'Geo-Log' 2020

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

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President's Introduction.

To members and friends

2020 has been a very challenging and unprecedented year presenting many obstacles due to the Covid-19 pandemic. The wellbeing of members has been the top priority of the executive and planning committees. Due to the ongoing Covid-19 pandemic and associated travel restrictions, some activities had to be cancelled or postponed.

Yet during this time, the Society managed to plan and conduct scaled back activities on a month-to-month basis that was constrained by government Covid-19 restrictions, which at times created many difficulties. However, congratulations to our very talented and imaginative executive and planning committees and activity leaders for conducting safe activities and continuing the tradition of expanding the knowledge and understanding of geology in the local area. As usual, all activities were most enjoyable.

I would also like to acknowledge and thank Ron and Brian on the annual edition of Geo-Log. Although this edition may not be as voluminous as in past years, their uncompromising standards and production have not diminished. The social committee has also managed to survive and conduct their monthly craft days as well as at short notice, organising a corona virus-safe Christmas get together in a park. Well done!

So let us hope that 2021 will present fewer challenges and that we will be able to resume normal activities in what will be a new Covid normal; whatever that may be.

With best regards,

Chris Morton.

Iconic Australian Landforms and Winton Dinosaurs

Presenters: Ron Evans and William (Bill) Hanley.
Date: Thursday 16th January, 2020.
Attendance: 38 members.

Introduction.

Over the last two years, during the hot months of January and February, the Amateur Geological Society of the Hunter Valley (AGSHV) has been conducting presentations in the air-conditioned auditorium at Hexham Bowling Club. This has proved to be very successful.

This year we were fortunate to have two guest speakers, Ron Evans, who gave a Power Point presentation on 'Iconic Australian Land Forms - A Geological Perspective' and William (Bill) Hanley who delivered an interesting insight on the Age of Dinosaurs Museum at Winton and his role in fossil discovery and preparation. Although their subject matter covered totally different themes, both presentations were complimentary to each other.

Most members met in the downstairs bistro where they enjoyed a pleasant lunch before proceeding upstairs to the auditorium where Ron was preparing to deliver the first of the afternoon's presentations.

Ron, a retired High School Science Teacher, studied and attained his BSc degree majoring in geology at Newcastle University. He is a foundation member of the AGSHV, joining in 1987. He has served as Vice President (1980), President (1981 - 1987) and Secretary (1984 and 1992 - 2007). In 2007, he became the Society's first Life Member. Ron is still an active trip leader, along with mentoring and helping the up-and-coming members within the Society. Since 2004 Ron has compiled the Society's magazine 'Geo-Log' which records the activities of the AGSHV during the year.

Ron's presentation on what he termed a 'travelogue' centered around Central Australia and covered the iconic destinations of the Devils Marbles (known to the Aboriginals as Karlu Karlu), Gosse's Bluff (known as Tnorala to the Western Arrente people), Kings Canyon (Watarrka National Park) and The Olgas (Kata Juta).

Although many of us, along with visitors from all over the world come to visit these places, we are mostly blinded by the rugged beauty and vastness of these areas and never really consider the geology and processes that have contributed to their formation.

Ron's Power Point presentation addressed many of the geological processes and features that make these places so special.

Presentation 1: Some Iconic Australian Landforms – A Geological Perspective.

Ron's presentation began at a time some 500 million years (Ma) ago when Australia was part of Pangaea, a super-continent made up of all the continents that exist today which then broke up into 2 smaller super-continents, Laurasia in the north and Gondwana in the south some 200 Ma.

Gondwana was made up of Arabia, Africa, South America, Antarctica, Australia and India. These continents then started to break apart 165 Ma with the final separation at 45 Ma.

A collection of photographs from Ron's private library took us on a virtual journey through some of the more unique landforms on offer in Australia's 'Red Centre', which have taken millions of years to form.

The Devils Marbles (Karlu Karlu).

The first landform Ron described in Australia's Red Centre was the Devils Marbles, a collection of massive granite boulders strewn across a valley 105 km south of Tennant Creek. The valley is surrounded by the 500 million year old folded sandstones of the Davenport Ranges.

Standing at up to 6 m high, the boulders (tors) are the surface remnants of granite formed about 1640 Ma when magma (molten rock below the surface) cooled, crystallised and hardened.

In the Aboriginal mythology the Devils Marbles are the eggs of the rainbow serpent, and many 'dream time' stories and traditions of the Warumunga, Kaytetye and Alyawarre Aboriginal people are linked with this area.

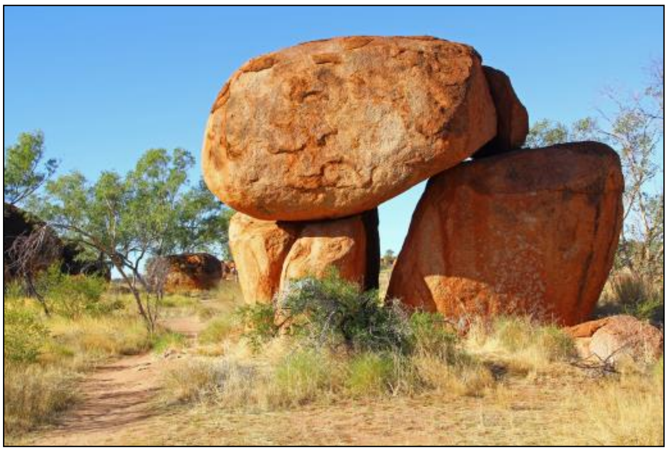
At a later time, tectonic forces caused folding within the surrounding crust, lifting the granite and fracturing the sandstone. As pressure on the granite diminished due to uplift and erosion of surface rocks, it expanded causing it to crack to form joints in 3 directions at 90° to each other creating large cubic blocks.

Over time, water seeping down through the joints decayed rock along the joints (chemical weathering).

When the blocks were finally exposed on the surface by erosion, the loose material along the joints was also removed. The blocks of granite then became rounded by the action of both chemical and physical weathering to the landscape we see today.

Devils marbles at dusk. Note how stacks of boulders are present.

Large isolated boulders are a common feature seen during walks through the Devils marbles.



Balancing boulders beside walking track.

An other spectacular balancing boulder, one of many present along the walks in Devils Marbles.

A large boulder cleanly split in half, probably the result of stress caused by expansion and contraction.

Gosse's Bluff Crater -Tnorala Conservation Reserve.

Ron then continued our journey to Tnorala (Gosse's Bluff) Conservation Reserve, a place of great cultural significance to the Western Arrernte Aboriginal people, as well as a site of international scientific interest.

