'Geo-Log'
2021 - 2022

Journal of the Amateur Geological Society of the Hunter Valley

'Geo-Log' 2021-2022

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

Contents:

Acting President's Introduction.

To members and friends.

We thought 2020 was a very challenging year for the club because of the Covid19, but we were wrong. We had just the same, if not worse disruption during 2021.

We had the wellbeing of members to consider in planning activities due to Covid.

As a society, we have a lot of talented members with a vast knowledge between them. We still held some outings and meetings during these years. Always in the back of our minds were the Covid restrictions we needed to have in place for our members' health and safety. I believe we did a good job of that. This did not just happen, as every member cooperated with activity leaders' planning. Well done everyone!

Lets see what 2022 brings us; no more rain, Covid restrictions and dry days for all outings this year.

The year has started well, with a trip in March to Inverloch in Victoria, followed by further trip up the coast to Stuarts Point and Corindi Beach in May. Both trips were just great.

Let us all stay healthy for the rest of the year.

Kind Regards,

Terry Kingdon (acting President).

The Amazing Apollo Discoveries

Presenter: Dr. Jeanette Dixon AM.
Date: Thursday 28th January 2021.
Attendance: 27 members, 3 guests.

This was the first talk presented at our new venue, Club Macquarie. It started off with a comedy of errors with several issues that we had to work through before we could have the presentation. These were things like incompatible data leads between computers and data projectors and microphones not working. But with a bit of luck and swapping around, the talk started a little later than scheduled.

The following is a summary of that talk.

Dr Jeanette Dixon AM *(photo 1)* has over 50 years of experience as a Space Science/Science/STEM educator, who has worked as a NSW secondary science teacher and at the University of Newcastle preparing trainee secondary science teachers and Master of Teaching students for their future profession. As a result of her Space Science and Geology educational research at the Johnson Space Centre in Texas, Jeanette is the only individual in Australia to be honoured by NASA's Manager of the Apollo Lunar Samples with a long-term loan of some of these samples. These are from the priceless national treasure of lunar samples collected by Apollo astronauts on Missions 15, 16, and 17. Outside of professional employment, her voluntary outreach initiatives have provided quality Space Science/Science/STEM education for students of all educational systems at regional, state, and national levels, professional development for practicing teachers, and space science talks for well over 200 community group invitations and events. She was a guest speaker for the Australian Government at Parkes Radio Telescope for the 50th anniversary of the Apollo 11 Moon landing.

1. Dr. Jeanette Dixon, AM.

Jeanette started off her talk with a review of the Apollo 11 mission to the moon. She then moved onto some basic information about the moon such as showing the disc of the moon overlaying and fitting inside a map of Australia. The Lunar Highlands which are the lighter areas of the Moon are about 4.51 billion years old and the darker 'seas' or Lunar Maria (mar-ee-ah) (singular Mare (Mar-ray) are about 3.7 billion years old. A full day (darkness - sunlight cycle) is 28 Earth days, gravity is 1/6 Earth's and temperatures vary between a "roasting 130°C to a bone-chilling -170°C". The Moon has no real atmosphere and is effectively a vacuum, with 200 times more radiation on the Lunar surface than on Earth. Footprints and rover tracks left by the Apollo astronauts on the Moon may last millions of years as there is no erosion by wind or rain to wear away the Lunar surface. "Mountains on the Moon are mainly the rims of the gigantic impact craters, plateaux, and volcanic domes." The Moon's surface is covered by igneous rocks.

The current leading theory of Moon formation is the "Giant Impact Hypothesis" describing a Mars-sized planet, known as Theia, which smashed into the early Earth approx. 4.51 billion years ago. The Moon started to solidify about 50 million years after the Solar System formed. The impact shattered both Theia and the early Earth exploding millions of tonnes of material into space some of which merged to form our orbiting Moon."

The Apollo missions have helped to answer many questions about the Moon. Retro-reflectors left on the moon allowed lasers to measure the distance to the moon which is an average of 384,400 km (30 Earth diameters - later demonstrated with scale models *(photo 2)* and length of string and is moving away at an average of 3.8 cm per year. The physics experiment of dropping

2. Jeanette with assistance from Roz, demonstrating to scale, the distance from Earth to Moon.

a hammer and a feather in a vacuum was performed by Apollo 15 to demonstrate that the rate of fall of the objects is independent of their mass. This removed any effect of resistance by air, as would be the case on Earth, as the astronauts were essentially in a vacuum. When the hammer and feather were released at the same time, they hit the surface at the same time.

The Apollo astronauts brought back 382 kg of Moon rock with almost all having an igneous origin.

1) *Anorthosite*, is the light-coloured rock from the Lunar Highlands and is about 4.5 billion years old. Predominantly plagioclase feldspar, >90%, and being less dense, it floated to the surface of the Moon's magma ocean when the Moon first cooled forming the original Lunar crust. Being first formed, it is also called the Genesis Rock.
2) *Basalt*, a mafic rock, forms the dark basins or maria found on the Moon's surface and is the youngest rock at 3.8 billion years old. This dark rock rich in iron with some samples rich in titanium, was formed from the solidification of lava. The basins were formed when large meteor impacts shattered the surface, allowing molten basalt to come to the surface and form large areas of flood basalt lava plains.
3) *Breccia* samples collected are composed of pre-existing rocks, that were smashed or welded together by meteorite impacts, that can vary from very cohesive to friable.
4) *Regolith*, or Lunar soil, is material that covers much of the surface of the Moon. Created from meteorite impacts, it is composed of loose rock fragments, fine dust, and glassy droplets.

The hard and abrasive lunar dust proved to be dangerous as it stuck to the astronauts suits via electrostatic attraction, abraded suit layers and clogged up the joints causing problems with movement. The dust entered the crew cabins, where it affected equipment and caused lung and eye irritation. Dust blown up by the rocket exhaust when landing on the moon obscured the landing site making it difficult to land. NASA has tested lunar soil to see its effects on various plants and animals with only the cockroach flourishing.

3. Samples of zircon ($ZrSiO_4$) crystals. These can be used to date a rock by measuring radioactive decay of U and Th to Pb within the crystals.

Analysis of the lunar rock samples, specifically the mineral zircon *(photo 3)*, found the age of the moon to be 4.51 billion years. (Zircons from the oldest continental crust in the Jack Hills in the Pilbara region, WA are 4.404 billion years old).

Tranquillityite, named after the Sea of Tranquillity, was first found at the Apollo 11 mission landing site mainly in lunar basalt. This rare mineral was only found on Earth in dolerite from the Pilbara in WA in 2011.

Apollo astronauts placed sensitive quake detectors to measure tremors called moonquakes. The molten core of the Moon is cooling and shrinking causing the brittle crust to crack and buckle forming ridges, cliffs, shallow trenches and causing some boulders to role across the surface.

Water was initially thought to be extremely scarce on the Moon. Since then, analysis of the orange glassy beads in the regolith, has found water at 0.05% levels. It is also found in small amounts in olivine in the lunar basalt and low ppm levels in plagioclase. Satellites have found large areas of volcanic glass containing trapped water. Water ice has been found in craters within areas in permanent shadow near both poles. Meteorite impacts are releasing puffs of water from just below the Moon's surface. The infrared spectra of water was detected at the Lunar south pole using the SOFIA telescope. 2019 analysis of data from the Lunar Reconnaissance Surveyor found that water molecules were hopping about from irregular-shaped grains on the Moon's surface near the poles, "jumping" in the heat of day to cooler shady spots where they become more tightly bound until exposed to heat again.

Hematite, Fe_2O_3, has been found on the Moon. This is formed when metallic iron, from metallic meteorites, is exposed to oxygen and water. The Earth's magnetic field trails away behind the planet like a windsock. Oxygen in the Earth's upper atmosphere can use the magnetic field to hitch a ride to the Moon's poles to react with the metallic iron.

Several of the Apollo samples contained low levels of amino acids suggesting that life was responsible for them. One of the 'big questions' has been whether there was life on the Moon or somewhere in space in general. Scientists looked for the source of these amino acids to determine their origin. The four possibilities examined were: rocket exhaust from the lunar lander, the solar wind coming from the Sun, meteorites (for example the Murchison Meteorite) or contamination from terrestrial sources. By looking at the types of amino acids and their C isotope ratios, it was concluded that the source was terrestrial life, specifically from the scientists and others that handled the lunar samples.

There are now strict protocols and the wearing of environmental suits to limit further contamination.

At the end of her talk, Jeanette showed us the samples that NASA had placed in her care *(photo 4)*. The Apollo rocks were embedded in a disc of plastic. She also had other samples including simulated lunar regolith, zircons from the Jack Hills in WA, and a sample containing tranquillityite (iron, titanium, zirconium) from WA. We were allowed to photograph and handle these samples. Pretty special when you consider their value and the fact they are from the Moon, brought back by the Apollo missions.

The Apollo missions proved to be a treasure trove. The value of the lunar rock samples and associated knowledge gained, can be calculated by looking at the cost of the Apollo program which amounts to about $283 billion in todays dollars. This includes not only material to fabricate the rockets but production processes and development of the Apollo rockets as well as all the man hours of thousands of technicians. But the value of the scientific research and knowledge gained from direct analysis of the samples and other questions answered by the astronauts as well as the spinoff products, materials and techniques developed from the Apollo program make them virtually priceless. The samples we looked at were valued in the order of millions of dollars.

Dr Jeanette Dixon AM Acknowledgement.

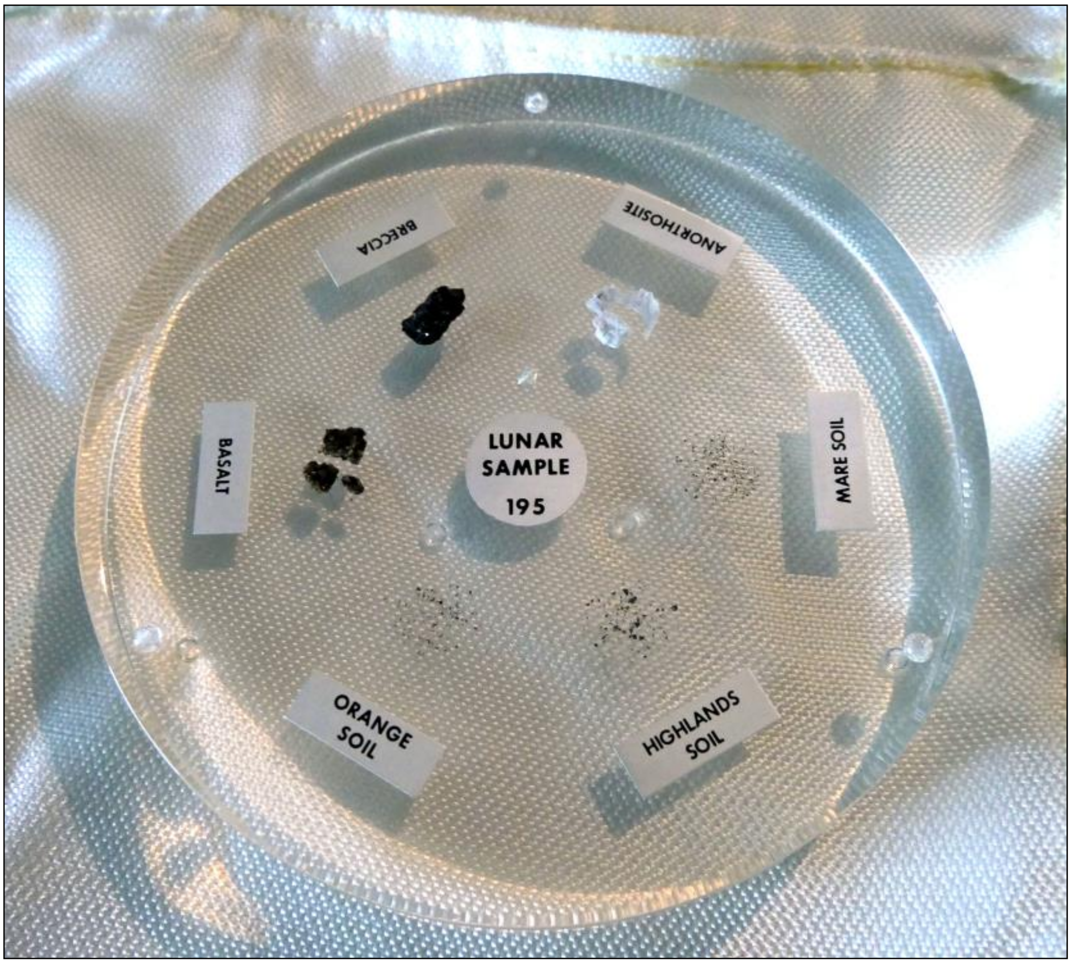
On behalf of the AGSHV, I would like to thank Dr Jeanette Dixon for taking the time to give her informative and interesting talk to our group.

Also, many thanks to Jeanette for allowing me to make use of the power point slides she had prepared and their information as a guide in preparing this report, as well as taking the time to review this report.

Club Macquarie acknowledgement.

On behalf of the AGSHV, I would like to thank Club Macquarie and their staff for providing facilities that supported our talk.

Report by Richard Bale with review by Jeanette Dixon.
Photographs by Ron Evans (1, 2 & 4) & Richard Bale (3).



4. Lunar Samples of Moon rock and soil, encased in plastic for protection.

Boat Cruise Newcastle Harbour to Wybung Head

Leader: Chris Morton.
Date: Wednesday 14th April 2021.
Attendance: 18 members.

Ever since the inception of the AGSHV in 1978, forty-three years ago, our society has explored and documented just about every nook and cranny and structural feature along the coast between Newcastle and south to Wybung Head in Munmorah State Conservation Area (MSCA). However, many places are totally inaccessible for obvious safety reasons and can only be viewed from an offshore position. So, with that in mind, we decided to charter a reasonably new enterprise by the name of CoastXP Coastal Tours. CoastXP operates a 10.8-metre rigid inflatable boat (RIB), called 'Atmos'. The vessel provides a fast, safe and smooth ride for up to 20 passengers *(photo 1).*

During the trip, the boat frequently stopped at a safe distance offshore, so we could have an uninterrupted view of the many inaccessible cliff faces that characterise this spectacularly beautiful rugged coastline, which includes at least five unspoilt National Parks and reserves.

Regional depositional framework.

In 2021 Stephen McLoughlin et. al. wrote in Frontiers in Earth Science/Palaeontology. *"The overall depositional environment and accumulation of the Sydney Basin was a lowland, probably coastal, alluvial plain crossed by sand- and gravel-bed rivers of varying size and planform. Predominantly southward-directed river systems drained the Bowen-Gunnedah-Sydney basin complex, with significant contributions of sediment derived from the rising New England Orogen to the east, and lesser additions from the stable craton to the west".* (Fielding, et al., 2001).

The coastline exposes almost the entire formation of the Newcastle Coal Measures. These were laid down in the Permian period, which underlies the younger Triassic sediments of the Sydney Basin. Their uplift and cross-sectional exposure by marine erosion have revealed them to spectacular effect along the beaches and headlands. The Newcastle Coal Measures comprises several separate seams, many of which are exposed at various locations along the coast. The strata dip generally to the south. The changes in the elevation of the coal seams and their intervening Permian sediments relative to sea level along this dip are apparent on cliffs. The Permian sediments which separate the coal seams include fossil-bearing shales as well as conglomerates, sandstones and tuffs indicating regional volcanic activity (modified from Glenrock State Recreation Area. Geological sites of NSW).

There are significant geological events recorded in the rocks along the southern Newcastle coastline, dating from the Permian to the Quaternary Periods. The timescale of events dates from 299 million years ago. Recorded in the rocks is evidence of several large-scale events, such as volcanic activity, the Permian/Triassic boundary (EPE) 252 million years ago, multiple ice ages, along with dykes that formed when Australia separated from Zealandia.

The outing.

For most of our activities, the weather has in very few cases hindered our exploits. Nevertheless, we were thwarted on our first attempt to conduct this activity in March due to the forecast weather and rough sea conditions. So, the activity was postponed to the 14th April, when the weather and sea conditions proved to be almost perfect, except for a slight south-westerly breeze that put a slight chill in the air and lifted a small amount of sea spray over the bow when we were travelling at slower speeds.

We gathered at 6:00 am with the sun rising, engulfing us in a soft hue of golden light before the blue of the morning sky *(photo 2)* at the wharf, from where the tour departs daily, known as the Harbour Square Boat Dock along the Honeysuckle foreshore directly out

1. 'Atmos', the 10.8 m CoastalXP coastal tour boat.

2. Skipper Dom welcoming us in the 'golden light'.

3. Skipper Dom presenting a safety briefing before departure.

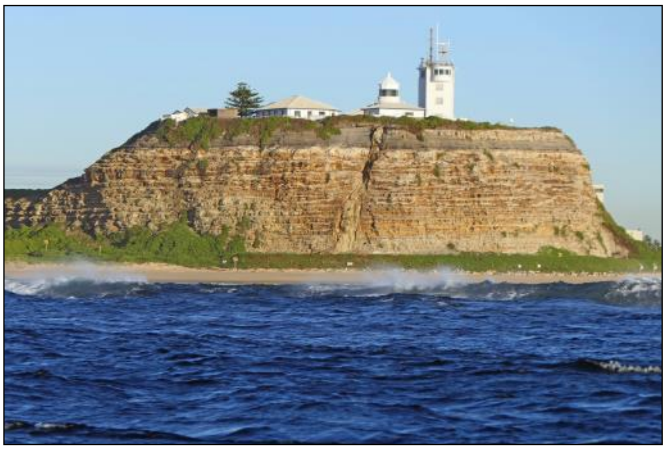
the front of Rydges Newcastle. Given the early time, I expected a few early morning grumbles, but not so due to the excitement of the impending boat trip and the opportunity to catch up with fellow members. After the usual formalities of signing in, our boat arrived and prepared for departure.

Our captain Dom invited us aboard, where we were welcomed and given a full safety briefing *(photo 3)*, a precaution in the event something unforeseen happening. We were informed where the life jackets were stowed and how to put them on, after which Dom gave us a rundown on what to expect on the 37 to 40 kilometre boat trip down to Wybung Head, an approximate 3 hour return journey.

It was a delightful scene as we slowly motored down the harbour past many yachts gently swaying at their moorings. Being a working harbour, we had to be wary of a returning fishing boat with a cluster of seagulls following *(photo 4)*, trawling in amongst the tug boats and coal vessels heading towards the coal loaders. It was not long before we stopped off Nobbys Head *(photo 5)*, where our skipper explained the history of this local landmark.

Very quickly, we were sailing past the Bogey Hole and Merewether Beach. Onward past the Strezlecki Lookout, where we could see many people undertaking their morning exercise on the Newcastle Memorial Walk that was opened in 2015 to commemorate the 100th anniversary of the ANZAC landing at Gallipoli. In the cliff at the northeastern end of Susan Gilmore Beach, you can see the thickest sequence of rocks along the Newcastle coast. This is because it is in the highest part of a fold in the rocks, and also because the resistant Merewether Conglomerate at the crest of the hill slows erosion. (Gilmore et.al., 2020).

4. Returning fishing trawler followed by opportunistic seagulls and pelicans.



5. Nobbys Head mainly composed of Nobbys Tuff cut by a large dolerite dyke.

We passed Burwood Beach, where we could see the deformed bedding and the prominent Burwood Beach Faults *(photo 6)* that we have visited many times. The faults are hosted by Early Permian siltstones, tuffs and coals of the Lambton Sub Group. It was not long before we reached the rocky escarpment between Little Redhead and Redhead Point where we could identify many of the features we are so familiar with.

Stopping briefly, we could identify features that cannot be seen from the rock platforms and beaches below the cliffs. A very interesting structure in the form of steep dipping bedding planes in the Redhead Conglomerate is spectacularly exposed in the cliff face *(photo 7)*.

These bedding planes show marked discordance with the gently-dipping coal seam underneath. Major bedding planes in the Redhead Conglomerate dip at 5 to 30 degrees with steeper dips up to 45 degrees (Diessel, 1998) resulting from creep and minor slumping (Hunt & Hobday, 1984).

There has been much debate generated over the years as to why the bedding planes dip, with several theories put forward and no general agreement. Diessel (1992) interpreted the discordant and palaeocurrent data as the result of compaction due to the loading of

6. Cliff behind Burwood Beach showing faulted Nobbys coal seam underlying Nobbys Tuff.

7. Dipping beds of Redhead Conglomerate sitting on coal of the Fern Valley Seam and shales of the Kotora Fm.

waterlogged peat by sand and gravel deposited during lateral expansion of the braidplain *(Figure 1)*. The compaction of the peat beneath the sediment load forced some peat to become squeezed upwards and form a bulge in front of the laterally migrating braidplain. Diessel (1992) suggests that the peat bulge protected the adjacent peat mire from epiclastic sediments, although some silts and fine-grained sands were deposited where ponding excess waters drained from the compacting peat (Bamberry, 1993).

The 12 kilometre run along Redhead Beach, Nine Mile Beach (that fronts the Belmont Wetlands) and Blacksmiths Beach was broken up by the many board riders and the campers and their 4 wheel drives scattered along the foreshore. The coastal area is comprised of a 1 kilometre wide belt of Quaternary barrier dune sand that is sparsely vegetated and has been heavily mined over the years for heavy mineral sands.

Our next stop after passing Swansea Heads was Caves Beach. Roz Kerr (2010) in her series of brochures "Inside Ancient Rivers" describing the cave system wrote *"Storm waves bursting with energy have carved amazing sea caves into solid rock of the cliffs at the southern headland of Caves Beach. Some caves are large enough to walk through, and some are interconnected. The caves taper back into the cliffs and reach up to 24 metres in length. The cave floors are at sea level and normally covered in sand. The roofs can reach up to 4 metres above sea level" (photo 8).*

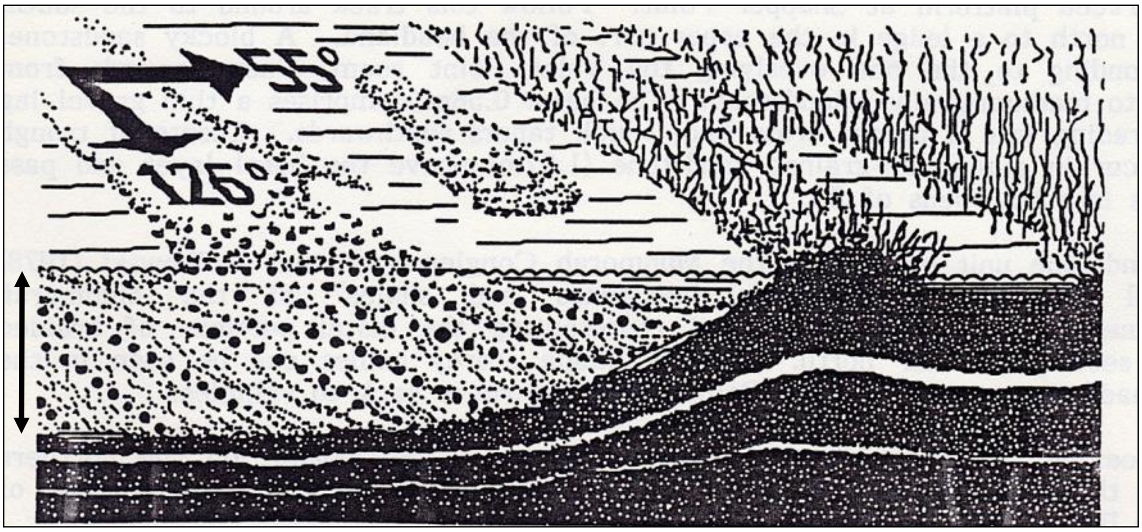


Fig 1. Depositional model for the development of the steep dipping beds at Redhead (from Diessel, unreferenced).

"The rocks that the caves are carved into are ancient river deposits. They comprise lenticular layers of sedimentary rock, sandstone and conglomerate (Belmont Conglomerate) originating as sand and gravel dumped here by fast-flowing rivers 250 Ma during the Permian period. Subsequent burial by a thickness of over 2 kilometres of sediment compacted and cemented the river sediments into solid rock. Uplift and erosion have exposed the rocks back at Earth's surface. The caves probably began forming 6,500 years ago, after the last glacial period when the seas stabilised at their present level".

Our next port of call was the Pinney Caves which cannot be seen from the shoreline (photo 9). These impressive caves are typical of this coastline formed where storm waves attack zones of weakness in the rock faces along vertical joints or faults. Surging waves force compressed air into the fissures. As the waves retreat, trapped air is released with explosive force. Repeated impacts and swirling waves containing sand and gravel abrade the inside surfaces of the fissures, slowly enlarging them (Kerr, 2010).

As the sea conditions were so calm, our skipper was able to navigate our vessel close to shore, allowing us to manoeuvre into a small cove by the name of the Shark Hole. The Shark Hole is a large eroded inlet surrounded by walls of conglomerate *(photos 10 & 11)*. This inlet was probably a large cave that has collapsed. The cave may have formed along an eroding dyke. Evidence of the weathered-out dyke can be seen disappearing into the cliff face creating a spectacular chasm *(photo 12)*.

We then made haste to Catherine Hill Bay. Catherine Hill Bay was the only ocean jetty port *(photos 13 & 14)*, on the northern coalfields. Coal from the Wallarah Colliery was loaded here for Sydney and Newcastle. By using an ocean jetty, this colliery could exploit the coal seams of Lake Macquarie without ships needing to enter the Swansea Channel. The port could still be dangerous under unfavourable weather conditions, and some ships came to grief there.

It was the last port used by the coastal coal trade in 2002. Coal was last loaded for the short trip to Newcastle for overseas export. The Wallarah Colliery closed in the same year (Wikipedia). The future of this iconic structure with its roots going back to the 1880^s is somewhat controversial. Dating back to 1889, Catherine Hill Bay remains relatively unchanged, making it both remarkably beautiful and rich in history.

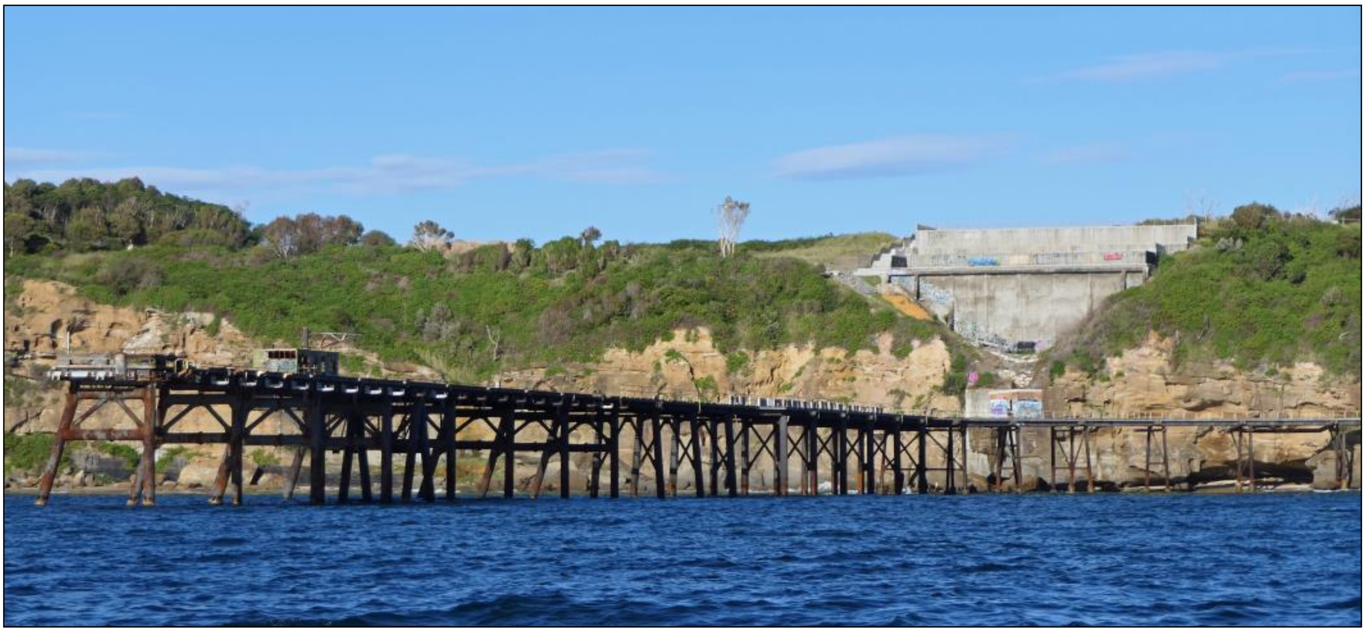
8. Southern headland of Caves Beach at low tide showing the many sea caves eroded into beds of Belmont Conglomerate.

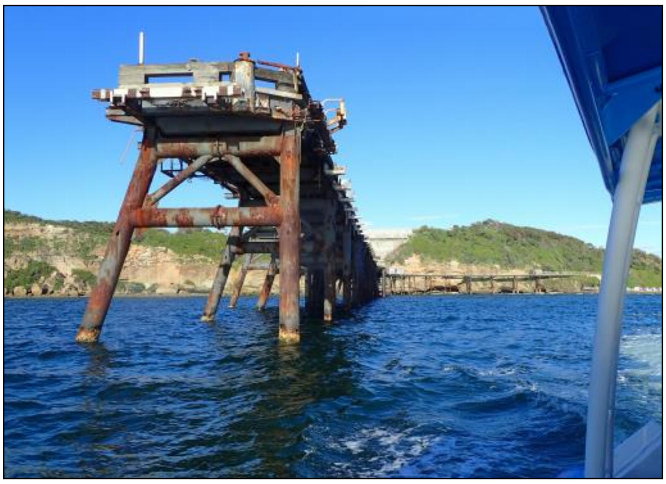
9. Pinney caves eroded into conglomerate. These caves are not visible from the shore. Note the dark vertical joint in the main cave that allowed erosion by the sea to occur, eventually forming the cave.

10. The Shark Hole.

11. Conglomerate wall beside the eroded dyke.

12. The vertical walls of Belmont Conglomerate with their possibly baked margins suggest that a dyke has been eroded away forming the cleft seen today.

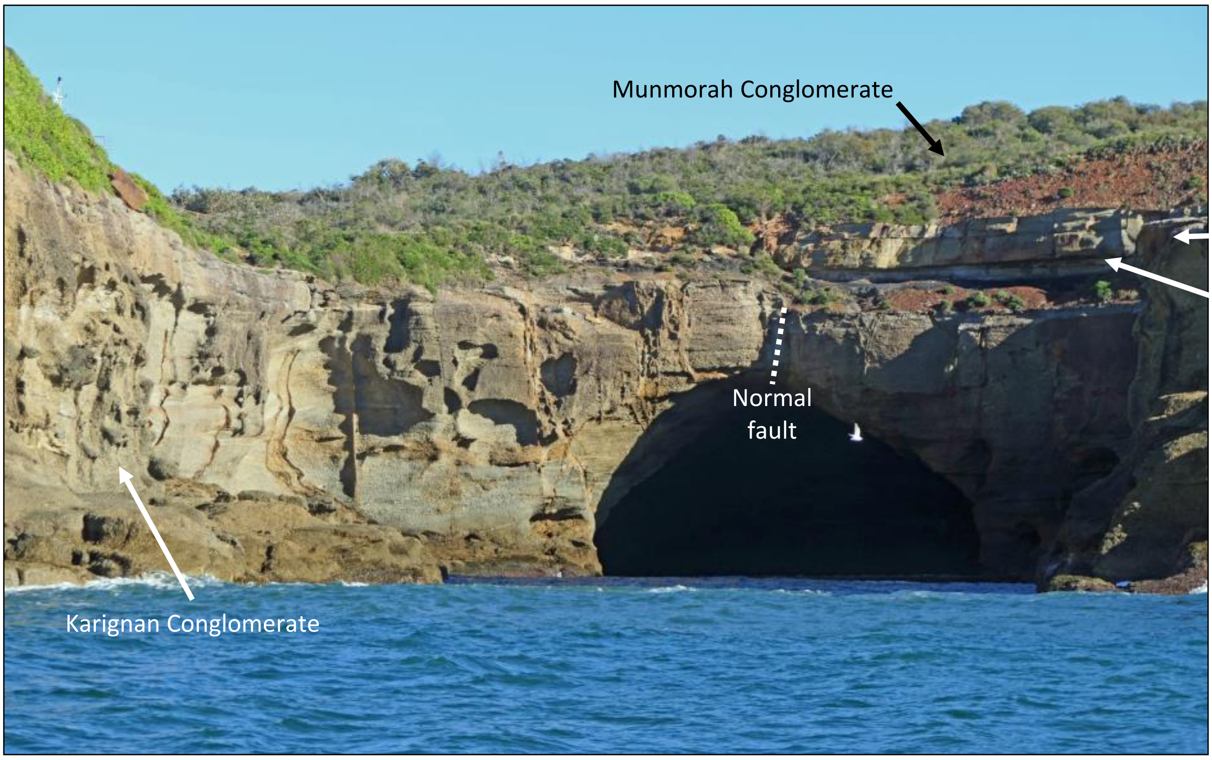




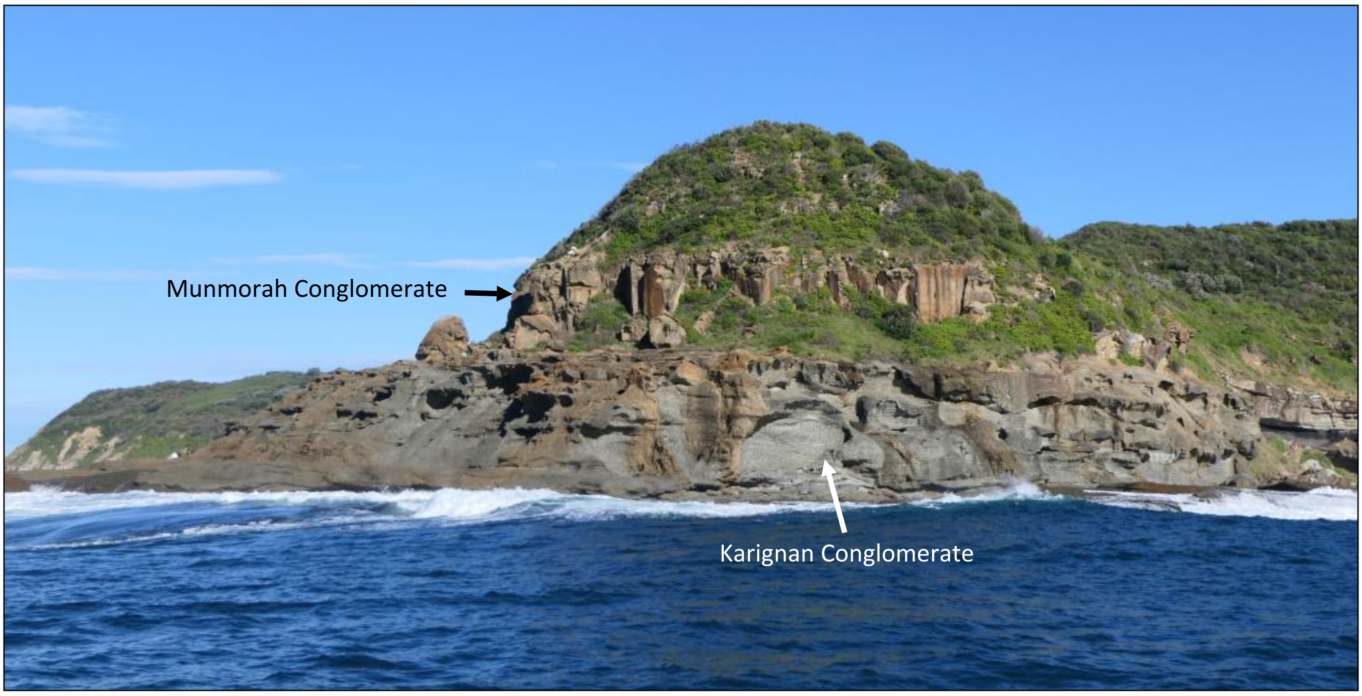
13 & 14. Coal Jetty at Catherine Hill Bay last used to load coal into ships in 2002.

