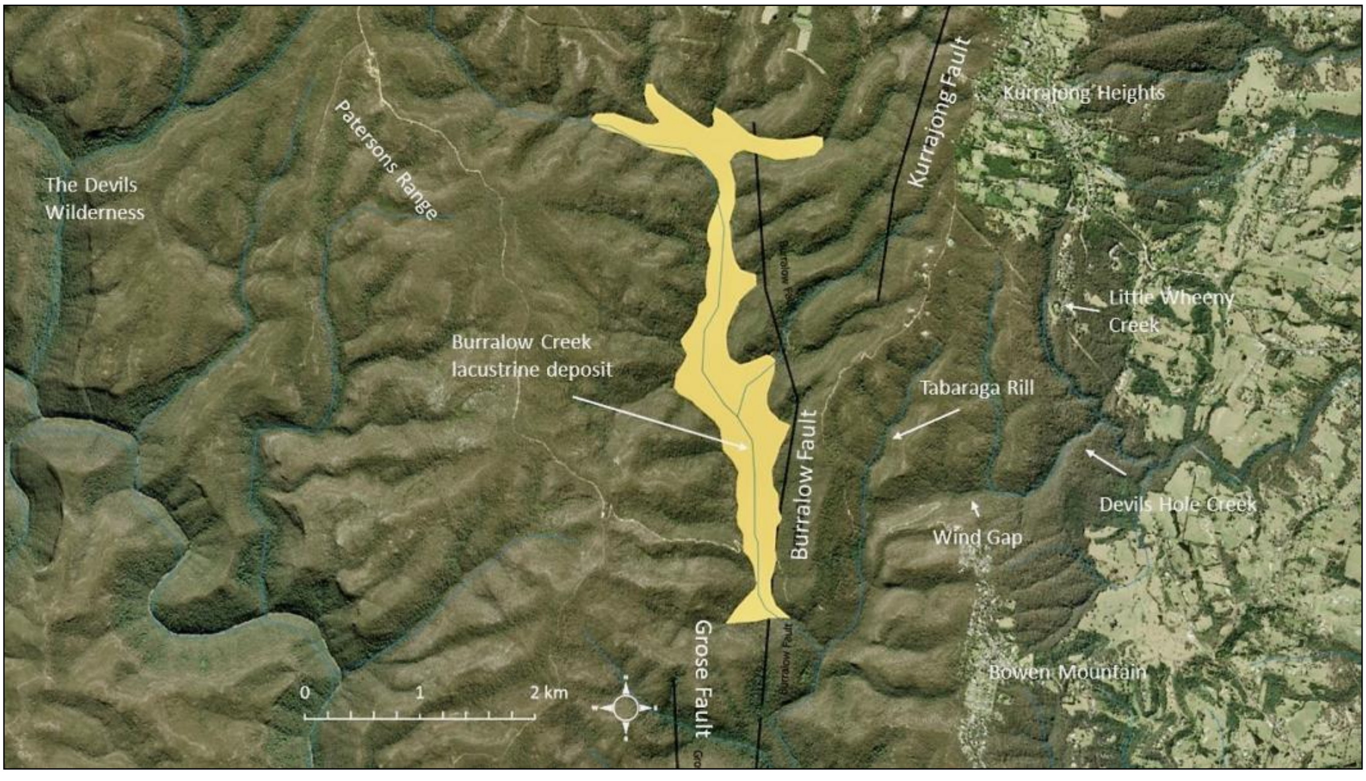
"The tunnel beneath Darling Causeway would have been two miles long, used ten million bricks, taken two years to build and cost £800,000. The colony did not have enough bricklayers. Other problems with the route included landslides &very sharp curves. The route was eventually abandoned in 1860."

Stop 6: Burralow Creek.

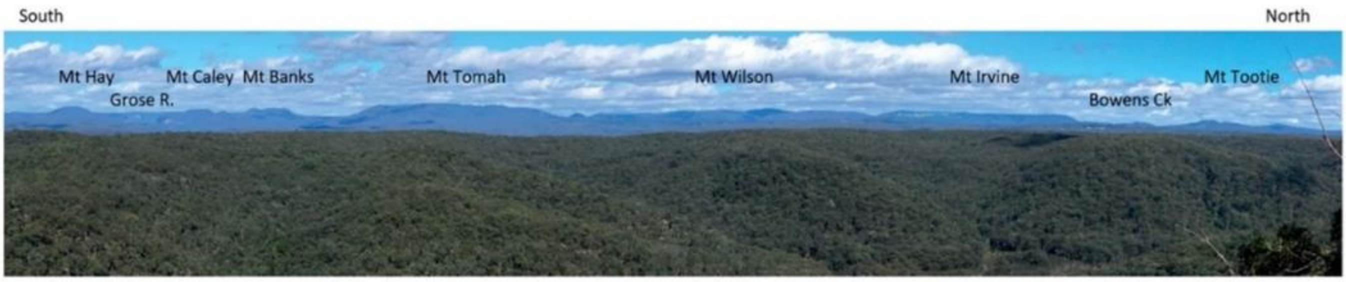
Unfortunately, flash flooding in the days previous had caused NPWS to close this area. I hope that the Society can visit it in the near future. *Map 7* shows the route that we would have taken. It is close to that of Caley.

Burralow Creek *(Map 8)* has an interesting history. This was the first area in which Lt Bowen tried to grow rice and was also part of the route suggested by Lt Bowen for the northern crossing.

At the junction of the Patersons Range and Burralow Trails we could have compared strata on either side of the Burralow Fault.



Map 8. Burralow Creek. A wind gap has developed immediately to the north of Bowen Mountain. Devils Hole Creek has captured a tributary of Tabaraga Rill. (Photo: R. Miller).



18. The basalt capped mountains can be seen in this view from Bowen Mountain looking west. The slight dip to the north east is apparent. (Hatherly, 2020).

Map 9. The flow track suggested for the Miocene basalt flows is shown on the map.

Stop 7: Mount Tomah.

The drive to Mount Tomah is along a ridge with Ashfield Shale as the predominant bedrock. Today it is occupied by many orchards and has been a major producer of apples.

At Mount Tomah we viewed and discussed the landforms seen from the Café deck. These include the basalt flows (ca 20-14 Ma)

The panorama in *photo 18* (Hatherly, 2020) shows most of the high land with basalt caps to the west of the LSC. They view is from Bowen Mountain. Geologists (David 1896) concluded that these caps were related and that river gravels occur beneath the basalts at Mt Irvine and Mount Tootie (Carne, 1908).

Van der Beek et al. (2001) suggested that the basalts were once continuous. He found this by mapping the base of the basalts and from geochemical analysis and dating. This built on work by Wellman and McDougall (1974).

Van der Beek found that there was no more than 250 m vertical relief at the time of extrusion and that there was a gentle tilt to the northeast. Pickett (1984) also identified an east-northeast-trending valley beneath the basalts *(photo 19)* at Mount Tomah. Multiple flows are also indicated because the basalts at the top of the basalt caps are younger than at the base (van der Beek et al., 2001).

The cross-sections of the basalt caps in *Figure 7* (Hatherly, 2020) confirm the gentle (0.850) slope to the north east.

Hatherly suggests that the basalts flowed along a paleo river channel with a base level the same as the plain over which the river carrying Rickabys Creek Gravel flowed. The flows appear to have crossed the Kurrajong Fault prior to uplift and from the pattern of knick points that he identified in the adjacent rivers, he suggests that the area was uplifted shortly after they occurred.

Given the evidence from Carter (2011) that the

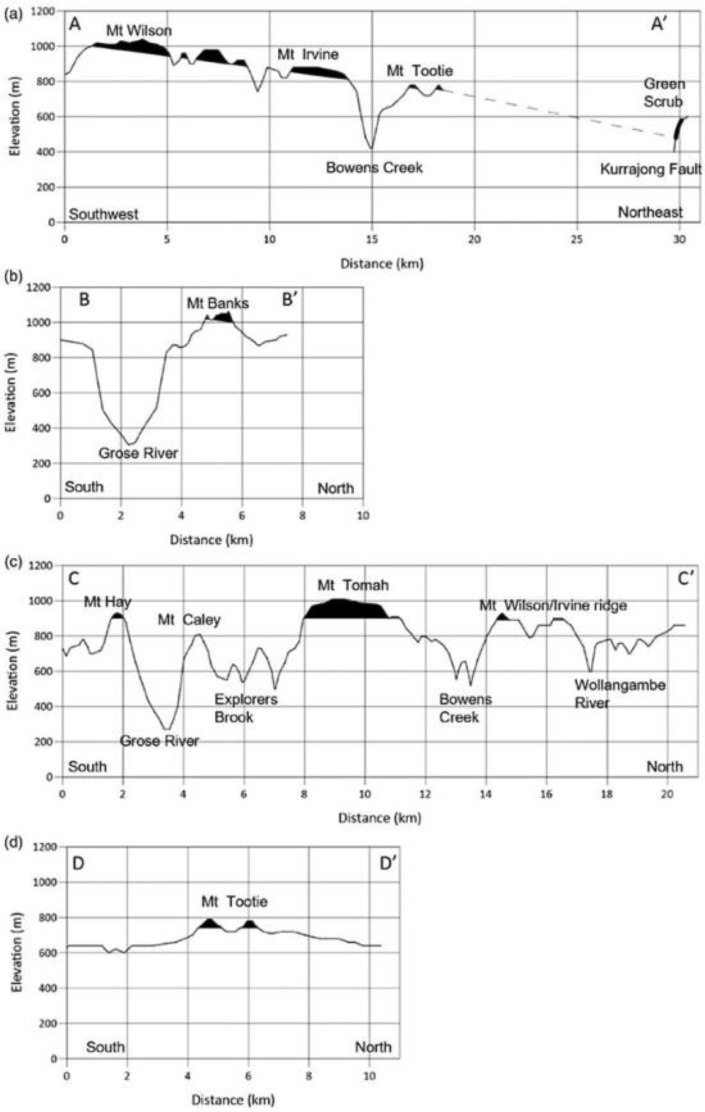


Figure 8. Cross-sections of the Blue Mountains Basalt. It is thought that the Green Scrub Basalts originally flowed over the current position of the Kurrajong Fault but have been moved/rotated since deposition. (Hatherly, 2020).

19. A remnant of the basalt cap at Mt Tomah. (Photo: B. Collier).

Hornsby Plateau had already been formed, a stream flowing into the area of the Green Scrub Basalts would have flowed onto the plateau *(Figure 8)*.

Mount Tomah was its Aboriginal name. In his journal, Caley refers to it as Fern Tree Hill because of the number of tree ferns growing on the basalt cap. The origin of the basalt flow here is not known. Most of the basalt has been used in the construction of the Botanical Gardens and some extra has been brought from other outcrops, including from Peats Ridge.

Photo 20 is a panorama of the features seen from Mount Tomah. Mount Tootie and Mount Irvine, with their basalt caps, are seen across Bowens Creek. They have been cleared to use their fertile soils.

Mount Yengo, seen in the distance, is 662 m asl and is part of the Airly Volcanics (59-27 Ma). These were formed as the land moved north over a plume or "hot spot".

The mountain is part of a volcanic dyke that is probably associated with the underplating that uplifted the Hornsby Plateau.

Mount Warrawolong situated near the Kulnura Anticline is much older and is from the Jurassic (201-145 Ma). Bar Lookout, about 300 m to the south of it, is a basalt flow from around 66 Ma.

Stop 8: The Emu Cave.

This is located beside Bells Line of Road near Mount Bell and is on land owned by Main Roads. Unfortunately, it has no protection, despite it being a site of great significance.

The cave is the result of weathering in the Banks Wall Sandstone which is from the Narrabeen Depositional Episode.