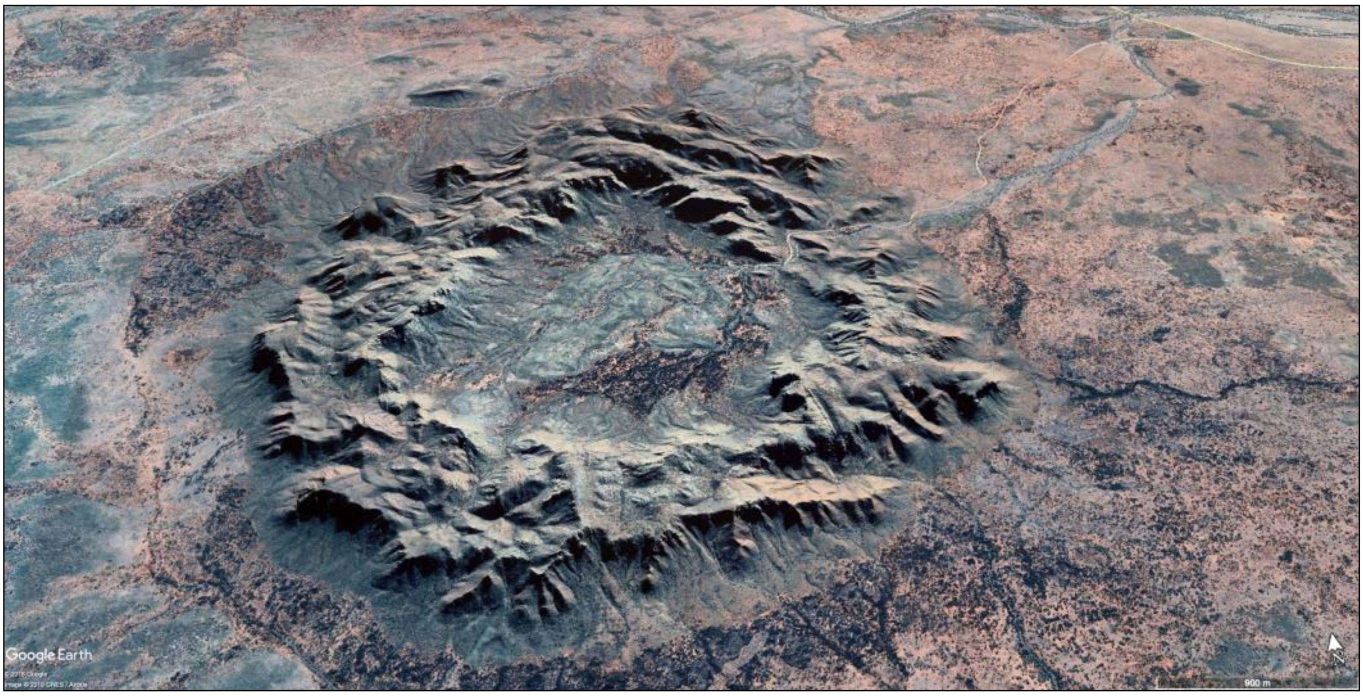
Gosse's Bluff, the remnant of an impact crater, is located on Missionary Plain about 175 km west of Alice Springs south of the western end of the MacDonnell Ranges.

Scientists believe that around 142.5 million years ago an object from space, (called a bolide, and either a comet, meteor or asteroid) about 600 m wide, crashed to earth, blasting a crater roughly 20-25 km in diameter.

Today the crater remnant is only 6 km in diameter with its rim 180 m above the surrounding Missionary Plain whose land surface about 2 km lower than the original impact surface.

A stream has eroded its way out of the crater on the northeast side removing the sediments that filled the crater. What is now left in the slightly raised centre of the crater are resistant rocks formed during impact.

The access road into the crater also follows the path of the stream bed.



Aerial view of Gosse's Bluff. Note the slightly raised center of the crater (due to rebound), the creek draining the present crater (also path of access road), and a remnant outer crater rim surrounding the present-day inner crater rim.

The crater rim of Gosse's Bluff seen from the entrance road.

Climbing to the crater rim. Note vertically tilted rock.

Inner wall of crater formed from vertically tilted rock.

Floor of crater seen from the rim.

Kings Canyon – Watarraka National Park.

The next landform described by Ron was Kings Canyon in Watarraka National Park. Kings Canyon is found in the George Gill Ranges with canyon walls reaching 200 m in height and the canyon stretching for almost 2 km. It's the deepest gorge in Central Australia.

The spectacular nature of the park has occupied the hearts and minds of the traditional 'Luritja' custodians for more than 20,000 years.

Two types of sandstone form Kings Canyon. Cliffs found on top are composed of Mereenie sandstone (which formed from sand dunes around 440 Ma) with Carmichael sandstone (formed from sediments washed into an inland sea around 400 Ma) making up the sloping lower parts of the canyon.

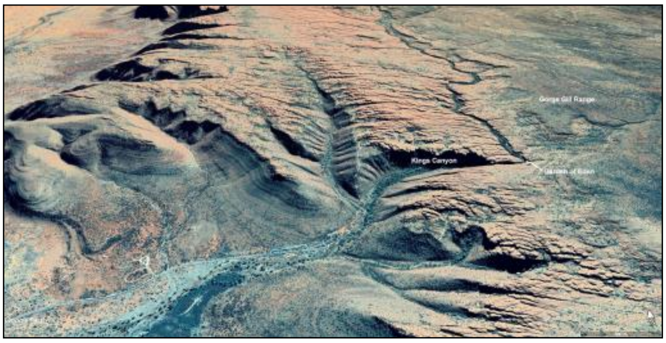
During uplift of the land some 350 Ma, the Mereenie sandstone cracked into two sets of joints at roughly 90° to each other. Erosion over 20 million years by Kings Creek has been responsible for forming Kings Canyon.

On top of the plateau domes of the *Lost City* are the result of differential weathering of cube-shaped blocks of sandstone formed during jointing.

The *Garden of Eden* is a deep pool that formed at the junction of the valley north of Kings Canyon gorge It is cool, shaded and contains water which provides a habitat for the cycad *Macrozamia macdonnellii* and other wet habitat plants.

Walking track on top of the plateau winds its way through domes of the 'Lost City'.

View down Kings Canyon from the northern rim.