Some refurbishment has taken place on the concrete coal bin

15. Snapper Point and a large sea cave in Karignan Conglomerate, Munmorah State Conservation Area.



16. Large sea cave Snapper Point. Gravel was collected by bobcat lowered into the cave on the right at low tide. A normal fault runs through the top of the cave.



17. Wybung Head.

Having State Heritage Listing, Catherine Hill Bay is a surviving example of a "Company Town", with no comparable coastal environment in NSW containing such an intact and compact representation of a 19th and 20th century coal-mining town (Lake Macquarie City Council). The colliery owners wish to rid themselves of it. But, the Lake Macquarie City Council rejected in 2010 an offer from Lake Coal to own the jetty and receive $1 million. It was estimated three years ago that the jetty would cost $3 million to restore and a further $3.5 million over 10 years to maintain (Newcastle Herald 2013).

It was not long before the sea caves at Snapper Point *(photos 15 & 16)* within the Munmorah State Conservation Area (MSCA) loomed up on our starboard bow. The MSCA and the caves system is well known to our society. We have been visiting this area for many years, as recently as October 2020 (See Geo-Log 2020 for further reading) when we revisited the End Permian Mass Extinction Event (EPE).

Then all too soon, we were at our turn around point at Wybung Head *(photo 17)*. Viewing this landmark from the sea put a different perspective on this prominent point.

We then headed back to Newcastle at full throttle watching the magnificent coastline pass by all the while appreciating this remarkable stretch of coast where ancient river systems once deposited sediments from far away mountains to eventually form the rock sequence along this coastline. Seams of coal are exposed in the cliff faces, with huge chunks of sandstone scattered at their bases like discarded building blocks. Landslips, where soil and vegetation tumble from the cliff lines after heavy rain were numerous only to be washed away by constant wave action. Nature is slowly reshaping the coastline, forever renewing the landscape.

After returning to Newcastle dock and bidding farewell to Dom as well as some members who were on a mission to be elsewhere, the rest of us went in search of refreshments. Given the very early start we were desperate for a coffee. This was somewhat problematic as most places were still preparing for the days business and were not open. Eventually we did find a small coffee shop where we enjoyed coffee and cakes, and relived parts of our morning adventure before bidding farewell till next time.

Report by Chris Morton.

Photos by Chris Morton (3, 4, 6, 10, 11, 12, 14, 17) and Ron Evans (1, 2, 5, 7, 8, 13, 15, 16).

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Lower Hunter Valley Ignimbrites

Leaders: Ron Evans and Brian England.
Date: Saturday 24th April 2021.
Attendance: 25 members.

Lower Hunter Valley Ignimbrite Background Geology.

Several sequences of Early Carboniferous (Visean: 346.7 to 330.9 Ma) ignimbrites ranging from rhyolitic to andesitic in composition outcrop along the western edge of the southern part of the New England Orogen.

They are found in three zones: the Muswellbrook -Rouchelle district, Paterson-Maitland district and Port Stephen's district *(map 1)*, which lie roughly 60 kilometres apart. The geology of the region is shown in *Map 2*.

Flow lineation measured in these ignimbrites indicate three source areas now lying on the western side of the Hunter Thrust along what was during the Early Carboniferous the Kuttung Volcanic Chain *(Map 3)*, which formed in a back-arc basin. The source areas are indicated by circular negative gravity anomalies best explained as calderas filled by low density lavas and pyroclastics which now lie buried beneath the Permian sediments of the Sydney Basin (Buck, 1988). These calderas are located 4 kilometres north of Muswellbrook (12 to 15 kilometres across), between Maitland and Branxton (25 kilometres across) and 5 kilometres WSW of Morna Point in Port Stephens (10 kilometres across) (Map 3). This excursion was only concerned with ignimbrites (and associated rocks) in the Maitland-Paterson district generally known as the Gilmore Volcanic Group (Nashar, 1964).

Ignimbrites close to their source usually outcrop on top of each other (older to younger), such as along Maitland Vale Road, while those deposited further from the source typically only form part of volcaniclastic/ sedimentary deposits, either terrestrial or shallow marine.

A possible explanation in the excursion area is that the surrounding back-arc basin may have been relatively flat so that the ignimbrite deposits close to the eruption centres were higher in elevation and hence out of reach of sedimentation from other sources between subsequent eruptions. Those ignimbrites deposited further away from the vents on the basin floor would have had a greater chance of being covered by marine or terrestrial sediments before the next eruption.

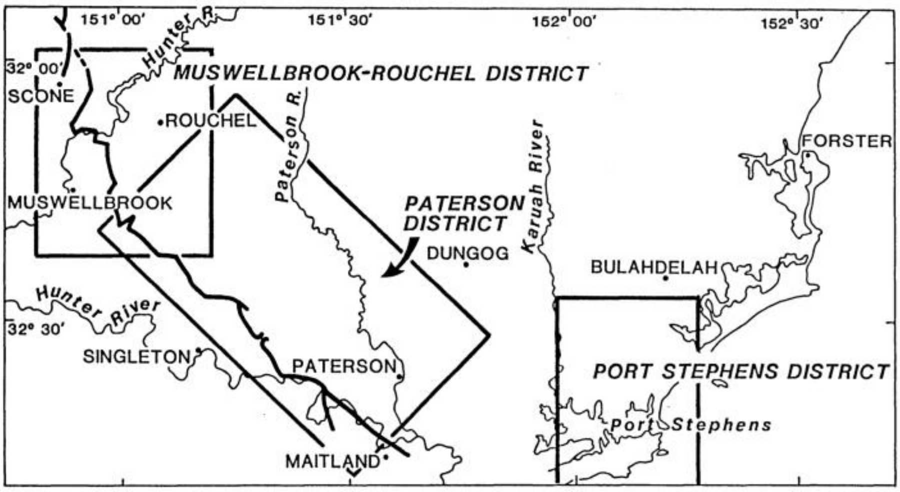
The Outing.

The purpose of this field trip was to examine the ignimbrite outcrops along Maitland Vale and Lambs Valley Roads, note the differences in mineral composition and texture between flows and explore the reasons for these differences.

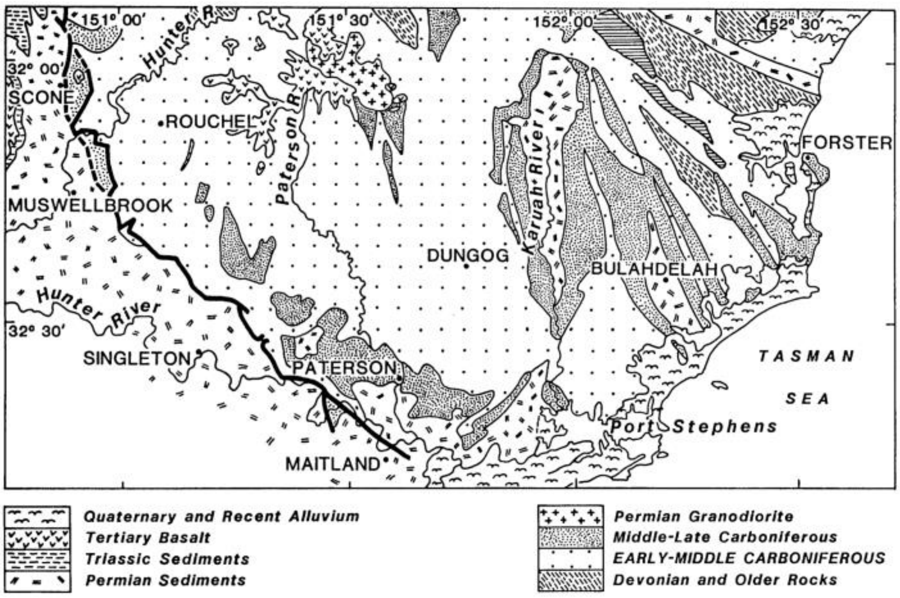
The study area enables the full Gilmore Volcanic Group to be examined in detail through easily accessible road cuttings, Maitland Vale Road intersecting the southern end of the outcrop width (in reverse order: younger to older) and Lambs Valley Road the northern part (in order of deposition: older to younger). This is because the outcropping sequence lies tilted at around 30 degrees to the northwest on the east limb of a prominent anticline. The region also provides illustrations of the the effect of geology on geomorphology (landscape), the resistant volcanic rocks forming a prominent ridge trending NW-SE beside Maitland Vale Road being the best example.

The group assembled at Bolwarra Heights Lookout at 9 am for a scheduled 9:30 am departure after car pooling.

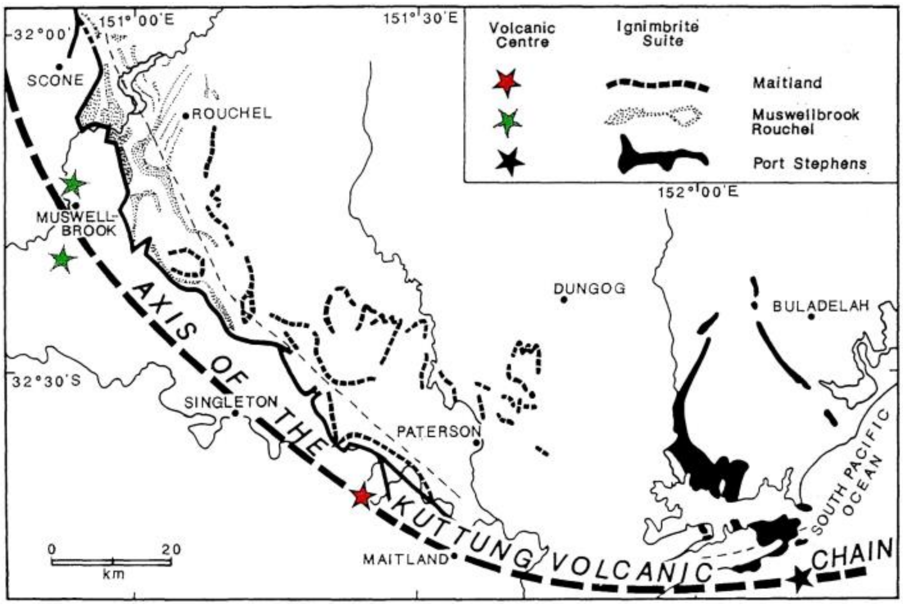
Distances were measured from the Paterson Road - Maitland Vale Road intersection. The route taken is shown in *Map 4*. Yellow safety vests were mandatory because of the proximity of fast moving traffic at each stop.



Map 1. Districts where ignimbrites are found in the Hunter Valley and Port Stephens districts. From Buck, 1988.



Map 2. Geology of the lower Hunter Valley and adjacent area to the east. The ignimbrites occur within the Early Carboniferous (refer to Map 3). From Buck, 1988.



Map 3. Position of the ignimbrite outcrops in relation to the Kuttung Volcanic Arc in today's lower Hunter Valley and Port Stephens areas. From Buck, 1988.

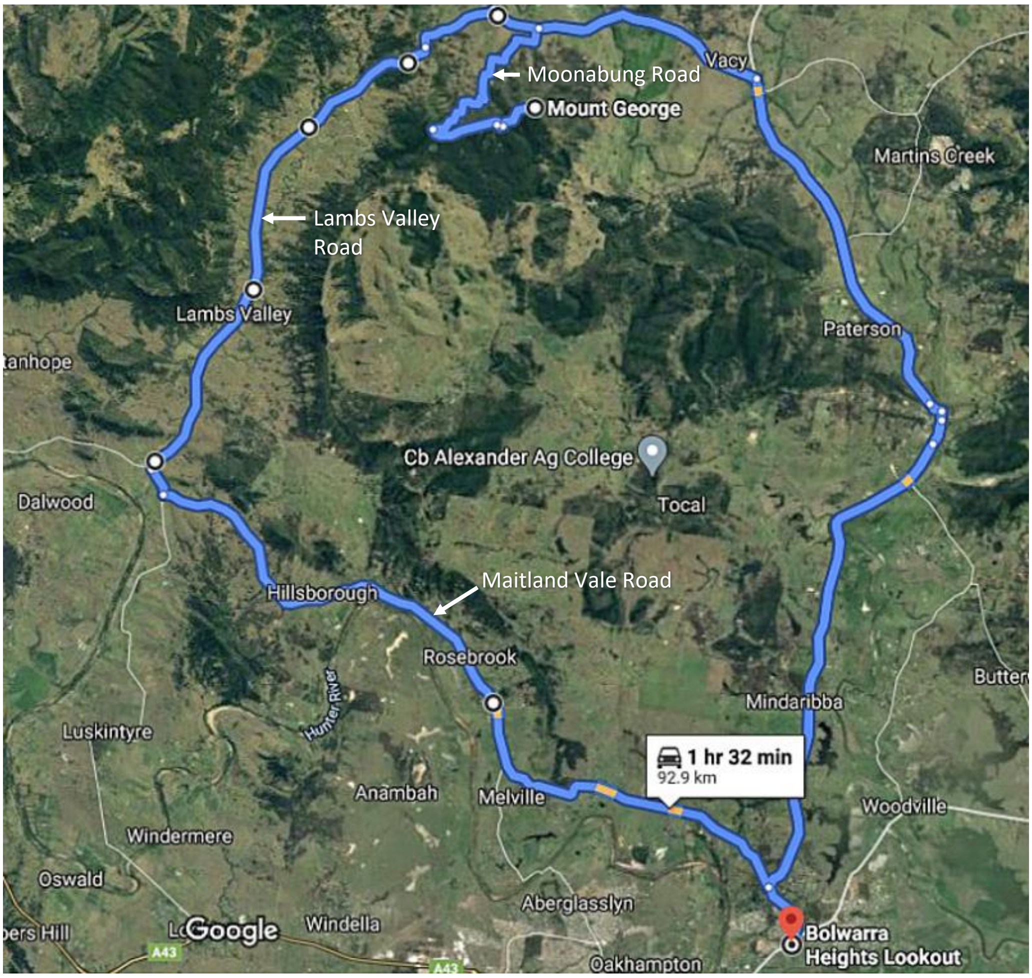
Initially Maitland Vale Road passes over amygdaloidal basalt and tuffaceous sandstone of the Lochinvar Formation, the lowest (oldest) sequence of rocks in the Permian Dalwood Group, then crosses the Hunter Thrust (not visible here) before turning sharply to the south and crossing the southern end of a prominent ridge formed by the outcropping Gilmore Volcanic Group.

Stop 1 at 5.7 km.

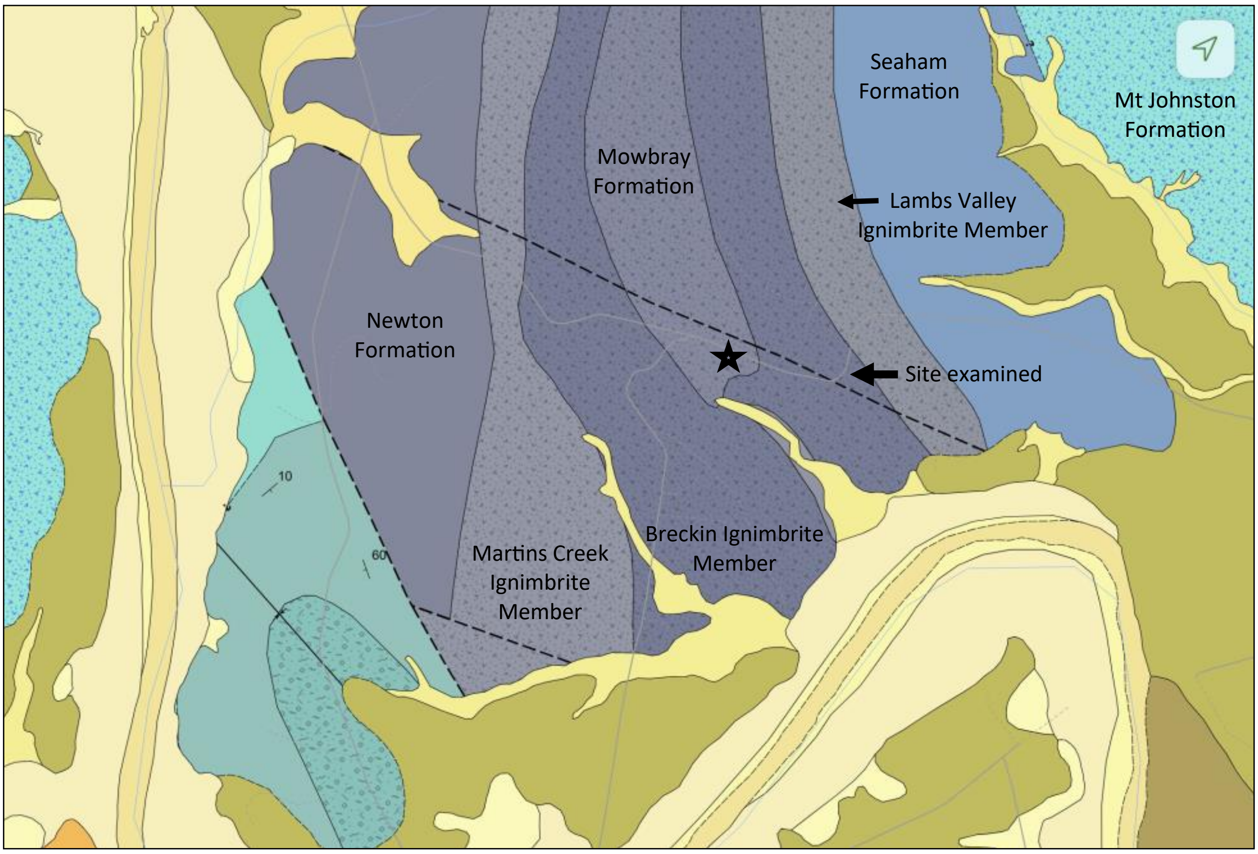
Parking at the start of this section near the entrances to private property is very limited and there is little room along the road shoulders for pedestrians to access the outcrops on the right hand bend so the vehicles were parked further up the road on the verge opposite the long abandoned Rosebrook quarry *(Map 5).*

Here we had morning coffee before walking back towards Bolwarra to the prominent outcrop of the Breckin Ignimbrite Member on the corner, taking care to stay well clear of approaching traffic *(photo 1).* The outcrop here is massive *(photo 2)*, rhyolitic in composition, very tough, and contains flattened pumice lenticles aligned in the flow direction plus pebbles of other rock types caught up in the flow (Nashar, 1964).

The rock is relatively pale in colour due to the abundance of quartz and K-feldspar *(photo 3).* The boundary between the overlying Lambs Valley Ignimbrite and Seaham Formation lies further back towards Bolwarra (near the 45 kph sign) but the outcrop is very poor so was not visited.



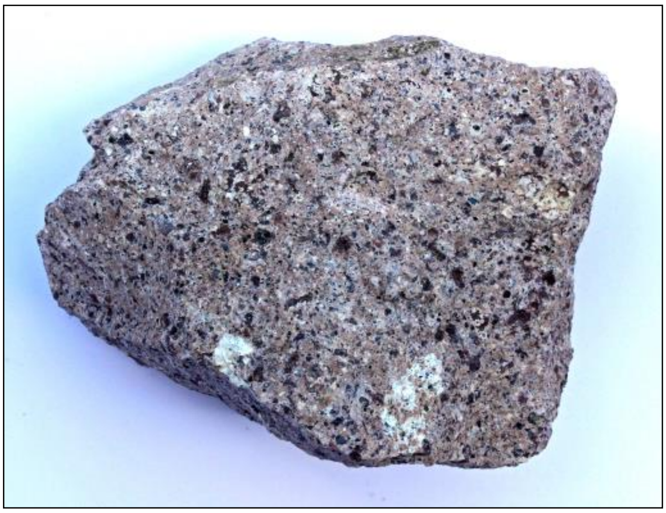
Map 4. Route followed in a clockwise direction during the field trip.



Map 5. Geological map showing location of the southernmost ignimbrites on Maitland Vale Road. Asterix shows the location of Stop 1.

1. Participants examining an outcrop of Breckin Ignimbrite beside Maitland Vale Road.

2. The outcrop of Breckin Ignimbrite at Stop 1.



3. Breckin Ignimbrite collected from stop 1. Specimen is 14 cm wide. (BME specimen R836).

Tough pale to medium grey rock with abundant glassy quartz grains and blocky white K-feldspar phenocrysts plus hexagonal biotite flakes in a microcrystalline groundmass. Flattened pumice lenticles are locally abundant. The K-feldspar is more evident in weathered surfaces.

4. Weathered andesitic Ignimbrite from the Mowbray Formation exposed at the Rosebrook quarry at Stop 1. Specimen is 5.5 cm wide. (BME specimen R837B).

The rock sample is deeply weathered with abundant plagioclase laths altered to clay.

We then returned to the vehicles and crossed the road to examine the underlying Mowbray Ignimbrite Member exposed by the quarry. Although the quarry is now inaccessible there is sufficient outcrop along the edge of the road near the gate to provide material to look at. The Mowbray Ignimbrite is andesitic in composition and deeply weathered *(photo 4)* due to the presence of a fault (see *Map 5*) which has allowed access to meteoric water. In fact the quarry was dug here because the weathered rock was easy to extract and did not require crushing before its use as road base. Diligent searching uncovered isolated core stones of unweathered rock *(photo 5)*. When the quarry was operating in the 1960's it was popular among rock hounds for the veins of red agate found here plus specimens of stilbite (zeolite group) and chlorite. Another find made here back then were round pebbles of unweathered andesite scattered through the weathered rock. It was only recently that Brian realised that these were lapilli *(photos 6 & 7)*, a form of tephra that fell from the sky close to the vent during explosive volcanic eruptions. Lapilli have apparently not been previously recorded in the Gilmore Volcanic Group.

The Mowbray Formation divides the Breckin Ignimbrite into eastern and western outcrops (see *Map 5*), the latter outcropping in a cutting 400 metres west of the quarry at 6 kilometres. The rock here is slightly paler in colour but identical in texture and mineral composition to the outcrop at Stop 1. But it was too dangerous to park a convoy of 6 cars here so we did not stop. However we were able to briefly take in the view from the top of the hill towards the north *(photo 8)*

5. fresh andesitic Ignimbrite from a core stone in the weathered Mowbray Formation collected at the Rosebrook quarry at Stop 1. Specimen is 10 across. (BME specimen R837A).

There are occasional unweathered core stones comprising abundant plagioclase laths and black hornblende phenocrysts in a fine dark groundmass. No visible quartz.

6. Brian explaining the origin of lapilli.

looking over a broad valley underlaid by rocks of the Newton Formation and weathered Martin's Creek Andesitic Ignimbrite (present along the road at 6.5 to 6.7 kilometres). These rocks are more easily eroded than the ignimbrites forming the ridge.

Stop 2 at 8.5 km.

Here an outcrop of the Newton Formation occurs in a low road cutting on the east side of Maitland Vale Road just before house lot 846. At first the outcrop is not obvious, being covered in part by grass and small shrubs *(photo 9)*. But examples of the conglomerate, lithic sandstone and ignimbrite making up this formation can be seen by walking south along the road from the entry to lot 846. Bedding is readily discernible *(photo 10)*. The ignimbrite component occurs as bulbous masses to 0.5m across enclosed within the sediments and its glassy nature *(photo 11)* suggests that it was erupted into a wet environment.

Continuing northwards along Maitland Vale Road the boundary between the Newton Formation and the Martin's Creek Ignimbrite Member is crossed at 10.5 km on top of a ridge at 'Glenmore' property. There is no outcrop here but deeply weathered outcrops occur at 11.3 km and 11.7 km in cuttings on the east side of the road. The Newton Formation is crossed again at 11.8 km.

7. Lapilli collected from the Mowbray Formation at the Rosebrook quarry back in the 1960's. largest is 3.5cm. (BME specimen R178).

Lapilli** is a size classification of tephra, which is material that falls out of the air during a volcanic eruption or during some meteorite impacts. Lapilli is Latin for "little stones". By definition lapilli range from 2 to 64 mm in diameter.* ***(Wikipedia)

8. View north over a valley underlain by softer easily eroded rocks of the Newton Formation including the Martins Creek Andesite Member.

9. Rocks in the Newton Formation can be examined by walking along the road cutting at Stop 2.

10. Coarse lithic arenite containing rounded pebbles exposed at Stop 2. Bedding is clearly seen.

At 17.0 km the John's Hill Ignimbrite Member outcrops in a cutting on a sharp bend on the western side of the road. This site was initially investigated by Ron and Brian but very limited parking meant the convoy could not pull in safely. However samples from this outcrop *(photo 12)* were shown around at Stop 3.

At 19.0 km our convoy turned north along Lambs Valley Road and at 20.7 km a low road cutting on a small rise exposed fresh outcrops of the Martin's Creek Andesitic Ignimbrite Member *(photo 13)*. Again this outcrop was examined on an earlier trip but very limited safe roadside parking precluded a visit by our convoy. However samples *(photo 14)* from this cutting were handed around at Stop 3.

11. Andesitic pitchstone from the Newton Formation at Stop 2. Specimen is 6.5cm wide. (BME specimen R838).

The rock appears to be andesitic pitchstone. Plagioclase laths with less abundant hornblende and biotite in a dark glassy groundmass.

12. Johns Hill Ignimbrite. Specimen is 9 cm thick. (BME specimen R839).

Abundant zoned plagioclase phenocrysts and scattered mafic rock fragments in a fine groundmass. Both weathered and unweathered zones present.

13. Martins Creek Andesitic Ignimbrite Member outcropping in road cutting on Lambs Valley Road.

14. Martins Creek Andesitic Ignimbrite. Specimen is 8 cm across. (BME Specimen R840).

Abundant zoned plagioclase phenocrysts and scattered mafic rock fragments in a fine groundmass.

Stop 3 at 21.5 km.

Here we were able to comfortably park at the small quarry on the eastern side of the road *(photo 15)*. In the quarry the Lambs Valley Ignimbrite Member is well exposed and although much of the outcrop is deeply weathered diligent searching *(photo 16)* unearthed samples of unweathered rock showing a number of interesting features *(photo 17)* including a wide range of textures and compositions. Later investigation of some of these samples revealed a few surprises requiring further investigation.

Continuing north through hilly lightly wooded country underlaid largely by sediments of the Mount Johnson Formation we passed through a gate (leave as found) onto private property with the bulk of the Moonabung Range with its line of sandstone cliffs of the Mount Johnson Formation off to the east. Shortly after the gate the dirt road climbed to the top of a ridge then plunged steeply into the next valley, affording passengers magnificent views of the Paterson River Valley to the north. At Summer Hill Road we turned east towards Vacy, pulling in soon afterwards at Stop 4.

Stop 4 at 33.5 km.

The long road cutting here provides an excellent section through a thick massive bed of well jointed lithic arenite in the Mount Johnson Formation *(photo 18)* with clearly defined pebble lag beds *(photo 19)*. These rocks were deposited in a fluvial environment and, while not present in this section, also include conglomerate and inter-bedded laminated sandstone, shale, poor quality coal, tuffs and minor chert.

Continuing along Summer Hill Road towards Vacy we turned right onto Moonabung Road which

15. Exposure of Lambs Valley Ignimbrite in the small quarry at Stop 3.

16. Members searching for samples of fresh Lambs Valley Ignimbrite.

quickly narrows and winds sharply up the west escarpment of the Moonabung Range to the Eagles Reach Resort. Just beyond the cabins and villas picturesquely nestled into the forest, the road terminates at the parking area for the Mount George Lookout from which a short steep track leads to the lookout point *(photo 20)* providing superb views to the north up the Allyn River Valley *(photo 21)* with Barrington Tops on the near horizon, beyond which lie the New England Highlands. To the east, the Martin's Creek quarry (in the Martin's Creek Ignimbrite Member) is clearly visible in the wooded hills beyond the farmland *(photo 22)*.

We then drove back through the Resort and turned south towards Goonarock Lagoon where we relaxed over a picnic lunch beside the very pleasant body of water *(photo 23)* before heading home.

Note: On page 22 is a geological map of the field trip route indicating the stops made.

17. Lambs Valley Ignimbrite. Specimen is 11 cm wide. (BME specimen R841).

Well-formed K-feldspar phenocrysts showing Carlsbad twinning plus hexagonal black flakes of biotite and flattened pumice lenticles in a fine granular groundmass. Abundant pink stilbite (zeolite group) as radiating aggregates of bladed crystals and well-formed crystals in tiny vughs. The stilbite is due to later alteration of the glass component of the ignimbrite. There are also scattered angular coasts of granodiorite and quartzite.

18. Lithic arenite in the Mount Johnson Formation exposed in the road cutting at Stop 4.

19. Lag pebble deposits in the Mount Johnson Formation sandstone exposed in the road cutting at Stop 4.

Lag deposits are a coarse-grained residue that is left behind after finer particles have been transported away, due to the inability of the transporting medium (in this case water) to move the coarser particles.

20. Members at the Mount George Lookout.

21. View north up the Allyn River Valley from the Mount George Lookout.

22. View east from the Mount George Lookout over farmland towards the Martin's Creek quarry.

23. Our view over Goonarock Lagoon while having lunch.

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

References.