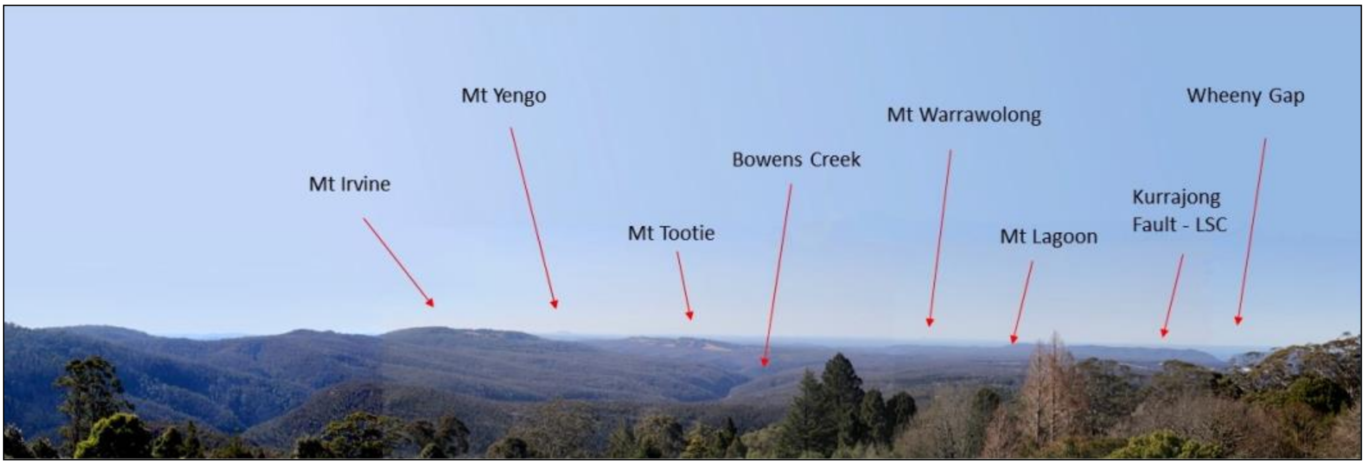
While it is in the territory of the Dharug people, the carvings have been dated as being at least 2000 years old and may have been related initially to people from the west. This is, however, not conclusive. (Kelleher 2023).

The emu was an important totem for Dharug peoples. Kelleher says that vertical engravings are rare in the mountains and Sydney area and are more common to the west. He thinks the site may have been significant to the Wiradjuri who would be looking to use the sandstone to grind axe heads made from the basalt caps.

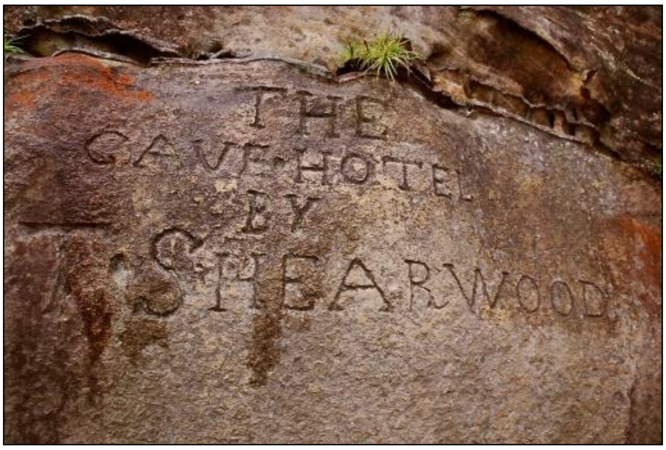
There are 172 engravings and 127 of these are of emu foot prints. Others are of kangaroo feet (Kelleher 2023).

On the rock near the cave entrance is the engraving seen in *photo 21*.

The name Shearwood in the engraving actually refers to Thomas Sherwood. He was

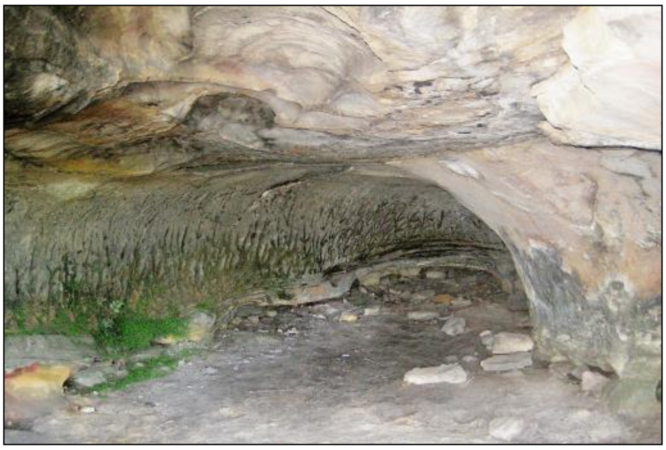


20. Panaroma from Mount Tomah.



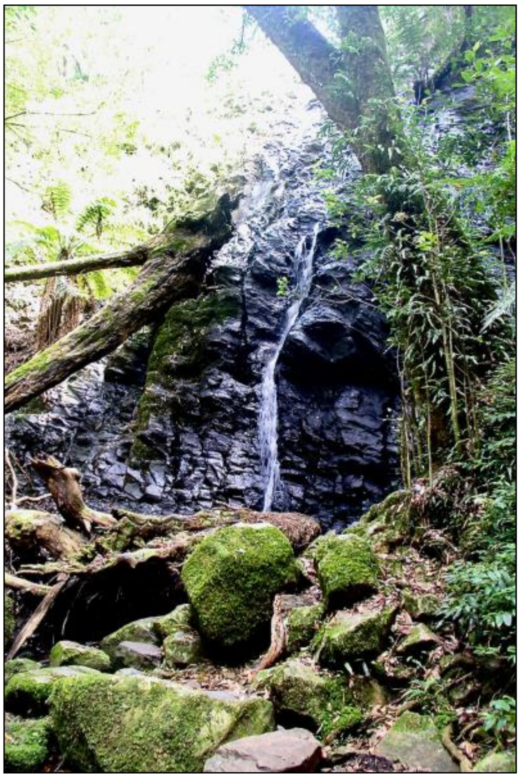
21. Inscription at the entrance to the Emu Cave. (Photo: B. Collier).

23. Kangaroo Emu Carvings - There are 172 carvings in the cave and 127 are of emu feet. Others include the kangaroo feet circled here. (B. Collier).



22. The engravings on the walls of this cave have been dated at 2000 BP. (Photo: R. Miller).

born in Richmond in 1824. This was the year after Archibald Bell junior opened up the new Line of Road. His relationship with the Emu Cave is described in the following extract from the Blue Mountains Heritage Review in 2016: "As a child he lived on the Bell estate of Belmont at North Richmond. In the 1830s Thomas worked with his father at his new farm at Kurrajong Heights.



24. Mt Wilson Waterfall. (Photo: R. Miller).

25. A Burrawang *(Macrozamia communis)*, fruiting in a large planting along the eastern scarp at Bowen Mountain. (Photo: R. Miller).

On bad terms with his father, Thomas left home in the 1840s and worked as a sawyer and timber-getter as well as doing some droving along Bells Line of Road to Bathurst and beyond. His association with the Mount Tomah area came when he acted as caretaker for Robert Town at Bulgamatta. He built a house with timbers from Bowen's old house there and offered accommodation to drovers and other travellers. In 1871 the cave was known only for its Aboriginal carvings. A correspondent writing in the Town and Country Journal for 2 June 1871 describes Mount Bell, 'at the end of which is Cave-Hill, named from a curious cave at the side of the road, the roof of which has some singular impressions resembling emu's tracks' *(photos 22 & 23)*.

Stop 9: Mt Wilson and the Waterfall Reserve.

Unfortunately a rain squall stopped our final visit to Mt Wilson and the Waterfall Reserve. This was an opportunity to walk to Upper Falls and examine columnar Basalt. It is a walk with moderate difficulty.

Photo 24 gives a view of the falls on a drier day. The water flows of a thick layer of columnar basalt. If you are lucky during the walk, you will hear lyrebirds imitating several others and at night, just before Christmas, Blue Mountains Fire Flies emerge and put on a show.

26. An example of cavernous weathering in Hawkesbury Sandstone beside the track to Poets Rock. (Photo: R. Miller).

Day 2. Bowen Mountain and the Grose Valley.

On the following day most of the group travelled to Bowen Mountain on part of the route that Lt. Bowen wanted the road across the northern mountains to follow.

Bowen Mountain is one of the inappropriate ridge top subdivisions in the Blue Mountains that a lack of planning has allowed. For many years part of Lt Bowen's grant here was operated as a tourist park. Some of it is still a public park and much of the rest is now housing. The views over the Sydney Basin and the Grose Valley are spectacular. In winter when the Basin is covered in fog it is like being in an aeroplane and during floods the lake below is extensive.

Our walk took us along the Southern Fire Trail to see a spectacular view of the Grose Valley. On the way we saw examples of native food and useful plants, including the seeds of the Burrawang *(Macrozamia*

27. The view of the Grose Valley from Poets Rock on Bowen Mountain. The Grose River is behind Patersons Hill.

communis) shown in *photo 25*.

Bowen mountain has a large group of these plants located on the eastern edge of the scarp, on the upper levels of the Hawkesbury Sandstone. Eaten raw the seeds are poisonous. Aboriginal people were able to remove the toxins by pounding the seeds, soaking them in water for several days and then roasting them. The resultant flour was made into cakes.

The water needed could be found in the permanent springs that feed from the sandstone into Hoomeroy Creek and outcrop below the scarp. I believe that the plants were part of a plantation and I have seen similar sites at Wrights Creek and Freemans Waterhole.

At the end of the Southern Trail, we walked along the cliff line to Poets Rock. The view is of the Grose Valley and Burralow Creek, near its junction with the Grose. The slope of the Lapstone Monocline is apparent and immediately to the west of Grose Head south is the Grose Fault *(photo 26)*.

The headland on which Poets Rock is situated has many significant examples of cavernous weathering in which only a thin hardened case is left *(photo 27)*.

Report by Rick Miller.

Resources.

ATTENBROW, V. (2023). *The Mountain Darug 2nd Ed. Edited by E Stockton and J Merriman*. Blue Mountain Education and Research Trust.

CARNE, J. E. (1908). *Geology and mineral resources of the western coal field. N. S.W.* Geol. Surv. Mem. 6:1–246.

CARTER, L. (2011). *Tectonic Control of Cenozoic Deposition in the Cumberland Basin, Penrith/Hawkesbury Region, New South Wales*. Bachelor of Science (Honours), School of Earth & Environmental Sciences, University of Wollongong, 2011.

CLARK, D. and RAWSON, A. (2005). *New field observations pertaining to the age and structure of the northern Lapstone Structural Complex, and implications for seismic hazard.* Proceedings volume of a one day workshop: Wednesday 13th April 2005, GEOSCIENCE AUSTRALIA.

DAVID T. W. E. (1896). *Anniversary Address*. Journal of the Royal Society of New South Wales. 30, 33-69.

HATHERLY P. J., BROWN I. (2022). *The Blue Mountains – Exploring landscapes shaped by the underlying rocks, uplift and erosion.* Windy Cliff Press, Mount Victoria NSW p53

HATHERLY, P. J. (2020). *Landscape evolution of the Blue Mountains revealed by longitudinal river profiles and Cenozoic basalts and gravels.* Australian Journal of Earth Sciences, 67:2

HERBERT, C. and HELBY, R. (1980). *A Guide to the Sydney Basin.* Geological Survey of NSW, Bulletin 26. Department of Mineral Resources. Ch 2.

KARSKENS, G. (2020). *People of the River - Lost Worlds of Early Australia.* Allen and Unwin.

KELLEHER, M. (2023). *Aboriginal Art in the Blue Mountains Blue Mountains Dreaming 2nd Ed.* Edited by E Stockton and J Merriman. Blue Mountain Education and Research Trust.