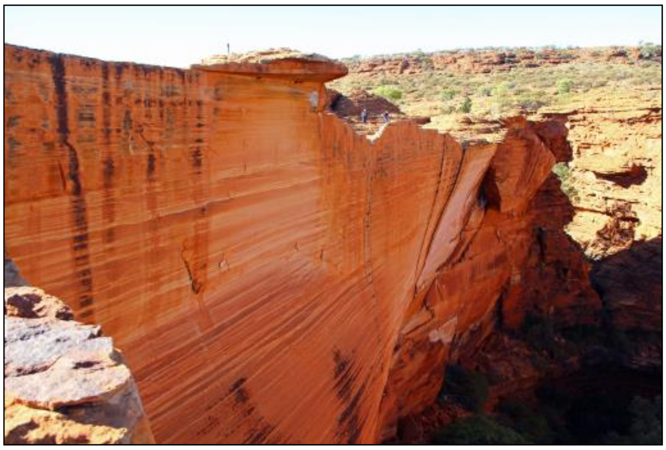


Google Earth view of Kings Canyon.

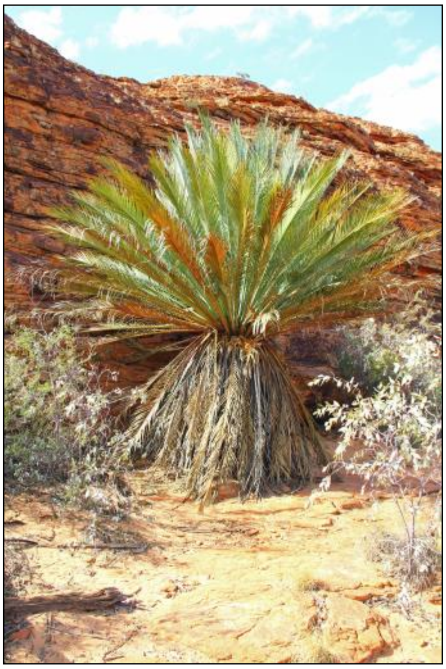
Looking west along the cliff line of the southern rim.

View up Kings Canyon.

Pool that forms 'The Garden of Eden'.



Northern rim of Kings Canyon looking east towards domes on top of the plateau.



The cycad *Macrozamia macdonnellii*.

The Olgas – Kata Tjuta.

Ron completed his presentation by describing and illustrating the spectacular landforms seen in the Olgas.

The Olgas are a cluster of more than 36 dome-shaped monoliths covering an area of 35 km². The highest, Mt. Olga at 546 m is 198 m higher than Uluru. Their heights decrease west to east.

The visible part of Kata Tjuta is only the top of a massive block of conglomerate (Mt. Currie Conglomerate) that extends down for 6 km and for tens of kilometres around the visible domes.

This concluded Ron's virtual tour of these present-day icons. His narrative illustrated with photographs on the development due to natural geological processes that has occurred over time, along with comments and questions from the audience regarding some areas, added to a deeper understanding of these 'Iconic Australian Land Forms'.

Google Earth view of Kata Tjuta showing the main domes on the left and the smaller eastern domes to the right.

Main domes of the Olgas. Right to left - Liru Mt., Mt. Olga, Mt. Wulpa and Mt. Ghee.

At the start of the 'Valley of the Winds' walk, the track leads into the domes.

Mt. Currie conglomerate, the main rock forming the Olgas.

Walking south between domes towards the second lookout.

View east from second lookout, Karingana into the Valley of the Winds and the eastern domes.

Valley of the Winds track looking towards the lower eastern domes.

Eastern domes - note the dipping beds in the dome.

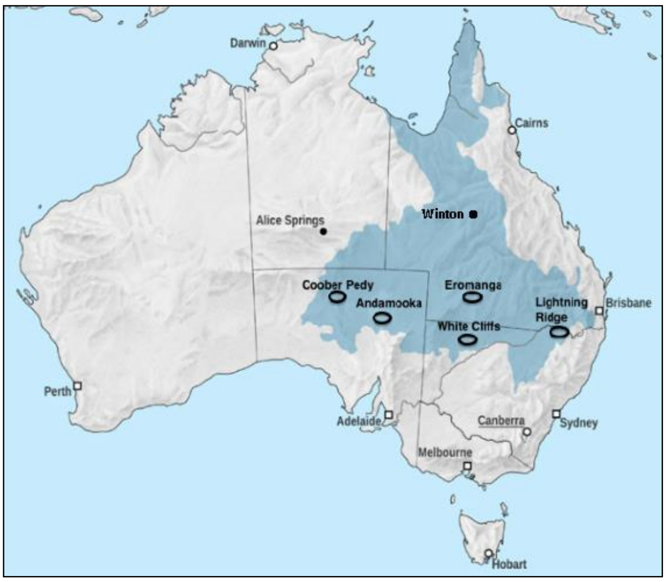
Presentation 2: Winton Dinosaurs.

Our second guest presenter was William (Bill) Hanley, a retired Pharmacist by profession. Bill's subject was the Australian Age of Dinosaurs Museum of Natural History and his experiences in finding and preparing dinosaur bones.

Bill's biography is impressive.

- William James (Bill) Hanley OAM, 2002 citation reading "For service to the communities of the Hunter through Local Government and a range of conservation, commercial, sporting and welfare bodies".
- Bill has accompanied Professor Michael (Mike) Archer and his team on a dinosaur dig in Alberta Canada, via the Australian Museum in Sydney.
- Participated in dinosaur digs and lab work with David Elliott, Chairman of Australian Age of Dinosaurs Museum Winton Qld, initially via Queensland Museum.
- Participated in an archaeological dig in Chile, also later on an archaeological survey of Mexico.
- Served on Newcastle City Council twice, and Lake Macquarie City Council twice.

Bill's 15 years' experience in field and laboratory work at The Age of Dinosaurs Museum comes on the back of the discovery by David Elliott in 1999 of one of Australia's largest dinosaurs, dubbed "Elliot", a gigantic sauropod from the Cretaceous Period (145 to 66 Ma). The dinosaur bones are from rocks found in the Winton Formation, in a geological layer 98 to 95 million years old.



Map of Australia showing the position of the Cretaceous Eromanga Sea and the present location of Winton.

David Elliot discovered the fossilised bone of what was, at the time, Australia's largest dinosaur while mustering sheep on his property 'Belmont' near Winton.

This bone was later identified as part of a giant femur from a Cretaceous sauropod that roamed the Winton area 95 million years ago.

Bill began his presentation by unfurling a 4 metre long scroll, on which he had diligently marked out the major events of Earth's history from the beginning of Earths formation some 4.5 billion years ago, to the Earth we know today. A 3 mm black line at the very end of the scroll showed where man fitted in, which seemed somewhat insignificant compared to other pre-historical events in time.