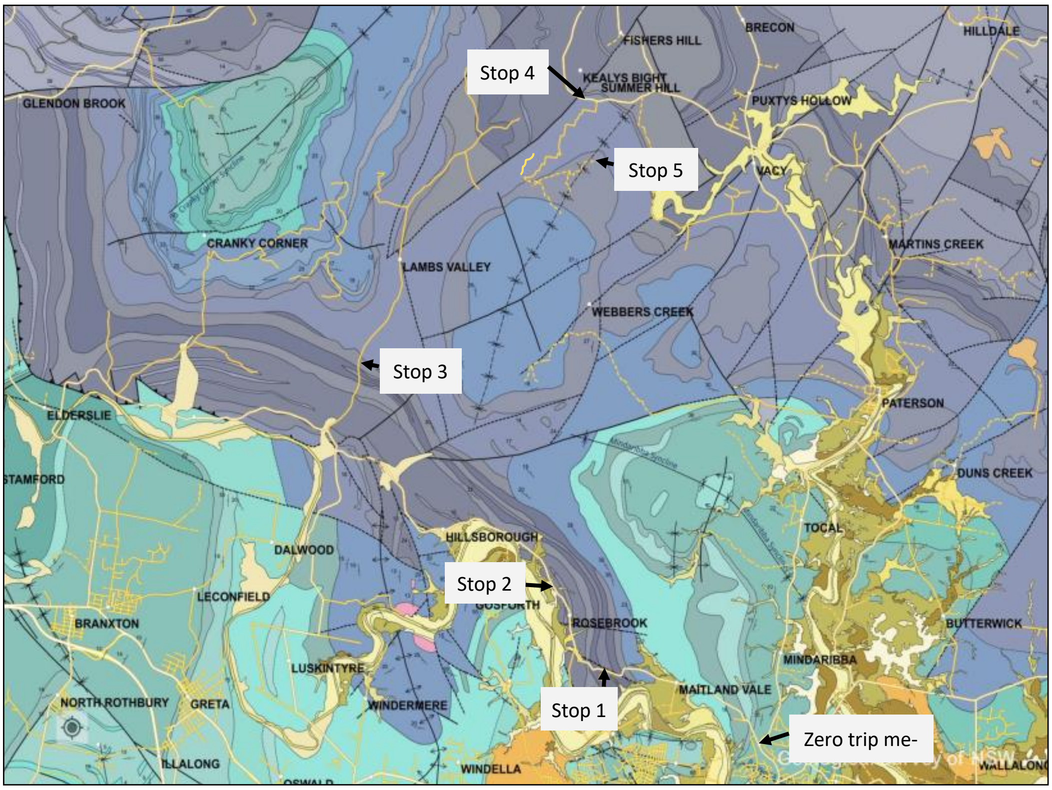
M. D. BUCK (1988). *Source Areas and Geochemistry of Lower Carboniferous Ignimbrites, Southern NSW, Australia.* Unpublished thesis submitted to Macquarie University, NSW, Australia.

B. NASHAR (1994). *The Geology of the Hunter Valley.* The Jacaranda Press.

ArcGIS Explorer. GSNSW - NSW Bedrock geology map. *App for smartphone or tablet.*

NSW Geology Maps, Geological Survey of NSW. NSW bedrock geology. *App for smartphone or tablet.*

https://www.wikipedia.org



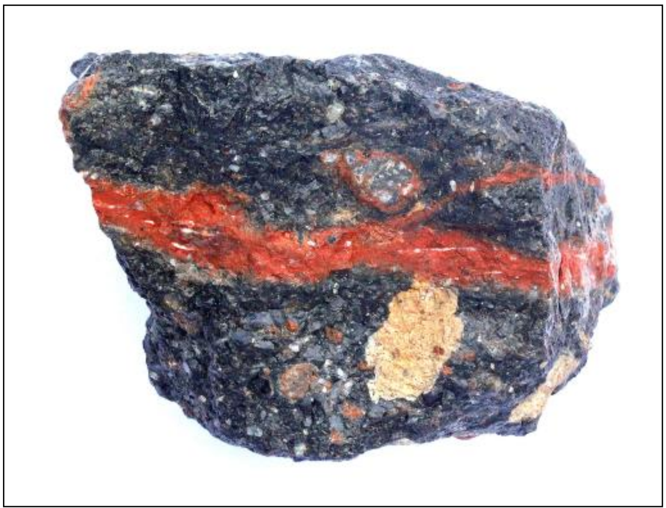
Geological Map indicating stop locations.
The blue and grey colour indicates Carboniferous rocks, the green Permian rocks and the yellow/orange recent alluvial deposits.

Lambs Valley revisited.

Chris, Ron and Brian returned to the Lambs Valley quarry on 1st June to reinvestigate some unusual ignimbrite textures found by Society members during the May excursion as scattered fragments along the road away from the quarry. We needed to determine if these unusual rocks formed part of the Lambs Valley Ignimbrite or had been carried in from elsewhere as road fill.

Our investigation showed that the Lambs Valley Ignimbrite comprises a wide range of textures which outcrop along the low road cutting south of the quarry. The outcrop is poorly exposed and largely covered by scree, regolith and grass. The beds dip at approximately 30 degrees to the northeast so that the full thickness of the ignimbrite sequence is present in the quarry and the roadside outcrop to the south, with the oldest beds at the southern end.

The range of textures found along the road cutting from south to north is as follows. Numbers refer to specimens preserved in the Brian England rock collection.



Glassy phase of Lambs Valley Ignimbrite - devitrification occurring. Specimen is 7 cm wide by 5 cm high.
(BME specimen R849).

R849: Dark glassy texture bordering on perlitic with idiomorphic biotite showing incipient alteration to muscovite on outer rims and less common crystals of K-feldspar. This texture is cut by veins similar in texture to that of R847.

Glassy phase of Lambs Valley Ignimbrite - devitrification occurring. Specimen is 5 cm wide by 8 cm high.
(BME specimen R848).

R848: Angular areas of obsidian with abundant idiomorphic biotite showing incipient alteration to muscovite in a dense pink matrix identical in texture to R847. The matrix appears to be the result of devitrification of the obsidian along cracks which may have formed through phreatic fracturing.

Lambs Valley Ignimbrite with clearly exposed biotite crystals. Specimen is 7 cm wide by 5 cm high.
(BME specimen R847).

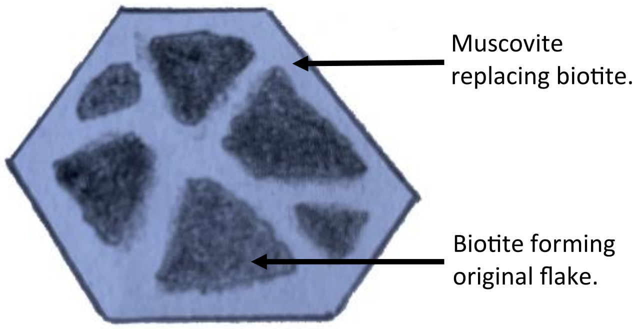
R847: very dense massive rock with scattered idiomorphic biotite, in some places showing crenulations due to localised directed stress, in a pink aphanitic matrix. Less common glassy crystals of K-feldspar and plagioclase plus rare small pebbles of feldspar porphyry and quartzite.

Lambs Valley Ignimbrite. Specimen is 14 cm wide by 9 cm high. (BME specimen R846).

R846: An intermediate zone between R847 and R845 showing inter-banding of these textures.

Lambs Valley Ignimbrite - glassy phase. Specimen is 14 cm wide by 11 cm high. (BME specimen R845).

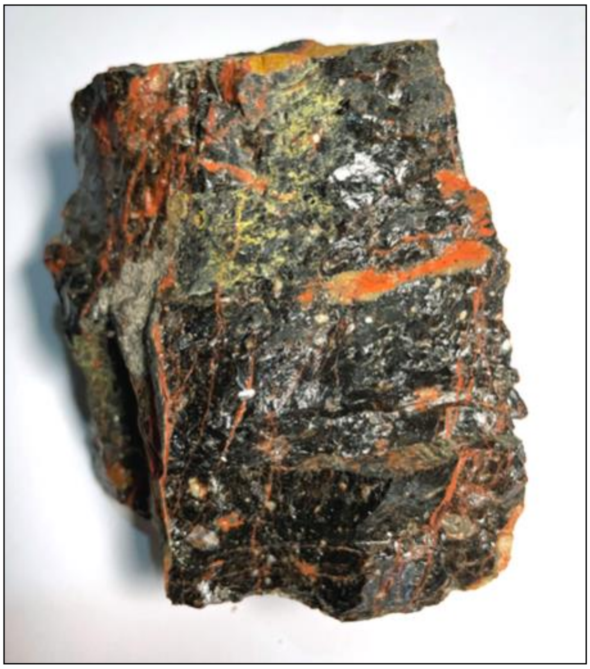
R845: Dense mottled foliated texture with waxy lustre and abundant idiomorphic biotite aligned in the flow plane. Some alteration of biotite to muscovite (see drawing below). Rare small rounded pebbles of feldspar porphyry.



Drawing of biotite flake partly replaced by muscovite around edges in R845. Size: 2mm across.

Lambs Valley Ignimbrite with a porphyry inclusion. Specimen is 9 cm wide by 8 cm high. (BME specimen R844).

R844: Brick red massive dense aphanitic texture with moderately abundant idiomorphic biotite, less common glassy crystals of K-feldspar and occasional sub angular blocks of feldspar porphyry. Small areas of slickensiding. The position of this rock in the sequence is uncertain as it was not found in outcrop.



24. Rhyolitic glass (ignimbrite) located at the base of the Lambs Valley Ignimbrite sequence. Collected just south of specimen 849.

R842. Lambs Valley Ignimbrite containing a large flattened pumice inclusion. Size is 7 by 10 cm.

The pumice inclusion contains fragments of feldspar crystals which would have been present in lava as it explosively erupted.

25. Specimen of Lambs Valley Ignimbrite containing light-coloured flattened pumice fragments. Specimen is 22 cm wide and 16 cm high. (BME specimen R843).

Discussion.

A common feature of specimens R846 to 849 is the presence of abundant idiomorphic biotite and the occasional rounded to sub-angular lithic fragments. These may have been entrained from shattered basement rocks around the vent or picked up during the flow of the pyroclastic mass. All these textures are assumed to have been associated with the initial eruption phase and the following is a suggested sequence of events.

The base of the Lambs Valley Ignimbrite consists of a dark rhyolitic glass (obsidian) *(photo 24)* showing incipient devitrification. It is very unlikely that this formed through an ash flow passing over a cold or wet surface as the resulting ignimbrite would not have welded due to sudden cooling below the temperature at which welding occurs (500-650 degrees C - Sigurdsson, 2000). It certainly could not have formed a fluid phase leading to a dense glass on cooling. Hence this initial layer could only have been a rapidly cooled rhyolitic lava. In fact many ignimbrite flows are preceded by a vitrophyric phase (Sigurdsson, 2000).

It is interesting to note that the Lambs Valley Ignimbrite is immediately overlain by the Seaham Formation fluvioglacials, suggesting that perhaps the initial lava outpouring may have flowed over a relatively cold surface resulting in rapid chilling.

Above the initial obsidian layer the glass becomes progressively more devitrified, beginning with replacement along cracks, perhaps the result of phreatic fracturing, to a dense pink aphanitic rock. This eventually leads to large angular areas of glass enclosed by devitrification and finally culminating in complete devitrification higher in the sequence. Devitrification is a delayed crystallisation of volcanic glass commonly seen in older volcanics (older than Cenozoic - Sigurdsson, 2000). Prior to devitrification the glass may hydrate by absorbing water from the atmosphere or groundwater to form a perlitic texture as an intermediate stage (Best, 1982). An incipient development of this texture can be seen in R849, collected from immediately below the zone of devitrification. Above the devitrified zone the devitrified material in interlayered with a dense foliated glassy rock (R845) of unknown origin.

Also found on 1st June were textbook examples of the classic ignimbrite texture comprising flattened pumice lenticles and idiomorphic K-feldspar in a fine pale grey matrix (R842). This texture would have formed after water entered the magma chamber causing a massive phreatic explosion and sudden ejection of large amounts of fragmented frothy pumice, ash and glass shards. This texture was found in boulders beside the road south of the quarry and the rocks presumably came from the quarry during road construction. This probably represents the last texture to form in the Lambs Valley sequence. One block was found naturally fractured parallel to the ignimbrite flow plane (R843), revealing the flattened pumice fragments *(photo 25)* in plan and showing most to be roughly circular in outline. Hence they show no well defined indication of flow direction. This means that in transverse sections of ignimbrite flows the alignment of flattened pumice fragments is NOT a true indicator of flow direction!

Report (Lambs Valley revisited) by Brian England.
Photos by Ron Evans.

References.

BEST, M.G. (1982). *Igneous and metamorphic petrology*. Freeman

SIGURDSSON, H. (2000). *Enclyclopedia of volcanoes*. Academic Press.

Liverpool & Warrumbungle Ranges

Leader: Sue Rogers.
Date: Tuesday 4th to Wednesday 12th May 2021.
Attendance: 24 members.

Geology of the Scone to Murrurundi Area.

The Liverpool Range, which is part of the Great Dividing Range, varies in elevation of between 350 and 1280 metres above sea level. The forested slopes provide mountain scenery that can be seen from the valley floor. The cliffs of Wingen Maid Nature Reserve are a prominent landscape feature as is Castle Rock with its steep rocky escarpments which are up to 50 metres high. The area is characterised by protruding spurs that extend from the Glen Range.

The Liverpool Range was formed by basalt outpourings from the Liverpool Shield Volcano 32 to 40 Ma during the Eocene and Oligocene Eras (Paleogene Period) (Morton and Pratt, 2012). These basalt sheets probably covered a large portion of the Hunter Valley, but, due to erosion now are restricted to the Liverpool Range and Coolah Tops Plateau.

The Liverpool Range beds are comprised predominantly of red and brown krasnozem soils, derived from the basalt, with some dolerite, conglomerate, quartzose sandstone and shale. The Liverpool Range extends west to encompass Coolah Tops National Park and north east to the Mount Royal Range. More recent unconsolidated sediments include alluvial flats adjacent to the Middlebrook and Dry Creek areas that are underlain by Triassic sandstone, mainly in the form of a pebble sandstone. The ruggedness of Liverpool Range has limited past disturbances to the landscape, such as grazing and logging while the surrounding plains have been cleared for agriculture.

1. Altar, Saint Josephs Church Murrurundi.

The Hunter is a valley within a valley, both physically and metaphorically. In the upper reaches of the Hunter, the rocks show the evidence of an ancient valley formed during the Paleogene Period between 12 and 70 million years ago. This valley has in turn been uplifted by faults and tectonic movements before being cut back into during a prolonged period of stability from the late Paleogene.

Day 1 – Tuesday 4th May, 2021.

Our planned meeting venue was changed to the camp kitchen at Murrurundi Caravan Park as the weather was not suitable for meeting at Paradise Park. However we did venture out in the drizzle for a driving tour of Murrurundi. We saw Bobadil House which was built of local sandstone for Henry Dangar in 1843 and has been extensively renovated to house an impressive art gallery. Our first stop was the site of the oil shale works in Doughboy Street that the British Australian Oil Co. Ltd built in 1909 when they re-opened the abandoned oil shale mine 11 km north of Murrurundi. We then stopped at St Joseph's Church which was consecrated by Bishop Polding in 1860. The altar was constructed from over 1000 pieces of marble and is listed with the National Trust *(photo 1)*. Next door is Murrurundi House which was built in 1880 for the Sisters of Mercy. We then viewed a number of the historic buildings in the main street before returning to the camp kitchen for happy hour.

Day 2 – Wednesday 5th May, 2021.

Despite the overcast sky we headed out at 8:30 am for the hike up Burning Mountain, 1 km south west of Mount Wingen that is 548 metres above sea level. It is the only example of a naturally burning coal seam in Australia. The exact location of the fire is a mystery, though we know it is about 30 m below the ground and heading south – meaning Burning Mountain actually moves at about 1 metre every year. Burning Mountain is the oldest known still burning coal seam fire.

There is a story from the Dreamtime handed down through the generations by the Wonnarua people of the Upper Hunter Valley that tells how one of the strangest natural phenomena in Australia came about. This is how it is re-told on a sign at the base of Burning Mountain:

"One day, the Gummaroi (or Kamilaroi) people to the north sent a raiding party to Broke to steal Wonnarua women for wives. The Wiradjuri to the west, who were friends of the Wonnarua, told them of the Gummaroi plans. The Wonnarua gathered all of their warriors and sent them to do battle with the Gummaroi.

The wives of the Wonnarua warriors waited for their husbands to return. All came back, except one. The wife of that one started to worry. She went up high and sat on top of a rock cliff overlooking the valley to the south to wait for her husband. She waited and waited, but when he did not return she knew that he had died during the battle. She cried until she could cry no more. She could not live without her husband, so she asked Baayami, the great sky god, to kill her.

Baayami could not kill her so he turned her to stone. As she was turning to stone she wept tears of fire which rolled down the hillside and set the mountain alight."

The township of Wingen takes its name from the Wonnarua word for 'fire', and it sits at the foot of this unusual mountain where the ground is hot and smoke and acrid fumes emerge from gaps in the rocks. In 1828 a local farm-hand out on a shooting expedition came across the smoking openings in the rocks. When he asked his Aboriginal companions if their people had lit the fire they said it had been burning for a long time. The following year geologist, Rev Charles Wilton, examined the site. Seeing the rocks were of sandstone, and there was no evidence of lava or a volcanic vent, Wilton concluded that something – presumably coal – was burning deep beneath the ground. The phenomenon of the burning mountain generated great interest and other explorers and scientists visited the site. Surveyor General Thomas Mitchell, W.B. Clarke and Professor Edgeworth David all visited Burning Mountain, speculating on its age and origins, and it soon became a favourite picnic spot for tourists.

More recent geological studies have shown that Burning Mountain is made of marine and coal-bearing sediments dating back to the early Permian period (around 300 million years ago). It appears that two coal seams, around 16 km to the north of Burning Mountain, somehow ignited and have been burning at a rate of about a metre per year. The distance it has travelled suggests that the underground fire began at least 15,000 years ago, although taking into account periods when the burning may have been much slower, the fire may be a great deal older.

Today, a two-metre-thick coal seam is burning with numerous outlets across the surface of the mountain. Air let in through the openings feeds the fires between 1400 and 1750 degrees Celsius (England 1982).

As the coal seam burns and the surrounding rocks are affected by the heat *(photo 2)*, the land collapses creating an uneven rocky landscape with abundant open fissures *(photo 3)* and small grabens (Percival, 1985).

Aboriginals probably used the sulphur and iron oxides as pigment and may have used the sulphur for medicinal purposes. For about 70 years from the 1890s, sulphur was collected by Europeans for the manufacture of medicinal ointments and soaps. More recently the mullite-rich rocks formed by the effect of high temperatures on the kaolinitic claystones have been mined in large quantities for refractories.

Along the walk we noticed the vegetation changes from eucalypt groves to the red gums that grow along subsidence cracks and narrow-leaved stringy bark, tea trees and stunted grey gums that reside in the burnt areas. The nature reserve comprises two small blocks joined by a narrow strip of land located on a prominent ridge. The northern block consists almost entirely of the Koogah Formation (fossiliferous sandstone, shale, conglomerate and coal), with a minor occurrence of the overlying marine Bickham Formation rocks (lithic sandstone, conglomerate). The southern block also contains Koogah Formation rocks as well as outcrops of Werrie Basalt (Percival, 1982). Away from the vent site, there are uniform clay soils on ridge tops, duplex soils on mobile sandy slopes and alluvial soils on the deeper layers, with colluvial sandy clay on the valley floors.

After morning tea in the picnic area we drove south along the highway and then west along Cressfield Road and then north on Middlebrook Road to Towarri National Park. We did a short walk from the picnic area along Middle Brook to observe the conglomerate pebbles deposited in the bottom of the stream *(photo 4)*. The bushland surrounding this tranquil spot is river oak forest and box woodland.

We had lunch in the well-equipped picnic area and then drove south along Middlebrook Road to Scone. Scone is the Horse Capital of Australia so the visitor's centre *(photo 5)* includes information on thoroughbred horses.

It was then time to head back to Murrurundi for a tour of the Pioneer Cottage *(photo 6)* with 88 year old Gwen. The cottage had been built near Timor in 1889 from hardwood slabs that were faced on one side by a pit saw. The cottage was moved in 1996 and restored by the community so that visitors can appreciate the tough life of their ancestors. We also viewed the array of contents housed in the Literary Institute including a number of rock and fossil specimens and details of the shale mining.

As the weather was holding we decided to drive to Paradise Park to complete the Eye of the Needle walk that had been scheduled for Tuesday afternoon. This steep walk took us through sub-tropical vegetation and giant conglomerate boulders to the path *(photo 7)* that leads to the lookout over the village of Murrurundi and surrounding hills

Day 3 – Thursday 6th May, 2021.

We left at 8:30 am again under overcast skies and headed north up the range and were soon at the village of Ardglen that is known for its quarry that has been operating for over 100 years. Ardglen quarry has provided crushed rock for railway ballast and road construction throughout NSW. The quarry is centred on three Paleogene olivine basalt flows dated 38 to 41 Ma. The upper flow extends up to 30 metres and the lower flows up to 14 metres. Minerals that have been documented from Ardglen quarry include analcime, aragonite, calcite, chabazite-Ca, chabazite-Na, gmelinite, gyrolite, apophyllite-(KOH), natrolite, prehnite and

2. Natural brick pit, Burning Mountain.

3. Collapse fissure at Burning Mountain.

todorokite (England and Sutherland, 1988).

Ardglen quarry is famous for its natrolite specimens. It appears throughout the quarry in all three lava flows. Natrolite occurs as colourless prismatic crystals from a few mm to over 4 cm in length. The minerals are found in the basalt lining vesicles from a few mm to over 1 m across. Various zeolites were also found in the nearby Ardglen Rail Tunnel which was opened on 13 August 1877.

We could not view the quarry so we made our first stop at Willow Tree Visitors Centre to observe the Kamilaroi grinding grooves. We then spent time reading the names of the crews, passengers, New South Wales corps and convicts that are chiselled in huge stones at Wallabadah's First and Second Fleets memorial. The histories of each ship are profiled on "sail" boards and the picnic area is shaped like a ship with sun shields for the sails.

Our morning tea stop was at the Mount Misery Gold Mine café in Nundle which included a visit to their museum *(photo 8)* which showcases the life and struggles of the pioneering people who lived and died with "Gold Fever".

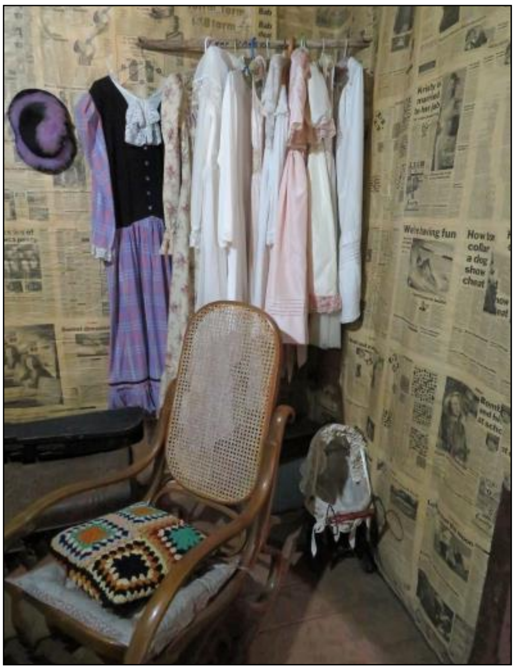
After some free time to explore the Woollen Mills and various stores we drove up the range further to Hanging Rock and onto Sheba dam undercover in the picnic shelter.

The Hanging Rock Run of 6,220 hectares, with a grazing capacity of approximately 500 head of cattle, was taken up by Nathan Burrows in 1848. Hanging

4. Conglomerate pebbles in the bottom of Middle Brook.

5. Scone Visitors Centre.

Rock took its name from a huge cliff face that overlooked the valley below. In August 1851, while out riding, Nathan Burrows spotted a stockman panning for gold along Swamp Creek. The stockman had stumbled across his good fortune while washing his pannikin after a meal and found a few shiny specs. Burrows rode to Tamworth to inform the local storekeeper, William Cohen, who within a few days rode to Hanging Rock, along with Charles Parsons and William Blackborn, to check out Burrow's claim and they found more gold. Thus a gold rush commenced to this area. By February 1852, 27 cradles were operating with some 200 diggers searching for their fortune.



6. One of many displays in the Pioneer Cottage Murrurundi.

7. Eye of the Needle trail.

8. Nundle Gold mine museum.

9. Admiring the view at a misty Sheba Dam..

Joseph Ruzicka arrived at Hanging Rock in 1879 and discovered one of the richest strikes of the Hanging Rock area at Harden's Hill, across from the local cemetery. Here Joe extracted 30 ounces of gold for every 26 cm that he dug, earning about £3,000 in one day. Ruzicka later found another good location where John Lord had worked 20 years earlier and had only found 30 oz. of gold. Ruzicka found 10 to 12 pounds (4.5 to 54. kg) of gold a few inches beneath the surface. Within ten days of the discovery, he was in possession of 344½ oz. of gold, and was paid £1,300/9/9 for ten days' work. He continued to make further good finds of gold plus some silver. In 1883 he sold his lease but the new owner only found 15 oz. of gold.

Just south of Hanging Rock are the Sheba Dams (with a surface area of 3.6 ha) which were erected by hand over a three-week period in 1888 to serve the sluicing needs of the miners *(photo 9)*. This construction was carried out by the Mount Sheba Company which leased the water rights for the area.

At its peak Hanging Rock had a population of several thousand people made up of several small communities, some having their own churches, schools, School of Arts building, general stores and hotels. Today Hanging Rock has a community hall, a NSW Rural Fire Service station and a few homes with a population of just 195.

It was too wet to venture to the Hanging Rock lookout so we returned to Nundle to view the Gil Bennett Rock, Gem and Mineral Collection *(photo 10)*. It features 1,554 specimens from all over Australia including petrified wood, gypsum, calcite, quartz, agate, jasper and aragonite. As a lapidary artist Gil was able to create many lapidary items including spheres, a testimony to his skill.

10. Gil Bennett mineral and rock collection.

Day 4 – Friday 7th May, 2021.

We packed up and headed north-west to Quirindi where Gordon Heath, CEO of Castle Mountains Zeolites (CMZ), gave us a presentation on the chemistry, mining and uses of zeolites. A zeolite deposit was uncovered in early 1989 on his family property and he decided to go into the risky investment of mining and developing applications for this unique mineral. The company aims to creating positive impacts for a better future and has a zero waste policy. The products have a diverse range of environmental and remedial uses including:

◊ Stockfeed and supplements including lick blocks
◊ Water filtration and/or treatment including fracking liquids and aquaculture
◊ Air filtration and/or treatment
◊ Remediation of soils including after nuclear accidents
◊ Soil conditioners including treatment for sodic soils
◊ Fertilisers
◊ Potting mixes
◊ Separation of gases and volatiles
◊ Cement and aggregate production
◊ Heating and cooling in commercial and industrial applications
◊ Domestic cleaning and malodour reducing products
◊ Spill products including clean-up of fluids
◊ Pet litter ingredient
◊ Infill for artificial grass
◊ Beauty products

Zeolites are a group of naturally-occurring hydrated aluminosilicate minerals comprising (at the time of writing) 101 confirmed species, making it the largest group of framework silicates in the mineral kingdom. However very few (around 4 or 5) have the adsorption and cation exchange capability that render them of commercial value. The most valuable species commercially are clinoptilolite, mordenite, chabazite and phillipsite. The CZM deposit contains the two best species, comprising 85% clinoptilolite and 15% mordenite.

The commercially important properties of zeolites are the result of their three-dimensional framework atomic structures which incorporate intra crystalline channels (open spaces) in which the weakly bonded exchangeable cations reside. The most important of these for most applications (such as kitty litter) is the ammonium ion which is the main cause of foul odorous organic waste. Other exchangeable cations are limited to calcium, sodium, magnesium, barium and strontium. Heavy metal ions (lead, mercury, cadmium etc.) are not exchangeable.

The CZM deposit is Carboniferous in age (300 to 330 Ma) making it one of the oldest commercial deposits in the world. It was formed when volcanic ash accumulated on the bed of a saline lake, the ash forming a bed of tuff as the lake dried up and became buried by later sediment. During diagenesis (compaction and lithification) the abundant volcanic glass shards in the ash devitrified through the presence of water to form the zeolites in a process called zeolitization. Variables including temperature, geographic location, water to ash ratio and salt content of the lake water contributed to the deposits unique composition.

CZM zeolite product is quite hard (>5 on Moh's scale of hardness). Other deposits, especially those in Europe, are much younger and softer. Hard zeolite product provides greater resistance to physical breakdown during use and is more applicable to water and air filtration end uses.

The zeolites are extracted by drilling and blasting the seam followed by excavation and trucking from the quarry to the processing plant where it is processed into smaller particles sizes for different uses.

Some features are:

- ◊ Very hard deposit (Moh's index >5) yet lighter than sand
- ◊ Stores heat for plants in winter and cools plants with watering in summer
- ◊ Uniform product with consistent density
- ◊ Very hydrophilic (absorbs water)
- ◊ Doesn't bind much water so releases water slowly
- ◊ Environmentally safe
- ◊ Very high crystallinity
- ◊ High content of clinoptilolite and mordenite
- ◊ High CEC (Cation Exchange Capacity)
- ◊ Blocky irregular shapes, great for filtration and use in soil or potting mixes.

We then made our own way to Coonabarabran and set up camp before catching up as a group at the Megafauna and Diprotodon display *(photo 11)* at the Visitors Centre for a talk on the discovery of Diprotodons in the area. Afterwards we visited the amazing collection of mainly local rocks and minerals on display at Crystal Kingdom *(photo 12)*. The museum is internationally famous for its displays of some of the worlds finest crystallised zeolites (heulandite and stellerite) which are found in the Jurassic Garrawilla Volcanics outcropping in the Warrumbungle Range to the east of Coonabarabran on private land. Also displays of some of the best fish and plant fossils from the Talbragar fish beds are another feature. The geological timeline displayed here showed the geological changes over the last 250 million years. At 5 pm most of the group attended happy hour in the caravan park.

11. Jaw of a Diprotodon - note the large incisor teeth.

Brief Geology of the Warrumbungle NP.

The Warrumbungle National Park contains the most outstanding volcanic scenery in NSW, including spires, plugs, domes, dykes, sills, lava flows, tuff layers, and horizontal and vertical columns. The story of today's landscape began 180 million years ago when the area was covered by large shallow lakes. At the bottom of these lakes, sediment laid down during the Jurassic period was slowly compressed over millions of years to form sandstone, now known as Pilliga Sandstone. Before the volcano, the area was probably like the Pilliga to the north -wooded, undulating to flat sandstone country cut by shallow valleys and creeks.

Around 18 million years ago thick trachyte lava welled up from different vents over a wide area as Australia moved north over a hot spot below Earths crust. This hot spot currently lies in Bass Strait (Troedsan and Bull, 2020). These subsequently became blocked as the trachyte solidified. About 16 million years ago as the volcano aged, more fluid basalt lava flowed from new vents, alternating with ash and scoria explosions. The later flows filled the spaces between the earlier trachyte domes, and built a large cone rising approximately 1000 metres, with a diameter of nearly 50 kilometres. As time progressed the magma became less and less viscous, spreading further and further from the vents and forming thick trachyte flows such as Mt Exmouth and Siding Spring Mountain. In the final stages from 15 million years ago, the flows became thinner, longer and more basaltic.

Since the end of volcanism, about 15 million years ago, erosion has cut through 90% of the volcanic pile, removing most of the later deposits and the softer rocks to expose the products of the early phases of the volcano. These are hard trachyte features, high in silica, and resistant to weathering and include domes, plugs and dykes, some reaching 700 metres. The Grand High Tops is a section where volcanic remnants are clustered. Pyroclastic rock is also found in this area.

Lava domes where molten rock has extruded to

12. Imprint of fossilised *Glossopteris* leaves from Gulgong on display in the Crystal Kingdom.

the surface and clogged up the source vent as a bulbous mass can be seen at Belougery Split Rock and Bluff Mountain, the largest dome in the park. There are lava flows at Mt Exmouth (highest point in Warrumbungles at 1,206 metres) and Siding Spring Mountain, these being the only remnant of deposits formed on the flanks of the volcano. Crater Bluff is a 'classic' volcanic plug (or neck) of trachyte. The plug formed below the surface from cooling magma which blocked the vent, pressure from below being insufficient to clear the solidifying mass. The resistant plug is prominent now as adjacent softer materials (tuff and breccias) have been removed by erosion, leaving the plug surrounded by a bowl-shaped depression. The rock making up Crater Bluff has been shown to be similar in composition to that of The Breadknife.

The Breadknife, a 90 m high narrow rock wall, is a radial trachyte dyke associated with Crater Bluff. It was formed when magma was forced through a crack in the earth's surface and intruded vertically into volcanic tuff and breccia, then cooled and set into a hard, narrow mass with numerous contraction joints. Because the rock surrounding the Breadknife was softer than the solidified magma, erosion has left a long sliver of stone exposed which is hundreds of metres long and only several metres wide.

Within the National Park, four types of trachytes with different mineral compositions can be distinguished by colour differences, which range from green to green-blue, to blue, to white. Later the chemical composition changed, resulting in eruption of hawaiites and trachyandesites, which are today found south-east of the park and at nearby Tonduron Mountain, which is just outside the boundary of the National Park.

The local topographic relief is considerable. Many peaks stand over 1,000 metres above sea level contrasting with the nearby plains to the west (max of 300 metres above sea level) and the hilly country to the east (about 600 metres above sea level). The rivers and creeks, which drain the Warrumbungle volcanic pile, form a radial pattern around the eruption centre, a pattern common to many volcanic landscapes. Quaternary deposits of unconsolidated sand and silt occur locally along the watercourses. The underlying Pilliga Sandstone is one of the main intake aquifers for the Great Australian (Artesian) Basin and marks the eastern margin of the Basin.

Day 5 – Saturday 8th May, 2021.

We left at 8:30 am for a drive to the Warrumbungle National Park. First stop was at the foot of Timor Rock, a volcanic plug. Next stop was the Whitegum Lookout carpark from which we enjoyed the easy walk to view the main features of the Grand High Tops area *(photo 13)*. Along the way you could examine the difference between the Pilliga Sandstone and the harder trachyte as well as regrowth after the devastating Wombelong wildfire of 2013 *(photo 14)*.