VAN der BEEK, PIETER, A., PULFORD, A. and BRAUN, J. (2001). *Cenozoic Landscape Development in the Blue Mountains (SE Australia): Lithological and Tectonic Controls on Rifted Margin Morphology.* Research School of Earth Sciences, Australian National University, Canberra ACT 0200, Australia et al.

WELLMAN, P. and McDOUGALL, I. (1974). *Potassium -Argon ages on the Cainozoic volcanic rocks of New South Wales.* Journal Geological Society, Australia. 21:247 –272.

YEOMANS KEYLINE FARMING - Links:

http://yeomansplow.com.au/8-yeomans-keyline-systems-explained/

https://soilandhealth.org/wp-content/uploads/GoodBooks/The%20Keyline%20Plan.pdf

https://www.youtube.com/watch?v=i5z5T378SM4
https://www.youtube.com/watch?v=9Dal2W2T4O0&list=TLPQMjkwMTIwMjR6RfbhhtJcmg&index=2

Blue Mountains Heritage Register Review Heritage Inventory - 2016 Heritage Review Item Name: Cave Hotel SHI Number 1170629 Study Number MT001

BMPH The Engineers Track - History - Blue Mountains Australia.
https://infobluemountains.net.au/history/engineers.htm

Heritage impact statement: St John of God Hospital.
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-12690718%2120210629T071022.164%20GMT

Mapping by R. Miller using QGIS and data from Six Maps and NSW Seamless Geology.

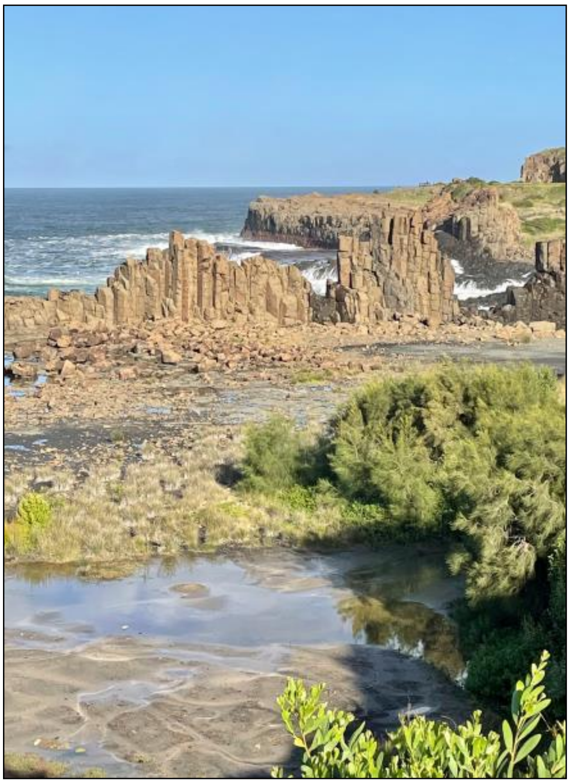
Kiama's Volcanic Coastline

Leaders: Brian England, Chris Morton and Ron Evans (in absentia).
Date: Monday 13th to Friday 17th May 2024.
Attendance: 24 members.

Preamble.

Although the Society had made several previous visits to this area in 1996 and 2007 our initial visit took place before the inception of our journal Geo-Log and the 2007 trip was poorly attended. The Kiama coastal geology is so extraordinary that it was decided to repeat the 2007 trip (England, 2007) to take advantage of the wealth of published information now available.

Chris and I arrived in Kiama around 12:30 pm on the Monday after passing through heavy showers down Mount Ousley Road – not a good sign for the next few days. Unable to access our cabin at Kendall's Beach until 3 pm, we decided to check out the Bombo quarry on Bombo Head, our main objective for this trip. But after three hours and 6 kilometres sloshing through swamp and mud, we had to conclude there was just no way in! After the torrential rain of the last few days along the Illawarra Coast, which had dropped 90 mm on Kiama and over 300 mm in some areas, the quarry floor was now effectively protected by a leach-infested swampy moat! Even the gumboots people were told to bring would not have helped.



1. View of the old Bombo quarry from the Bombo Head Lookout Track at the top of the abandoned stairway. (Brian England).

2. Basalt dyke following the joint pattern in the Bumbo Latite on the floor of the old Bombo quarry. (Ron Evans, from Geo-Log 2007)).

Locals walking their dogs knew nothing and even a local sewerage worker I managed to flag down could only suggest following the Kiama Coastal Walk behind the Sewerage Plant and taking the side track out to the Bombo Head Lookout. Indeed a few hundred metres up this wet and slippery path we came to what appeared to be a new stairway leading down into the northwest corner of the quarry. But it had been barricaded off with a sign "Permanently closed to residents and visitors"! There were good overall views of the quarry and its seawall from here *(photo 1)* but our hopes of visiting the quarry floor were dashed. Further up the track there were further views over the quarry and at the lookout we could look down on one of the famous basalt dykes snaking its way between the latite columns *(photo 2)*.

We found out later that this stairway was in fact a stairway to nowhere and had never been used! Before COVID hit the Kiama Council had received a grant of $500,000 to provide safe public access to the floor of this historic quarry. The contract was awarded to a Sydney firm, but then COVID hit and work stopped. When life returned to a new normal the contractor requested a further $20,000 to cover increased cost of materials but the project was halted when it was discovered that the section of quarry wall to which the stairs had ben anchored was dangerously unstable!! So, the stairway, which at first seemed such a great idea, turned out a costly failure. The little digger used in the project still lies abandoned, pushed into the bush at the side of the track.

The sea around Bombo Head was in absolute turmoil, so wild in fact that any thoughts of exploring the rock platforms, even at low tide, were simply out of the question. So, we moved on to our very comfortable cabin at Kendall's Beach Holiday Park, totally deflated and wondering what to tell people at the 5 pm meeting in the camp kitchen – the bad news or the really bad news! Everything, including the tides, was against us and to top things off one of the leaders, Ron Evans, was forced to pull out just a few days before.

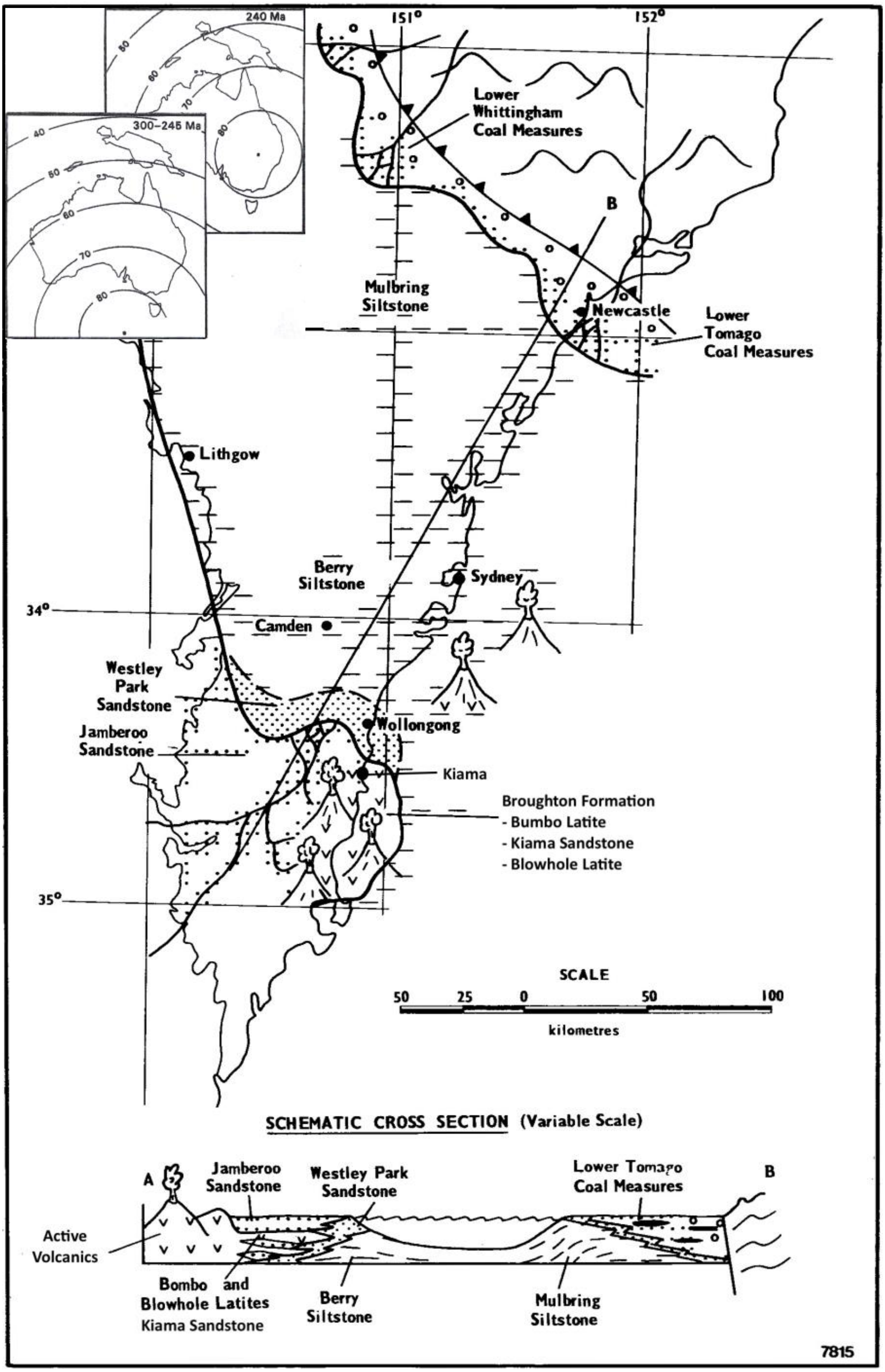


Figure 1. Palaeogeography during the early part of the Lower Tomago Depositional Episode.

(Modified from Herbert and Helby (1989).

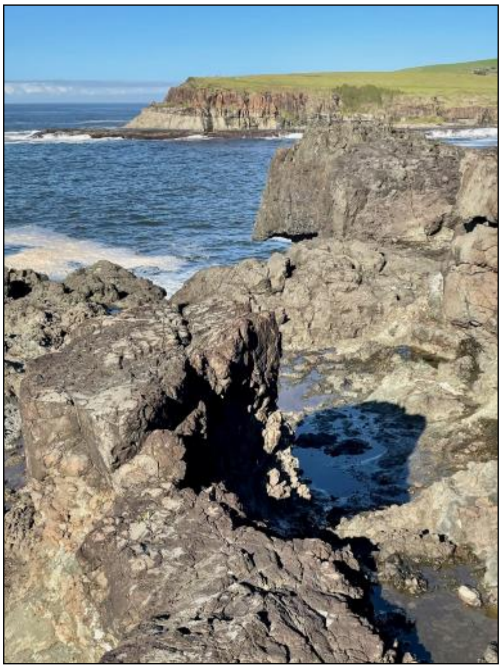
Inset shows palaeolatitude diagrams from Australia from Early Permian to Middle Triassic.

(Veevers, 1984, page 14)

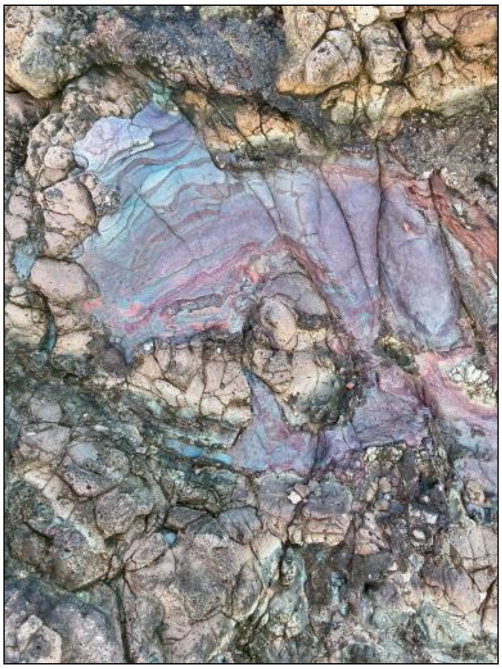
Background Geology.