Bill's Power Point presentation started with an animation of the breakup of the supercontinent Pangaea. Earth hasn't always had seven continents, but began with one massive supercontinent called Pangaea. After Pangaea broke-up some 200 Ma due to tectonic plate movement, two smaller supercontinents called Laurasia and Gondwana formed. Gondwana was made up of Arabia, Africa, South America, Antarctica, Australia and India. These continents then started to break apart 165 Ma with the final separation around 45 Ma.

Bill's subject matter concentrated on a period of time some 100 million years ago, when dinosaurs roamed the lands around a great Australian inland sea.

Giant sauropods, ferocious theropods and diminutive ornithopods shared this world with everything from crocodiles and turtles to tiny mammals, yabbies and snails. Lightning Ridge was once a forested plain near this ancient sea. However, Bill's focus was on the Winton area where Cretaceous aged rocks of the Winton Formation (sandstone, siltstone and claystone) are exposed. At this time, a large shallow inland sea was in the process of slowly retreating from the land. Within sediments that formed in and around the bottom of the inland sea many dinosaur skeletons have been found. The best fossils are of sauropods, the largest of dinosaurs.

It was explained how these fossils were preserved by being quickly buried within the sediments that excluded oxygen, preventing decay and allowing the slow process of remineralisation. Seasonal movement in the soils of the area slowly push bones to the surface so they can be found.

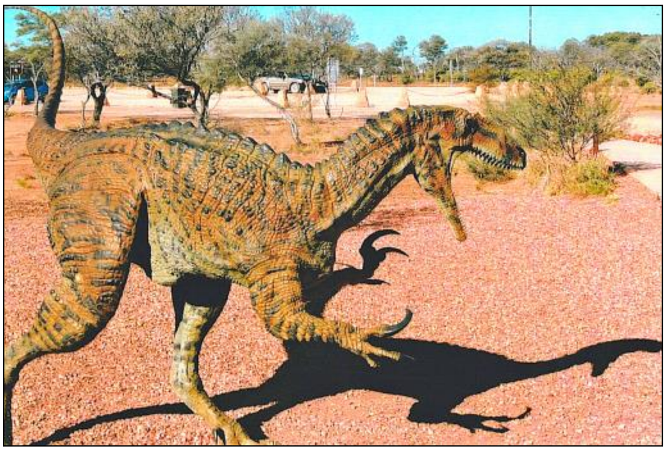
Bill showed images of dig sites, where the long painstaking processes of exposing these fragile fossils and encasing them in plaster take place, a necessary procedure before they can be transported to the laboratory. Once at the Laboratory, preparation, preservation and restoration work is carried out by technicians, so the fragile dinosaur fossils can be scientifically studied and then put on exhibition. Bill explained and illustrated how he participated in this process.

The building that houses the laboratory is divided into unprepared fossil storage, prepared fossil storage and a large preparation area where staff and volunteers work. As the dinosaur fossils are usually preserved in solid-rock boulders or covered in thick bands of iron-stone matrix, it is often a long and time-consuming task to chisel the rock away. Work undertaken at the Australian Age of Dinosaurs Laboratory includes mechanical preparation of the bones with pneumatic scribes which remove rock from the bones. Other activities include restoration, repairs, consolidation of specimens, sieving, sorting of matrix for microfossils and 'jig-saw puzzling' bone fragments together.

David Elliott and Bill Hanley.

Bill Hanley prepping 'Judy' in the laboratory at The Age of Dinosaurs Museum.

Matilda Rib prepped by Bill Hanley 2012.



Life-sized sculpture of 'Banjo' situated in front of the The Age of Dinosaurs Museum Visitors Centre.

Dr. Steve Porot, Bill Hanley and Bob Elliott in the laboratory at The Age of Dinosaurs Museum.

To finish his presentation, Bill handed around fossil fragments and interacted with the audience by answering questions and clarifying certain elements that puzzled some.

Report by Chris Morton and Ron Evans.
Photographs by Ron Evans (Iconic Australian Landforms) and Bill Handley (Winton Dinosaurs).

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Map Images.

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NSW Geotrails - Newcastle to the Central Darling

Presenter: James Ballard.
Date: Thursday 13th February 2020.
Attendance: 14 members.

The main talk was presented by James Ballard, a Geoscientist from the Geological Survey of NSW (GSNSW), focussing on NSW Geotrails. James has a BSc (Honours) from the University of Newcastle and was awarded the University Medal in Earth Science. His Honours research focused on mapping snow covered areas in the Murray Darling Basin. His work at GSNSW includes the compilation and delivery of geological datasets, the development of geology phone maps and web applications, supporting geotrails and engaging in outreach activities.

James started off his talk with a Geotrail Definition – *A geotrail delivers geotourism experiences through a journey linked by an area's geology and landscape as the basis for providing visitor engagement, learning and enjoyment.*

The Geological Survey of NSW Geotrail Vision is to develop several self-guided geological tours around NSW.

Self-Guided Geotours App - can operate completely offline, can work with GPS guidance if GPS is enabled on a smartphone and comes with text, audio and video.

Newcastle Coastal Geotrail - currently Beta-version and looks at how landscapes have changed in the last 250 million years. It runs from Nobby's Headland down past Merewether Beach and follows the Bathers Way with an overall length of 6 km and has 14 stops.

Port Macquarie Geotrail - released May 2018, has 5 stops and covers large scale tectonic processes such as plate tectonics and continental subduction with representative sections covered in a short walking distance.

Warrumbungle Volcano Geotrails - Beta version and is about a hotspot volcano that erupted 13-17 Ma. Some areas have been remapped by Geological Survey staff with the new data incorporated into the app. Some sections follow existing walking trails, and another follows regional roads.

Central Darling Geotrail - Proposal is mainly a driving trail that starts at Balranald and Wentworth and goes north up to White Cliffs.

Mutawintji National Park Geotrail Proposal, near Broken Hill, is a walking trail using existing walking tracks and will incorporate significant Aboriginal Heritage features.

James then gave us a live demonstration of the Newcastle Geotrail Beta version app.

James Ballard giving his talk on NSW Geotrails.

- ◊ To use it, you must download it first to your smart phone.
- ◊ Use the side tabs to jump to various sections.
- ◊ It has a General Overview, and also has Transport and Public Facilities information, Local Aboriginal and European History Information.
- ◊ There is a Geological Overview which then goes into information on each stop/section.

He also had a number of Geotrail Pamphlets and another about resources available to the public from the Geological Survey of NSW. There was also handout on the upcoming March 11 HEDG Meeting celebrating International Women's Day and Apollo Mission Moon Rocks.

To conclude, James gave a demonstration of the new version of NSW Geology Phone Maps.

This was followed by a question and answer session. Some of our group wanted more information and several of our group suggested further ideas for the geotrails which James was taking back to the Survey.