13. View from Whitegum Lookout across to the Grand High Tops.

14. Whitebox reshooting after the 2013 bushfires.

15. Rock wall at the Warrumbungle National Park Visitors Centre

16. Sample of Pilliga Sandstone on display in the Visitors Centre rock garden.

17. Wambelong Gorge.

18. Burbie Canyon.

19. Belougery Split Rock, the remnants of a small lava dome formed by very viscous lava that accumulated around the source vent.

20. "Spectators" beside the walking track.

We then drove to the new Visitor's Centre *(photo 15)* to view the impressive displays and the rock garden *(photo 16)* before having morning tea at the Canyon Picnic Area.

We then followed the Wambelong Nature Track along a gorge *(photo 17)* cut into a trachyte lava flow.

After lunch we drove to the Burbie Canyon car park. Some walked the 1 km Burbie Canyon (*photo 18*) track and then returned to the cars the same way. Others walked the canyon trail and then took the 2 km fire track that provided excellent views of Belougery Split Rock (*photo 19*) before returning to the cars. We then returned to camp passing curious kangaroos (*photo 20*) with our cameras loaded with photos.

Geology of the Pilliga Area.

The Pilliga Sandstone is the foundation rock for the entire Pilliga Forest area. Around 150 million years ago (the Jurassic), vast horizontal layers of sediment were laid down in a series of lakes. The resulting rock formation was later intruded by the volcanic eruptions that formed the Warrumbungle and Nandewar ranges. Today, the sandstone is up to 300 metres thick and stretches from Dubbo to Queensland. The Pilliga features low ranges that rise up to 600 metres in the east and fall gently to wide plains in the west.

The Pilliga is an iconic landscape with its low rocky hills and infertile soils. It has survived as the largest forest in NSW west of the Great Divide with around 500,000 hectares of public bushland. The forest includes cypress pines, iron barks, scribbly gums and box and changes according to changes in soil texture, moisture, fire and human activity.

Day 6 – Sunday 9th May, 2021.

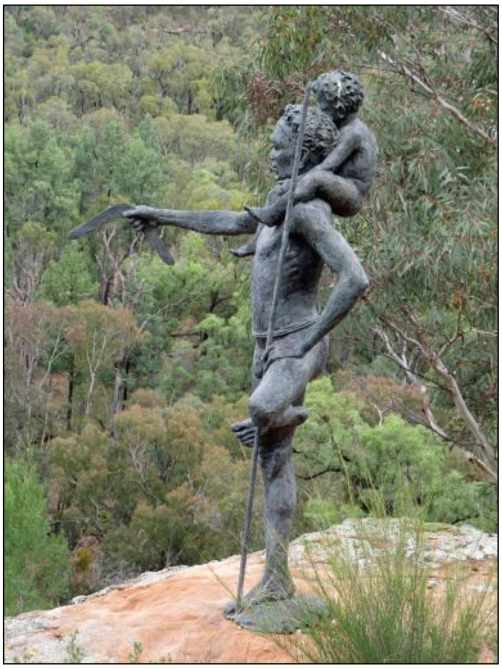
Despite the forecast for no overnight rain we awoke to a muddy caravan park and drizzle and thus had a schedule change. We headed west to the indoor Pilliga Forest Discovery Centre at Baradine *(photo 21)*. This gave us knowledge of the fauna and flora of the Pilliga as well as its cultural history. It didn't rain while we were inside the centre so we headed out on the dirt roads to the Sculptures in the Scrub picnic area for morning tea. We then set off on the interesting loop walk past the five sculptures *(photo 22)* and through Dandry Gorge *(photo 23)*.

Following lunch we drove along more dirt to the Salt Caves picnic area. Most of the salt has been removed from the caves but it was interesting to read about the various stockmen, housewives and travellers that called in here to get a supply of salt for preserving their meat *(photo 24)*. The salt built up over time as ground water carries salt with it when rising up through the sandstone. The salt gradually becomes more concentrated and forms crystals which grow in the pores exerting pressure between the sand grains causing them to fall apart. Thus over thousands of years the caverns have formed.

Some navigated the new fire tower for superb views of the surrounding country side before walking to the Salt Caves Dam *(photo 25)*.

It was then time to head back to camp happy that we did complete all the planned activities for the day. However, car owners were not impressed with the condition of their cars after travelling through mud all day.

21. Admiring the displays in the Pilliga Discovery Centre, Baradine.



22. "First Lesson", a bronze statue of a father teaching his young son.

23. A wonderful example of cross-bedding exposed by weathering in Pilliga Sandstone, Dandry Gorge.

24. The Salt Cave from which early settlers collected salt to preserve meat.

27. Differential weathering patterns in the Pilliga Sandstone forming the sandstone caves.

25. Salt Caves Dam.

28. One of several hollows observed on the walk. Note the honeycomb weathering and cross-bedded strata.

26. Tool-making groves at Tara Cave.

29. A beautiful pattern due to weathering of the Pilliga Sandstone.

30. Morning tea in the Blue Wren Café located in the Pilliga Pottery.

31. Pottery demonstration to make a vase.

32. Decorating a completed vase before glazing and firing.

Day 7 – Monday 10th May, 2021.

This was a designated free day so many took the chance to enjoy the coffee shops and book store in Coonabarabran. Laurel, Charlotte and I decided to walk up the 1,000 steps to Fan's Horizon, a lookout on the exposed sandstone cliffs of Balgatan (700 metres above sea level) for the fine views of the Grand High Tops. The lookout is named after Fanny Gould, wife of Alick Gould who was a long time secretary of the Park Trust. We then had lunch at Woolshed picnic area before walking to Tara Cave. Tara Cave is a rock shelter that has tool making grooves on a rock *(photo 26)* at the front of the shelter and gave us good views of the features of the Warrumbungles.

Day 8 – Tuesday 11th May, 2021.

Our last day together and I think a highlight of the trip. Departing at 8:30 am we headed north to the colourful Sandstone Caves in the Pilliga Nature Reserve. The caves are a series of cathedral type caves and overhangs that have many interesting colours and formations. Many photos were taken as the group completed the short loop walk around the formation *(photos 27, 28 & 29)*.

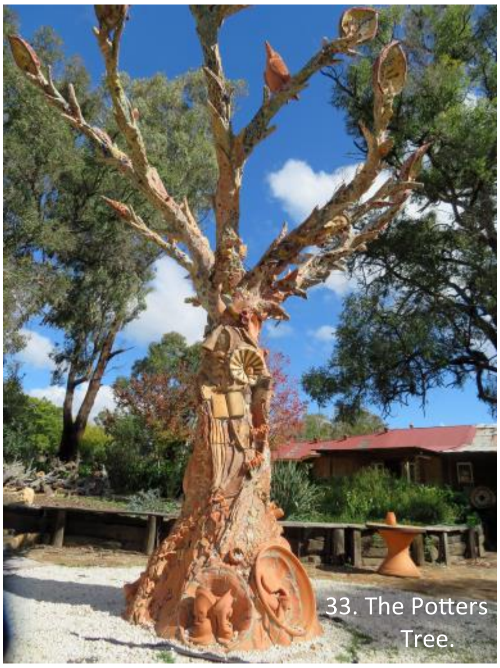
It was then a short drive to Pilliga Pottery where we enjoyed morning tea in the Blue Wren Café *(photo 30)* amidst unique hand-made pottery and furniture. We then had a pottery demonstration *(photo 31)* which included a discussion on the type of clay used, the firing and decorating of the product *(photo 32)*. Many were tempted to make a purchase of the beautiful articles for sale in the gift shop. The Potters Tree was an interesting sculpture in the grounds of the pottery *(photo 33)*.

After lunch we drove out to the beginning of the Conglomerate Canyon walk. It was an uphill challenge but everyone who started managed to finish and were rewarded with some interesting geology. It was mainly Pilliga Sandstone but did have evidence of conglomerate formed from sediments laid down in large deltas during the Jurassic Period about 150 million years ago *(photo 34)*.

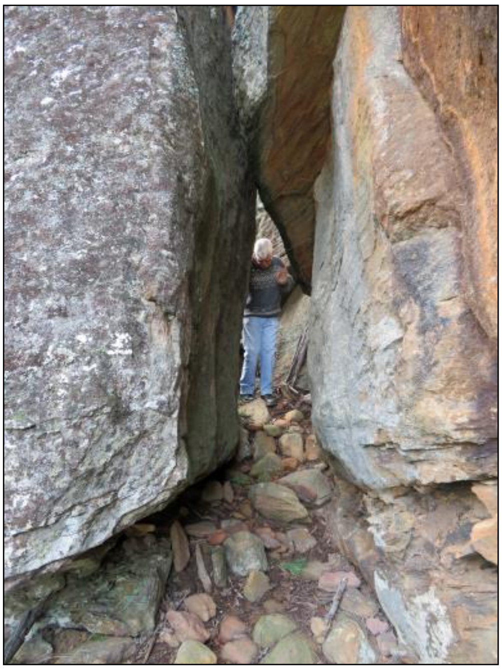
Our next stop was the short walk to the appropriately named Lip Cave *(photo 35)*. Interesting weathering features were seen during its exploration *(photos 36 & 37)*. A few then walked to the waterhole *(photo 38)* and passed many more caves along the track. We returned to camp to get ready for a night out at the Imperial Hotel to celebrate a fabulous trip.

Day 9 – Wednesday 12th May, 2021.

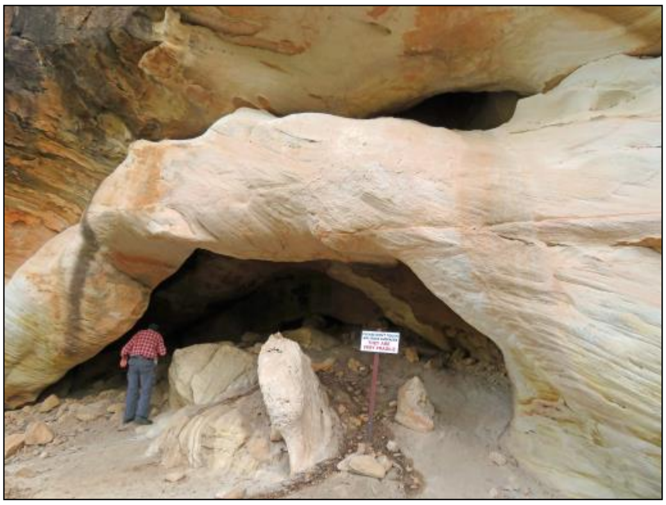
Today we packed up and made our own way home after an amazing time with a wonderful group of participants.



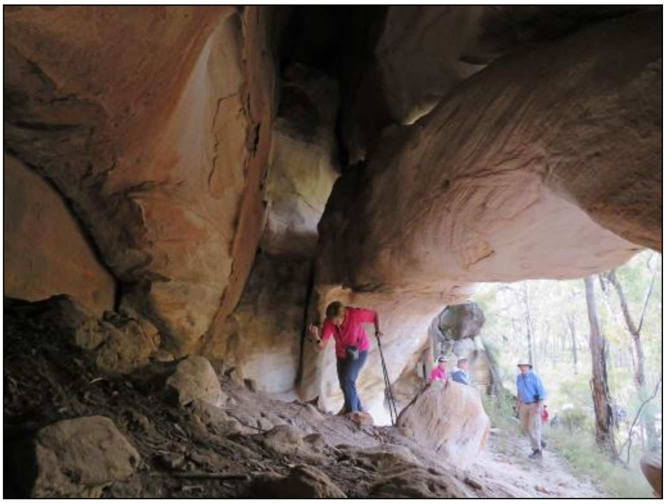
33. The Potters Tree.



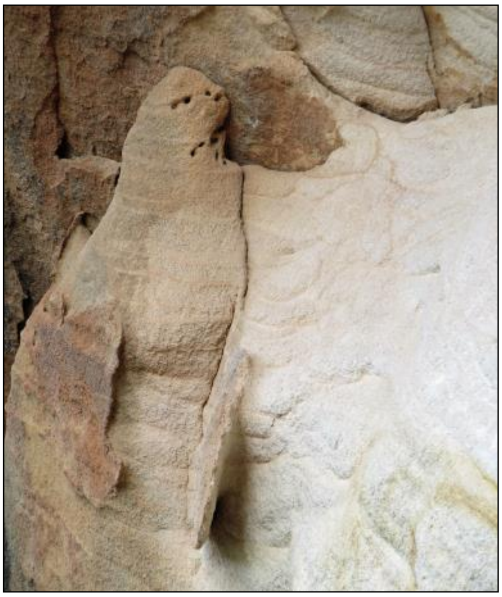
34. Navigating the Conglomerate Canyon.



35. Lip Cave. Note how the cross-bedded sandstone is differentially weathered.



36. Exploring Lip Cave.



37. What is this?

38. Small waterhole.

Report and photos by Sue Rogers with some geological input by Brian England.

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Pokolbin Inlier Field Trip

Leaders: Ron Evans and Brian England.
Date: Saturday 12th June 2021.
Attendance: 27 members.

Introduction.

The Pokolbin Inlier is a sequence of Carboniferous rocks centred around Mount Bright and Mount View in the Mount View Range which is surrounded by younger rocks of the Permian Maitland and Dalwood Groups, including the Greta Coal Measures. Lying just to the west of the Inlier are the Triassic sandstones of the Banks Wall Sandstone in the Narrabeen Group. The area has previously been described as the Mount Bright Inlier of the Mount View Range (Brackel, 1972) and the Mount View - Mount Bright Inlier (Willey, 2010).

The geology of the Pokolbin Inlier is quite complex, comprising plutonic, volcanic and volcaniclastic rocks that have undergone folding and faulting *(see pages 49-51 for a brief geological history of the area)*. The Lochinvar Anticline is the main structural feature to the east of and crossing the southern part of the Inlier in the vicinity of Bimbadeen Lookout.

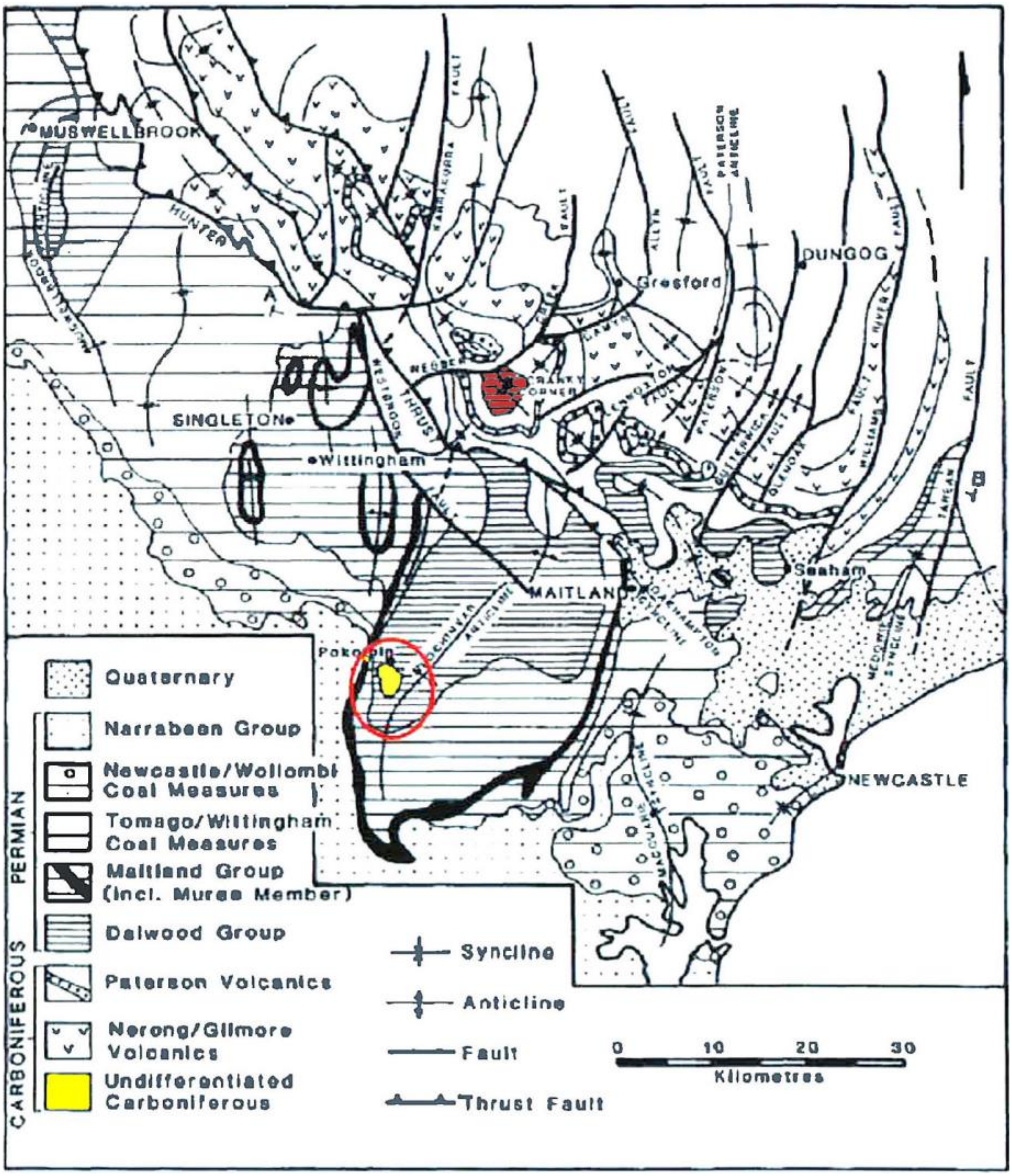


Figure 1: Geology of the Lower Hunter Valley Region (Gilmore and Greenfield, 2012).
The Pokolbin Inlier (yellow) is surrounded by a red circle and the Cranky Corner Outlier is highlighted in red.

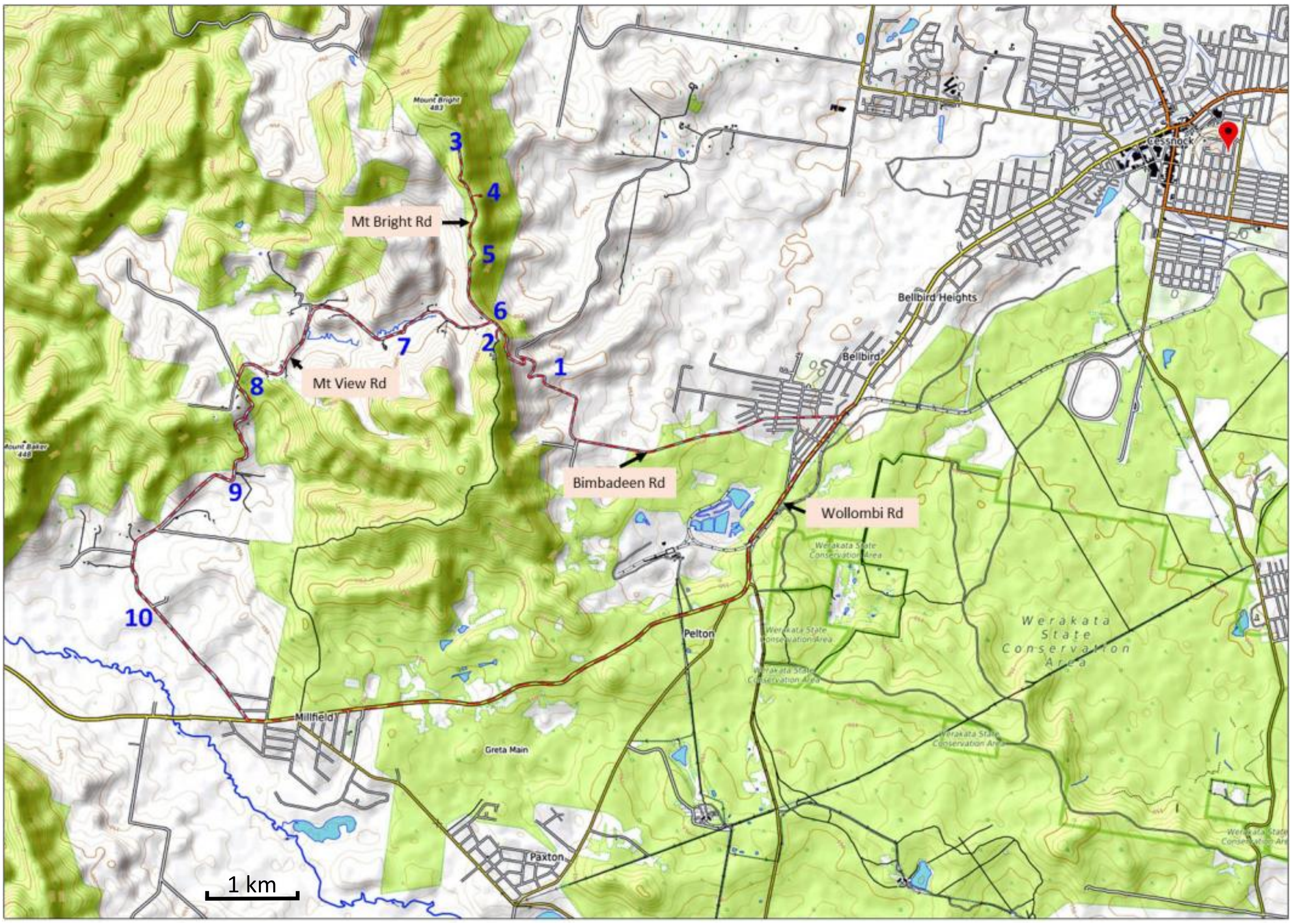


Figure 2. Stop locations shown by **blue** numbers.

It is thought to have formed as a result of east-west compression during the deposition of the mid to upper Maitland Group sediments in response to uplift and compression in the New England Orogen, after the deposition of the Greta Coal Measures (Gilmore and Greenfield, 2012). The surrounding Permian sediments dip gently away from the Pokolbin Inlier on all flanks, suggesting that the Inlier may have been a basement high during deposition of the early Sydney Basin sediments. The location of the Pokolbin Inlier in relation to Lower Hunter Valley geology is shown in *Figure 1* (after Gilmore and Greenfield, 2012).

Purpose of the Field Trip.

The purpose of this excursion was to observe some of the local structural elements, examine the rocks present and relate their composition to their origin and to appreciate how structures and rock type can control topography. The route taken in shown in *Figure 2*.

Miners Memorial Park, Bellbird.

Participants met at Miners Memorial Park in Bellbird where a monument to the Bellbird mine disaster of 1923 is located. Twenty one men and horses were killed by underground explosions and fires in the old Bellbird colliery. Car pooling to a maximum of seven vehicles was organised here as parking would be very limited at some stops. Safety vests were mandatory as many of the locations were cuttings along narrow winding roads where safety and minimum disruption to traffic had to be prioritised. During the introductory discussion *(photo 1)* it was pointed out that the Memorial Park is underlain by rocks of the Permian Branxton Formation (Maitland Group), with the Greta Coal Measures crossed as we drove along Kendall Street, then passing down sequence into the Permian shallow marine rocks of the Farley Formation (Dalwood Group) on the edge of town. The Farley Formation would continue to be traversed till Stop 1.

Stop 1 - **Mount View/Paxton Fault**.

Suitable parking for this site was found off road near the Bimbadeen Estate sign *(Figure 3)*. Here members gathered for an explanation of the geological and topographical features *(photo 2)* before walking back down Bimbadeen Road to examine the geology of the Mount View/Paxton Fault *(photo 3)*. The fault is evident as a wide crush zone characterised by heavily jointed and fragmented rock. The fault has resulted in the juxtaposition of the Farley Formation and underlying Rutherford Formation *(photos 4 & 5)*.

1. Brian presenting a brief explanation of the geological processes leading to the formation of the Pokolbin Inlier.

2. Ron (red cap) giving an explanation of features to be examined at Stop 1.

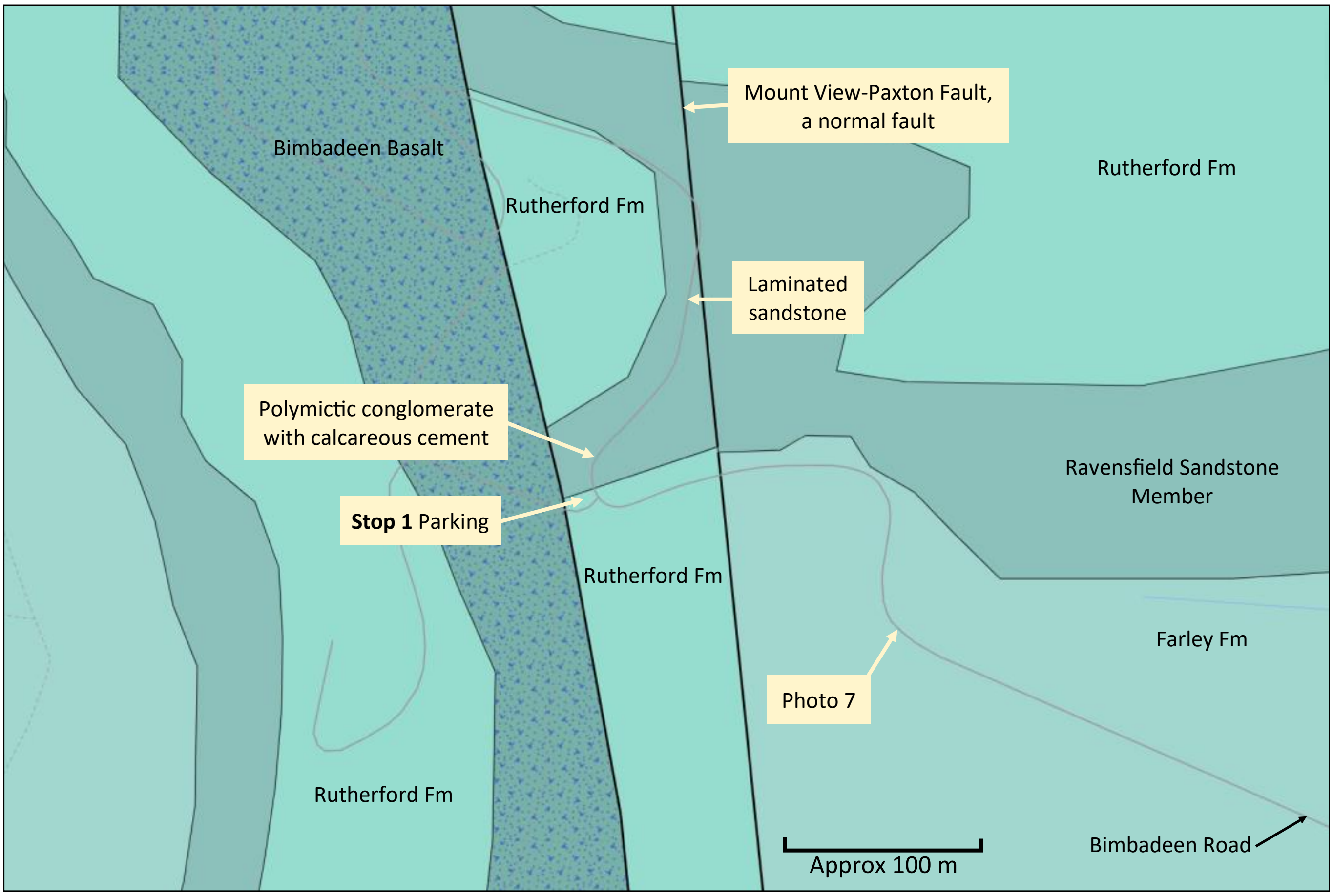


Figure 3. The geological features at Stop 1 are quite complex.

Further down the road are excellent exposures of rocks of the shallow marine Farley Formation comprising finely bedded fissile silty sandstone with an interbedded band of fine grained tough cross bedded sandstone about 0.5 m thick *(photo 6)*. A drop of dilute hydrochloric acid (HCl) caused this rock to effervesce strongly showing the toughness of the rock is due to a pore-filling calcite cement. The rocks in this cutting were seen to dip to the east, the result of being in the eastern side of the Lochinvar Anticline. Further down Bimbadeen Road is an excellent example of how tree roots aid erosion *(photo 7)*. Also noted was how differential erosion between the more easily weathered friable silty sandstone and the dense tough cross bedded sandstone caused the latter to stand out from the face of the road cutting as a result of its greater resistance to weathering and erosion.

We then walked back up Bimbadeen Road past where the cars had been parked to examine rocks of the Ravensfield Sandstone Member at the base of the Farley

3. Members examining the Mount View/Paxton Fault.

6. Massive hard cross-bedded fine-grained sandstone that forms a prominent bed in the Farley Formation on the eastern side of the Mount View/Paxton fault.

4. Mount View/Paxton Fault. On the left is the Farley Formation and to the right the Rutherford Formation.

7. The calcareous sandstone bed is massive when compared to the silty sandstone above and below. Note how tree roots have aided weathering by growing through and displacing blocks of the hard sandstone.

5. Mount View/Paxton Fault. Note how the beds to the right of the fault plane are tilted up more that those on the left.

8. Polymictic conglomerate from the Ravensfield Sandstone Member. The rock is very hard probably due to its calcareous cement . Its origin is shallow marine as evidenced by fossils (*polypora, fenestella* and brachiopod fragments) found in some samples.

9. Ron testing for the presence of calcite cement with dilute hydrochloric acid (HCl).

10. The section of road running down the slope follows the Mount View/Paxton fault. Because it's a normal fault, the land to the left has dropped down with respect to the land on the right.

11. Laminated shaly sandstone exposure at the top of the road cutting.

Formation immediately above the Rutherford Formation. On the way it was a perfect opportunity to observe the topography resulting from the Mount View/Paxton Fault.

Where the road turns sharply to the right as it climbs steeply along the eastern side of the Mount View Range there is an outcrop of polymictic conglomerate within the Ravensfield Sandstone Member in the cutting in the left side. The surface of the outcrop is very weathered and gave no indication of the rock's texture or composition until a sample was broken off and the freshly exposed surface examined *(photo 8)*. The pebbles in the conglomerate range up to 8 cm and comprise a wide range of rock types including granite, hornfels, fine grained sedimentary rocks and a variety of volcanic rocks, indicating a geologically complex source area. A drop of dilute HCl placed on the rock causes it to effervesce strongly, indicating that a calcite cement was responsible for the rocks' toughness *(photo 9)*.

Continuing up Bimbadeen Road until it swung to the left we walked along the Mount View/Paxton Fault (see *Figure 3*), with the land surface to the east dropping away steeply suggesting a normal fault (Willey, 2010) with rocks to the east dropped down with respect to rocks on the western side *(photo 10)*.

A small section of laminated shaley sandstone *(photo 11)* exposed at the bend in the road still forms part of the Ravensfield Sandstone.

Stop 2 - **Bimbadeen Lookout**.

Shortly after departing Stop 1 we turned hard left onto Mount View Road which took us steeply uphill to the top of the Mount View Range where we turned into Bimbadeen Lookout. From here there were extensive views over the Lower Hunter Valley and it's topography.

Permian marine rocks (Dalwood Group) and the Greta Coal Measures form the lowlands in the foreground while the hills to the north comprise resistant Carboniferous age volcanics and terrestrial sediments. The high country to the east and south (including the Mount Sugarloaf Range) is capped by Triassic sandstone of the Narrabeen Group. The crest of the Lochinvar Anticline runs north from the lookout (see *Figure 7*).

After morning coffee we walked to the southwest up the Watagan Track where loose boulders and outcrops of marine sandstone in the Ravensfield Sandstone Member were found, some containing scattered marine fossils (mainly brachiopods).

Reassembling at the vehicles we drove northwards up Mount Bright road (unsealed) until it's end at Stop 3.

Stop 3 - End of Mount Bright Road.

We parked at the end of the road where there are prominent outcrops of the Mount Bright Rhyolitic

12. Chalcedony nodule found on the ground at Stop 3. Specimen is 4.5 cm high.

13. Banded chalcedony. Specimen is 5 cm wide.

14. Outcrop of Mount Bright Rhyolitic Ignimbrite at Mount Bright Lookout. The view is north over Permian rocks underlying the Hunter Valley vineyards to Carboniferous rocks forming ranges in the distance.

15. Members next to an outcrop of Mount Bright Rhyolitic Ignimbrite at Mount Bright Lookout.

16. Mount Bright Rhyolitic Ignimbrite with distinct flow-banding. The brown patch is due to weathering. Specimen is 9 cm wide. (Brian England specimen R235).

Ignimbrite (Late Carboniferous Pokolbin Hills Volcanics). From here a marked walking track (Mount Bright Fire Trail) leads along the spine of the range to join the Vineyard Lookout road after a few kilometres.

The rhyolitic ignimbrite contains networks of irregular pockets formed by escaping gases which have been filled with chalcedony. This material has been used by lapidaries to make jewellery after tumble polishing.

However the nodules are difficult to remove intact from the rock, but weathering has released some which can be found scattered through the soil *(photo 12)*. Most of the chalcedony is rather bland in colour but one fragment of banded chalcedony (agate) was found *(photo 13)*.

Driving back down Mount Bright Road we pulled in to the Mount Bright Lookout, labelled Stop 4 in *Figure 2*.

Stop 4 - Mount Bright Lookout.