Formerly known as the Gerringong Volcanics, the series of latite flows and sedimentary rocks exposed along the Bombo to Gerroa coastline now form part of the Broughton Formation (Carr, 1983., Sarkis, 2023), laid down during a Mid-Permian episode of crustal deformation known as the Lower Tomago Depositional Episode *(Figure 1)* between 265.1 and 254.14Ma (Seamless Geology).

The sequence comprises seven submarine and two terrestrial latite flows (the Blowhole and Bumbo Latites) erupted from volcanoes then located a short distance offshore as well as large amounts of tuffaceous material. Erosion products from the volcanics (including the Kiama Sandstone sandwiched between the Blowhole and Bumbo Latites) were transported northwards into the Sydney Basin, which was then a marine trough, and deposited over a small delta. The top of the delta comprised oxidised red sands (Jamberoo Sandstone) while the delta front was made up of green silty sand (Westley Park Sandstone) supporting a very rich marine fauna, examples of which would be seen on the rock platform at Gerroa, south of Kiama. Prodelta silts are represented by the Berry Siltstone, which is the equivalent of the Mulbring Siltstone in the Hunter Valley (Herbert and Helby, 1980). Geological maps of the excursion area are given in the Appendix. Only the section between the Westley Park Sandstone and Bumbo Latite are covered in this report.



3. The rugged outcrop of Blowhole Latite along the cliff top below Attunga Avenue, Kiama. View south across Loves Bay towards more Broughton Formation rocks on the next headland. (Brian England).



4. Deformed thinly bedded tidal mudflat sediments sandwiched between latite blocks in the Blowhole Latite forming part of a peperite outcrop. Diameter is around 15 cm. (Brian England).

Tuesday 14th May.

Almost miraculously, the rough seas had subsided overnight and the day dawned bright and sunny with a light breeze, although at 19°C it was a little cold! The group assembled at the end of Attunga Avenue in Kiama Heights at 8:15 am. Out along the foreshore below masses of white froth had accumulated as a result of the wild seas yesterday.

I had not been here since the 2007 excursion and finding a way down to the areas of interest along the top of the sea cliffs seemed a bit of a challenge. Looking down into the tangle of long grass and rough latite outcrops I thought no way! But a route was found down along the edge of the dry-stone wall at the north end of the reserve. It was rough, slippery and boggy in parts but most made it down to the rugged bench several metres above the water *(photo 3)*. What we found astounded even me!

Here there are superb exposures of the upper chaotic part of the Blowhole Latite Flow, the first of the flows to become emergent above sea level and spectacular examples of the interaction between basalt magma at 1100°C and wet sediment could be examined in close detail *(photo 4)*.

Particularly abundant are text-book examples of a rock texture known as "peperite", a complex mixture of lava and sediment formed when hot lava impinges on wet sediments. Boiling water and fracturing of plastic water-saturated sediment leads to complex mixtures of solidified lava and sediment which often defy interpretation (Jones, 1969; Skilling, et.al., 2002) *(photo 5)*. Also present are patches of vesicles in the more solid latite up to 10 cm lined with white crystalline quartz *(photo 6)*. There were also memorable views to the south looking across Loves Bay to the next headland of Westley Park Sandstone and overlying Blowhole Latite.

We left the area via the southern end of the outcrop and walked back up the grassy reserve to our vehicles. There is no access to the Princes Highway from Kiama Heights so we returned to Terralong Street in town and headed north under the highway underpass, turning right into Spring Creek Drive which took us onto the Princes Highway heading north. We then took the second exit (marked Bombo). The next turn to the right (marked Bombo Beach) took us under both the Highway and railway to Bombo Beach Reserve on the southwest corner of Bombo Head at the north end of Bombo Beach. Here there were toilets and picnic tables where the railway sidings for the Bombo Quarry once stood. We paused here for morning coffee before attempting our next adventure, the Old Bombo Quarry.

The first documentation of Bombo was by James Dwight Dana and William Clarke in 1840 in which Dana famously sketched the columnar jointing in the latite. The age of the Bumbo Latite given by Rb-Sr radiometric dating is 249±0.7Ma (Wass and Shaw, 1984). The latite is distinctly porphyritic, containing laths of plagioclase (labradorite to andesine in composition) to over a centimetre and minor clinopyroxene in a fine black groundmass. Vesicular zones are common, often showing elongation in flow direction, but are typically devoid of any secondary minerals such as calcite or zeolites. However, some vertical joint planes display thin crystalline coatings of pink heulandite. A cream-coloured capping visible along the top of the northern quarry wall represents a sharply defined zone of surface weathering of the latite to kaolinite, the weathered rock still showing the porphyritic nature of the underlying latite *(photo 7)*.

There have been three quarrying operations on Bombo Head, the first in 1880 on land known as the Eureka Estate owned by Captain Samuel Charles. Almost the whole point then resembled the Giants Causeway in Ireland. Captain Charles had leased this part of the estate to George Hill in Sydney, who, having won a contract to supply blue metal to the New South Wales Government, erected a 300 ft long wharf to which the quarried stone would be conveyed by a steam tramway. Hill's quarry was opened in a small gully and the stone removed was hand-knapped into cubes to be laid in association with Sydney's tramway tracks (Longworth, 2024). It was later to become an important source of ballast for the New South Wales railways. A number of other quarries still operate in the Kiama area.

For a time, this unparallelled geological site seemed destined to be partly destroyed and closed off to the public and students alike, as the Metropolitan Water Sewerage and Drainage Board had planned in the late 1970's to use part of the quarry floor for the construction of a sewerage treatment works for the town of Kiama. However, representations made to the Heritage Council of New South Wales by the Geological Society of Australia and Macquarie University resulted in the Bombo Headland Geological Site being accorded the protection of a permanent conservation order (PCO) in July 1983. So, it will always remain accessible to anyone wishing to study or simply observe and photograph its unique geology (Percival, 1985), providing weather conditions allow!

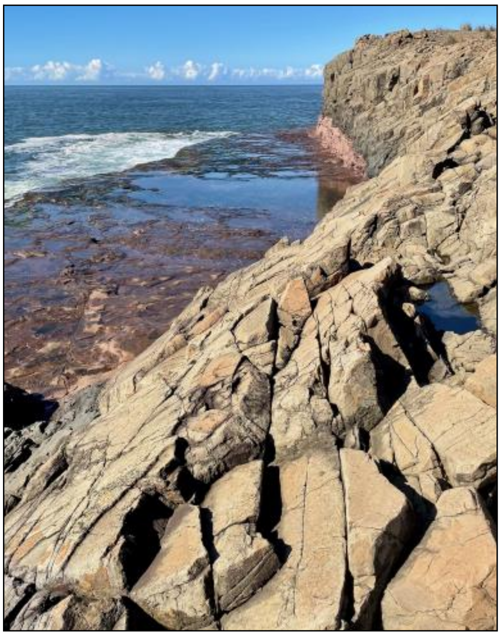
The Bumbo Latite is of international significance in providing one of a number of rock samples which helped define the Kiaman Magnetic Interval, one of the

5. Superb example of peperite in the Blowhole Latite. (Brian England).

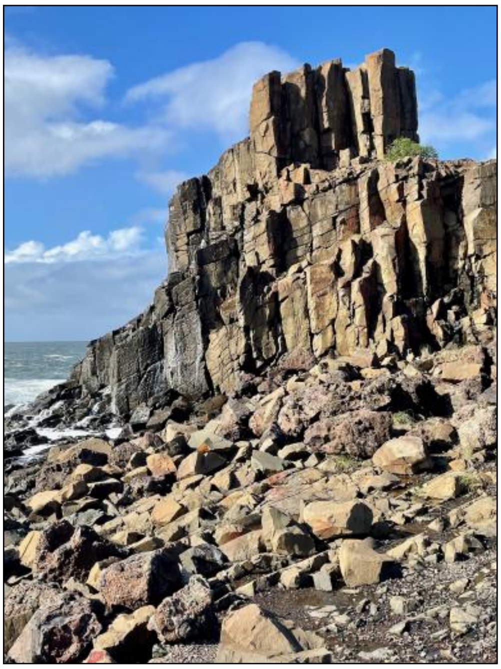
6. Group of quartz-lined vesicles in the Blowhole Latite. Largest vesicle is around 6 cm. (Brian England).

7. Weathered Bumbo Latite showing kaolinite replacing plagioclase crystal. (BME specimen R253).

10. Phreatic breccia ridge (centre left) beneath the Bumbo Latite, looking from the east. (Brian England).



8. Kiama Sandstone on the rock platform below the Bumbo Latite at the southeastern



11. Bumbo Latite overlying the phreatic breccia shown in Photo 10 looking from the west. Note the northerly dip in the chatter marks. (Brian England).

9. Kiama Sandstone/Bumbo Latite contact. (Ron Evans, from Geo-Log 2007).

several magnetic pole reversals recorded throughout geological history (McElhinny, 1969).

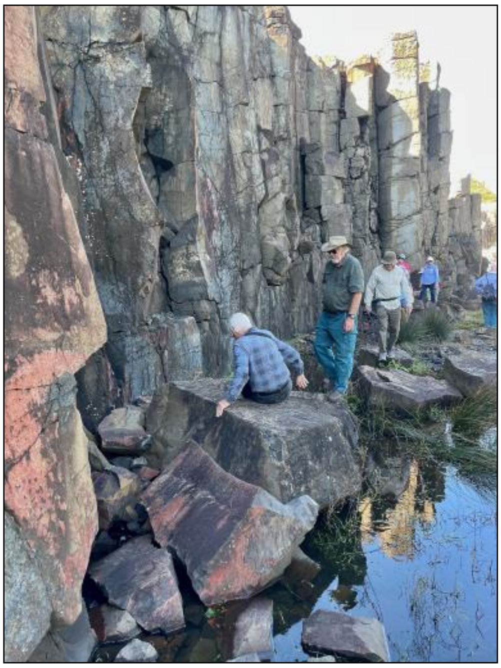
Chris and I already knew that there was no current access to the quarry floor via the normal routes, so we walked up the pathway from the picnic area to the large flat area at the top of Bombo Head. Here there were already spectacular examples of columnar jointing in the Bumbo Latite making up part of a former seawall on the south side of the headland. From here an old road led northwards down to the rugged foreshore and more spectacular groups of latite columns. Unfortunately, access to the rock platform of Kiama Sandstone below was no longer possible due to erosion but we could carefully look down over the edge to its contact with the overlying Bumbo Latite on which we were standing *(photo 8)*. How this contact appeared in 2007 is shown in *photo 9*.

At this point the latite flow had encountered either a zone of wet sand or a small active stream bed, resulting in violent phreatic (steam-generated) explosions which disrupted the underlying sediment and tore the rapidly cooling latite apart, leaving a ridge of breccia *(photo 10)* which trends southwards to emerge on the southern face of Bombo Head. Above the breccia the pooled lava still developed the vertical columnar jointing characteristic of pooled basaltic rocks, but the horizontal cracks (chatter marks) formed as the columns cooled and contracted follow the contours of the underlying breccia ridge *(photo 11)* and not the surface of the flow as would normally be expected. This means that cooling of the lower part of the lava flow, initially at least, took place progressively from the bottom up, not from the top down. Piles of breccia dug out during construction of the sewerage outlet provided an opportunity to examine the nature of the breccia *(photo 12)*.