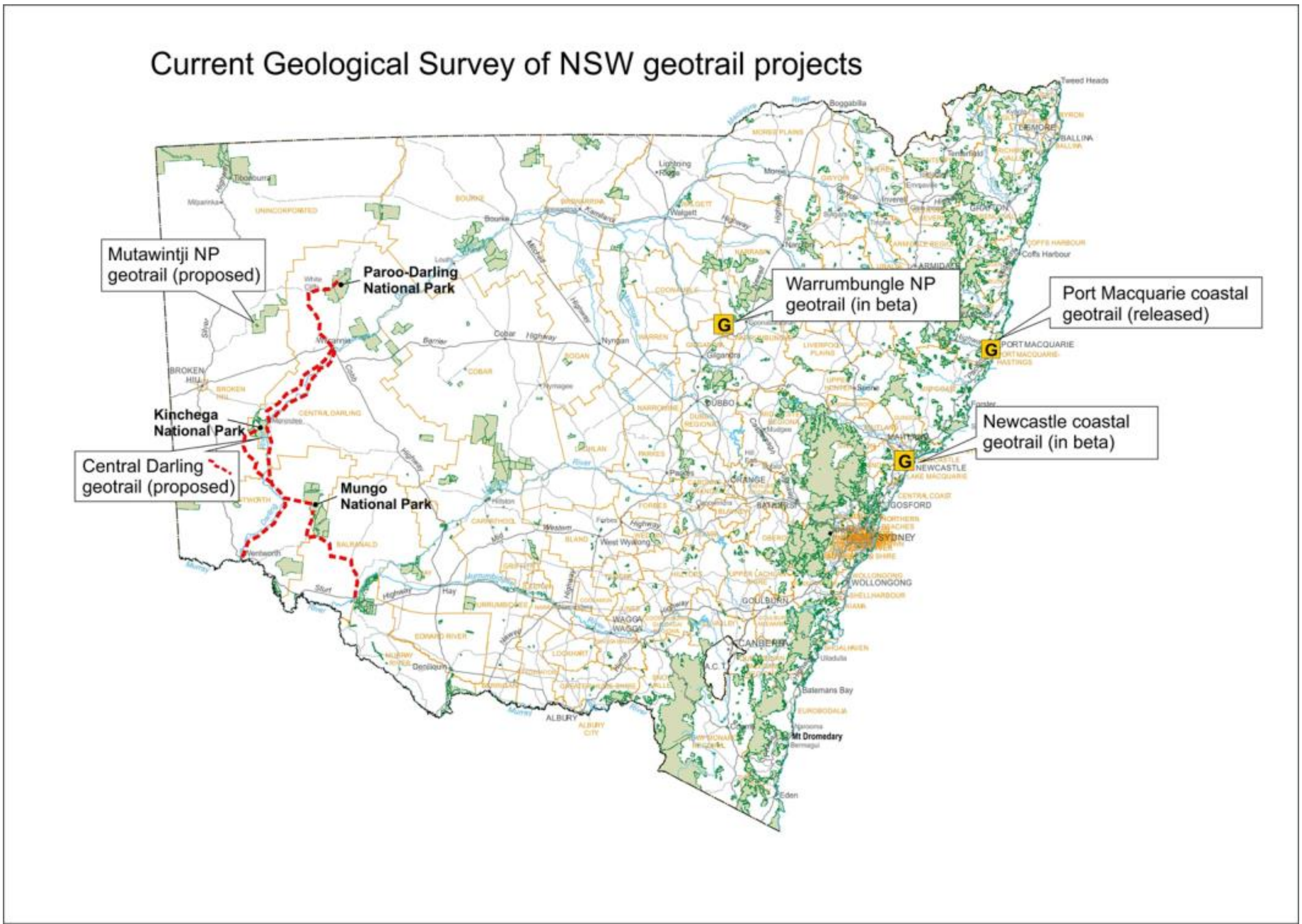
James talk started at 1:30 pm and was slated for about 45 minutes. He was still answering questions at 3:15 pm, proving how popular and interesting the talk was to our group.

Slides.

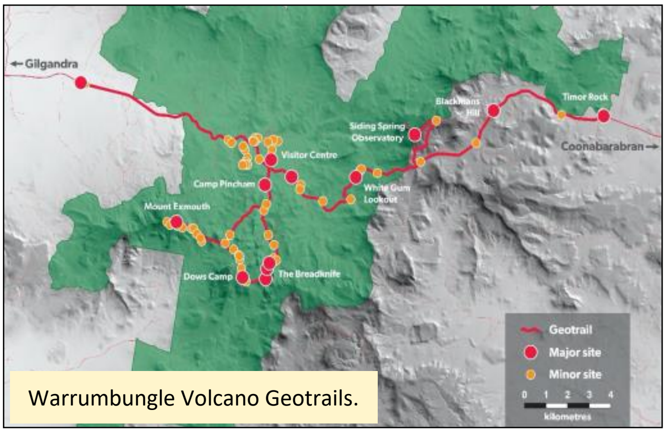
Permission to use power point slides presented by James Ballard granted by personal communication, 13/2/2020.

Hexham Bowling Club acknowledgement.

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



Path of Newcastle Geotrail, currently a beta version.



Warrumbungle Volcano Geotrails.

Currently available Port Macaquarie Geotrail.

Long Reef Field Trip

Leaders: Peter Mitchell & Phil Colman.
Organiser: *Chris Morton.*
Date: Sunday 8th March 2020.
Attendance: 19 members, 1 guest.

The idea for this activity was first suggested to us by Peter Mitchell OAM after his very successful Muogamarra excursion conducted on 19th October 2019 (See 2019 Geo-Log, Muogamarra Nature Reserve p 84). Long Reef Headland is one of the many destinations geology students visit in pursuit of their degree. So, this invitation was eagerly accepted.

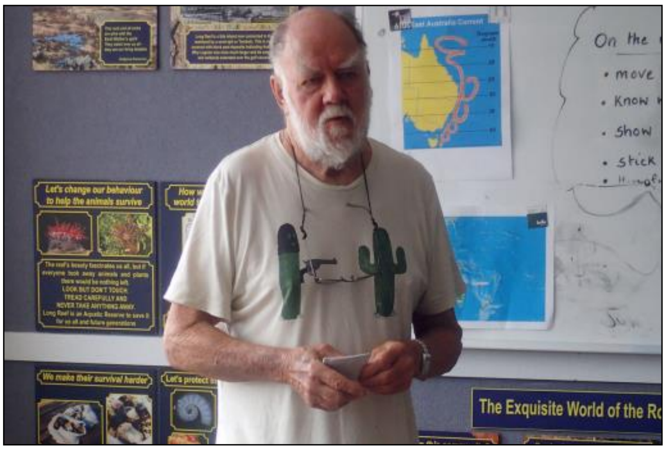
Peter Mitchell and Phil Colman co-authored the book 'Exploring Tidal Waters on Australia's Temperate Coast', based on the geological and biological features of the long Reef Aquatic Area & Reserve. Although this book focused on the Long Reef area, the information is universal, and can be used as a reference for temperate waters around Australia.