Mount Bright Lookout provides another superb extensive view out over the Lower Hunter Valley and it's topography. Here the Mount Bright Rhyolitic Ignimbrite is over 400 m thick and outcrops to form the eastern cliffs on the Mount View Range *(photos 14 and 15)*. The rock shows a variety of ignimbrite textures including fragmented pumice and fiamme (black streaks of volcanic glass). Some freshly exposed rock surfaces show pronounced flow banding *(photo 16)* with easily visible quartz and sanidine (K-feldspar) crystals. Some gas cavities are lined with tiny quartz crystals.

At the base of the eastern cliffs an elongated fault -bound outcrop of the Carboniferous age (349.3 Ma) I-type Mount View Range Granodiorite occurs. The outcrop is only accessible from the base of the cliff via private property. A specimen of the granodiorite *(photo 17)* was passed around while Brian pointed out that exploration for copper within the granodiorite had taken place around 1907/08 but no payable deposit was

17. Mount View Range Granodiorite. Specimen is 15 cm across. (Brian England specimen R 283).

18. Bimbadeen Basalt in situ in the road cutting at Stop 6. Note the white amygdales of secondary calcite.

19. Ron pointing out features in the Ravensfield Sandstone Member outcrop at Stop 8.

20. Labile silty sandstone beds exhibiting cylindrical onion skin weathering patterns.

found. The copper occurs as chalcopyrite (copper iron sulphide) filling veins and fractures with assays showing around 32 percent copper plus 6g/t gold and 179g/t silver (Carne, 1908).

Departing the lookout, we parked at the junction of the Mount Bright and Mount View roads, Stop 6 on *Figure 2*.

Stop 6 - Junction of Mount Bright and Mount View roads.

Here the Permian age Bimbadeen Basalt outcrops in the road cuttings. Although this basalt is reasonably extensive in the area, outcrops are few. Luckily the road cuttings here expose reasonably fresh outcrop.

The basalt has a fine sandy texture and greenish tint due to the presence of epidote formed by the alteration of the ferromagnesian minerals. Also present are amygdales of calcite *(photo 18)* which effervesce strongly with dilute HCl.

Stop 8 - Mount View Road.

Here we parked at a small roadside quarry where a fine labile silty sandstone in the Ravensfield Sandstone Member outcrops *(photo 19)*. The beds here dip gently to the west, the result of this outcrop being on the western side of the Lochinvar Anticline. An unusual form of onion skin weathering was noted in the sandstone in that some beds display a cylindrical form *(photo 20)* instead of the usual spherical form.

We then walked 100 m down the road towards Millfield to where an abrupt facies change occurs. Massive beds of vertically jointed sandstone appear beside the road *(photos 21 & 22)*. These rocks are part of the Ravensfield Sandstone member, indicating that the boundary between the Farley Formation and the Ravensfield Sandstone Member had been crossed (see *Figure 8*).

21. Massive beds of sandstone beds belonging to the Ravensfield Sandstone Member.

22. The sandstone was silty and not well sorted.

23. Jerusalem Rock.

Resuming our journey, the road swung to the left then crossed the Mathews Gap Fault East just as a hill composed of siltstone and sandstone of the Rutherford Formation appeared away from the road to the left.

After crossing Cedar Creek there was a clear view up the valley to a hill of bare rock called Jerusalem Rock, which is another outcrop of the Mount Bright Rhyolitic Ignimbrite.

Stop 10 - **Branxton Formation**.

We parked next to the Millfield Winery access road and walked to the low cutting immediately to the south *(photo 24)* where fine grained fossiliferous sandstone typical of the lower Branxton Formation is exposed. Numerous marine fossils, mainly spiriferid

24. Outcrop of fossiliferous sandstone south of the Millfield Estate access road.

25. Shells of spiriferid brachiopods were plentiful in the sandstones exposed in the road cutting.

26. Fossil of the pedicle shell of a brachiopod (spirifer). Some original shell still exists - part of the internal mould of the shell can be seen at the bottom of the shell fragment.

27. Angular dropstone.

brachiopods *(photos 25 & 26)* were found in the sandstone.

Also present are scattered dropstones both rounded and angular *(photo 27)*. Rounded drop stones are cobbles plucked from coastal beaches as sea ice began to melt, move offshore and float away to drop the cobbles attached to the underside of the floating ice rafts some distance from their source into unconsolidated marine sediments. Angular drop stones probably fell from coastal headlands onto the surface of the ice which then rafted them away to be dropped elsewhere when the ice finally melted.

Supplementary Information.

Due to the large group of members and vehicles involved on the field trip. Stops 5, 7 and 9 were not examined.

The following information outlines the geological features present at each of these localities.

Stop 5 - Seaham Conglomerate.

Park opposite the large Telecom tower.

A small outcrop of Seaham Formation Conglomerate (Carboniferous) outcrops on the eastern side of the road. Samples of the rock may be found among the grass beside the parking area *(photo 28)*.

28. Sample of Seaham Conglomerate composed of rounded pebbles within a sandy matrix.

Stop 7 - Mount View Road next to Cedar Creek.

Look east as you drive along Mount View Road. When the eastern bank of Cedar Creek comes into view *(photo 29)*, park on the side of the road.

The exposed bank of Cedar Creek has an exposure of the Dalwood Group in the form of a reworked conglomerate ("Lakes Folly Formation"?).

29. Eastern bank of Cedar Creek with its exposure of conglomerate.

30. Reworked conglomerate with a layer of coarse sandstone exposed in the bank of Cedar Creek.

Note how the conglomerates are interbedded with coarse sandstone *(photo 30)* and also note the apparent dip of these beds which unconformably overly the Pokolbin Hills Volcanics.

Jerusalem Rock is the hill seen to the south which is composed of Mount Bright Rhyolitic Ignimbrite.

Stop 9 - **Cessnock Sandstone Member**.

The Cessnock Sandstone Member consists of hard, massive to planar-bedded quartz lithic sandstone, sporadically conglomeratic with marine fossils in sandy phases.

Stratigraphically, this member sits between the Greta Coal Measures and the Branxton Formation.

After parking on a right-hand bend opposite a house on tar road, large blocks of sandstone can be examined *(photo 31)*.

Figures 4, 5 & 6.

A brief outline of the depositional history and relationship between the rocks observed in and around the Pokolbin Inlier.

Figures 7 & 8.

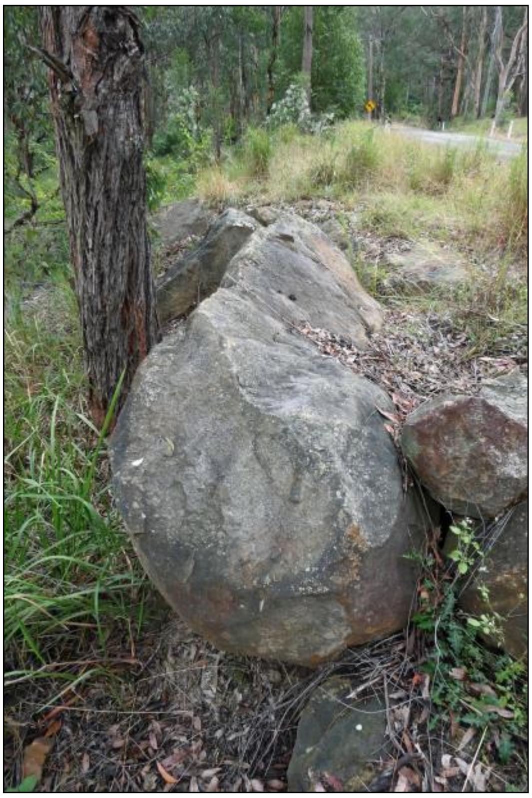
Two geological maps to show the precise locations of the stops described in the report.

The Key indicates the rock formations/members examined during the field trip.

Report by Ron Evans and Brian England.

Photographs by Ron Evans (4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 16, 17, 18, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30 & 31).

Photographs by Shayne Kerr (1, 2, 3, 9, 15, 19 & 26).



31. Large blocks of hard sandstone beside the road, part of the Cessnock Sandstone Member.

Reference:

BRAKEL, AT. (1972). *Geology of the Mount View District, Pokolbin,* NSW. Journal of the Royal Society of New South Wales, 105, 61-70.

CARNE, J.E. (1908). *The copper mining industry and distribution n of copper ores in New South Wales*. NSW Department of Mines, Geological Survey. Mineral Resources No. 6.

GILMORE, P. and GREENFIELD, J. (2012) *Field excursion guide to the Mount View area, Hunter Valley, New South Wales*. Geological Survey of New South Wales.

HERBERT, C. and HELBY, R. (1980). *A Guide to the Sydney Basin.* Department of Mineral Resources, Geological Survey of New South Wales, Bulletin No. 26.

WILEY, E. C., (2010). *Pokolbin Inlier – a restraining bend positive flower: Implications for timing of the Hunter-Bowen Orogeny*. University of Southern Queensland.

ArcGIS Explorer. GSNSW – Seamless Geology of NSW. App for smartphone and tablet.

Australian Geology Travel Maps and NSW bedrock geology map, Geological Survey of NSW. App for smartphone and tablet.

Depositional History and Relationship Between the Rocks Observed in and around the Pokolbin Inlier.

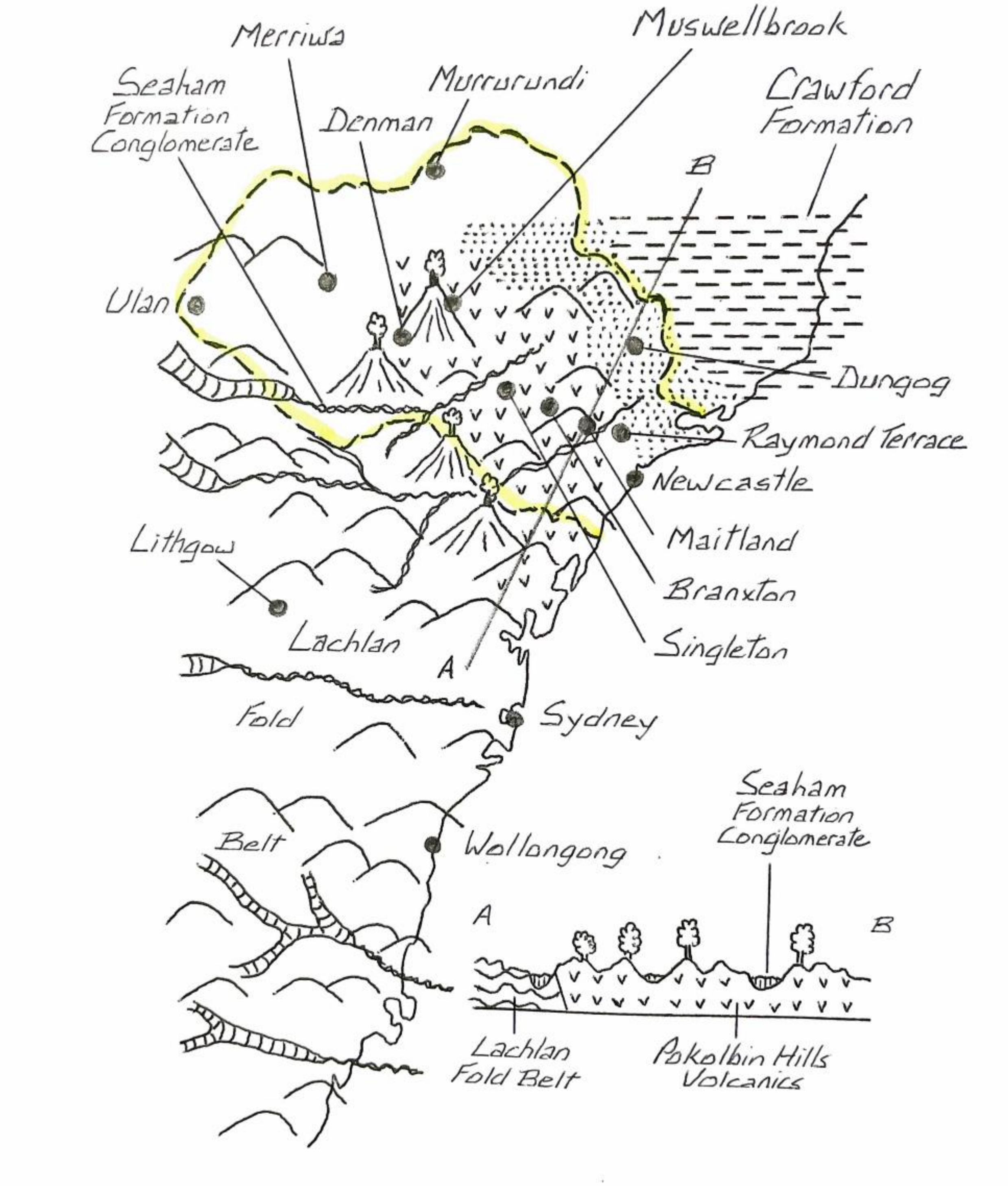


Figure 4.

In the Late Carboniferous to Early Permian the presently defined outline of the Sydney Basin had not yet evolved. The area consisted of a glaciated mountain terrain with an active volcanic rift zone to the north and marine conditions in the northeast with Early Permian pro-deltaic, intertidal to swamp sediments deposited across a broad continental shelf, transgressing the Lachlan Fold Belt. Seaham Formation conglomerates were laid down by braided streams coming from alpine and valley glaciers to the west, between the Late Carboniferous volcanic peaks of the Pokolbin Hills Volcanics, which have been correlated with the Paterson Volcanics. The Pokolbin Hills Volcanics are underlaid by the Mount View Range Granodiorite which today is only seen in faulted contact with the more recent overlying rocks.

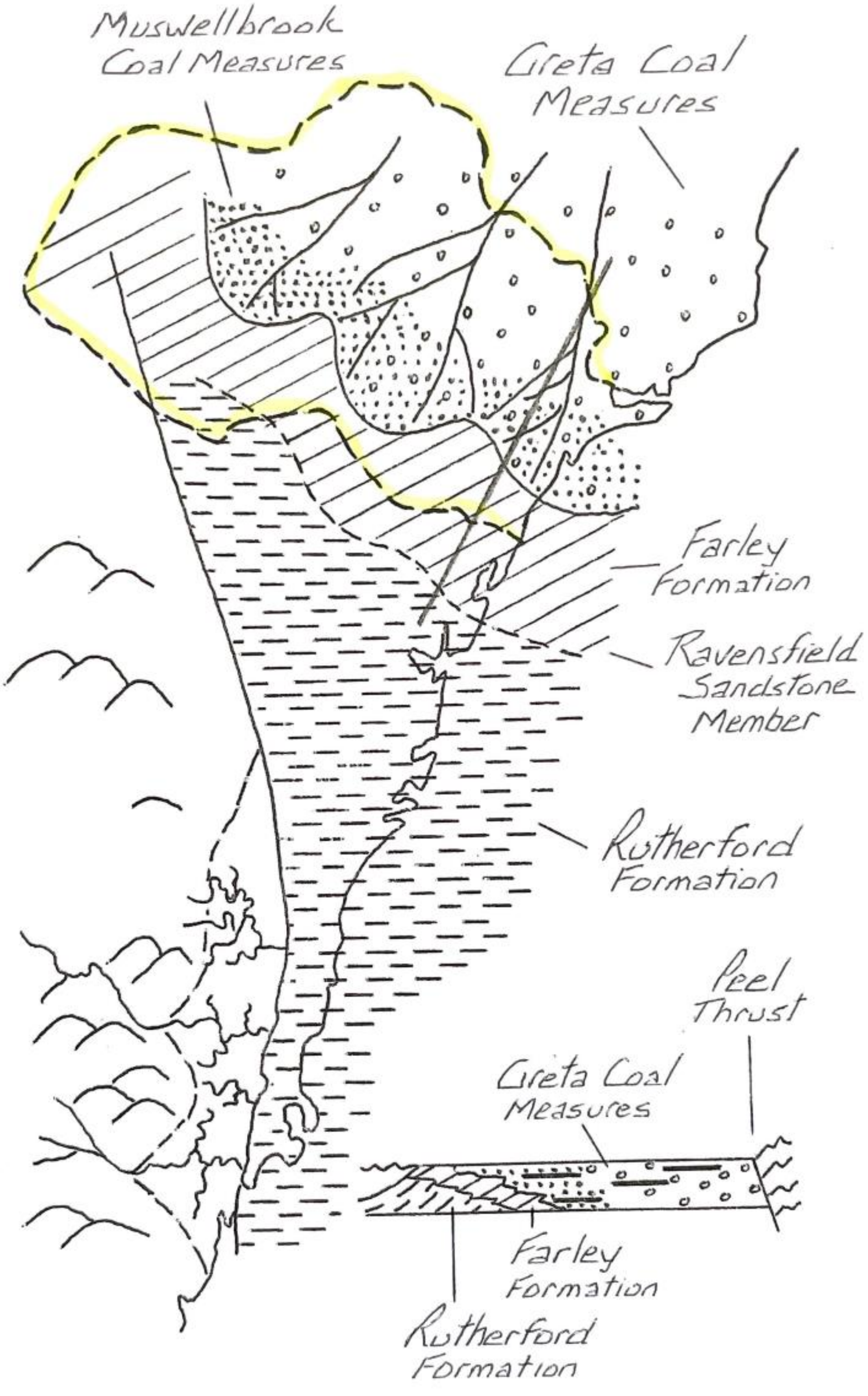


Figure 5.

During the Hunter Tectonic Stage NW-SE rifting occurred and Early Permian marine transgression continued westwards to begin in filling the Sydney Basin. However a brief episode of tectonism to the north caused a regressive wedge of terrestrial (alluvial, alluvial fan and deltaic) sedimentation (the Greta Coal Measures) to penetrate southwestwards into the northern part of the Sydney Basin, probably from a source area in the New England Fold Belt. These sediments were deposited over the marine, pro-deltaic and bay silts of the Farley and Rutherford Formations and extend to just south of Cessnock. These formations were deposited contemporaneously, with the Farley Formation representing near-shore deposition. After the initial transgression most of the sediments in the Farley and Rutherford Formations were deposited during a slow regressive phase.

Note that the Lochinvar and Allandale Formations (at the base of the Dalwood Group) have not been recognised in the area around the Pokolbin Inlier. Instead the Bimbadeen Basalt (probably emplaced in a marine environment) has been correlated with basalt in the Lochinvar Formation.

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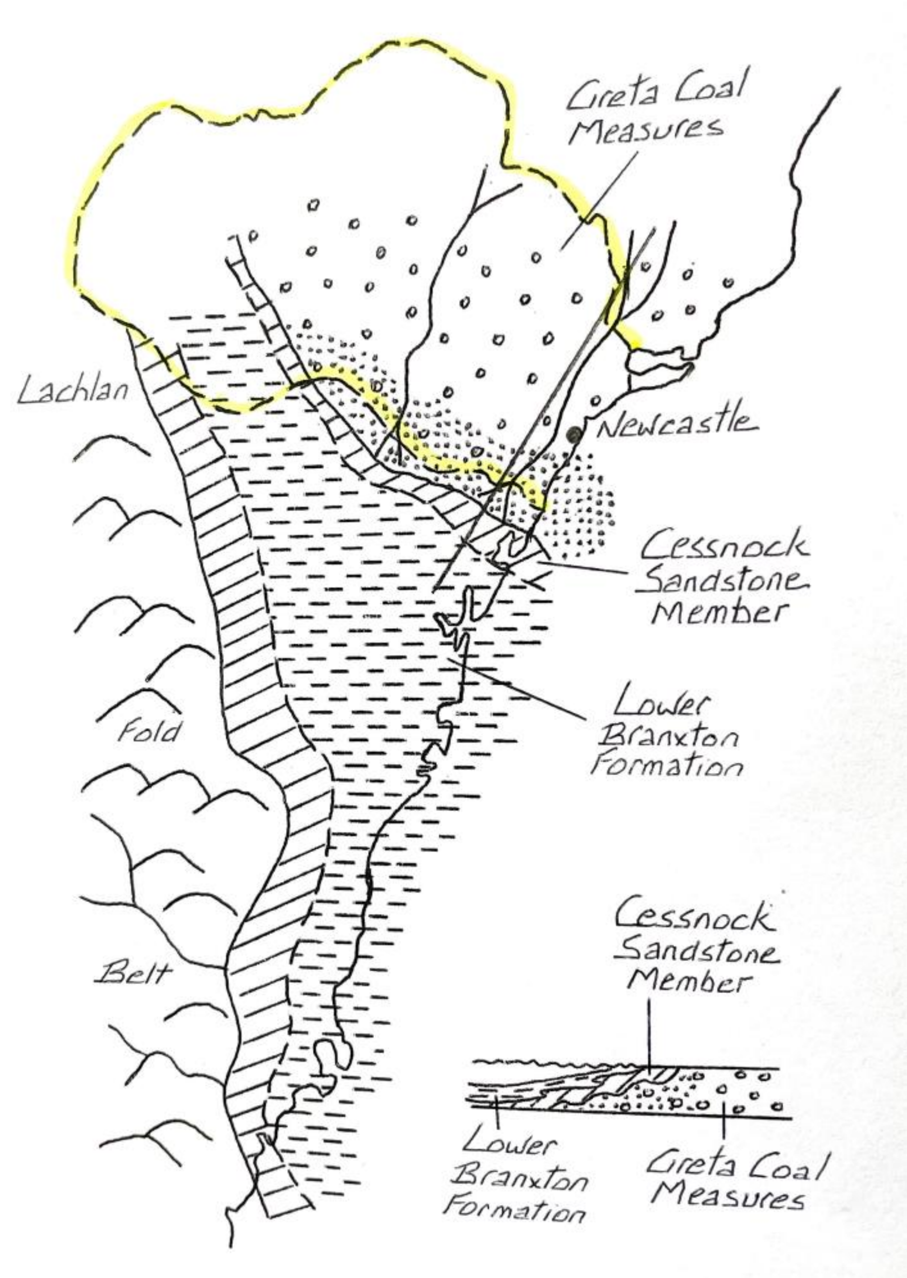


Figure 6.

Basin-wide subsidence resulted in the former fluvio-deltaic plain of the Greta Coal Measures being transgressed in a northerly direction by a thin shoreline sand, the Cessnock Sandstone Member at the base of the Branxton Formation. This sand probably derived from the underlying fluvio-deltaic sediments. The overlying Branxton Formation was deposited during a steady marine transgression with the sediments derived from a source to the north or northwest.

Uplift of the New England Fold Belt and rapid subsidence of the adjacent Sydney Basin did not occur till after the Mid-Permian Hunter Orogeny.

Information Sources.

The maps are based on Figures 2.6, 2.9 and 2.10 in HERBERT, C. and HELBY, R. (1980). *A guide to the Sydney Basin*. Department of Mineral Resources. Geological Survey of New South Wales. Bulletin No. 26.

Geological data was sourced from the above reference and GILMORE, P. and GREENFIELD, J. (2012). *Field excursion guide to the Mount View area, Hunter Valley, New South Wales*. Geological Survey of New South Wales.

Compiled by Brian England.

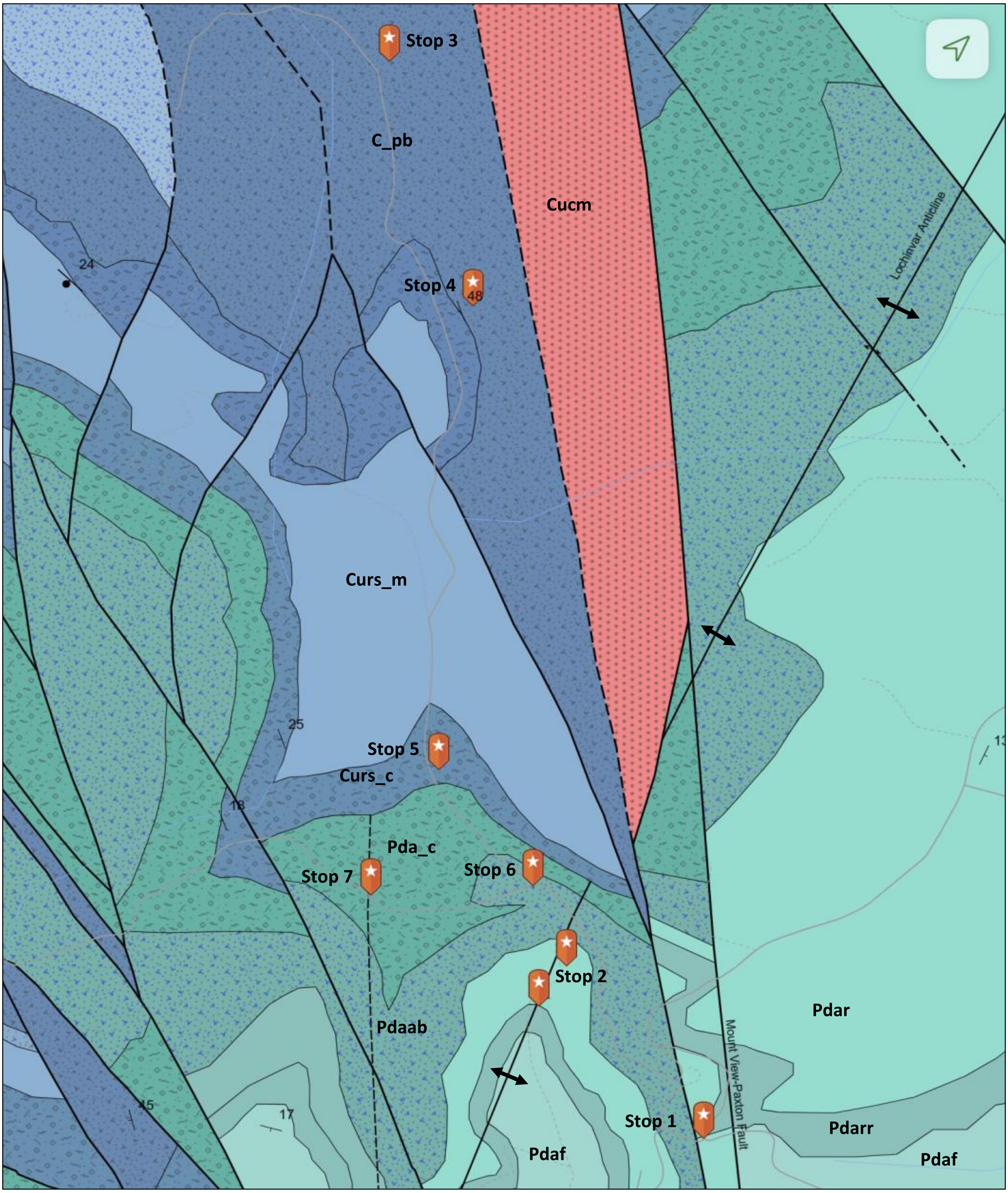


Figure 7.
Geological map showing the precise locations of Stops 1 to 7.

<u>Key</u>:

Pdaf:	Farley Formation	Pdar:	Rutherford Formation
Pdarr	Ravensfield Sandstone Member	Pdaab:	Bimbadeen Basalt
Pda_c	Dalwood group - Conglomerate	Curs_m	Seaham Formation - Mudstone
Curs_c	Seaham Formation - Conglomerate	C_pb	Mt. Bright Ignimbrite Member
Cucm	Mt. View Range Granodiorite		

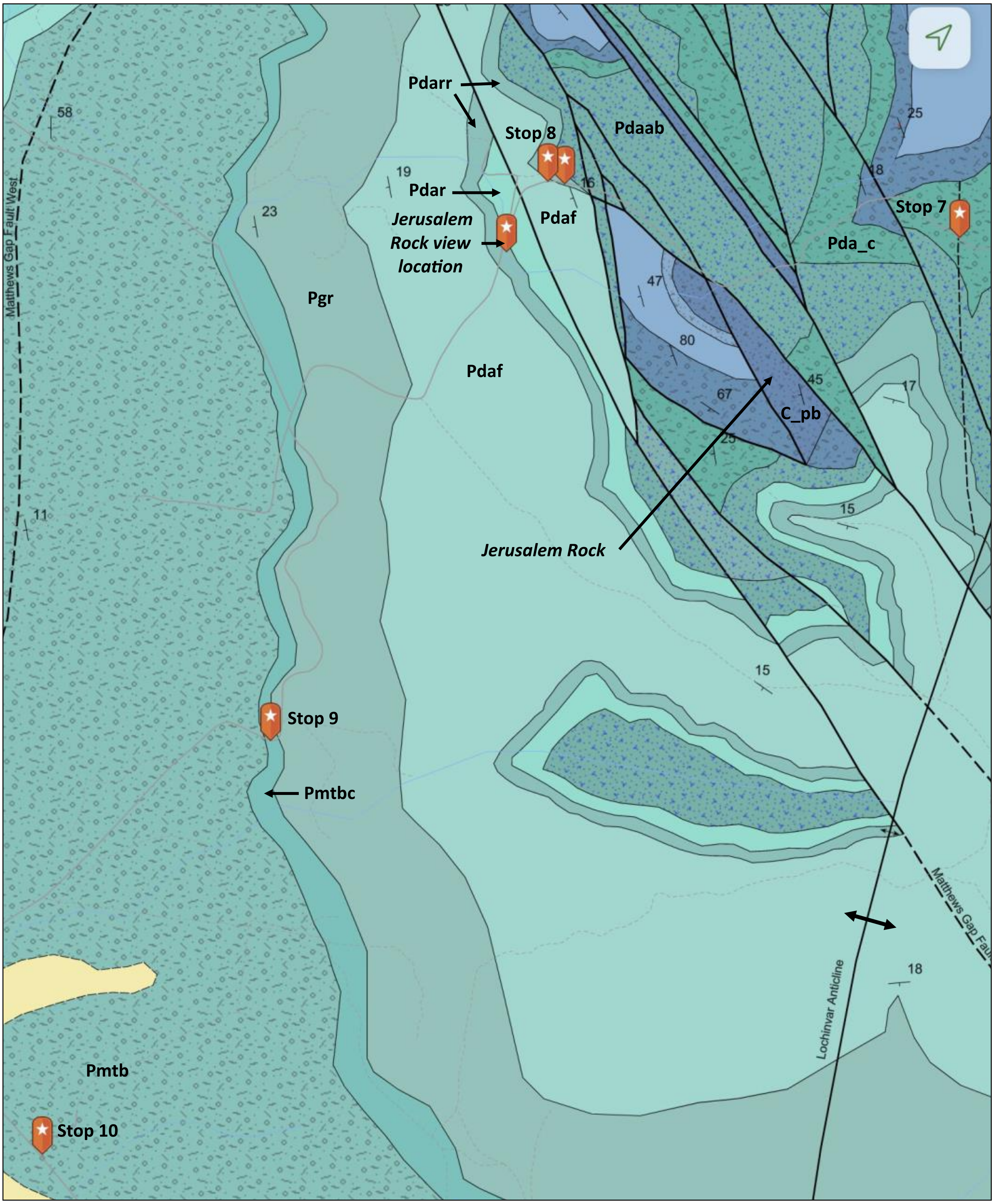


Figure 8.

Geological map showing the precise locations of Stops 7 to 10.

Key:				
	Pgr	Greta Coal Measures	Pmtbc	Cessnock Sandstone Member
	Pdaf:	Farley Formation	Pdar:	Rutherford Formation
	Pdarr	Ravensfield Sandstone Member	Pdaab:	Bimbadeen Basalt
	Pda_c	Dalwood group - Conglomerate	C_pb	Mt. Bright Ignimbrite Member

Mission to Mars

Presenter: Dr. Jeanette Dixon AM.
Date: Thursday 17th February 2022.
Attendance: 16 members and 3 visitors.

This was the second talk presented by Dr Jeanette Dixon to our group at Club Macquarie. Once the slide show had been transferred to another computer, the talk proceeded relatively smoothy. The Power Point presentation consisted of 74 slides loaded with information. The following is a summary of that talk with some selected interesting highlights.

Dr Jeanette Dixon AM has over 50 years of experience as a Space Science/Science/STEM educator, who has worked as a NSW secondary science teacher and at the University of Newcastle preparing trainee secondary science teachers and Master of Teaching students for their future profession. As a result of her Space Science and Geology educational research at the Johnson Space Centre in Texas, Jeanette is the only individual in Australia to be honoured by NASA's Manager of the Apollo Lunar Samples with a long-term loan of some of these samples. This is from the priceless national treasure of lunar samples collected by Apollo astronauts on Missions 15, 16, and 17. Outside of professional employment, her voluntary outreach initiatives have provided quality Space Science/Science/STEM education at regional, state, and national levels for students of all educational systems, professional development for practicing teachers, and space science talks for well over 200 community group invitations and events. She was a guest speaker for the Australian Government at Parkes Radio Telescope for the 50th anniversary of the Apollo 11 Moon landing.

Nasa Ingenuity Mars Helicopter.

The presentation started off showing a short clip of the Ingenuity helicopter flying around on Mars.

Dr Jeanette Dixon AM starting her presentation.

Currently a trip to Mars, with Earth and Mars aligned in optimal positions, may take 6 to 9 months. A return trip including time spent on Mars would take about 3 years. Recently a suggestion has been put forward that could cut the trip to 6 weeks using lasers on earth to boost the spaceship using an onboard reflector to focus on the reaction chamber.

Mars compared to Earth.

A good way to get some perspective on Mars is to look at it in comparison to Earth. Mars has featured long in our history and is named after the Roman God of War. A day on Mars is 24.62 hours and one Martian year is equivalent to 1.88 Earth Years.