Meanwhile, Chris had gone off to reassess one of the nearby access points to the quarry floor we had looked at yesterday, at the end of an obviously well-used track around the breccia pile and leading towards the columnar southeast wall of the quarry. Yesterday there had been just too much water, but within minutes Chris rang me to say he had reached the quarry floor without getting his feet wet!

Turns out that, without any further rain, the water level around the quarry edge had dropped considerably since yesterday and we found we could cross into the southeast corner of the quarry by using the large latite blocks fallen from the adjacent quarry wall as stepping stones *(photo 13)*, albeit with considerable care! On the other side only a low ridge of rubble covered by low undergrowth and then a veritable volcanic wonderland opened out before us! Little wonder this place is often used as film set and as background for SUV advertisements.

12. An example of the latite breccia. (BME specimen R309. 16cm across).



13. The first challenge! Accessing the floor of the Bombo quarry along the base of the southeast seawall. (Brian England).

14. Latite cooling columns forming part of the quarry seawall. (Brian England).

From this point a well-defined track bordered by latite cobbles led out across the quarry floor, passing an unimaginable vista of latite columns rising to over 6 metres along the seaward edge of the quarry *(photo 14)*. These are the remnants of a protective seawall left from quarrying operations, which finally closed around 1947. The early afternoon light and cloudless sky were perfect and the photographers in the group simply went 'nuts' trying to decide whether to look at the fascinating rocks scattered under their feet or photograph the astounding scenery.

Much of the quarry floor had been almost completely cleared of sediment by the recent rains and only the huge blocks of latite torn from the seawall by the sea lay scattered over its surface, mute testimony to the power of the sea during storms!

The internationally famous xenolith-rich basanite (basalt) dyke named after Sue Wass (a geologist from Macquarie University who discovered the dyke and recognised its significance) was clearly visible snaking its way between latite columns on the quarry floor. This dyke has been dated at 204.6±45.6 Ma (Jurassic) (Alcorn, 2016) and is related to back-arc activity behind an arc then lying to the east and was a precursor to the opening of the Tasman Sea (Sutherland, et.al., 1985). It is unique in that it contains xenoliths from both the upper crust and lower mantle which constitute up to 70% of the volume of the basanite (Percival, 1985).

Coarse-grained xenoliths comprise layered olivine gabbro from deep in the magma chamber, mantle dunite, minor eclogite, metasediments and granitoids (Alcorn, 2016). There is also peridotite, lherzolite, and coarse aggregates of lustrous black ferrohornblende plucked from altered basalts. Other minerals present in the xenoliths include varying amounts of clinopyroxene, apatite, biotite, titanomagnetite, ilmenite, rutile, and calcite (Percival, 1985). The gabbroic xenoliths show well-preserved plutonic igneous textures, are of Carboniferous age, and provide supporting evidence for the existence of a gabbroic pluton underlying the Sydney Basin (Alcorn, 2016). Fragments of this dyke *(photo 15)* are liberally scattered over the quarry floor, providing enough material for further study and collection without further damaging the dyke itself.

It was easy to follow this dyke across the quarry floor to the sea wall where it appears in vertical section *(photo 16)*, clearly showing the pulsed injection of magma which occurred as the fissure was filled in stages as it gradually opened to create what is known as a sheeted dyke. Here only the core of the dyke contains xenoliths. There are at least 5 other basanite/basalt dykes exposed in this quarry, but none of these contain xenoliths.

The group left the Bombo quarry at 12:30 pm. Some followed Barry along the Bombo Head Lookout Track to view the quarry from above and then explore Boneyard Beach. The remainder retired to the Central Perk Café in Terralong Street for coffee.

Wednesday 15th May.

Another brilliant day weatherwise! Woke to the call of the laughing jackass but no sound from the sea only metres from our cabin. All was now peaceful after the turmoil that had hit the region over the weekend.

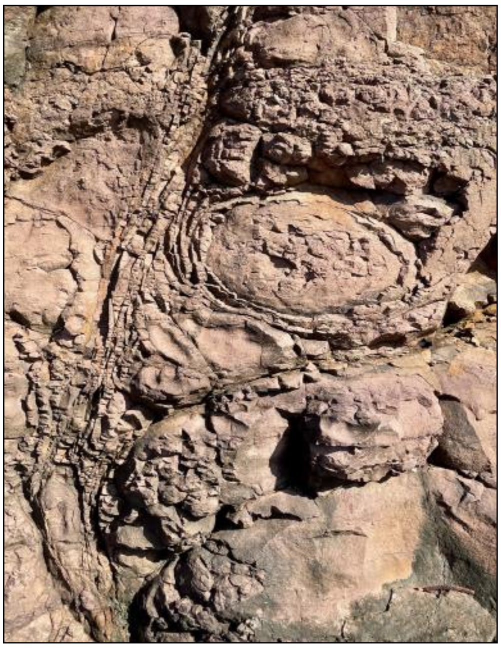
Low tide was at 8:29 am so everyone made their own way to Terralong Street in town, parked where they could, and assembled outside the Fire Station at the

15. Basanite (basalt) dyke rock crowded with xenoliths.
(BME specimen R890. 9 cm across).

16. The sheeted basanite dyke exposed in the quarry seawall. (Brian England).

corner of Shoalhaven Street at 8:30 am. From there we walked down to the Kiama Harbour foreshore and followed the concrete path northwards to the rock platform below Pheasant Point. Compared to what we had seen yesterday, the outcrops of Blowhole Latite slowly emerging from the falling tide were not worth even a second look.

Almost immediately, the Kiama Sandstone exposed in the cliffs and rock platform along this stretch of coastline began to reveal its secrets, beginning with a fine example of spheroidal weathering *(photo 17)*. Nearby the rock platform showed unusual examples of tessellation *(photo 18)*, probably initiated by slight tectonic flexing of the sandstone bed. The Kiama



17. Spheroidal weathering in Kiama Sandstone below Pheasant Point, Kiama. (Brian England).

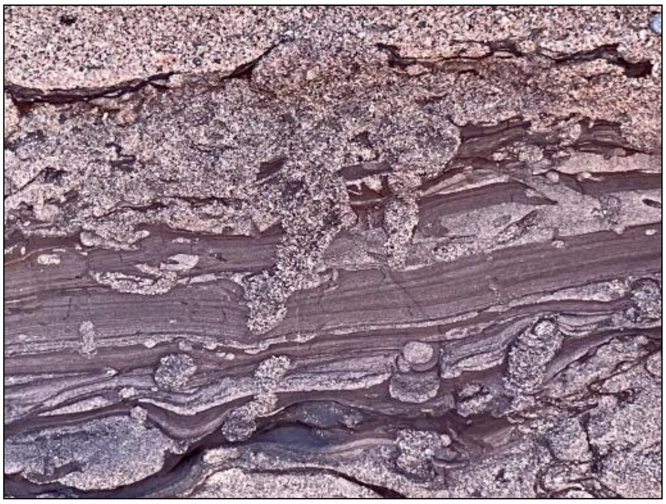
19. Pebble band in Kiama Sandstone in the cliff below Pheasant Point. Note the heavy bioturbation below the pebbles. Largest pebble is 4 cm. (Brian England).

18. Tessellation in Kiama Sandstone on the rock platform below Pheasant Point, Kiama. (Brian England).

20. Angular block of porphyritic latite in Kiama Sandstone. Dropstone or ejecta? (Brian England).

Sandstone was laid down over tidal mudflats around the emerging edge of the volcano. It comprises alternating beds of fine dark grey mudstone, fine to coarse conglomerate and occasional pebble bands *(photo 19)*, with the finer beds showing heavy bioturbation *(see photo 19)*, ripped up mud clasts and occasional large (over 6 cm) angular to subangular blocks of porphyritic latite *(photo 20)*. Muddy bands also contain sand-filled burrows *(photo 21)* formed by marine worms. As new sediment was washed in periodically these organisms would migrate upwards to maintain their ideal position in the sediment pile. These vertical burrows are indicative of shallow water suspension feeders who had to maintain access to the sediment/water interface (Pettijohn, 1975). There are also occasional dropstones of metamorphic rocks *(photo 22)* completely foreign to the local geology and probably rafted from the south attached to floating ice.

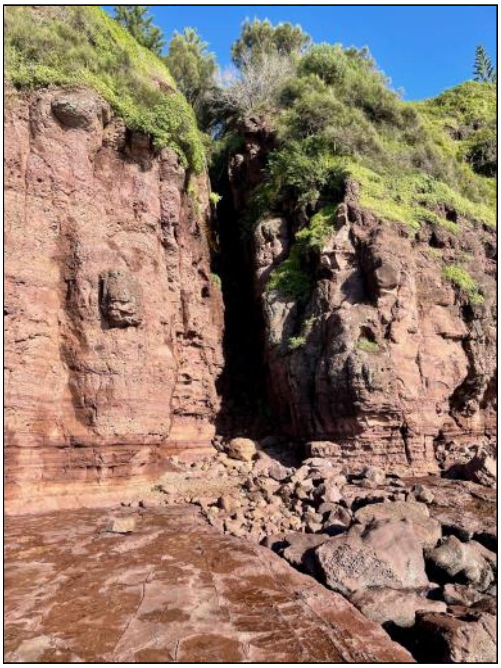
The large angular rocks seen in the cliff, often associated with pebble bands, present an enigma. Are they also dropstones? Some authors suggest they are.



21. Sand-filled burrows in mudstone band in Kiama Sandstone. Note the distortion due to pressure of overlying sediment. (Brian England).

23. Ejected cobble of porphyritic latite fond on the rock platform below Pheasant Point. (BME specimen R891. 8 cm).

22. Dropstone of metamorphic rock in Kiama Sandstone. (Brian England).



24. Cleft in the sea cliff at Pheasant Point formed by erosion of a basalt dyke. (Brian England).

But this was a shallow water environment, as indicated by the vertical burrows of filter feeders, and hence unlikely to be accessible to floating ice. The coarse porphyritic nature of these rocks *(photo 23)* is typical of material that would temporarily block a volcanic vent and lead to violent explosions, throwing large rocks far and wide across the surrounding mudflats

Further around Pheasant Point a basalt dyke had intruded the Kiama Sandstone and its erosion has left a deep cleft in the cliff face *(photo 24)*. We were able to continue right to the north end of the rock platform, but parking restrictions back in town allowed less than two hours to explore and we had to be back to move our vehicles (even if ever so slightly) before 10:30 am to avoid having to make annoying donations to Kiama City Council. Then we crossed Terralong Street for coffee at the Central Perk Café.

Our coffee and cake cravings satisfied we drove up to the Kiama Blowhole car park at Blowhole Point for a close-up encounter with Kiama's most popular tourist attraction, the Kiama Blowhole, the World's largest *(photo 25)*. Here we crawled over further outcrops of Blowhole Latite. The weathered latite surface showed an interesting vertical pseudo-foliation appearing as thin close spaced ridges, perhaps representing differential weathering of flow lines in the lava. Here and there were occasional solid bodies of latite up to 16 cm, presumably ejecta *(photo 26)*. Looking south from the edge of the latite outcrop there was a good view into the sea cave leading into the blowhole. From here the upper chaotic flow and the underlying columnar flow are clearly discernible *(photo 27)*. Of greatest interest however, was an outcrop of altered latite breccia infilled by white crystallised laumontite (zeolite group) beside the concrete path at the foot of the stairs, clearly of the remnants of a hydrothermal spring *(photo 28)*.

The first European to discover the blowhole was George Bass on December 6th 1797 during his voyage of coastal exploration. This phenomenon resulted from the partial collapse of a large sea cave eroded along a basalt

25. The Kiama Blowhole in action, well, sort of! (Brian England).

27. View south from Blowhole Point showing the cave entrance and the upper chaotic and lower columnar parts of the Blowhole Latite. (Brian England).