We met Peter outside the Surf Club building and boat ramp at Fishermans Beach, on a warm Autumn morning that had the potential to shower at any time. The meeting place is a short walking distance from the headland and rock platform that we came to explore. The late 11.00 am start was to coincide with a very low 2 pm spring tide.

After pleasantries we were ushered into a small room below the two-story building owned by the surf club where Phil Colman was waiting to greet us. The surf club has set this room aside for Phil so he can conduct sessions on the marine environment for the public. The room has been decorated with educational displays of marine life and other interpretative material *(Photos 1 & 2).*

Phil describes himself as a Malacologist, which is a fancy name for a shell collector, but his interests are much greater and over the years he spent time in the highlands of PNG chasing insects for the Bishop Museum of Honolulu. His longest period in one place was at the Australian Museum in Sydney in the Department of Malacology. Peter and Phil's connections there were through the Director Professor Frank Talbot. Phil worked under him in the Museum and Peter worked under Professor Talbot when he started the Centre for Environmental Studies at Macquarie University. Another early link was through one of Peter's students who did work experience with Phil and who later roped them both, along with a bunch of others, into a Scientific Advisory Panel to Manly Council. In that capacity they acted as community based pro-bono consultants on all sorts of projects where Council needed better scientific understanding. They continued that for about 12 years and pride themselves on having made a difference!

1. AGSHV members being addressed by Phil Colman.



2. Phil Colman addressing AGSHV members.

Not content with keeping Manly Council honest, Phil regularly stirs local government along the North Shore. One of the great things about aging and no longer being tied to an employer is that you can say what you think and sometimes people listen. As for Long Reef, Phil has lived right on the shore there all his life and is forever guiding groups over the rocks and revealing the wonders of life at the shore.

Phil gave a short presentation on the East Australian Current (EAC) that flows south along the east coast of Australia from near Queensland's Fraser Island to Tasmania and how these currents act much like the wind, in that they are carrying and dispersing marine life from tropical waters to areas much further south, more so presently than in past times *(diagram 1: East Australian Currents).*

It is an important feature of the Tasman Sea between Australia and New Zealand, which has been warming faster than other parts of the ocean. Occasional erratic bursts southward of the East Australian Current (EAC) are thought to have moderated the weather of south-east Australia this autumn and winter and they continue to introduce tropical and sub-tropical marine species to Tasmanian waters.

Over the past 50 years sporadic warm bursts have become more common as the EAC moves further south. With global warming, the warm burst we've seen this year may also become the norm.

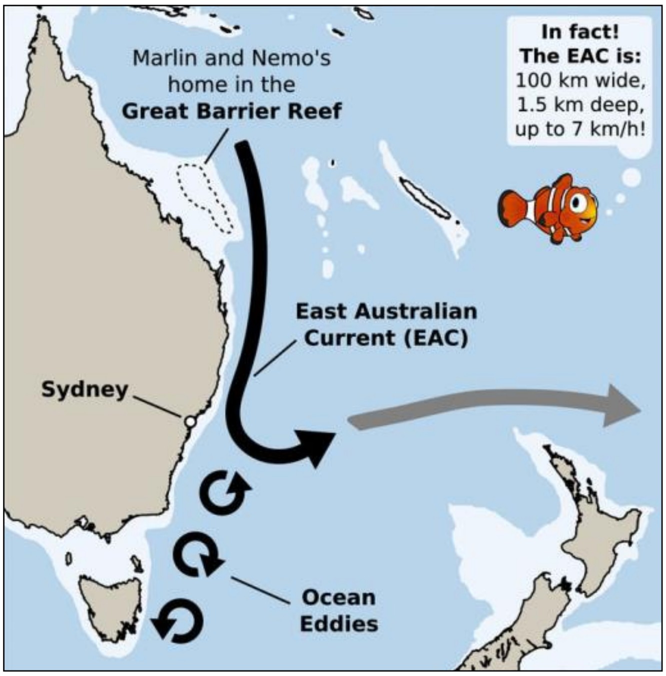


Diagram 1. East Australian Currents.

After Phil's talk and interesting discussion, Peter lead us on our exploration of the Long Reef rock platform.

Peter Mitchell's report.

Long Reef Geology.

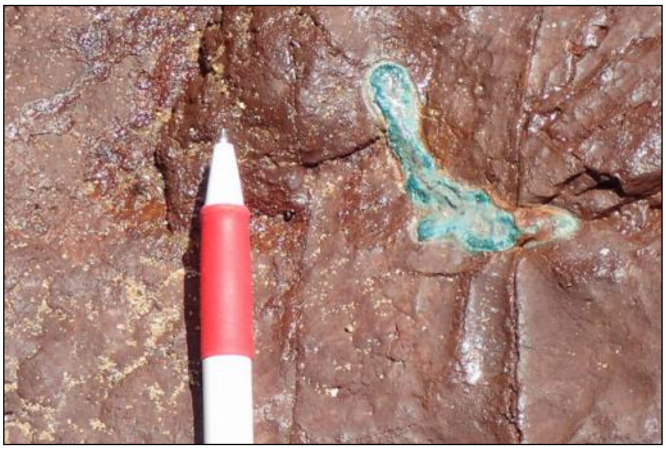
The cliffs and shore platform on the Long Reef Headland are formed in the Triassic Bald Hill Claystone where the full thickness of this unit is exposed *(photos 3 & 4)*. Other sections through it can be seen at Turrimetta and Mona Vale Headlands and much further south at the type locality of Bald Hill near Stanwell Tops.

The Bald Hill Claystone is a sequence of mud rocks and siltstones, with thin conglomerates and grit beds. The overall colour is red-brown, often referred to as 'chocolate' with the coarser beds being grey-green (reducing conditions). The rock has a minor volcanic ash content and that may be linked to the presence of small blue-green blobs of copper minerals found in the platform near the boundary between red-brown and grey-green rocks. According to Dolanski (1975) the minerals include a small amount of native copper and atacamite (basic copper chloride) associated with organic matter (coal) *(Photo 5)*.