Mars has approximately half the diameter of Earth, is 11% of Earths mass and has 38% of Earth's gravity. A person weighing 100 kg on Earth would only weigh 38 kg on Mars.

Mars circles the sun at about 228 million kilometres. The average distance from Earth is about 78 million kilometres

Currently Mars is a cold desert world with only a thin atmosphere. Mars formed about 4.5 billion years ago. At that time, it had a much thicker atmosphere and flowing water and its core was liquid iron producing a magnetic field protecting the atmosphere. About 4 billion years ago, the magnetic field shut down, allowing the solar wind and radiation to strip away the air and the water to evaporate away.

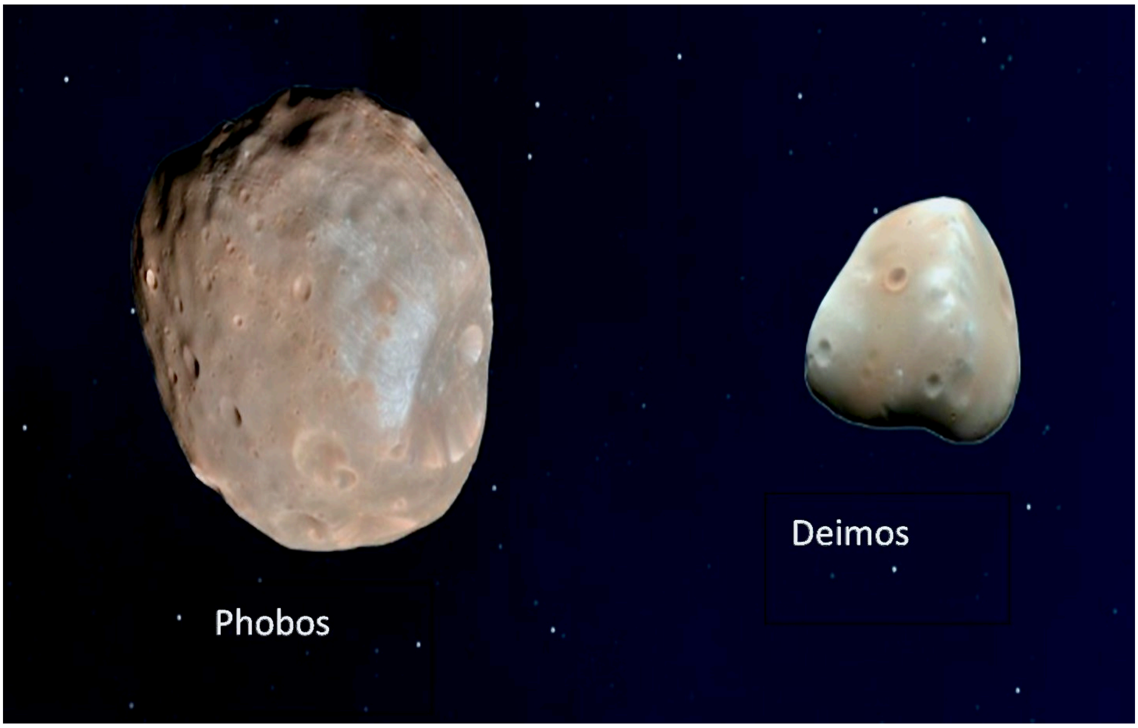
Mars has two small moons. The larger of the two, Phobos, is named for the Greek God of Fear and Panic. It is slowly moving inwards towards Mars and will eventually breakup, forming a ring around Mars. Phobos travels around Mars three times a day. Deimos, named after the Greek God of Dread and Terror, is slowly moving away from Mars and will eventually escape its gravity. It travels around Mars in 30 hours, or about 1¼ days.

The Martian sky is a butterscotch colour due to the fine rusty red coloured dust in the atmosphere. The sky at night is dark blue and the sunset is blue. The brightness or strength of the daylight on Mars is like wearing sunglasses on Earth.

The Martian atmospheric pressure is less than 1% that of Earth. The Martian air is not only unbreathable because of the low pressure but it mainly consists of CO_2 95%, N_2 2.7%, Ar 1.6% and O_2 is only 0.13%.

Clouds have been observed on Mars. The Martian clouds are icy, consisting of frozen CO_2 or water ice H_2O. The northern winter can have water-based snowfalls. In the southern winter, it is cold enough for carbon dioxide snowfalls to occur around the South Pole.

Dust storms are a common feature. Wind driven dust has been measured at 4 to 5 micrometres, much like smoke particles. Wind speeds in the strongest dust storms rarely exceed 100 km per hour, and most have less than half typical hurricane speeds on Earth, but due to the thinness of the air, they lack the intensity to those on Earth and would feel more like a breeze. Dust devils can be 8 to 10 kilometres high, but they are like very, very weak tornados and would not cause any major problems with equipment or people. The main problem with the dust is its electrostatic nature meaning it will stick to surfaces like solar panels and clog exposed moving parts such as gears.



Martian Moons.

Surface Geology and Landscapes.

Mars is classified as a terrestrial planet, with surface rocks of primarily tholeiitic basalt and small amounts of other rock types. The Martian surface is covered by rocks, glaciers, cliffs, dunes and polar ice caps and other landforms like those of Earth. The regolith consists of a layer of loose, unconsolidated deposits covering solid rock including fine dust, sand and broken rocks. In the past, liquid water flowing in gullies and river valleys may have shaped the Martian regolith.

Volcanos are evident on Mars. The Olympus Mons Volcano, a shield volcano, at 27 km high is the largest volcano in the solar system, dwarfing the shield volcanos of Hawaii. (The height is 22 km above the surrounding plains or 27 km high above the average surface height depending on how it is measured.)

Lava tubes have been found on the flanks of some Martian volcanos and have been suggested as possible future habitat with the rock tube sealed, offering radiation protection and breathable environment once pressurised.

Impact craters are a common feature. "splosh craters" are an impact crater that formed when a meteorite hit an area rich in water. Some of the ejected material behaved more like mud than rock. After impact, one crater had part of its wall breached with water flowing out as evidenced by river channel flow patterns.

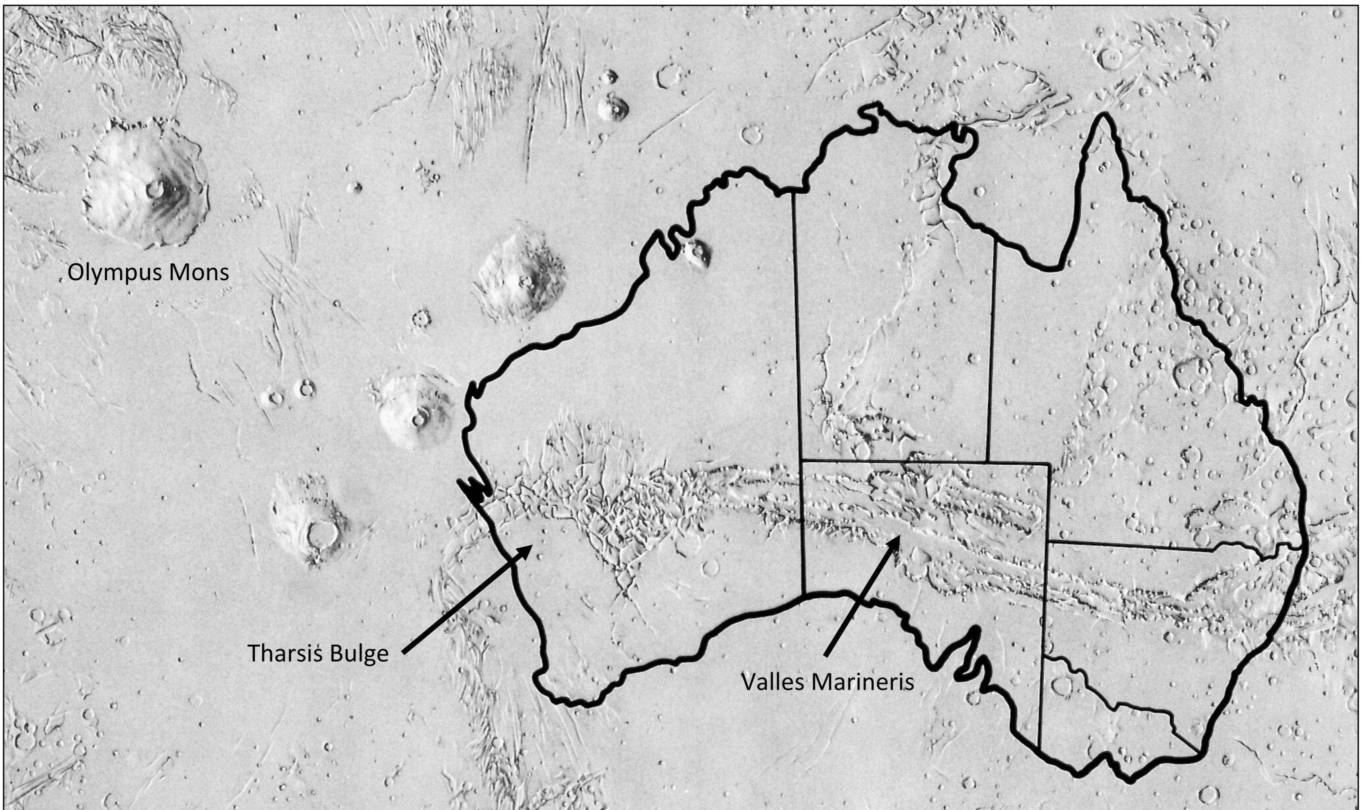
There is an impact crater called the "Tree Stump" Crater that looks just like a tree stump with its characteristic growth rings. It is probably filled with water-ice rich material that has shrunk and swelled with seasonal temperature changes creating these quasi-circular and polygonal patterns of fractures.

Aeolian dunes occur in many areas and have a variety of characteristic dune shapes.

Valles Marineris is a huge canyon feature along the Martian equator, many times larger than the Grand Canyon. It has a length of 4000 kilometres, up to 200 km wide and 6 -10 km deep and if superimposed would sit across Australia or the USA.

The Insight Lander had a sensitive seismometer as part of its equipment. It has since recorded hundreds of earthquakes with approximately 35 being between the magnitude of 3 to 4. It has shown that there are no tectonically active plates on Mars. It is thought that quakes are caused by stress as the interior of planet is cooling and contracting. Most of the larger quakes originate around Cerberus Fossae, an extensional fault in a region that was volcanically active in the last 10 million years and comparatively young. Mars is composed of three layers, crust, a solid mantle and a surprisingly large liquid core with a radius of 1830 km compared to Mars's radius of about 3400 km.

Most Martian volcanism occurred 3 to 4 billion years ago with some as recent as 2.5 million years ago. The most recent volcano was 50,000 years ago.



Comparison of Valles Marineris, the Tharsis Bulge, and Olympus Mons with Australia.

Evidence of Ancient Water.

Curiosity Rover in the Gale Crater found desiccation cracks indicative of significant water such as a lakebed. It found eroded sedimentary layers of sandstones, conglomerates and mudstones. In Gale Crater, there have been found rounded pebbles that are orientated, indicating a stable flowing stream. Hydrated minerals such as gypsum, clays and carbonates suggest there was once significant amounts of water. Boron has been found in veins of gypsum, an element that may be necessary for life to form.

Mars Opportunity Rover has found so-called "Blueberries", small spheres that appeared blue in the blue-shifted false colour photos and analysis showed that they were composed of hematite. It has been suggested that these nodules or concretions can only have formed in water, and it is speculated that they are actually hydrohematite, Fe_2-x(OH)xO_3-x, where hydroxyl has partially substituted for the Fe i.e., water substituted into the hematite crystal lattice. A more sophisticated analysis of these "Blueberries" will be needed to resolve the issue. Due to the quantity found, they may potentially be a source of water.

Ancient lakes, flood plains and river channels and meanders can be seen. There are tear-drop shaped islands indicating flowing water around high standing impact craters indicating a flooding event.

As described above, splosh craters show that some areas have substantial amounts of water in the subsurface.

Phoenix Lander with its robotic scoop exposed and photographed water ice as it evaporated.

Mars at the present has significant amounts of water in the form of sheet ice, permafrost, and glaciers.

Other Discoveries by the Curiosity Rover.

Rock analysis by the Curiosity Rover in Gale Crater has found them to be enriched with the smaller lighter ^{12}C compared with the heavier ^{13}C. This contrasts with the Martian atmosphere which is enriched in ^{13}C. This enrichment in ^{12}C could be from early times when Mars passed through a cosmic cloud, also enriched in ^{12}C, or that radiation preferentially reacted with CO_2 to produce organics deposited in the rock enriched in ^{12}C. Another explanation is that it could be an indication of ancient microbial life on Mars, as life on Earth prefers to use ^{12}C in its biological processes.

The Curiosity Rover has detected seasonal variations in methane (CH_4) levels increasing in summer and dropping in winter along with transient plumes of methane. Methane persists in the Martian atmosphere for about 340 years indicating that it is continually replenished. Scientists say that methane could be released from being trapped in the ice below the surface by fracturing of the ice, or when temperatures warm. Methane could also be produced by geological processes via chemical reactions in rocks or UV degradation of organic compounds from comets or meteors. Another explanation is that methane could be released by bacteria, as happens on Earth, consistent with signs of life on Mars, but not yet proved.

The Viking, Pathfinder, Spirit, Opportunity and Curiosity landers have analysed the chemical composition of the regolith. "Based on these data sources, scientists think that the most abundant chemical elements in the Martian crust are silicon, oxygen, iron, magnesium, aluminium, calcium, and potassium. The elements titanium, chromium, manganese, sulphur, phosphorus, sodium, and chlorine are less abundant, but are still important components of many accessory minerals in rocks and of secondary minerals (weathering products) in the dust and soils (the regolith)."

A large range of organic compounds was found including complex compounds such as kerogen and thiophenes. Curiosity Rover in the Gale Crater, identified these by drilling into mudstone, heating the grit and the resulting gasses analysed by mass spectrometer. "The mass patterns looked like those generated on Earth by kerogen, a goopy fossil fuel building block." Kerogen can be typically found with large sulphur-bearing carbon ring compounds called thiophenes. The presence of carbon-sulphur bonds in the macromolecules could have contributed to the preservation of the organic matter for a very long time.

Kerogen is a complex mixture of organic chemical compounds in the form of an organic waxy insoluble matter. On Earth, it is found in sedimentary rocks such as mudstones and oil shale. The original organic matter can be derived from algae, plankton, bacteria and plants. They can also be found in stromatolites and microfossils. During diagenesis, including pressure and heating, the mixture changes to larger macro-molecular and aromatic compounds. On further heating, kerogen starts breaking down to tar, oil and gas.

On Mars these organic compounds can act as possible indications of ancient life, but is not yet conclusive

Both the Curiosity and Perseverance Rovers found Martian rocks having coatings similar to desert varnish. The colour can vary from green to purple and black. Spectroscopy found the coatings to contain manganese, different types of iron oxides (rust) mixed with clay minerals. It was suggested that water played a role in the formation of the rock coatings. This rock varnish on Earth is associated with microbes such as cyanobacteria using the coatings as a sunscreen.

Perseverance Rover in Jezero Crater was sent to test for signs of life. Jezero Crater was once a lake with a river delta visible today. Organic molecules have been detected within rocks and but also dust their surfaces. It has found olivine inside pyroxene crystals indicating that the crater floor bedrock was once molten magma. Clays and carbonates. that only form with liquid water, suggest the lake was fresh water.

Martian soil has a pH of 7.7 and contains perchlorate ClO_4^- salts of Mg, Na and Ca at about the 1% level. This is toxic to plants, rendering crops grown in it unsafe, and toxic to humans. Perchlorates indicate water as brines and can persist at very low temperatures, that could allow liquid water on Mars. Perchlorates as a resource, can be used for a source of Oxygen. It is also a powerful oxidant and as ammonium perchlorate, can be used in rocket fuel and explosives.

Martian soil can be used for growing crops as it has all the basic minerals but would need a good hydroponics setup to remove perchlorates and to add nitrogen and soil microbial supplements.

After the talk, Dr Dixon was presented with a bottle of wine as a small token of our thanks for her presentation followed by lunch at the Club Macquarie bistro.

Dr Jeanette Dixon AM Acknowledgement.

On behalf of the AGSHV, I would like to thank Dr Jeanette Dixon for taking the time to give her informative and interesting talk to our group.

Also, many thanks to Jeanette for allowing me to make use of the power point slides she had prepared and their information as a guide in preparing this report.

Club Macquarie acknowledgement.

On behalf of the AGSHV, I would like to thank Club Macquarie and their staff for providing facilities that supported our talk.

Report by Dr Jeanette Dixon,
edited by Richard Bale.

Photographs.

Dr Jeanette Dixon AM – Taken by Maree Bale

Ingenuity Helicopter - nasa-ingenuity-mars-helicopter_9kzf.960-modified.jpg

Martian Moons - (Picture after https://mars.nasa.gov/all-about-mars/moons/summary/)

Picture: Comparison of Valles Marineris, the Tharsis Bulge, and Olympus Mons with Australia. https://www.flickr.com/photos/lunarandplanetaryinstitute/4090063712/

Half a Lifetime of Archaeology

Presenter: Dr. Peter Mitchell.
Date: Thursday 21st April 2022.
Attendance: 20 members, 1 visitor.

For the past 40 years I have worked with archaeologists and Aboriginal communities over much of the eastern half of Australia and this talk described how I became involved in archaeology as a geomorphologist and presented some examples of my experience. What I have written here is not a verbatim account but it carries the same messages – enjoy, or jump up and scream if you prefer.

Like most of us of 'a certain age' my education provided very little understanding of Aboriginal people or their history. Although I grew up in a country market town I never knowingly met an Aboriginal person, textbooks of the day barely mentioned them, and only one teacher ever inspired me with an interest in Australian history, thank you Dr Barry Jones – yes, that one!

Ernest Scott's Short History of Australia had 32 Chapters on the history of everything – except the First Australians. In fact, 'the blacks' are mentioned less than 10 times and nearly all in reference to Batman's treaty in Victoria or 'The Black Wars' in Tasmania. Things didn't get much better with the publication of Manning Clark's six-volume A History of Australia, published between 1962 and 1987, and even some of his sources are suspect. He repeated the erroneous story of Bennelong meeting King George by drawing on the fictional account by Eleanor Dark in her The Timeless Land (1941). It has been said that Clark would have liked to write the convicts out of the Australian story too, except that they had 'gentlemen' in charge of them.

As a Victorian I knew about Pastor Doug Nicholls – well he was a footballer wasn't he? School kids had heard of loyal Jackey Jackey because he was mentioned in school magazines. The faithful guide to Edmund Kennedy exploring Cape York in 1848 who was with him when Kennedy was killed. He made it into history books because the Government of the day rewarded him for his courage and commitment. But did you know that he was only 15, that his real name was Galmahra, that he was a Wonnorua boy from the Hunter Valley?

Our ignorance often leads us astray and even when we are well meaning we often gets things wrong.

In fact, on my way home from the talk my eye caught a new image promoting Holy Cross College in Ryde. It acknowledges Wallumadegal land – an action that I approve, but it uses an X-ray style image of a barramundi. So, it's Aboriginal isn't it? Wallumudegal actually refers to the snapper fish people. Snapper don't

Dr. Peter Mitchell presenting his talk on archeology at Club Macquarie.

look anything like barramundi and X-ray style paintings are limited to Arnhem Land. The image is inappropriate to the message and I haven't even asked if the College has permission to use it. Is this really just ignorance or is there something deeper in the Australian psyche that keeps tripping us up?

Let's put those injustices aside and get to some archaeology.

Some of the first serious archaeology in Australia was examination of shell mounds on the northern rivers of NSW in the 1890s. They were very extensive at Ballina where a road engineer E.J. Statham was digging them up to use as road base, but he took an interest and sectioned one. He compared his finds with shell mounds in Denmark and estimated that it contained 12,000 m^3 of oyster shell that would have taken 1,800 years to accumulate. He also recorded human burials in them. That age guess was remarkably good and has since been matched by ^{14}C dates. But the bad news is that almost all of those huge shell mounds have vanished with very little real investigation.

Having trained as a geologist and then becoming a geomorphologist how did I get into archaeology?

My first real connection was with a midden at Kurnell – Cook's landing place. Excavated in 1970 by a team of students under Prof Vincent Megaw from Sydney University, it produced a wealth of data from about 10 m^3 of deposit with a basal date of 3,700 years. We found a variety of shell species, shell fish hooks and fish hook files as well as remains of dingo, seals, fish, and a few European artefacts near the top but nothing you could link to Cook, although we know he walked over that very ground.

I made two latex peels of the excavated face. One ended up in the Kurnell museum and the other rather larger one is at Macquarie University. It's ironic that peels that were made for display and would not be expected to survive more than a few decades are still in good condition 52 years later and are the only tangible record of the stratigraphy. This dig was probably the first big excavation done under the then new heritage legislation managed by NPWS but it is also typical of their legacy of management and record keeping as the data was never fully worked through or published.

From that time on I began to get calls for assistance on dig sites. My Honours degree had looked at soil material distribution on the sandstone slopes and across the floor of Peats Crater in Muogamarra, and we came up with a new model of soil genesis that substantially changed our understanding and which had important implications for understanding the archaeology of open sites. Prior to my work the standard story was that soils with a marked texture contrast between topsoil and subsoil were mature profiles that could be as much as 30,000 years old. My explanation said; No, they can be formed in only a few centuries as a result of the combination of active bioturbation by ants and worms etc, plus frequent surface erosion by rain-wash. And what is more, the stone layer you find at the base of the topsoil, which is where all the artefacts accumulate is actually a time transgressive unit that cannot be used to date the archaeology. Well, that was all news to the archaeologists but 30 years later most have come round to my way of thinking, but what they don't know is that I have moved on! Keep that to yourself or I'm out of a job.

To be fair archaeology has also moved on. It used to be treasure hunting, searching for axes, grindstones and skeletons and taking almost no notice of their context. Look at the collections of any folk museum in the country and you'll find boxes of treasures in the back shed with no provenance.

Beginning in 1965 and in all States by 1975 we had legislation that was intended to control the treasure hunters. Artefacts legally belong to the Crown, but morally local Aboriginal communities should have greater rights, although they don't. Before the 1980s excavation rarely involved consent or involvement of Aboriginal people and then with the need to write environmental impact statements and the like it suddenly became big business and communities began to benefit through employment. That has been a mixed blessing. On the one hand we have learnt a lot about Aboriginal pre-history but on the other hand development pressures have driven the research agenda and we have dug an awful lot of uninformative sites at considerable expense. We would now be better off doing salvage work on places that will be disturbed and having developers invest in more focussed research at other locations where there may be answers to our questions about the >60,000 years of human occupation. At present the legislation does not enable that sort of offset and despite several attempts to review legislation we have not achieved much change and Aboriginal people still do not have control over their heritage.

And what a heritage it is! Think rock art sites in shelters, engravings on sandstone, deep and ancient midden deposits that have recorded human responses to changing climates through the late-Pleistocene ice ages and so on …

Some examples; Narrabeen man, an accidental discovery under a bus shelter when a cable trench was being installed. Dated at 3,677 years he had the misfortune to die from two spear wounds and a couple of blows to the head. His body was left to lie on a bare sand patch on the crest of the dune where it was partially burnt and buried by natural processes. This is the earliest evidence in Australia of death by spearing. His diet was dominated by marine foods. The incident occurred when sea level was 2 m higher than present, and when Narrabeen Lagoon was probably an open estuary.

Was the higher sea level a local stress factor causing social unrest? That's archaeological speculation. Or was he just a naughty fella who was caught running away with a local girl as Alan Madden suggested? That Aboriginal story-telling, but I don't mind either way.

Open site in the Hunter Valley. Every flag indicates an artefact.

Magnetometer search for graves on a soil mound at Mapoon.

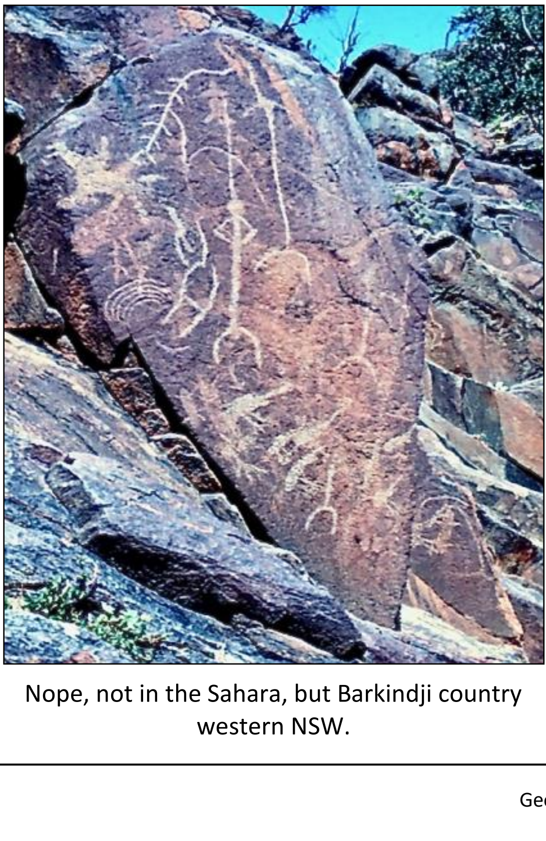
Rock shelters with or without art can have stratified and dateable occupation deposits. These are the best locations for serious work but they are scarce, you need a good reason to dig them, you'll only be allowed to dig a small proportion, you need the right tools and people, and must report the results, because once dug that part no longer exists. Archaeology can be very destructive.

We have spent considerable time in the Flinders Ranges searching for rock engraving sites and rock shelters where we hoped to find older material. It took several years but we found both and only really worked on two properties. Two of the engraving sites we found have as many as 2,000 figures and are totally unrecorded. We have no idea of their age except that they look 'old' and local people claim to have little knowledge of them.

We got really lucky in a very small shelter with 1m of depth of deposit, all very finely laminated with a base date of 49,000 years. When published in 2016 it was the oldest arid zone site in Australia but that has since been eclipsed. We literally made headlines around the world for about two weeks and if you Google 'Warratyi' you'll get about 200 hits in every language you can think of.

I have spoken to many of you before about my unfinished business with Woollarawarree Bennelong (1764-1813). It's still unfinished! The history books have his story all wrong as the real man was an important Wangal elder, our first Aboriginal envoy, an important negotiator between the Sydney clans and the First Fleeters and even though he did go to Britain with Phillip he did not meet King George III.

Bennelong died in 1813 and shares a grave with the two first stolen generation children - Boorong, the daughter of Maugoran, a Burrumattagal elder, and Gooroberra, and Nanbarry, a nephew of the Cadigal leader, Colebee.



Nope, not in the Sahara, but Barkindji country western NSW.

We know quite a lot about these three and you would think that the grave of such people would be well known. Well, it isn't but with a lot of sleuthing I managed to locate the site in urban Putney and with a lot more lobbying we somehow convinced the State to purchase the property at market price 9 years later. That was nearly 4 years ago and I am still waiting for the Feds to come to the party and for all the politicians to make a big stand and acknowledge the place in the name of reconciliation.

Politicians are weird people (assuming they are actually people), it's a no-brainer in my mind and they could garner buckets of brownie points at little expense but none have yet seen the light. Never mind, if you guys all vote the right way we'll get a change of government in a few weeks and I'll start pushing them again.

Bennelong is fascinating bloke and if you would like to learn more chase the web site 'Finding Bennelong' and watch out for a series of podcasts coming soon!

Report by Dr. Peter Mitchell.

Bennelong, National Library.

Mid to North Coast Safari

Leader: Chris Morton.
Date: Sunday 8th to Saturday 21st May 2022.
Attendance: 26 members.

Aim.

To investigate coastal geology and structural evolution of the early Permian Nambucca Block and Coffs Harbour Beds within the Coffs Harbour Block. (New England Orogen, eastern Australia).

Introduction.

This expedition to the Mid North Coast of NSW enabled AGSHV society members to examine and assess some of the geological and structural aspects that are important in understanding the evolution of the New England Orogen (NEO) and the orogenic curvatures termed the New England oroclines *(Figure 1)*.

Many of the structural elements that help define the processes involved with these events outcrop on the coastal rocky platforms and headlands between Crescent Head within the Nambucca Block (NB) to the south, and Brooms Head within the Coffs Harbour Block (CB) to the north, termed as the northern part of the Southern New England Fold Belt (SNEFB).

Leitch (1974) described the Southern New England Fold Belt (SNEFB) as a subduction/accretion complex formed during continental plate-oceanic plate collision during the Devonian and Carboniferous. The western forearc (Tamworth Belt) and the eastern subduction/accretion complex (Tablelands Complex) formed during the subduction of a west-dipping oceanic plate. The SNEFB is still not completely understood and is the subject of ongoing debate, but is becoming clearer as further studies are presented.

This excursion will be restricted to the northern two blocks of the SNEFB, namely the Nambucca and the Coffs Harbour Block *(Figure 2)*. So, to gain an understanding of the complexities involved, we will follow in the footsteps of former and present geologists such as Korsch, Johnston & Offler et al., Fielding,

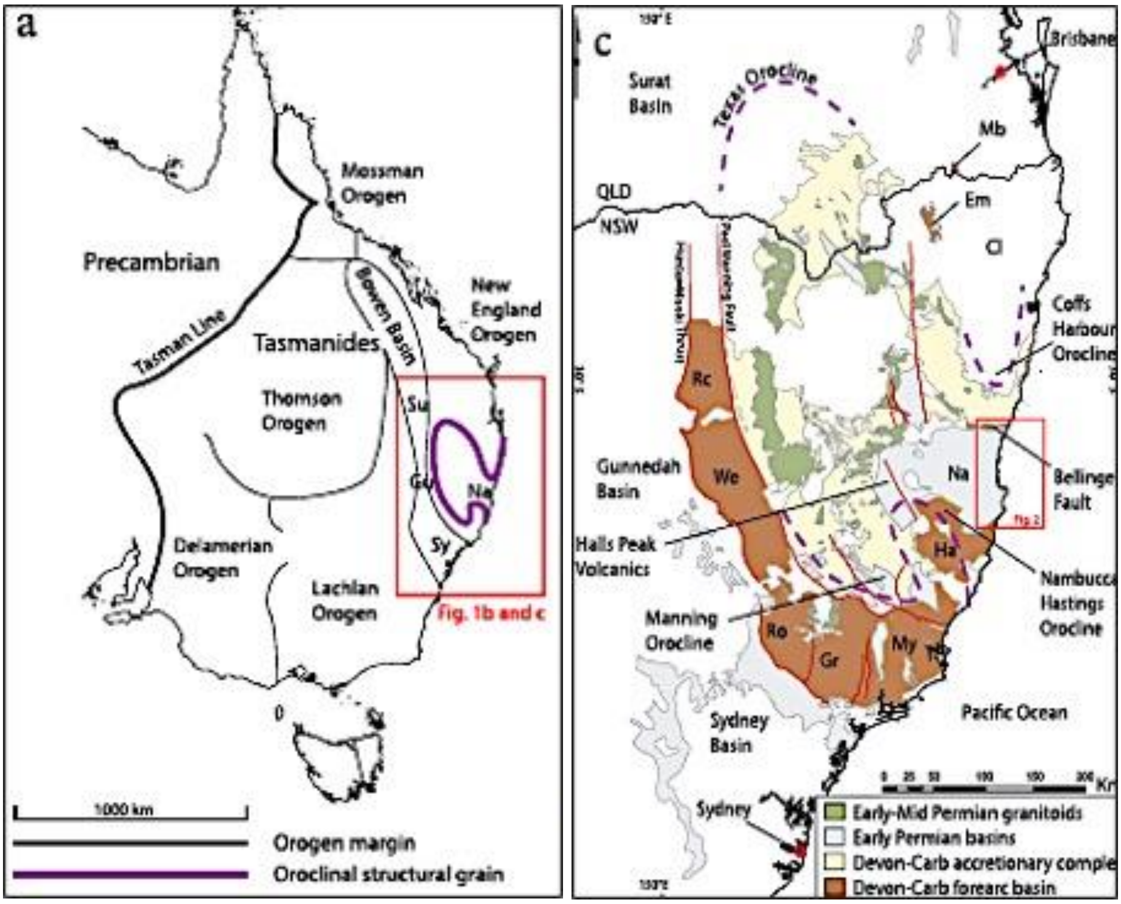


Figure 1. (a) Simplified tectonic map of eastern Australia showing the location of the New England Orogen within the Tasmanides [after Myers et al., (5) 1996; Glen (6*), 2005; Cawood and Korsch, (7*) 2008]. Purple line indicates the structural grain of the New England oroclines. (c) Geological map of the southern NEO highlighting mid-Permian and older rocks. Abbreviations: Cl - Clarence-Moreton Basin; Em - Emu Creek Block; Gr - Gresford Block; Ha - Hastings Block; Mb - Mount Barney; My -- My-all Block; Na - Nambucca Block; Rc - Rocky Creek Block; Ro - Rouchel Block; We - Werrie Block.* (Diagram by, Shaanan, Rosenbaum, Vasconcelos, et al., 2014).

Shannan and Rosenbaum, et al., who have written several scientific papers on these areas.

Plain language summary.