26. Dense latite bolder in Blowhole Latite at the Kiama Blowhole. (Brian England).

28. Latite breccia infilled by white crystallised laumontite. The remnants of a hydrothermal spring. (Brian England).

dyke in the Blowhole Latite. The collapse took place just short of the landwards end of the cave, leaving a large void inland of the hole. Incoming waves compress the air in this void which then escapes explosively as the wave recedes, forcing water through the opening as a column of spray. The spectacle is usually greater at high tide and in a strong southeast swell spray heights of over 30 m have been recorded.

We returned to our vehicles and drove down to Endeavour Lookout and Little Blowhole on the shore of the small bay north of Marsden Head in South Kiama.

At Little Blowhole the lower columnar-jointed part of the Blowhole Latite is exposed along the shoreline like a miniature Giants Causeway. This diminutive but very active blowhole formed when a single latite column collapsed into a sea cave below. This blowhole is more consistent than its big brother, particularly in a northeast swell, often putting on a show when the main Kiama Blowhole does not *(photo 29)*. In fact, its performance can sometimes be seen from the Kiama Blowhole car park. The rows of latite columns on the grassy slope above the blowhole provided ideal seating for a picnic lunch while watching blowholes of a different kind out to sea – passing whales heading north.

29. The Little Blowhole. (Brian England).

30. Cathedral Rocks from the north. (Brian England).

31. Shallow water sediment feeder tracks in Westley Park Sandstone on the rock platform at Black Head, Gerroa. (Brian England).

32. A surprising find! The crinoid fossil (10 cm) found by Joan Henley. (Joan Henley).

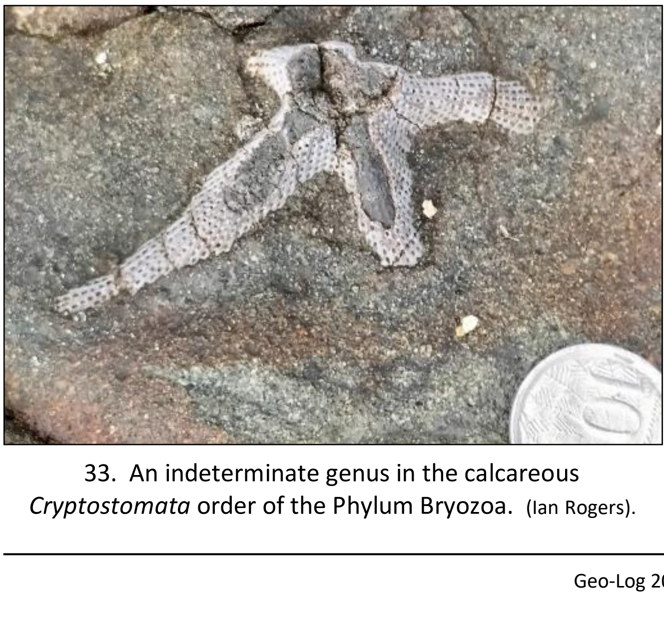
Looking for something to fill in the afternoon we decided to drive up to Cathedral Rocks, just north of Bombo Head at the northern end of the Kiama Coastal Walk. We initially approached this coastal ikon via Cliff Street, but were disappointed to find the view from there restricted and in shadow. Also, there was no track down to the rock platform. But local knowledge came to the fore and we were advised to drive to the car park near the south end of Jones Beach and walk along the sand to the headland. Even through it was now close to high tide there was no problem with access. At the end of the beach, we found more coastal cliffs of columnar Bumbo Latite and more stupendous coastal scenery. We were first met by a spectacular latite pinnacle just offshore. Then the magic unfolded with the rugged latite coastline providing enough variation in foreground for the photographers to frame the majestic Cathedral Rock from a number of angles, standing like a tall ship surrounded by crashing waves in the small inlet *(photo 30)*. Unfortunately, the small sea cave often used by photographers to frame the Rocks was not accessible. It can only be entered at very low tides.

Thursday 16th May.

Everyone made their own way to the turning circle at the end of Staford Steet on Black Head in Gerroa, all arriving at around 8:30 am. Today was specifically chosen to explore the Permian marine fossils on thew rock platform here due to the low tide of 0.33 m at 9:20 am. We had prayed for an overcast but fine day, and lo – it came to pass! Ideal conditions for fossil hunting and photography.

The southern part of the extensive rock platform around the foot of Black Head was accessed by a rather steep and slippery fishermen's trail, still very wet from the recent rain. This proved an error of judgement as will be explained later in this report.

At this locality a 12 m thick section through the lower part of the Westley Park Sandstone (Budgong Sandstone) contains an abundant exquisitely preserved Late Permian marine fauna (Percival, 1985). The rocks comprise green-grey lithic sandstone with interbedded conglomerate and siltstone lying directly below the Blowhole Latite. The sandstones are composed mainly of volcanic rock fragments and detrital plagioclase with only minor quartz. These are prodelta and delta front sands (Herbert and Helby, 1980). The sequence contains an authigenic mineral assemblage, mainly laumontite (zeolite group). The area is one of the classic sites of Australian palaeontology and is the type locality for several species of brachiopod, bryozoans, pelecypods and gastropods. Between 1838 and 1842 the site was visited by James Dwight Dana, geologist to the Wilkes US Exploring Expedition. Despite the relatively coarse lithology, preservation of the fossils is superb! Many of the shells are articulated and preserved in life position (Percival, 1985). The brachiopod and smaller gastropod genera are often concentrated in patches, suggesting they were colonial in lifestyle.



33. An indeterminate genus in the calcareous *Cryptostomata* order of the Phylum Bryozoa. (Ian Rogers).

34. The Black Head Aboriginal shell midden. (Brian England).

Initially the fossils exposed on the rock platform were disappointing. In fact there were none! Only abundant trace fossils were evident, the complex feeding trails of shallow-water sediment feeders such as brachiopods *(photo 31)*. But one surprise was a nice crinoid fossil found by Joan Henley *(photo 32)*, on a flat cobble amongst the shoreline rubble. Also found here was the only example of a bryozoan *(photo 33)*.

The initial lack of fossils, particularly the brachiopod genera, suggests that this horizon represented an earlier level of habitation which was abandoned when the animals moved upwards in the sediment pile as its depth increased. Too much sediment too quickly and they would be buried alive.

An unexpected bonus here however was the presence of a large Aboriginal shell midden beautifully exposed in vertical section along the back of the rock platform *(photo 34)*. Consisting largely of broken shells set in a dark ash-rich soil this is an important site documenting part of our Aboriginal cultural history dating back around 8,000 years. Scattered amongst the cobbles at the back of the rock platform are examples of rocks used for abrading, milling, filing and chopping eroded out of the midden during the relentless attack by the sea, which is eating into the midden at the rate of around 0.5 metres per year. Observe but do not disturb!

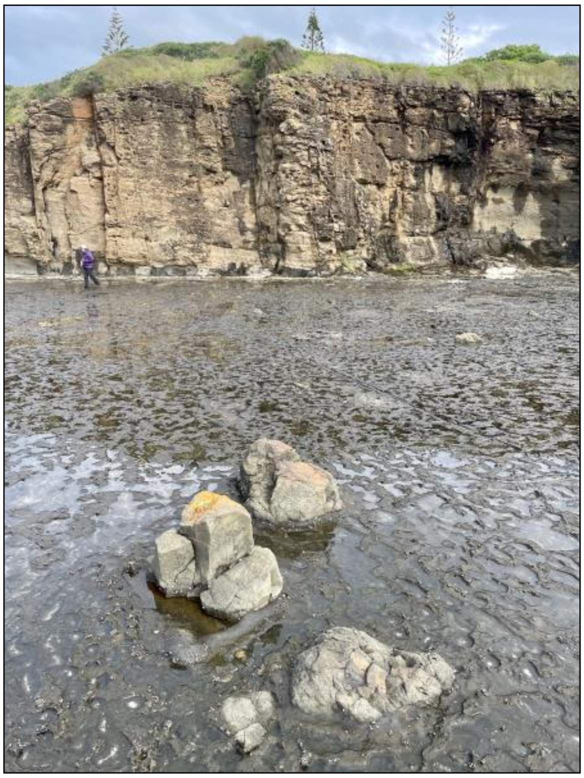
The cliff line above the rock platform exhibits many interesting features, including bedding, tafone (small caves), and spheroidal weathering, but it was not until we were two thirds of the way around that that the fossils began to appear in the rock platform, still wet, not from the sea but from fresh water oozing from the saturated soil on the headland above.

Many of the fossils are still composed of the original carbonate material and stand proud of the sandstone surface. The first to be encountered were

35. The bryozoan genus *Stenopora* on the rock platform at Black Head. (Brian England).

36. The brachiopod genus *Ingelarella* on the rock platform at Black Head. (Brian England).

37. The brachiopod genus *Notospitifer* on the rock platform at Black Head. (Brian England).



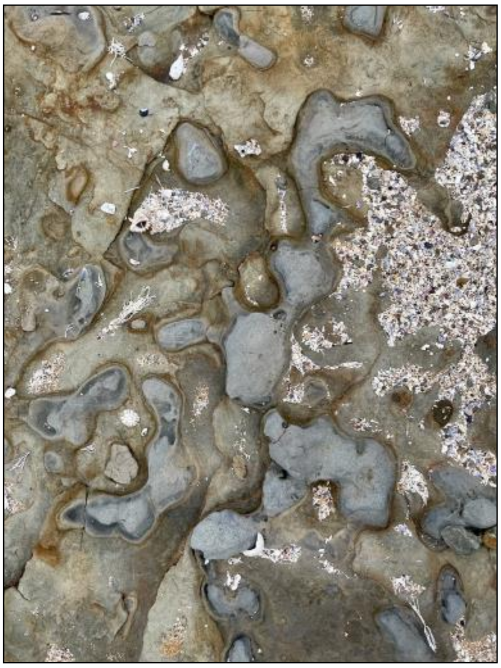
38. Large dropstones in the Westley Park Sandstone on the rock platform at Black Head. (Brian England).

superb examples of the bryozoan genus *Stenopora crinita (photo 35)*. Then other marine genera began to appear in profusion, including the brachiopods *Ingelarella (photo 36)* and *Notospirifer (photo 37)*, the gastropods *Peruvispira* and *Keeneia ocula*, and the pelecypod *Myonia*. Also present on the rock platform and in the cliff are scattered large ice-rafted dropstones *(photo 38)*, testimony to the periglacial climate prevailing in the Late Permian. In a few instances the dropstones occur in groups. These fell to the sea floor cemented by ice! Concentrations of brachiopods were underlain by zones of heavy bioturbation (masses of feeding burrows).

Towards the north end of the rock platform were more, quite different, feeding trails left by deep water sediment feeders *(photo 39)* and patches of unusual infilled burrow-like structures *(photo 40)* found to contain the brachiopod *Ingelarella*. Perhaps these are also feeding burrows. One modern example of marine fauna was an abundance of white bryozoan scattered in depressions and washed up in deep banks at high water level around the base of the cliff.

We returned to our vehicles from the north end of the rock platform and over the top of the grassy headland. Had I remembered, it would have been far easier to use this as the access point after parking in the large car park in Headland Drive. But we would have

39. Deep water sediment feeder tracks in the Westley Park Sandstone at the northern end of the rock platform at Black Head. (Brian England).