Samples of copper ore described to Joseph Banks by George Caley in 1800 were probably obtained from this location. Optimistic locals drove an adit into the headland from the south western corner in the hope of finding copper and silver, but when? 1835, 1880s, 1930s? We know that the Department of Mines once had a map of the lease and workings but ever since their archives were digitised no one has been able to find it. The only firm reference I have been able to track down

3. Long Reef Headland and sea cliff formed from Bald Hill Claystone.

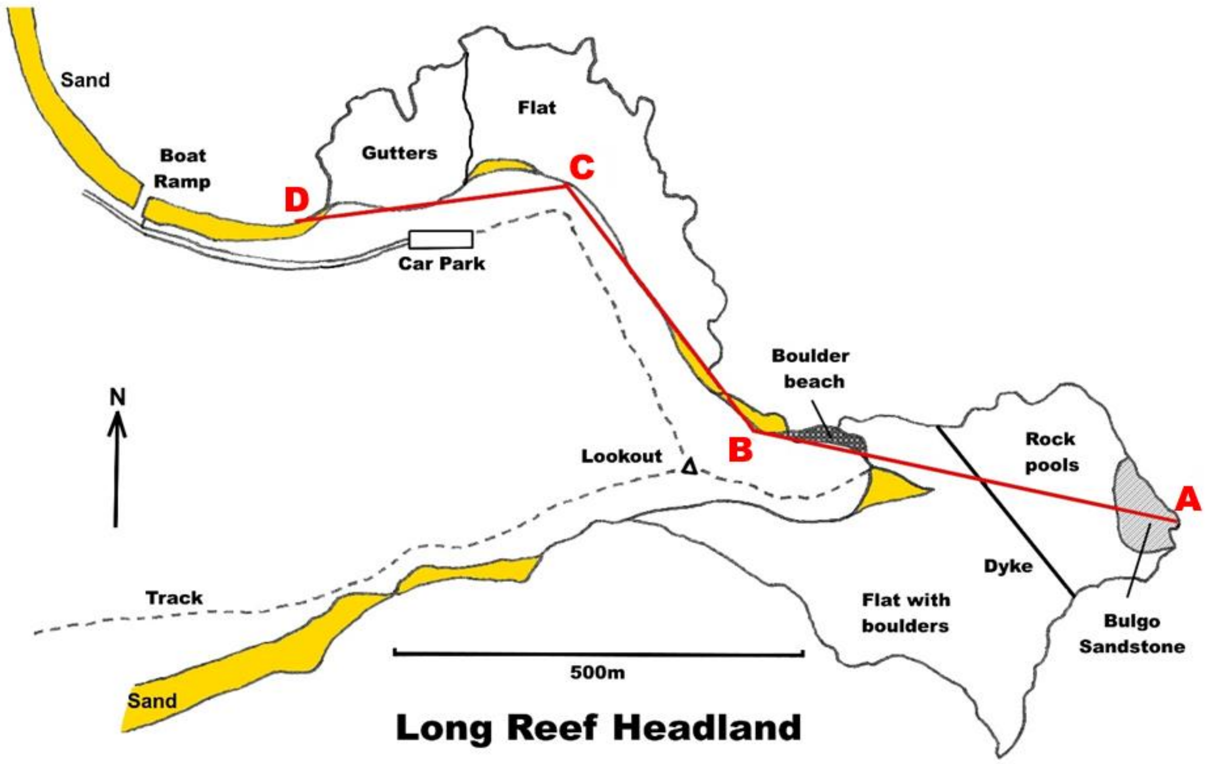
4. Fractured and indurated Bald Hill Claystone exposed on the sea cliff.

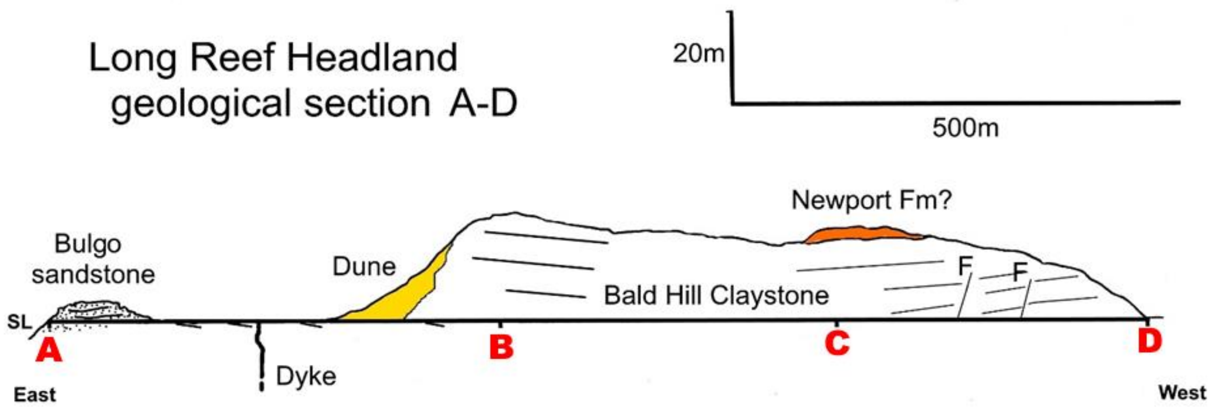


5. Blobs of copper minerals within Bald Hill Claystone.

was a one-liner in the 'The Worker' (published in Wagga) on 28/11/1903 mentioning prospecting for copper and silver at Narrabeen.

On the highest part of the cliff the rocks have been altered to a few metres of a reddish ironstone in which much of the original iron oxide has been converted to hematite. It is likely that this material belongs to the overlying Newport Formation rather than the Bald Hill Claystone. Large blocks are scattered on the shore





platform where their 'honeycomb' structure can be recognised as cavities from which white kaolin clays have been eroded. Some texts refer to the ironstone as 'laterite' but it is quite unlike the laterite found elsewhere on the north shore such as at Terrey Hills which have a pisolitic texture. The iron deposit at Long Reef shows characteristics (including irregular thin layering, incorporated sub angular sandstone cobbles, and ironstone-filled cracks in adjacent sandstones) typical of iron deposits layed down by groundwater springs (often called in the past 'chalybeate springs') such as occurred at Mittagong and presently forming on Lakes Beach at Budgewoi. At the far eastern end of the headland the rocks standing above the platform forming a small island at high tide are quartz sandstones belonging to the Bulgo Sandstone which is stratigraphically below the Bald Hill Claystone. Only the highest part of this unit is seen here but offshore drilling shows it to be 100 m thick. This particular outcrop probably fills a former river channel.