Giving a definitive and complete interpretation of the geological setting is somewhat problematic and is beyond the scope of this activity due to the discord and controversy among many authors. So, in general, I have tried to depict a general overview of the area. Beyond that, we will concentrate on the structural evidence that many geologists have based their theories on.

Planning for this excursion began in 2018/19 with the first reconnaissance trips. A third reconnaissance trip took place early in 2021, with the expedition planned to take place in October 2021. However, the Covid pandemic was in full swing during this period. So we postponed the event until May 2022. But then, early in 2022, the North Coast and most of the east coast of New South Wales endured unprecedented flooding to most river systems. Continuing record rain events put the trip in jeopardy. But fortunately, we were able to proceed with this adventure working around most obstacles and managed

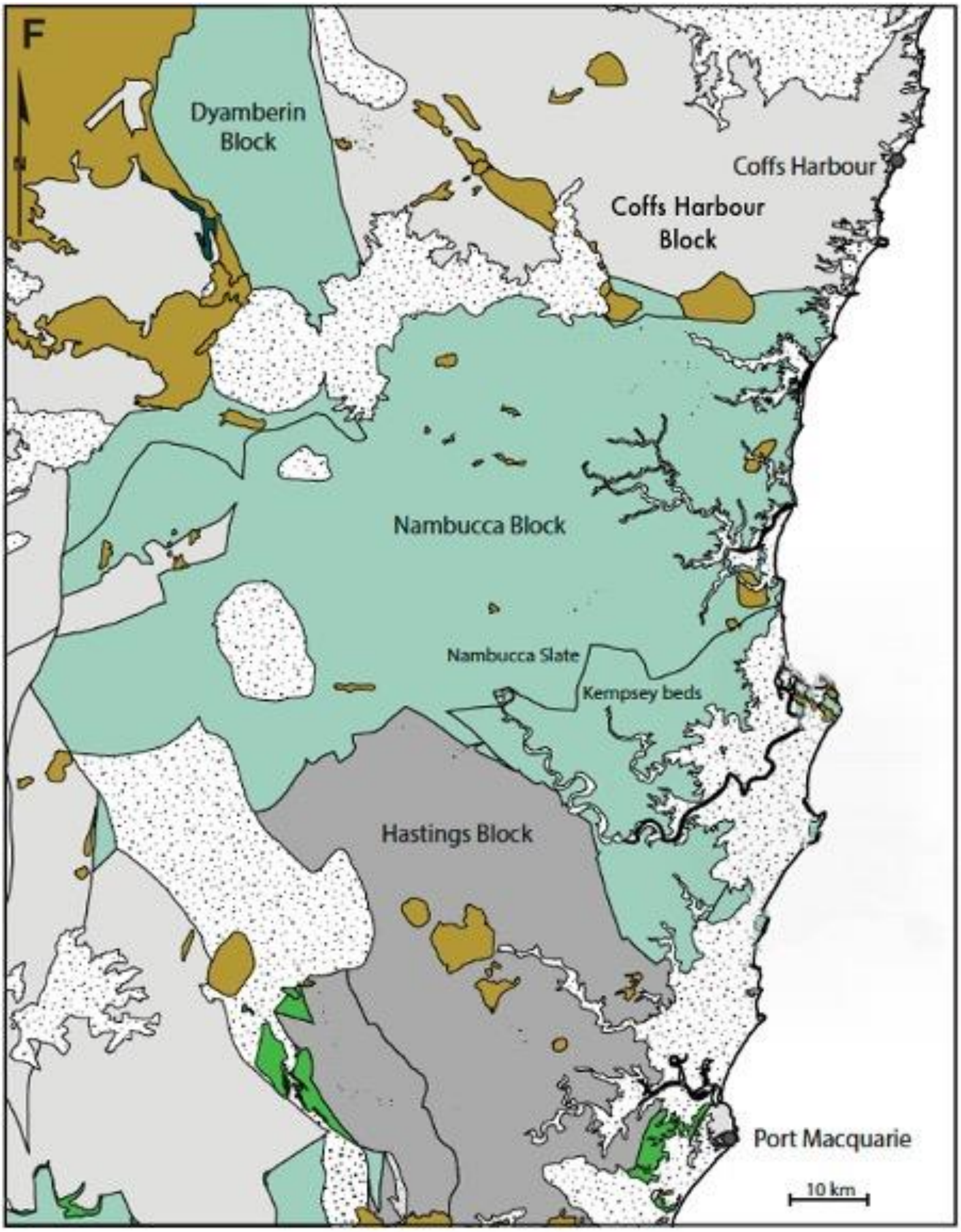


Figure 2. Geological map of the Nambucca block and its vicinity. Devonian to Carboniferous. (Modified from- Fielding, Shaanan, Rosenbaum, 2016)

to visit all but two of our planned destinations.

In many aspects, considering all the obstacles placed in our way, it goes without saying, that if it were not for the tenacity and resilience of our members, we would never have been able to run this safari.

Geological Setting.

Nambucca Block.

Structural studies of Lower Permian sequences exposed on wave-cut platforms within the Nambucca Block (NB) *(Figure 2)* indicate that one to two ductile and two to three brittle-ductile/brittle events are recorded in the lower grade (sub-greenschist facies) rocks. Evidence for four, possibly five ductile, and at least three brittle-ductile/brittle events occur in the higher grade (greenschist facies) rocks.

Further, the studies reveal a change in fold style from W-SW trending, open, S-SE verging, inclined folds at Grassy Head *(photos 1 & 2)* in the south, to E-NE trending, recumbent, isoclinal folds, at Nambucca Heads to the north, suggesting that strain increases towards the Coffs Harbour Block. The deformation and regional metamorphism in the Nambucca Block is believed to be the result of indenter tectonics, whereby south-directed movement of the Coffs Harbour Block during oroclinal bending sequentially produced the E-W trending structures (Johnston & Offler, 2010).

Coffs Harbour Block.

This block is bounded on the south and west by the Bellinger and Demon Faults respectively, and the area where these faults should intersect is covered by a thick sequence of Cainozoic basaltic rocks. Structural studies indicate three generations of folding within the Coffs Harbour Block (CB) *(Figure 2)*.

The Upper Palaeozoic deformed clastic sediments consist of massive to well-bedded greywackes, siltstones, mudstones, cherts and jaspers. Bedding is distinct in the north but is progressively less distinct in a southerly direction until it is nearly obliterated by increasing deformation and metamorphism. A low-grade regional metamorphic event of sub-greenschist to greenschist facies has been overprinted on the southern portion of the block by a static thermal event. One major episode of deformation produced mesoscopic folding with an axial plane cleavage, and there has been subsequent minor folding of a localised nature. Both syntectonic

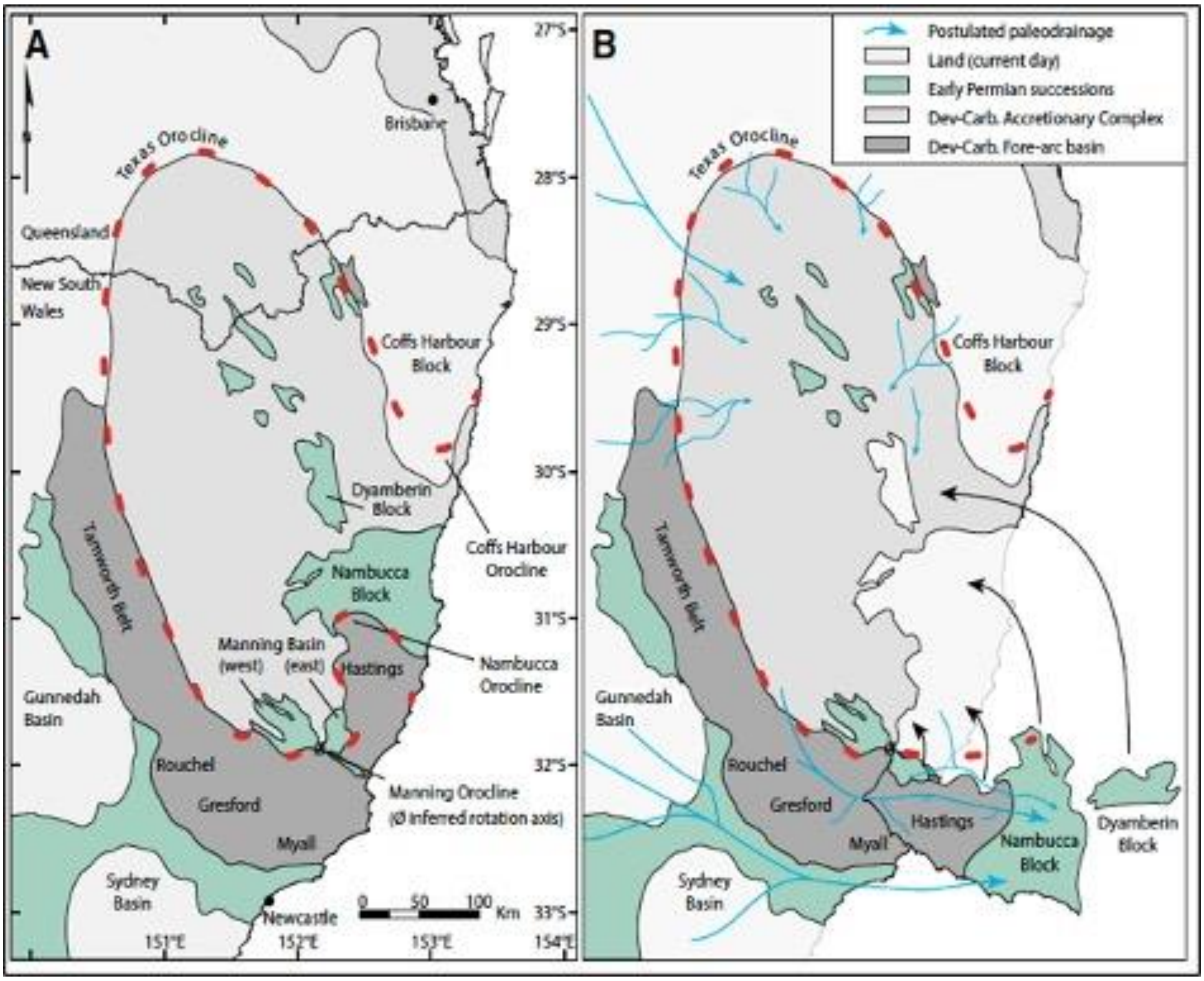


Figure 3. *Suggested reconstructions for the rotation of the blocks of the eastern limb of the Manning orocline, southern New England Orogen, eastern Australia* Devonian to Carboniferous. (Diagram by, Fielding, Shaanan and Rosenbaum, 2016)

1. Folded strata in Kempsey Beds, Grassy Head rock-shelf.

2. Inclined folding in Kempsey Beds at Grassy Head.

and post-tectonic granitic intrusions have been emplaced into rocks of this block (Korsch,1975).

Tectonic Implications for Oroclinal Bending.

In their paper 'Sedimentological evidence for rotation of the Early Permian Nambucca Block (eastern Australia). Fielding, Shaanan, & Rosenbaum, (2016) noted that; "a sedimentological study, complemented with a synthesis of detrital zircon geochronological data, was conducted on the lower Permian Kempsey beds of the Nambucca block. The Kempsey beds, comprising a lower conglomeratic association and overlying heterolithic sandstone-mudrock-dominated associations, are interpreted to have formed in initially shallow water or even emergent fans and fan deltas, evolving over time into deeper marine slope environments. This implies the existence of a large, deep-marine basin along the present -day eastern Australian coast during the Early Permian. North to northeastern palaeocurrent and palaeoslope measurements suggest post-depositional counter-clockwise northward rotation of the Nambucca Block *(Figure 3)* around the hinge of the inferred Manning Orocline. The proposed kinematic reconstruction is supported by structural evidence from other blocks in the eastern limb of the Manning Orocline, including the Devonian–Carboniferous blocks of the southern Tamworth Belt, Hastings Block, and the Early Permian Manning Basin. A compilation of palaeomagnetic and geochronological constraints places the rotation of the blocks, and the formation of the Manning Orocline, between 285 and 275 Ma. These results provide indications for the much-debated existence of the Manning orocline, place time constraints for its formation, and contribute toward a fuller understanding of the oroclinal structure and the late Palaeozoic Gondwana margins".

Shaanan, Rosenbaum, et al. (2014), state the following. "It is unknown when exactly extensional deformation terminated. However, from 288 Ma to 265 Ma, the volume of magmatism in the southern NEO decreased substantially, with only a minor record of magmatic activity at 280-270 Ma, (Cawood, et al. 2011), (Rosenbaum, 2012). Several authors have suggested that during this period, subduction processes ceased and that the plate boundary was controlled by dextral wrench faulting (Li & Powell, 2001), (Offler, et al. 2008), (Veevers. 2013). We adopt this interpretation to account for the second stage of oroclinal bending in the Texas-Coffs Harbour Oroclines and for the ~ N-S contractional deformation (F1) in the Nambucca Block".

Day 1: Arrival on Sunday 8th May.

Most Society members arrived at various times during the afternoon after their trip from the Central Coast, Newcastle, and the Hunter Valley. Those members who had arrived in time were happy to meet at 4:45 pm in the camp kitchen for a briefing to discuss the geology and proceedings for the excursion and indulge in a happy hour to catch up.

Day 2: Monday 9th May - Grassy Head & Scotts Head.

A large car park outside the Stuarts Point caravan park was an ideal meeting place for our daily excursions.

Greeting us this morning was a beautiful fine day for our trip to Grassy Head Reserve. Soon after all had arrived at Grassy Head Reserve, we walked south along the beach to where there is a rough eroded track leading to the top of Grassy Head. On arrival at the top, there are breathtaking views of the Macleay Valley Coast.

After soaking up the scenery, we made our way down to the eastern wave-cut rock platform to view and examine spectacularly deformed Lower Permian metasediments.

Grassy Head lies within the Nambucca Block and consists of very complex, deformed Lower Permian metasediments that are exposed on the wave-cut rock platforms. Five deformation episodes have been recognised at Grassy Head, the earliest manifested as quartz veins which have subsequently been ptygmatically folded. Also present are open upright

3. Box folding at Grassy Head.

4. NE trending, bifurcating felsic dyke that has cut metasiltstone, leaving 1 m metasiltstone strip enclosed in the middle of the dyke.

5. Strongly cleaved metasiltstone.

folds with the occurrence of box folding with an average wavelength of 7 to 10 metres *(photo 3)*. The wave-cut platform and cliff section consist of Kempsey Beds metasediments which are dominated by laterally continuous, medium-grained, sandstones interbedded with finer-grained sandstone/siltstone units (Johnston, 1997).

Profile section of the rock types shows fining upwards sequence which can be correlated with facies C and D of a Bouma turbidite sequence. Graded bedding, erosional bases and cleavage refraction in the interbedded units of fine-grained sandstone and siltstone indicate that all units are the right way up (Johnston, 1997).

After some time examining and discussing the complicated geology, we returned to the carpark for morning tea, after which we drove to Wakki Beach near Scotts Head, a 10 min drive.

Our second stop for the morning was at Waratah St, Scotts Head. Parking is limited here, and we needed to be careful not to hinder property access.

Soon after assembling at the top of a track on the headland that gave an impressive view towards the south and Wakki Beach, we descended the slippery narrow track to the beach. Upon reaching the bottom, the first thing of note is an impressive 8 m wide bifurcating NE trending felsic dyke *(photo 4)* that has cut the well-cleaved metasiltstone, leaving a 1 m wide metasiltstone strip enclosed in the middle of the dyke. The felsic dyke is probably associated with the nearby Triassic granitic intrusion of Mount Yarrahapinni (Johnston,1997).

Due to the difficult nature of the rocks, we did not examine the northern end of the rock platform, mainly due to the unevenness of the strongly cleaved metasiltstone *(photo 5)*. Structural features between Wakki Beach and Elephant Head overlooking an inaccessible cove contain numerous structures that would help to give a more extensive overview of this area.

Following some discussion, we turned our attention to the southern rock platform towards Snapper Point, where it is much easier to negotiate. The sloping rocks here are very smooth and can be slippery.

The well-cleaved rocks show intense veining resulting from multiple deformation events. Evidence of these events shows up as *en echelon* sinistral vein arrays, showing subsequent deformation, low angle extension veins with subsequent off-setting are evident and isolated boudinage pods of calcareous siltstone have undergone late deformation *(photos 6, 7 & 8)*.

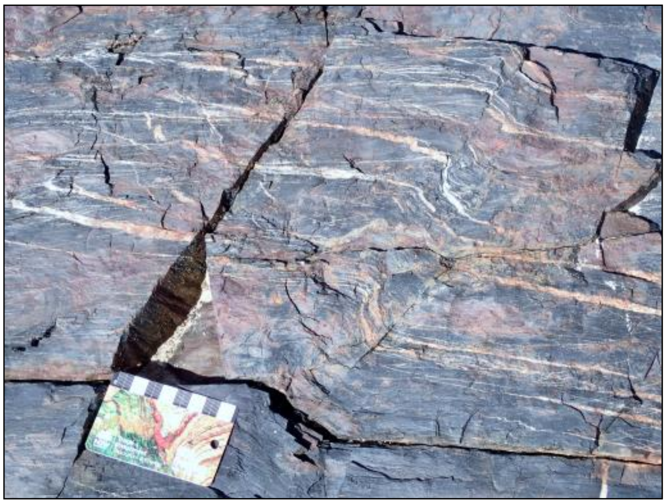
Returning to our vehicles, we drove to the well-groomed Scotts Head Reserve adjacent to Scotts Head Surf Life Saving Club in Short St. It was a great place to enjoy lunch before embarking along the walking track and enjoying the views around the Scotts Head.

Departing from our lunch spot, we drove to North Middle Head and then to South Middle Head; both these stops are well worth a visit. At these stops,

6. Metasiltstone wavecut platform containing Intensely veined, discontinuous calcareous siltstone pods (or boudinage).

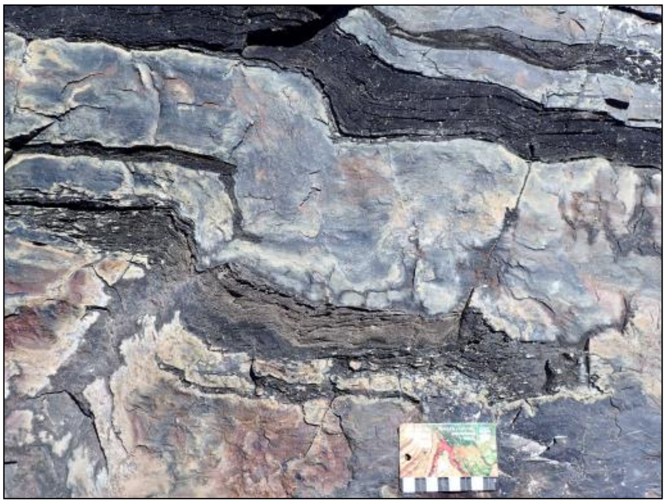
the rocks display well defined cleavage with uncommon exposures of conjugate *en echelon* veining *(photo 9,* along with great examples of what I describe as crazy veining or intense crack seal veins. Unfortunately, weather conditions of recent times had stripped the sand off the beach, making it dangerous to examine the northern end of Middle Head. Although South Middle Head had suffered similar conditions, we did manage to study some of the extensive and erratic vein arrays showing multiple episodes of intense deformation *(photo 10).*

Being the last site to visit for the day, we all headed back to our digs for happy hour and instructions for activities for the next day before settling down for the evening.



7. Kink folded *en echelon* gash veins showing subsequent deformation.

9. Uncommon conjugate *en echelon* gash veins in metasiltstone showing multiple deformation events.



8. Late-stage deformation of calcareous siltstone pod (or boudin).

10. Intense crack seal veins showing multiple deformation structures in metasiltstone at south Middle Head.

Day 3: *Tuesday 10th May - Crescent Head & Point Plomer.*

For our trip today, we travelled the scenic route through Smithtown and Gladstone to Crescent Head. This route mostly passes through verdant flood-prone farmland beside the Macleay River. Upon arriving at the car park on the foreshore of Crescent Head, we walked to Little Nobby past the golf course to examine the rocks at the headland.

The sedimentary sequences at Crescent Head belonging to the Crescent Head Formation are thought to represent Permian accretionary complex sediments, deposited to the east of a prominent continental, 'Andean-type' volcanic arc (Becker, 2014).

The sedimentary sequence found at the northern end of Pebbly Beach is interpreted to be an overall fining up sequence, consisting of interbedded atypical Bouma turbidite sequence with coarse-grained, massive ungraded sandstone beds with uncommon granule conglomerate lenses (Becker. 2014).

The Crescent Head Beds are interpreted as being deposited in a deep marine environment, proximal to shelf deep-marine steeply dipping turbidite sequence, consisting of clastic-rich sandstone interbedded with siltstone, mudstone and granule conglomerate lenses (Becker. 2014) *(photo 11)*.

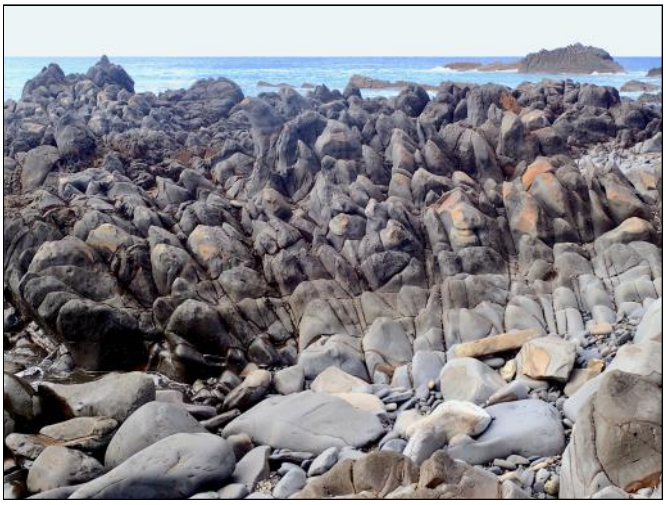
Throughout the Crescent Head Bed sequence, the presence of rip-up clasts *(photo 12)* indicates high energy events. Meanwhile, the presence of seismic deformation features possibly caused by movement on a localised fault associated with the wider volcanic-arc setting present during the time of deposition in the latest Permian, fits in with the regional tectonic setting of the New England Orogen (Becker. 2014).

Spheroidal weathering of joint blocks bounded by conjugate and orthogonal jointing in the sandstone beds at the northern and southern ends of Pebbly Beach has produced unusual rounded sandstone blocks.

Rounded sandstone blocks at Little Nobby do not show normal characteristics of spheroidal weathering because there are no concentric rings of rock surrounding the core, which are usually the result of chemical weathering. At the southern end of Pebbly Beach, the sandstone blocks are unusually weathered into upright conically shaped pods *(photo 13)*, more so than at the northern end of the beach (See Field Guide for geomorphological & geological Structures at Crescent Head…agshv.com → Go to documents).

11. Society members discussing aspects of the geology, while others negotiate steeply dipping strata.

12. Interbedded sandstone layer with poorly sorted rip-up clasts. Note how many of the rip-up clasts tilt left to right (imbrication) indicating current flow from left to right.



13. An unusual form of spherical weathering at the southern end of Pebbly Beach. Weathered into upright conical pods that are becoming rounded by processes of spherical weathering. Note that the tops are somewhat pointed.

Our second stop was at the southern end of Pebbly Beach below spectacular steeply dipping beds of Big Nobby *(photo 14)*, where it is possible to examine a prominent recumbent fold with a very high interlimb angle, along with a wedge block corresponding with a possible back thrust *(photo 15)*.

The sedimentary sequence present at the southern end of Pebbly Beach is seen to be independent of the sequence located at the northern end of Pebbly Beach. The southern sequence is interpreted to be an overall fining up sequence, consisting of interbedded atypical Bouma sequence turbidites. The sedimentary sandstone sequences found at the southern end of Pebbly Beach are relatively physically unweathered,

14. Southern view of Crescent Head (Big Nobby) from Little Nobby, note steeply dipping beds and the folded strata at the southern end of Pebbly Beach.

15. High angle recumbent fold with associated back thrust fault and wedge.

Goolawah National Park, where we walked to the beach along a tree-lined sandy track to view Delicate Nobby. The rocks at Delicate Nobby *(photo 16)* are similar to the Point Plomer sequence and show close-spaced jointing that has endured multiple deformations *(photo 17)* (see next stop for geological details). We did not stay here too long, mainly because of an imminent rain squall approaching from the south. Fortunately, most of us made it to our cars before the heavens opened, leaving everything drenched.

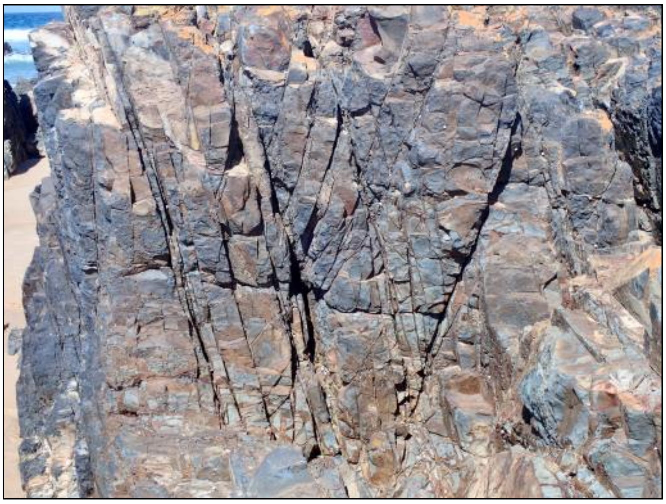
although many have secondary iron mineralisation present (Becker, 2014). Returning to our cars we then drove to the main street of Crescent Head, where most of us descended on Bennets Bakery where we devoured coffee and cake with great enthusiasm, yum.

After smoko, we headed towards Point Plomer, along Point Plomer Rd., stopping at Racecourse campground car park in Goolawah NP for pictures south along the pristine beach towards Race Headland to where the surfers were enjoying their morning surf.

Our fourth stop for the day was at the southern entrance of the Delicate Camping Ground within

We then continued to Point Plomer campground within Limeburners Creek National Park. Sheltering from the rain under the large covered area where we enjoyed our lunch overlooking the picturesque Barries Bay. After lunch, we donned our wet weather gear before setting off along the Point Plomer Walking Track. This easy walk leaves from the eastern end of Point Plomer Campground beside Barries Bay and leads to the lookouts on top of Point Plomer. These vantage points offer spectacular views north along the coast and south to Port Macquarie. They also overlook the steeply dipping beds cropping out between Point Plomer *(photo 18)* and Queens Head.

16. Delicate Nobby.



17. Multi directional close spaced jointing, indicating multiple deformation events.

18 . Steeply dipping strata from Point Plomer headland lookout.

The Point Plomer Carboniferous sedimentary sequence is assigned to Boonanghi Beds within the Hastings Block located between Queens Head Beach, south of Point Plomer and Racecourse Head north of Delicate Nobby (GSNSW, Seamless Geology of NSW). They are seen to be independent of the Crescent Head Permian sedimentary sequence, located to the north within the Nambucca Block. The Point Plomer

19. Society members enjoying morning tea under cover at Pines Picnic Area.

sequence is interpreted to be a fining-up sequence, consisting of dark-coloured, fine-grained shale evolving into a more clastic-rich fine-grained sandstone interbedded with atypical Bouma sequence turbidites (Becker, 2014).

Whereas the Crescent Head sequence is interpreted as proximal to shelf, deep-marine turbidite sequence shed from a continental arc system, the stratigraphic data suggests that the Point Plomer Head sequences were sourced from distinctly different island arc systems. Despite this, the stratigraphic data suggests the Point Plomer and Crescent Head sequences were deposited in very similar environments, by very similar mechanisms (Becker, 2014).

Day 4: Wednesday 11th May - Yaraibinni National Park & Mount Yarrahappini.

Today we were to travel to Georges Junction in the Macleay River Valley. Unfortunately, we had to change plans because of road closures, due to a section of road that had collapsed during recent floods.

So we decided we would tour Yaraibinni NP and Mount Yarrahapinni, leaving camp at 9:30 with the weather conditions overcast and threatening. The wet conditions saw some of our members feeling somewhat apprehensive, mainly because the dirt roads may have been slippery. Their worries were fruitless as the road proved to be very safe.

We entered the park along the Grassy Head Forest Road, climbing steadily through alternating moist sclerophyll eucalypt forests and lush rainforest. This popular touring route passes through the bubbling crystal clear waters of Way Way Creek several times before reaching The Pines Picnic Area set beneath a beautiful backdrop of tall hoop pine forest. By the time we arrived at the picnic area, steady rain was falling. Fortunately, there is a covered area surrounded by vibrant green rainforest, (*photo 19)* where we could all gather and enjoy morning tea.

After refreshments and the cessation of the rain, most of us ventured along the short 300 m rainforest walking track that follows the crystal-clear waters of Way Way Creek, set amongst an incredible natural world under the forest canopy. The walk displays a delightful diversity of plant life with several different species of rainforest trees, Bangalow palms and colourful fungi hiding amongst the forest litter *(photo 20)*.

Back at the picnic area, there is some striking Aboriginal artwork in the form of a mosaic sculpture, which prompted some discussion. It was designed and created by local Aboriginal artists with the assistance of a mosaic artist.

We then continued towards the top of the mountain, but before arriving at the lookout, we stopped to view a spectacular shear zone outcropping in Way Way Creek. The rocky creek bed consists of foliated metamonzogranite displaying *en echelon* gash veins and intense veining *(photo 21)* known as leucosomes. Leucosomes are coarse-grained, quartzofeldspathic veins, varying in thickness from a few centimetres to a metre or two, and found as a high-grade metamorphic rock. The gash veins have extension veins emanating from the wings, but what is strange is the extension veins, not the *en echelon* veins, along with the foliated rock display crenulation.

Perpendicular to this is a complicated array of leucosomes that show deformation and possibly the intrusion of a small dyke. These leucosomes continue through the clear waters of the shallow creek to the opposite bank.

We continued up the mountain through Triassic Yarrahapinni monzogranite, dated 237-201 Ma. GSNSW, Seamless Geology of NSW describes it as white to pink fine to medium-grained equigranular to weakly porphyritic, biotite leocomonzogranite with minor hornblende-biotite leucomonzogranite, containing small pegmatites, intruded by felsic dyke swarms and veins.

At the Yaraibinni Lookout, the views stretch southeast over lush macadamia farms to the Macleay River estuary and Trial Bay. On a clear day, the coastline near Smoky Cape in Hat Head National Park to the south makes a dramatic backdrop to the towns of South West Rocks and Arakoon. Some of our members continued up further to where there are several Telstra transmission towers and disrupted views to the west and southwest.

While some members decided to head to other destinations, some of us went back to the picnic area, where we enjoyed lunch before heading back to camp for an early end to the day.

<u>*Day 5*</u>*: Thursday 12th May - Rest day.*

The forecast for a wet and dreary day did not turn out as expected. So most Society members had a leisurely day sight seeing some areas that they had an interest in and had not been able to achieve in the past. Although quite a few ended up at Trial Bay Gaol they

20. Yellow coral fungi near the Pines Picnic area.

21. *En echelon* gash vein associated with shear zone in leucomonzogranite located in Way Way Creek.

did not bump into the others, whilst others went shopping and toured some of the sites around Kempsey.

<u>*Day 6*</u>*: Friday 13th May - Nambucca Heads and Wenonah Head.*

On the final day of activities at Stuart Point, we woke to a very wet morning with consistent rain, so we decided to delay our outing. The weather improved as the morning wore on, allowing us to leave at 10 am. Our first stop for the day was at the Wellington Drive foreshore car park, on the Nambucca River at Nambucca Heads. Once all had gathered, we strolled along the concrete walkway to the headland that follows the colourful rocks that make up the revetment wall, known as the V-Wall Outdoor Gallery.

Over the years, many visitors have painted their holiday messages, inspirational words, and memories on the large rocks at the V-Wall. This creative space provides a great read with comments from locals and visitors from around Australia and across the globe.

The pathway follows the shoreline to the wavecut

22. Wellington Rocks, Nambucca Heads.

rock platform known as Wellington Rocks *(photo 22)*, where we examined the many structural features of the rock platform *(photo 23)*. The tide was falling so we were able to make our way around the base of the headland at Shelly Beach, where we examined the rock wall behind the fish cleaning tables. This site provides excellent exposures of deformed early Permian phyllites of the Nambucca Block.

23. Typical example of rocks at Wellington Rocks showing overprinting deformation fabrics in early Permian rocks.

In a field guide written by Rosenbaum (2012), he suggests that "Four generations of structural fabrics can be recognised in this outcrop *(Figure 4)*. The dominant fabric element is defined by the layering of quartz and mica domains and is generally oriented ~N-S. The differentiation to quartz-mica domains is a characteristic feature of intense crenulation cleavage (Ashley, 1995), indicating that the dominant fabric must be an overprinting fabric element (at least an S2) that was superimposed on an earlier structural fabric (S1). In thin sections, traces of S1 are locally recognised in low strain zones within the quartz-rich S2 domains. The prominent crenulations in the quartz-mica domains are F3 folds, and this crenulation cleavage (S3) is further folded around F4 folds", in other words, quite complex.