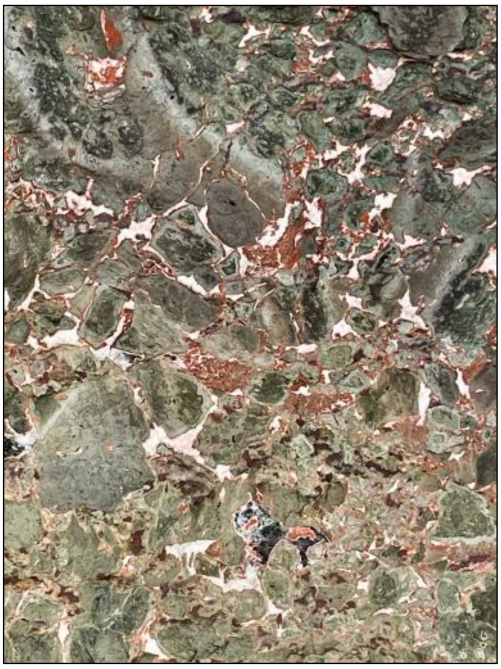
40. Burrow-like structures in the Westley Park Sandstone at Black Head. (Brian England).

missed some important sites and Joan would not have found her crinoid!

Lunch at the cars marked the planned end of the trip. However, Roz and Shayne told of some spectacular rocks on the low headland at the southern end of Easts Beach. So several members went off to explore, accessing the site by walking through the Easts Beach Holiday Park at the end of Ocean Street in South Kiama.

Here we found further spectacular examples of peperite *(photo 41)* and laumontite/quartz-infilled hydrothermal springs *(photo 42)* in the Blowhole Latite. Now close to exhaustion, most had had enough at this stage, but Chris ventured further around the headland and came back to report some interesting dykes cutting the latite.

41. Spectacular peperite in Blowhole Latite on the headland at the south end of East Beach, Kiama. Field of view 20cm across. (Brian England).



42. Peperite texture infilled by crystalline quartz/laumontite. Vertical height 25 cm. (Brian England).

The rest of the day was free for people to explore other areas of interest, including the Minnamurra Rainforest Reserve and Saddleback Mountain. The trip officially ended with a farewell dinner at the Kiama Bowling Club.

Epilogue and Acknowledgements.

A trip such as this needs a lot of things to go right! Weather forecasts and the drive down to Kiama on the Monday did not bode well for the following week, plus the seas on Monday were extraordinarily rough, making rock platforms far too dangerous to explore. Also, the tides seemed to be against us! But from Tuesday morning we were blessed with almost perfect weather, even though the ground remained a little damp underfoot. This provided more than a few challenges with access to some sites. The Saturday after the trip the showers and wind returned, with a 40 kph southerly and almost freezing temperatures., We were so lucky!

Everyone contributed in some way. Thanks to Roz, Joan and others who shared their own little snippets of wisdom and helped answer some of the continuing barrage of questions, particularly from our new member Ian Hill, whose unbridled enthusiasm just has to be admired. But this helped the whole group better understand what they were looking at. Thanks to Richard Bale who sent out copious amounts of information prior to the trip and also to Chris Morton, a very capable co-leader and very inept at seeking out obscure but interesting publications on the internet. And then Ron Evans, who did a lot of preparation (maps, etc.) but was unable to attend at the last minute. And finally, a massive thanks to all who took part and made this trip such a resounding success. Although many of us are getting older, we all faced the challenges with enthusiasm. We are definitely not a group of has-beens!!

The Blowhole Genie.

Water shoots skywards
from the Little Blowhole
with a whumpf!

Like a genie from a
tight-necked flask
a column of water sprays up.

Coin-sized drops
sparkle back down
while vertical mist
writhes and curls,
then drifts softly, still upright,
with the breeze.

From a combination of elements -
water, air and stone,
Nature creates a phenomenal plume,
granting the onlookers their wish -
and they go, 'Aaahh!'

Poem inspired by Ross Staines after visiting the Little Blowhole, Kiama.

Report by Brian England.

References.

ALCORN, C. J. (2016). *Zircon geochronology and geochemistry of xenoliths in a Jurassic dyke at Bombo NSW, Australia. Evidence of a deep crustal structure under the Sydney Basin*. Unpublished BSc Honours thesis. School of Earth and Environmental Sciences, University of Wollongong.

CARR, P.F. (1983). *A reappraisal of the stratigraphy of the Upper Shoulhaven Group and Lower Illawarra Coal Measures, Southern Sydney Basin, New South Wales.* Proceedings Linnean Society NSW, 106(4), 287-297.

ENGLAND, B.M. (2007). *Kiama District-Geology and landforms.* Geo-Log 2007, 14-19.

HERBERT, C. and HELBY, R. (1980). *A guide to the Sydney Basin.* Geological Survey of New South Wales. Bulletin 26. Department of Mineral Resources. Page 79.

JONES, J.G. (1969). *A lacustrine volcano of Central France and the nature of peperite*. Proceedings of the Geological Association, 80, 177-188

LONGWORTH, J. (2024). *Quarry railways on Bombo Point*. Light Railways, No. 295, 3-15.

PERCIVAL, I.G. (1985). *The geological heritage of New South Wales. Volume 1*. National Parks and Wildlife Service.

PETTIJOHN, E.J. (1975). *Sedimentary rocks*. Harper and Rowe, pp130-31.

SARKIS, A. (2023). *The age, duration and provenance of the Broughton Formation (southern Sydney Basin, Australia), and its temporal relationship to the Permian climate ch*ange. Honours Thesis. Wollongong University.

SKILLING, I.P.; WHITE, J.D.L. and McPHIE, J. (2002). *Peperite: a review of magma-sediment mingling*. Journal of Volcanic and Geothermal Res*earch*, 114, 1 -17.

SUTHERLAND, F.L.; FRANKLIN, B.J. and WALTHO, A.E. (1985). *Volcanism in eastern Australia with case histories from NSW*. Geological Society of Australia, New South Wales Division, Publication No.1

WASS, S.Y. and SHAW, S.E. (1984). *Rb-Sr evidence for the nature of the mantle, thermal events and volcanic activity of the southeastern Australian continental margin*. Journal of Volcanology and Geothermal Research, 21, 107-17.

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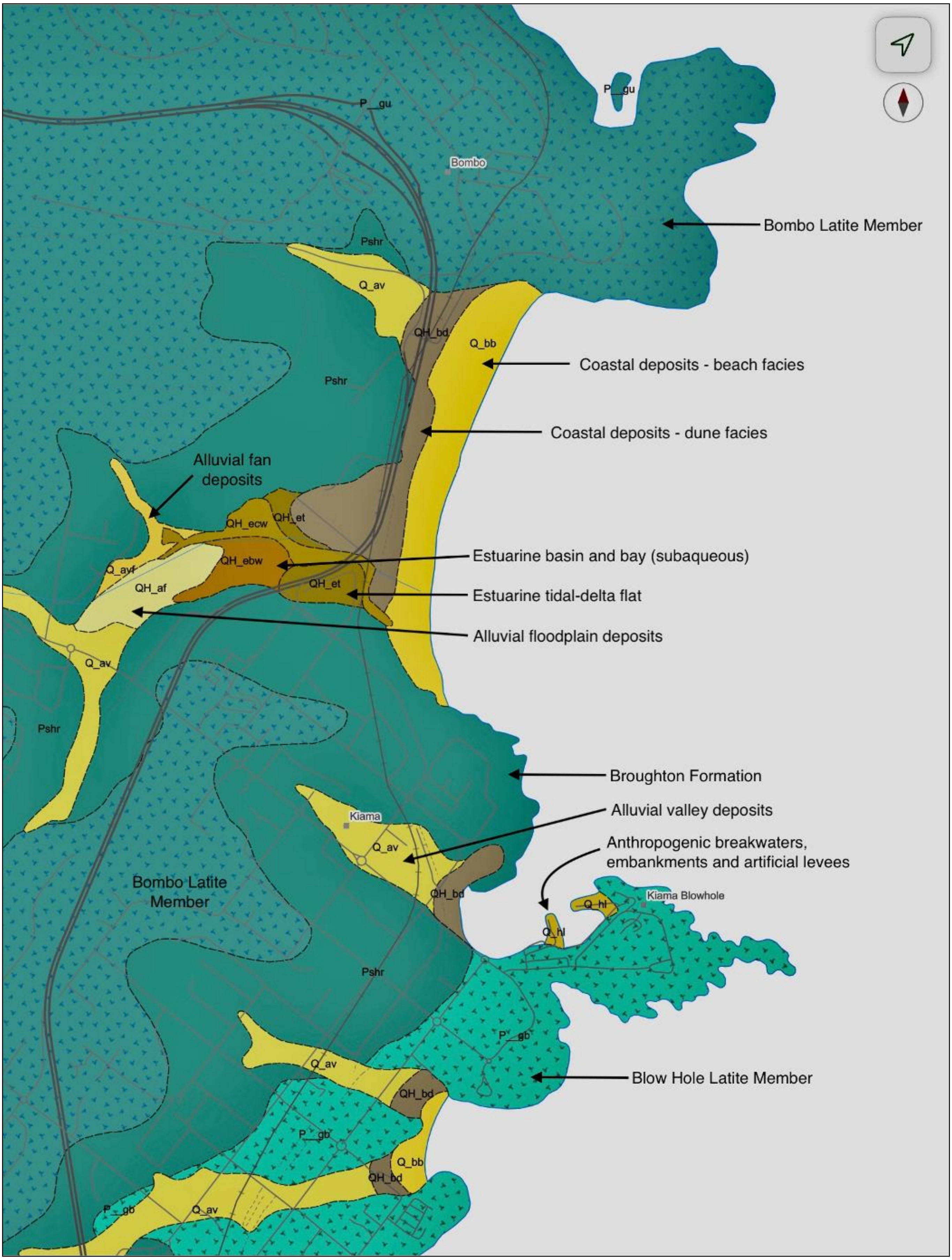
Appendix.

KIAMA GEOLOGICAL MAP.



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KEY to Kiama Geological Map:

Blow Hole Latite Member (P_gb) - 259.10Ma to 251.90Ma
- Mid-grey with brown latite, fine-grained groundmass with plagioclase and zeolite clusters to 2 mm, chlorite-coated augite phenocrysts. Sporadic pillow structures, sporadic columnar jointing, breccia zones and an intrusive basal contact.

Broughton Formation (Pshr) - 265.10Ma to 254.14Ma
- Red-brown or green-grey, lithic to feldspathic sandstone (sporadically quartzose) with minor interbedded siltstone and polymictic pebble conglomerate, sporadic shelly fossils, varying degrees of bioturbation.

Bombo Latite Member (P_gu) – 259.10Ma to 251.90Ma
- Dark grey to black, porphyritic basalt (in hand specimen), phenocrysts are plagioclase with minor clinopyroxene; sporadically vesicular. Columnar jointing and breccia zones common.

Alluvial Valley Deposits (Q_av) – 2.58Ma to 0.00Ma
- Silt, clay, (fluvially deposited) lithic to quartz-lithic sand, gravel.

Coastal deposits – beach facies (Q_bb) – (02.58Ma to 0.00Ma
- Marine-deposited quartz-lithic fine- to medium-grained sand, shell and shell material, polymictic gravel.

Coastal deposits – dune facies (QH_bd) – 0.01Ma to 0.00Ma
- Marine-deposited and aeolian-reworked coastal sand dunes.

Estuarine tidal-delta flat (QH_et) - 0.01Ma to 0.00Ma
- Fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell material, polymictic gravel.

Estuarine channel deposits (subaqueous) (QH_ecw) - 0.01Ma to 0.00Ma
- Fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell, gravel.

Alluvial floodplain deposits (QH_af) - 0.01Ma to 0.00Ma
- Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.

Alluvial fan deposits (QH_af) - 0.01Ma to 0.00Ma
- Fluvially-deposited quartz-lithic sand, silt, gravel, clay.

Estuarine basin and bay (subaqueous) (QH_ebw) - 0.01Ma to 0.00Ma
- Clay, silt, shell, very fine- to fine-grained lithic-quartz (÷ carbonate) sand (fluvially- and/ or marine-deposited).