After returning to our cars, we had refreshments before driving to Wenonah Head. Here we examined the small, low rock shelf. Although the geology is similar to that of Wellington Rocks at Nambucca Heads it was noticed that the coarser sediments of Crescent Head are very different from the finer sediments at Wenonah Head, with a general fining upwards as you travel north. This difference is the exact opposite in the Coffs Harbour Block. The boundary between Coffs Harbour and the Nambucca Block is between Wenonah Head and Urunga and is defined by the Bellinger Fault.

As the rest of the day was free, some had a picnic lunch here or stopped at Valla Beach before heading

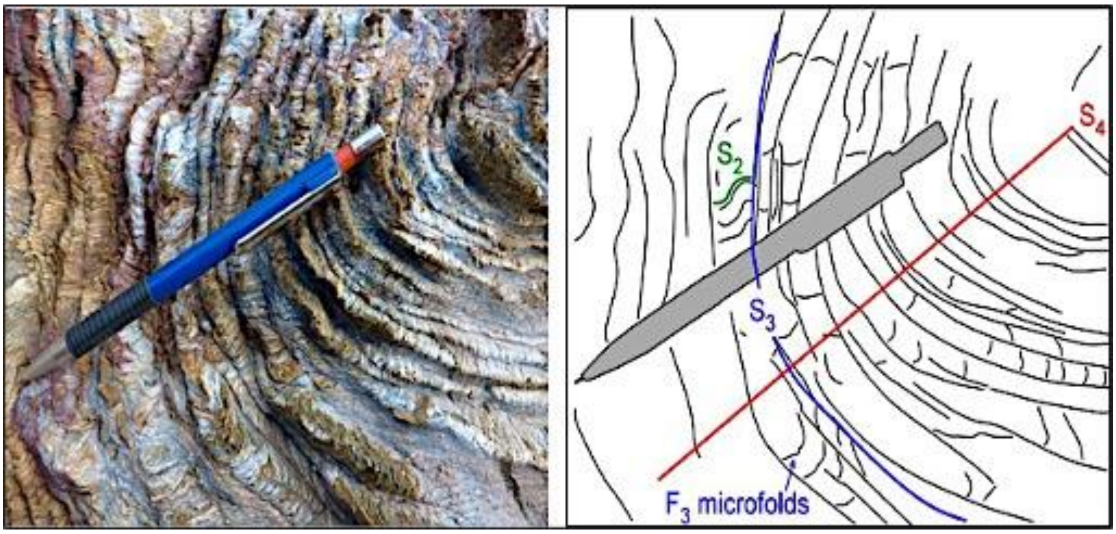


Figure 4. *Typical example of rocks at Nambucca Heads and Wenonah Head showing overprinting deformation fabrics in early Permian rocks, Nambucca Heads. Note that traces of S1 can only be recognised in low strain zones under the microscope (Rosenbaum, 2012).*

back to camp to prepare to move to Corindi the next day.

Day 7: Saturday 14th May - Corindi.

Today was pack up day before driving to Corindi 112 km north (1.5 hr), where we set up and chilled out for the rest of the day, with a meeting planned for 5 pm in the camp kitchen for instructions and happy hour.

Day 8: Sunday 15th May - Dorrigo National Park.

Today we headed to Dorrigo Plateau and Dorrigo National Park. This entailed driving 110 km along the narrow less travelled back roads, stopping at the Community Centre in the small village of Ulong for morning tea. Ulong is a small town located 36 km inland from Coffs Harbour (population 131). Whilst only a short distance, it takes 45 minutes to drive the steep narrow windy roads through rainforest. Ulong is on the Dorrigo Plateau and sits at 518 metres (Australian Height Datum (AHD)).

Coincidently, while most were enjoying their morning tea, it was noticed, that under the covered porch of the community centre, the locals had filled an old fridge with pre-loved books*(photo 24)*. Of course, the avid readers amongst us were enthralled and spent some time sorting through the books finding many that they had not read before. Unfortunately, they did not have any books to swap with them.

We continued, immersing ourselves in rich undulating verdant forests and farmland negotiating precipitous mountainous gravel roads through lush rainforests that merged from towering moist eucalypt forests and back again into rainforest. Briefly stopping at the Giant Tallowwood Tree known as the Jack Feeney Memorial.

Soon the forests gave way to the rich farmland on top of the Dorrigo Plateau. The narrow road crossed over and under the now-abandoned historic Dorrigo railway line *(photo 25)*, which was intended to be part of a much larger rail system linking the coastal port of

24. AGSHV members eagerly waiting there turn to examine book exchange library at Ulong community hall.

25. Abandoned historical wooden rail bridge on Coramba Road near Megan.

Coffs Harbour and Grafton with the northern and western lines.

According to a Wikipedia post titled 'Dorrigo Railway Line,' the Dorrigo area was settled in the early 1900s by pastoralists and tree fellers. Due to the steep terrain, it was decided to build a railway to allow products to be brought to nearby port towns. Several routes were surveyed, with the route from Glenreagh eventually chosen. The line climbs 664 m over a length of 69 km.

Dorrigo was the terminus from Glenreagh, situated on a plateau at 730 metres ASL in dairy country. It has consistently high rainfall and is the main township for the area known as "The Dorrigo" (short for 'The Dorrigo Plateau'). The town is situated in a geographical location best described as mountainous. Being a rainforest area, it has high rainfall and fertile soil, but it is also given to landslides and land subsidence. It was in this setting that a line of railway was built, encountering many difficulties in its construction.

On 28th December 1910, the Glenreagh to Dorrigo Railway Act received assent to sanction the construction, which commenced in August 1914.

During the First World War, progress foundered due to the lack of finance and disputes with the contractor and the contract was terminated on 28th March 1917. Responsibility for construction passed to the Railway Commissioners who promptly suspended work.

Two years after the end of World War 1, the Railway Commissioners decided to resume construction. Landslips and wash aways delayed progress until 27th September 1924 when a construction train reached Dorrigo. Construction was finalised by 5th December.

The line opened on 23rd December 1924 and was considered to be one of the costliest branch railways built in New South Wales. It had some of the steepest gradients and tightest curves in the system and experienced high maintenance and running costs. It suffered repeated losses throughout its entire existence.

The line lost its passenger service in December

26. Beilsdown River cascading over Dangar Falls, from viewing platform near car park.

27. View from bottom of Dangar Falls displaying examples of radial columnar structure in 30-metre-high basalt walls of the amphitheatre

1957. Goods and services were suspended in October 1972 after flood damage. The line required two tunnels of 170 m long to be carved out of the mountain. These tunnels are now the home of eastern microbats. (Wikipedia 2014).

We soon arrived at the Dangar Falls rest area and the newly completed viewing platform, located above the Bielsdown River on the Dorrigo Plateau with stunning views over the falls *(photo 26)*. Dangar Falls is of geological significance, a cascade waterfall set amidst scenic agricultural and dairy farmland. Dangar Falls may not be the highest waterfall, however it offers an eye-catching spectacle. The 30 m basalt walls that have been carved into the shape of an amphitheatre house several fine examples of radial columnar joint structures adjacent to and behind the waterfall *(photo 27)*.

Local geology.

Dangar Falls and Dorrigo National Park lie partly on the eroded surface of the Ebor-Dorrigo Volcano dated 19 million years old which is one of several Miocene volcanoes in NSW. This is important because they outline the chronology of the evolution of the eastern Australian landscape (Gray. 1977). The Ebor Volcano and its remnants are dominated by lava flow sequences up to 400 m thick and cover an area of 480 km^2. In mid-Miocene time, the Ebor Volcano was conservatively 45 km across and of low shield form, standing at least 800 m above the basement. The subsequent erosional retreat of the Great Escarpment has removed about 90% of its volume (Gray. 1977).

The rest of the afternoon was left up to individual members to do their 'own thing'. Some visited Dorrigo National Park Information Centre, taking a walk on the Sky Walk and admiring the lush subtropical rainforest and spectacular gorge scenery below. The more energetic of our members walked down to Crystal Shower Falls. What is possibly not known by many is that the Crystal Shower Falls hides a secret by day.

28. Contorted, disrupted, upturned turbidites of the Coramba Beds at Green Bluff.

29. Off-shore stack showing isoclinal folding and micro veining in ribbon cherts at Red Rock.

During the night the falls are lit by hundreds of twinkling blue lights from a hidden glow-worm colony. The rest followed the Waterfall Way, stopping to wander through the craft shops at Bellingen before continuing through Coffs Harbour back to camp.

<u>Day 9</u>: Monday 16th May - Mullaway, Woolgoolga, & Green Bluff.

Greeting us this morning was very wet and gloomy conditions, with no improvement in sight as our starting time arrived we set off to our first destination for the day at Mullaway. A decision to brave the conditions and commence our walk around the headland, given the wet conditions, proved to be foolhardy. So, it was decided we would go back to camp and review the situation at 10:30 am.

With the weather improving by the designated time, we decided to meet at the picnic area at Moonee Beach Reserve to explore Green Bluff. After taking in the natural beauty of the picnic area, we followed the pathway over a footbridge that crosses a small creek that feeds into the scenic estuary. The path continues through a beautiful littoral rainforest out to the end of the grassy Green Bluff. A few of us decided to take a narrow track that runs off to the left soon after entering the forest. This route offers great photographic opportunities and the chance to view contorted, disrupted, upturned turbidites *(Photo 28)* before returning via the main track that proved to be very muddy.

The headlands and rock platforms outcropping between Coffs Harbour and Brooms Head belong to the Coramba Formation, part of the "Coffs Harbour Association" deposited during the Carboniferous period (360-300 million years ago). Korsch (1971) described the rocky beds of Woolgoolga, Mullaway and Arrawarra Headland as. "well-bedded units of alternating fine sandstones and mudstones, the products of turbidity currents".

These units represent second-cycle mass movement deposits resulting from the remobilization of the turbidites. They are megabreccias formed by submarine slumping of the open-face type. The matrix of the slump breccias consists of medium to fine-grained sandstones and contains blocks of massive, muddy cherts. The blocks and matrix existed together as interbedded units prior to movement and the megabreccias resulted from gravitational instability and mass-movement of the pile of stratified rocks.

Mechanisms by which a stack of soft wet sediments may be brought into a condition of instability are numerous. Tectonic steepening of the seafloor (Waterhouse & Bradley, 1957; Grant, Mackie and Lowry, 1964; Lietch & Mayer, 1969), an increase of excess fluid pressure in the sediments (Carey, 1963), and over steepening as a result of differential compaction (Snyder & Odell, 1958) are thought to be common.

From Moonee Beach, we travelled to our last stop for the day at Woolgoolga Headland Lookout. The lookout offers spectacular 360 degree views of the inland hills, north and south along the coast and far out to sea, where five of the main islands sit off the coast, these are North Solitary Island, North West Solitary Island, South West Solitary Island (Groper Island), South Solitary Island and Split Solitary Island. The islands are known to be rock comprised of the same assemblage as the mainland throughout the area called the Coramba Beds in the Coffs Harbour Block or Coffs Harbour Association. (Korsch, 1993).

<u>Day 10</u>: Tuesday 17th May.

Today was supposed to be our rest day, but this turned out to be quite the opposite. Managers Steve and Janine at the Reflections Holliday Park offered a complimentary pancake and sausage breakfast. This was heaven to the ears of our members and was eagerly accepted, with a suggestion from Richard Bale, our society secretary, that we would donate $5 per head for breakfast that would go to a local charity. Our members donated $185 during breakfast. Steve and Janine not only supplied the food and drink, but they also added

30. Combination of folded and faulted sedimentary rocks, dominated by anticlinal fold In southern cliff face below car park at Brooms Head Headland lookout.

extra money to bring the total up to $300, being donated to the 'Lismore Flood Appeal'. A fantastic result on behalf of Steve and Janine and our members.

After our pancakes, we decided we needed to work off some calories, so a few of us drove to Red Rock to show those members who had not been there before the anomalous geology of this area. The unique rocks are an enigma to geologists and only occur at Red Rock *(photo 29)*. Unlike the surrounding rocks, it is not known whether they were deposited and deformed elsewhere before emplacement in their current location.

Their age range is from Silurian to Carboniferous (420 Ma to 350 Ma). (Brown and Vickery, 2008 & Rosenbaum, 2015). After examining the faulted and highly folded rocks around the beach and headland, we decided to wander over to the wetlands area for a walk that runs beside the Corindi River before taking it easy for the rest of the day.

<u>Day 11</u>: *Wednesday 18th May - Brooms Head, Red Cliff and Sandon.*

Clear sparkling skies greeted us for our trip north to Brooms Head, arriving in time for morning tea on the picturesque beachside reserve below the prominent rocky promontory at Brooms Head. We then drove to the lookout at Brooms Head, where there are spectacular 360 degree views. The headland lookout consists of metasedimentary rocks (Coramba Beds) and shows a range of deformed geological structures that we were keen to examine. The Carboniferous rocks exhibit numerous faulting, folding, sandstone intrusions and great examples of weathered profiles.

This area hosts many geological features of special interest. One of the more eye-catching structures at Brooms Head is a spectacular anticlinal fold and associated faulting that dominates the northern face of the headland *(photo 30)* (Brown and Vickery 2011, Tour Notes). Eventually, after some time exploring, we drove to Camp Ground at Red Cliff in Yuraygir National Park for lunch.

Red Cliff trig and lookout above Lake Arragan rest area boasts spectacular, panoramic coastal views

31. Deep red lateritic soils giving Red Cliff its name.

both south to Brooms Head and north along the low coastal heathlands fringing the Yuraygir coastline.

Living up to its name, the upper profile of lateritic soil at Red Cliff is deep to bright red and is not seen elsewhere *(photo 31)*. Below the towering cliff, a stratigraphy of grey, cream and red rocks rises up from the beach. To the north, the coastline gently dips away to Lake Arragan campgrounds, where you can gain access to the beach and view what is described by GSNSW, Seamless Geology of NSW, as Late Triassic sediments of the Clarence-Morton Basin. These comprise thin-bedded to laminated carbonaceous claystone and siltstone, interbedded with lenses and beds of pebble-granule conglomerate and breccia (debris flows); minor carbonaceous fine lithic sandstone, coal partings and lenses of coal *(photo 32)*.

Down from Red Cliff in the low scarp near the entrance to Lake Arragan, there seemed to be evidence of coal mining in the past. According to Yuraygir National Park Contextual History (2007) 'Coal was reported to be hacked straight off the clearly visible coal strata in the red cliffs of the area by passing ships, and the remains of a coal shaft are reportedly visible on the headland at Red Cliff'.

To get to our next and last stop for the day, we were supposed to drive through pleasant coastal vegetation where the 9 kilometre dirt road eventually runs parallel to the picturesque Sandon River and the historical buildings dating back to 1914 that line the opposite side of the road. It turns we were ambushed by a particularly vengeful, nasty set of road conditions hiding in wait, no one noticed the historic houses nor the picturesque river due to the atrocious conditions of the road. I must say of all the roads I have travelled in Australia and they are wide and varied, there have been none worse than this road. Richard Bale was heard to say he couldn't look at the scenery and practise his survival skills at the same time.

Before the nineteenth century settlement of the Sandon River, archaeological and oral evidence shows that the estuary, headland and beach were favourite meeting and camping places for the Yaegl people. The area's fishing fame carried over into settler history.

32. View from Lake Arragan end to Red Cliff showing multiple bedding forms.

While the first bark hut to be built in the area was on the southern headland in 1901, the first house was built by Jack Gallagher on the north side in 1914 for fishing holidays. He took out a mining lease which allowed him a title to build. The huts located in the park at Sandon River were generally constructed between the 1930s and 1960s on Crown Lands under Permissive Occupancies granted by the former Lands Department before the creation of this section of Yuraygir National Park (Yuraygir N. P. Plan of Management, 2003).

After arriving and much admonishment from my fellow travellers, we crossed to Plover Island *(photo 33)* which is connected by a sand isthmus to the mainland. GSNSW,` Seamless Geology of NSW refers to Plover Island as, 'Lithospathic wacke, minor siltstone, mudstone, metabasalt, chert and jasper, rare calcareous siltstone and felsic volcanics, with sandstone the dominant lithology. These form part of the Coramba Beds within the Coffs Harbour Association.

33. Plover Island (Coramba Beds) at Sandon accessed at low tide across the sandflat.

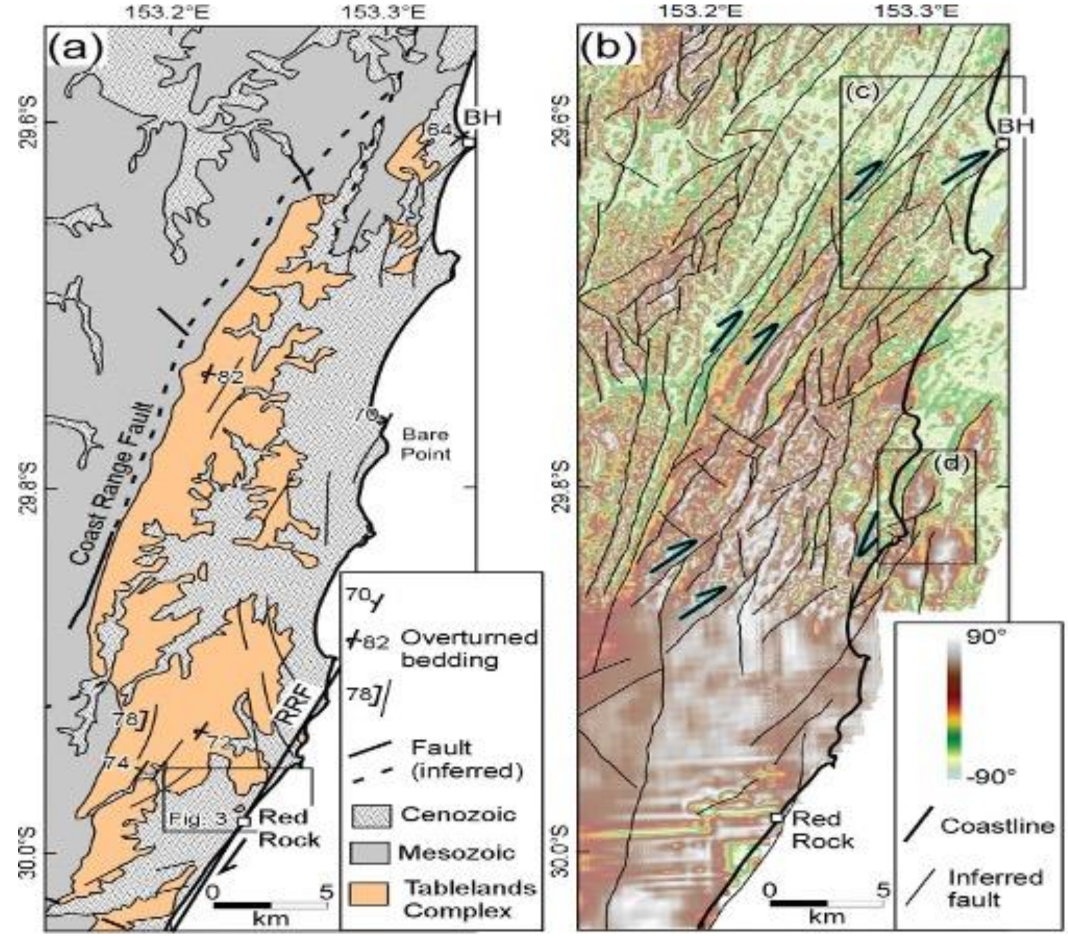


Figure 5: Geological map of the eastern limb of the Coffs Harbour Orocline showing orientations of bedding and axial plane fabrics (after Korsch (40)1981a, (33*)1993), and the location of the Bare Point Fault, Brooms Head. (Modified and adapted from Rosenbaum et al. 2015).*

The island and the surrounding area were the traditional lands of the Yaegl people.

The interpretation board near the path to the beach mentions, 'The Yaegl people quarried greywacke and quartzite from Plover Island where several quarry faces show signs of traditional use'. Unfortunately, we did not find evidence of quarrying nor grinding grooves on the flat rocks, but the eagle eye of Brian Dunn noticed what looked suspiciously like discarded tools in the form of stone knives and cutting implements.

Day 12: Thursday 19th May - Diggers Camp & Bare Point-Minnie Water.

Today we were treated to a beautiful sunny morning for our trip to Diggers Camp Reserve, where we parked at the foreshore reserve overlooking the beaches and rock platforms before touring Diggers Camp village which has only two streets, Nugget Street and Miners Street, both of which reflect the mining history. Diggers Camp received its name because of gold mining operations in the late 1800's. European and Chinese settlers mined for rutile and gold at Diggers Camp Creek just north of the village, where marine sediments contain concentrations of heavy minerals. These are evident as sorted strandlines of dark material on Diggers Beach.

The village encloses 44 freehold residential allotments and associated public reserves that makeup Diggers Camp. The settlement has no power, water or sewerage. However, there is a telephone service and regular garbage collection. The surrounding Crown Reserve and National Park is a major constraint to future expansion or servicing of Diggers Camp. (Australia's Guide, NSW. Diggers Headland. Diggers Camp, Clarence Valley, NSW).

We then drove to Wilsons Headland parking and picnic area. Now, this is where the landscape and geology become quite fascinating. This section of the National Park occupies the eastern land margins of the Clarence-Moreton Basin. The Clarence-Morton Basin formed during the Late Triassic to Late Jurassic as an intra-montane basin within the New England Fold Belt and has remained relatively undeformed by major geological events since. Originally it extended some distance to the east. Contrasting with older Carboniferous sediments of the New England Fold Belt that we find on the rock shelves from Brooms Head south along the coastline to Arrawarra, these outcrops represent N-S striking Coramba Beds of the Coffs Harbour Association on the eastern limb of the Coffs Harbour Orocline. The faults *(figure 5)* seem to be related to the structures described by Rosenbaum et al. (2015).

The Park encompasses parts once occupied by the Gumbaingirr and Yaegl people. The name 'Yuraygir' is derived from the Yaegl (Yaygirr) language group.

Evidence of past occupation includes open campsites, middens, scarred trees and quarry sites along coastal headlands, bays and estuaries. A large midden located in the Station Creek camping area has been carbon dated and found to contain material dated 1,650 years before the present (Yuraygir N.P. Plan of Management. 2003).

From the car park at the start of the Wilson Headland walk the first thing of note is the dune swale sequences that include distinct vegetation patterns, which are a result of both localised relief and groundwater levels. The Quaternary sands also form low coastal plains supporting wet heath, sedge land and swamp forest, making these communities particularly complex (Yuraygir N.P. Plan of Management. 2003).

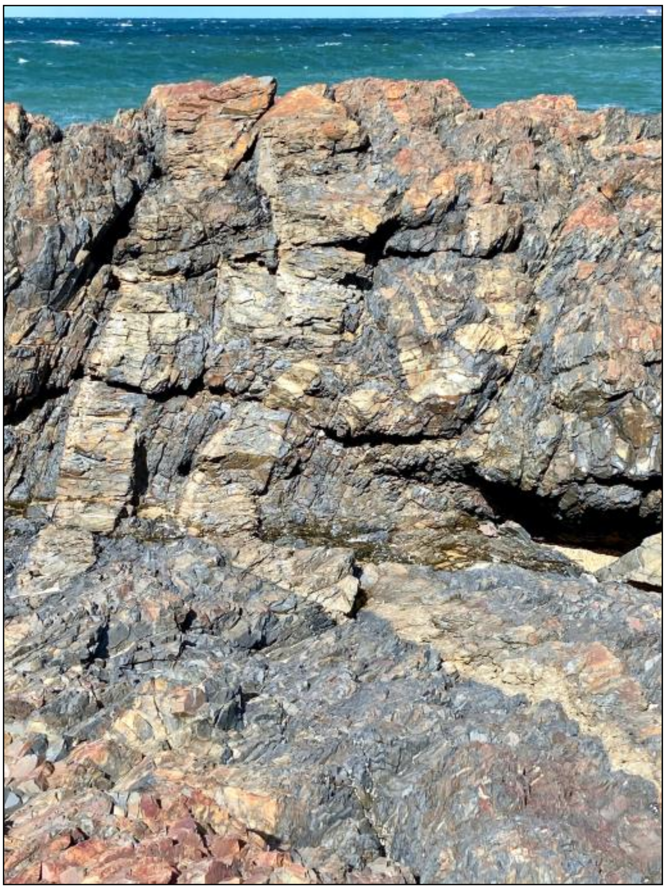
Major events in the geological history of this region have seen the sea level rise and fall in large cycles with the onset and melting of icecaps and glaciers brought on by successive ice ages over the past two million years. Because the continental shelf is both wider and shallower in the north compared to the south coast of NSW, successive incursions of the sea over the continental shelf swept abundant amounts of sand and other weathered littoral debris onshore (Yuraygir N.P. Plan of Management. 2003).

Three phases of this coast building process are of importance to the understanding of the Clarence coast landscape:

1. During earlier periods of high sea level, extensive deposits of marine sediments were laid down, forming the inner dune barrier.
2. A drop in sea level produced the swampy plains of the inland coastal plain sections in this area, which are fluvial and/or estuarine in origin. Some swamps are probably caused by the surface exposure of impermeable clay layers laid down earlier in the Quaternary period.
3. The latest rise in sea level took place between 17,000 - 6,000 years ago. This incursion of the sea drowned the shoreline and produced the current coastline. The progradation of the coast by deposition has resulted in offshore islands being encapsulated in the mainland and rocky bays and coves being filled with sand deposits.

The Quaternary sands of the beach barrier systems and coastal plain therefore overlay the Clarence Basin Mesozoic sediments. The characteristic dune swale formations of the barrier systems give an insight into past fluctuations in sea level. The depositional landforms include irregular longitudinal sand ridges through which meander freshwater and saline drainage depressions and swamps. Here lies a most unusual

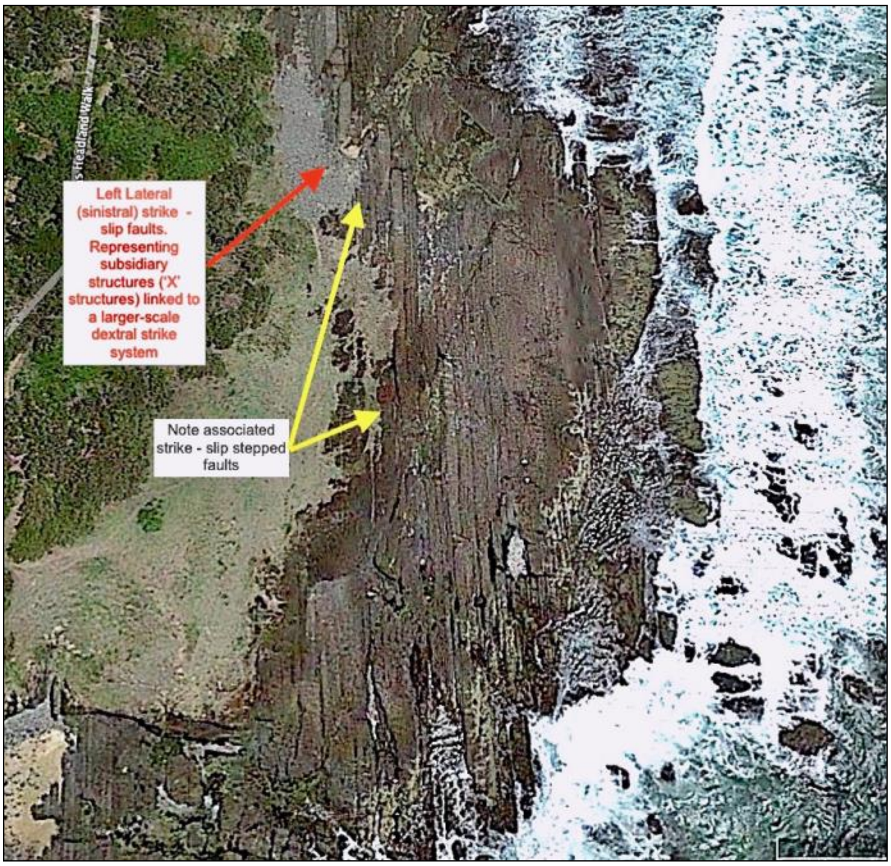
34. Bare point, upturned turbidites showing left lateral (sinistral) strike slip faulting.



35. Bare Point, upturned Coramba beds displaying multiple folding and faulting.

feature comprising a small freshwater lake surrounded by exceptionally high vegetated sand dunes. These dunes give rise to a most distinctive landscape. This waterbody is perched on an underlying impervious layer of organically bound sand; the so-called 'coffee rock'. The lake has great scenic beauty (Yuraygir N.P. Plan of Management. 2003).

From the car park situated amongst beautiful coastal heathlands and the interestingly shaped, ancient weather-beaten trees, we made our way down to Bare



36. Satellite image of Bare point showing magnitude of strike-slip faulting

37. Northern end of Bare Point showing upturned turbidites displaying substantial movement of bedding in a strike slip regime. Notice how truncated bedding has turned back on itself.

38. Interbedded mudstone, siltstone and sandstone displaying folding in alternate layers.

Point through vegetated swales of dunes via a well-made walkway and wooden bridge constructed by National Parks. The pathway passes by a scenic perched lake before reaching a set of stairs leading to the beach. From the top of the steps, there are spectacular views along the coast to the south. Once down on the beach, we made our way onto the rocks that display some very impressive geology. These rocks represent older Carboniferous turbidites deposited in deep water beyond the continental shelf.

Safety was an issue here, as these sub-vertical rocks are uneven and jagged from constant buffeting from the sea. However, the excellent examples and instances of faulted, folded rocks are well worth the risk *(Photos 34 & 35)*. Although it is possible to continue on around the bottom of the vertical cliffs, the risk of injury posed an unacceptable risk. So we headed back up to the walkway that curves around the top of the headland and where there are ample opportunities to wander over to the edge of the cliffs to view the

39. Sigmoidal *en echelon* gash veins showing secondary deformation. A result of shear strain, the fractures rotate and buckle and that resulted in the formation of 'S' shape of the veins.

40. Turbidite interbedded with fine-grained buff to grey mudstone, siltstone and sandstone occurring in graded beds, showing incipient deformation

41. Ron evaluating further aspects of this remarkable outcrop.

geological structures from above.

Returning to the well-formed walking track above the rocks we continued north, pausing here and there to observe structural features in the rocks below, before descending back down to the rock shelf to view a large, remarkable fault zone. In a personal communication, Gideon Rosenbaum suggested that 'these strike-slip faults are sinistral (left-lateral). They might represent subsidiary structures X structures, linked to a larger scale dextral strike-slip fault' *(image 36 & photo 37).*

Returning to our cars at the Wilsons Head picnic area, we drove to Minnie Water, a 20 minute trip for lunch at the Tree of Knowledge Lookout picnic area that overlooks the very scenic Minnie Water Beach and boat ramp.

Descending onto the beach, we walked south to the rock platform. What is interesting is that the rock shelves and headlands from Woolgoolga to Brooms Head all belong to the same Coramba Beds of the Coffs Harbour Association. The rock platform holds an array of sedimentary and deformational structures for example, faulting, folding *(photo 38)*, quartz filled *en echelon* gash veins *(photo 39)*, extension jointing, boudinage, scour marks (flute casts) and concretions.

Further south along the rocky/pebbly beach, a rocky point has a totally different lithology. The rocks here are well-formed turbidites showing Bouma sequence displaying spectacular graded bedding that has undergone minor deformation *(photos 40 & 41).*

Time was of the essence today because the social committee had arranged to have an end trip meal in the caravan park camp kitchen at 5:30 pm. So, we had to depart Minnie Water in time to purchase food and prepare for the get-together. In the past, tradition would have seen us visit a local club or pub to celebrate a successful trip. All the same, with some still concerned with the ongoing Covid risk, a celebration with just our members in the camp kitchen was considered the best option for all concerned.

Gathering at the prearranged time in the camp kitchen, we all enjoyed a lovely meal, and an opportunity to thank Chris and Dianne for planning and delivering an activity covering the coastal areas from Point Plomer in the south to Red Cliff in the north and inland to Dorrigo Plateau, a distance of over 1,050 kilometres possibly more, with diversions, and 23 destinations.

The next day being the last day for the excursion, members were left to their own devices, before readying themselves for their trip back home. Some decided to go sightseeing, while others made the decision to head home before the predicted inclement weather the next day.

Report by: Chris Morton.
Edited by: Brian England.
Photos: Chris Morton and Ron Evans (5, 22, 23, 33 and 35).

Credits:

My thanks to Professor Gideon Rosenbaum, School of Earth Sciences, Queensland University, for permission to copy and use his maps (some modified), diagrams and interpretations of various sites for this report.

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Due to Covid 19 restrictions, only a few of planned 2021 activities took place. It was decided to produce a Geo-Log that combined the few 2021 activities with those from the first half of 2002, hence Geo-Log 2021-2022.

Geo-Log 2021-2022 as usual, is a collaborative publication with reports from trip leaders who organise and conduct activities. Various members also provided photographs for inclusion in Geo-Log 2021-2022.

Activities conducted during this period were conducted, when necessary, within Covid-19 protocols.

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He was ably assisted with some editing by Ron Evans.

Life Member Ron Evans compiled Geo-Log 2021 -2022 and organised its publication by Lakemac Print, Speers Point.

Ron Evans.