Anthropogenic breakwaters, embankments and artificial levees (Q_hl) - 2.58Ma to 0.00Ma
- Large concrete blocks and/or very large quarried boulders; unconsolidated conglomerate of either quarried or local cobbles to boulders with a clay to sandy matrix; sporadic sandy loam capping layers.

Note:

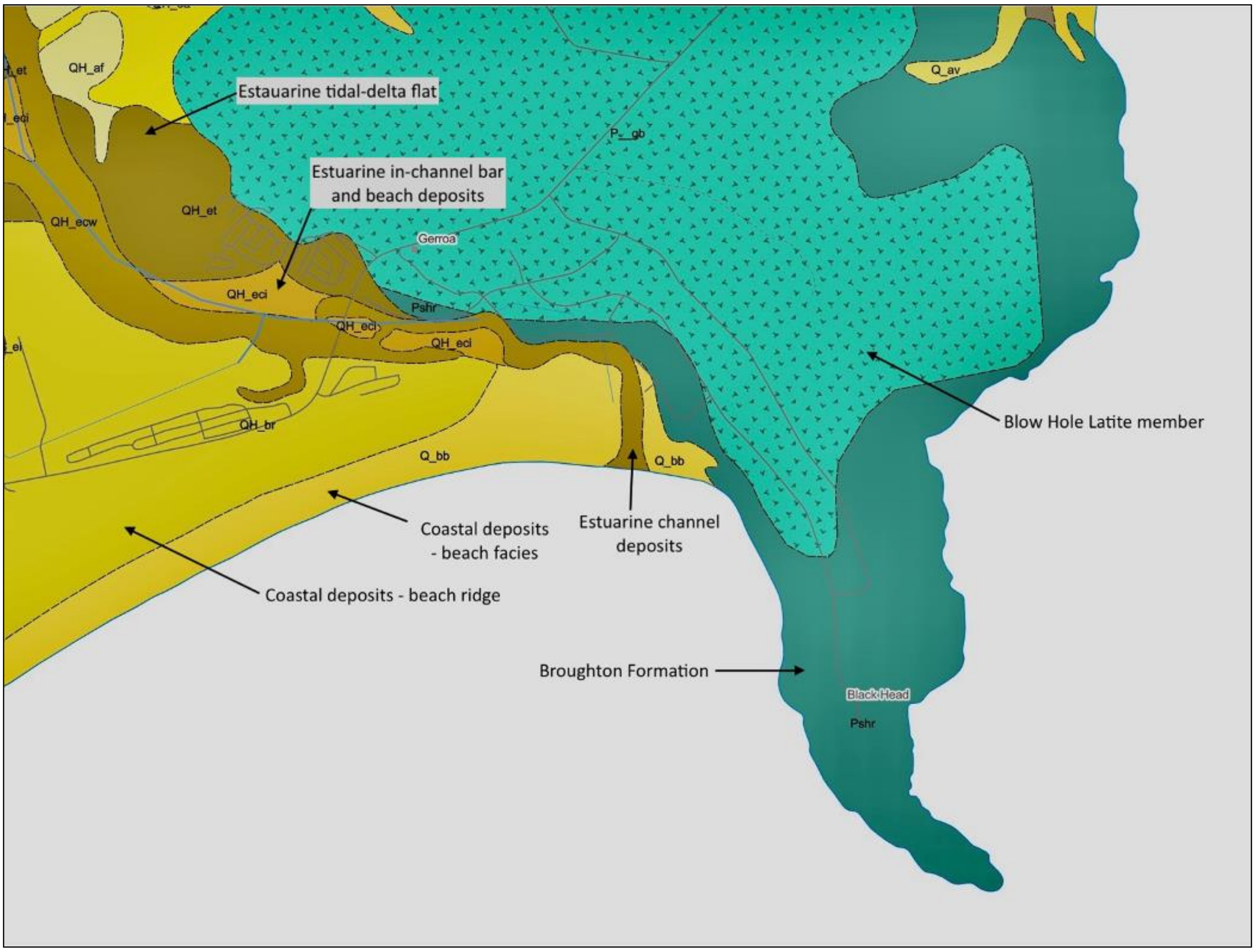
The Broughton Formation comprises the following (Carr, P.F. (1983):
- Canbewarra Latite
- Dapto Latite
- Saddleback Latite
- JAMBEROO SANDSTONE
- BUMBO LATITE
- KIAMA SANDSTONE
- BLOWHOLE LATITE
- WESTLEY PARK SANDSTONE

The Broughton formation is overlain by Illawarra Coal Measures and underlain by Berry Siltstone (equivalent of Mulbring Siltstone in Hunter Valley). This can be seen on the Minnamurra to Gerroa geological map.

This is underlain by the Norwa Sandstone visible on higher ridges.

The Broughton Formation has replaced the Gerringong Volcanic Facies in current usage.

BLACK HEAD GERROA GEOLOGICAL MAP.



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KEY:

Broughton Formation (Pshr) - 265.10Ma to 254.14Ma

- o Red-brown or green-grey, lithic to feldspathic sandstone (sporadically quartzose) with minor interbedded siltstone and polymictic pebble conglomerate, sporadic shelly fossils, varying degrees of bioturbation.

Blow Hole Latite Member (P_gb) - 259.10Ma to 251.90Ma

- o Mid-grey with brown latite, fine-grained groundmass with plagioclase and zeolite clusters to 2 mm, chlorite-coated augite phenocrysts. Sporadic pillow structures, sporadic columnar jointing, breccia zones and an intrusive basal contact.

Estuarine channel deposits (subaqueous) (QH_ecw) – 0.01Ma to o.00-Ma

- o Fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell, gravel.

Coastal deposits – beach facies (Q_bb) – (02.58Ma to 0.00Ma

- o Marine-deposited quartz-lithic fine- to medium-grained sand, shell and shell material, polymictic gravel.

Coastal deposits – beach ridge (QH_br) - 0.01Ma to 0.00Ma

- o Fine- to coarse-grained quartz-lithic-carbonate sand (marine-deposited), shell and shell-fragment-rich beds, polymictic gravel.

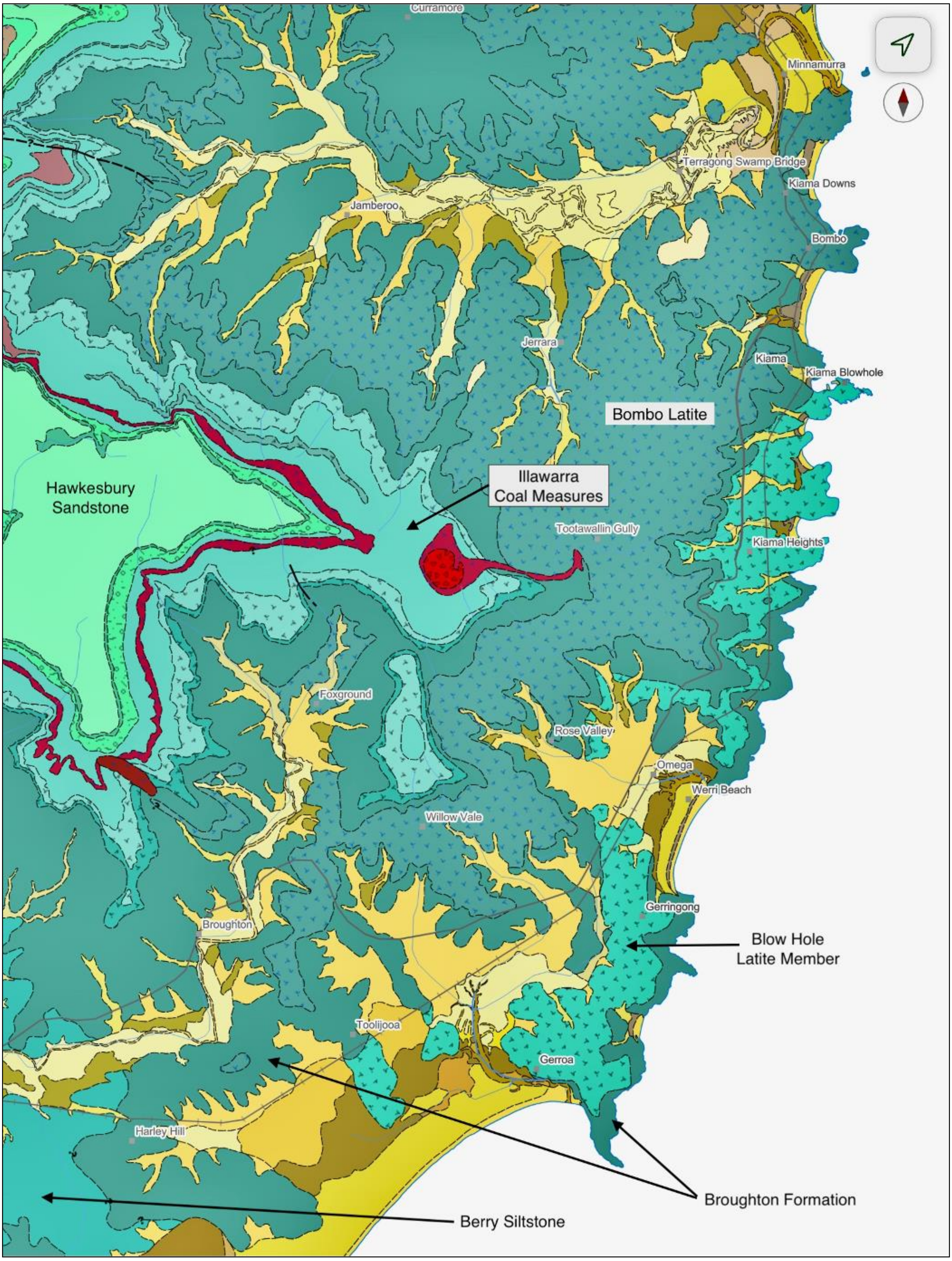
Estuarine tidal-delta flat (QH_et) - 0.01Ma to 0.00Ma

- o Fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell material, polymictic gravel.

Estuarine in-channel bar and beach deposits (QH_eci) - 0.01Ma to 0.00Ma

- o Fine to medium-grained lithic-carbonate-quartz sand (marine- deposited), silt, clay, shell, gravel.

COASTAL GEOLOGICAL MAP from MINNAMURRA to GERROA.



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Publication Acknowledgements.

Because of the disruption caused by COVID to AGSHV activities, this publication contains reports on activities undertaken during the financial year and not the calendar year , hence Geo-Log 2023-2024.

Some extended activities occurred in both 2023 and 2024. Because Geo-Log now covers the financial year and not the calendar year, a much longer Geo-Log than normal has been produced.

It's also the 20th Geo-Log produced by the AGSHV. The first Geo-Logs' were smaller publications with poorer quality photographs (some were copied from 35 mm colour slides or prints), run off on a home printer and then compiled by Ron Evans with help from some AGSHV members.

Since the early days, membership has increased with more people having a geological background joining. This has resulted in activity reports of greater depth containing more geological information.

Geo-Log is still a collaborative publication with reports from trip leaders who organise and conduct activities together with photographs from the leader and various members who attend activities.

Activities conducted during this period were conducted, when necessary, within COVID-19 protocols.

A special thanks to Geo-Log editor Brian England (Life Member) for the onerous job of checking the geological content and seeking out errors in the reports submitted for inclusion in Geo-Log 2023-2024.

He was ably assisted with some editing by Ron Evans.

Life Member Ron Evans produced Geo-Log 2023-2024 and organised its publication by Lakemac Print, Speers Point.

QR Code.

To quickly log into the Amateur Geological Society of the Hunter Valleys website, scan the code below with your phone or tablets camera (or QR Code reader) or log onto www.agshv.com

Ron Evans