Two other rock types are worth mentioning. The eastern end of the shore platform is crossed by a dolerite dyke, *(photos 7 & 8)*, a vertical sheet of volcanic rock that extends several kilometres into the crust. Dykes are common in Sydney but it is very rare to see one with fresh rock. We do not have a date on it but it must be younger than the Bald Hill Claystone which is early Triassic or 250 million years, suggesting that the dyke is about 200 million years in age.

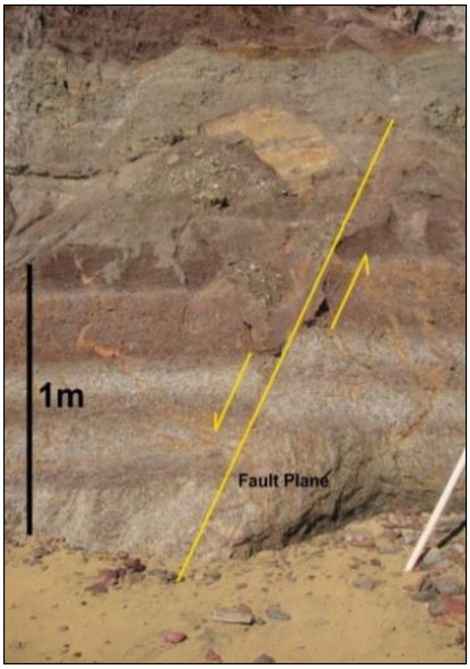
The last rock type is very young. This is beach sand cemented by calcium carbonate which occurs at the base of the dunes near the eastern end of Long Reef headland and on the beach at the end of Florence Ave.

Both units are formed when calcium carbonate dissolved from shell fragments by fresh water in the sand is precipitated and cements the sand at the salt water interface. 'Beach rock' is often described as a tropical coastal deposit, but is found here because of the abundance of shell *(photo 9)*. As to age, it is time transgressive and is being formed today. You might try and link its formation to Holocene changes in sea level but that's a

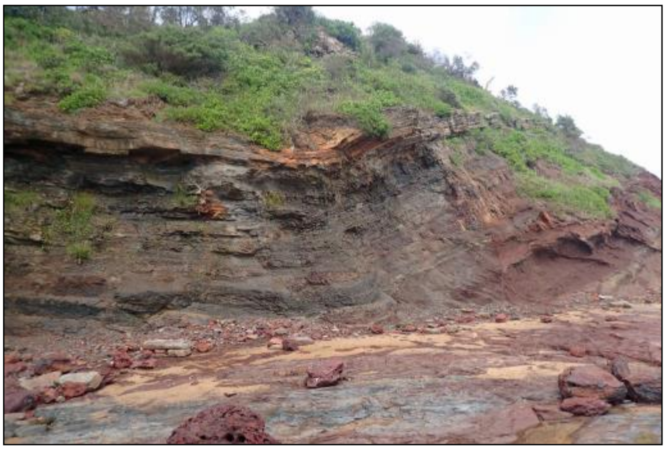
7. A dolerite dyke intruding Bald Hill Claystone that has been displaced by faulting.

8. AGSHV members examining the displaced dyke.

9. Calcium carbonate cemented beach sand.



10. Faulted beds (normal fault) near Fishermans Beach.



11. Faulted syncline in cliff face near Fishermans Beach.

fraught question without easy answers.

The widest section of the shore platform is on the red-brown shale which is almost featureless except for some very persistent cracks which are eroded joint planes in the rock in which sea urchins have drilled lots of holes in the process of bioerosion.

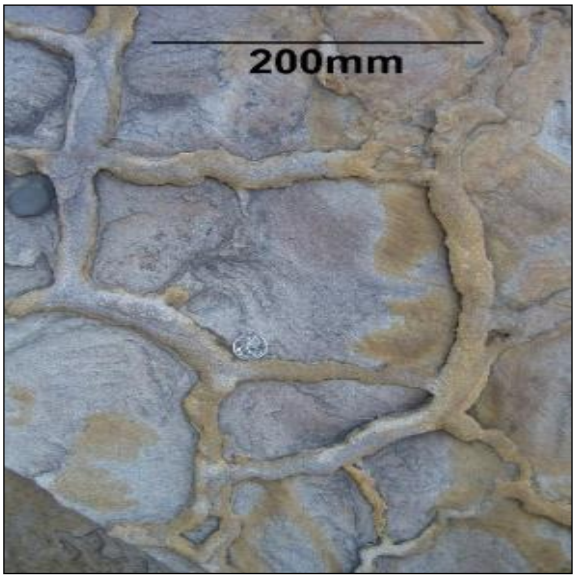
In the cliffs near Fishermans Beach several small faults can be seen where different coloured beds have been displaced *(Photos 10 & 11)*. In the same area the shore platform has a varied micro-topography of pools, gutters, and steps all of which relate to subtle differences in the nature of the rock. These create habitat for different assemblages of inter-tidal species.

The shales and fine-grained sandstones carry fragmentary plant fossils and even small logs and branches converted to coal *(Photo 12)*. The shales also have numerous invertebrate feeding trails preserved on bedding planes which are very similar to the trails formed by molluscs on the floor of modern rock pools. In other places fossil ripple marks *(photo 13)*, and preserved mud-cracks *(photo 14)* are found, and years ago the fossilised remains of an amphibian were found on the headland.

The presence of these fossils and trace fossils and the absence of any fossil shell suggests that the environment in which the volcanic mud and sand was deposited was more likely to be a swamp or estuary than deeper

12. Fossilised tree branch.

13. Fossil ripple marks.



14. Infilled mud cracks

15. Top of worm burrows.

16. Infilled worm burrows, 3 cm high.
(Brian England)

marine. Preserved ripple marks and infilled mud cracks suggest shallow water conditions.

One author published extensively on the different rock units along this part of the coast, and described beds with numerous infilled burrows as 'fossil soils' that he believed supported a swampy coniferous forest in Triassic times. *(Photos 15 & 16)*.

This work is often cited but it badly needs to be revised and should be read with caution. These rocks were never soil in any normal sense of the word.

Sea levels; then, now and tomorrow.

It's common these days to cite a model of Pleistocene sea levels as if we have known about them forever. It was 3 - 5 m higher than present circa 130,000 years ago, fell to about -120 m at the peak of the last glacial 18,000 - 20,000 years ago, then rose rapidly to the present level 6,500 years ago.

There is some evidence that it might have been 1 - 2 m higher than present around 3,000 years ago. That's the general story but be prepared to see it revised in the next few years.

One recent study at Bulli has pushed the high stand back to nearly 8,000 years ago and there are indications that it might have remained at that 1.5 to 2 m level until perhaps 2,000 years ago. One study doesn't make a firm case but it sure points in some new directions.

If you have never had any reason to question this picture you may be surprised to know that the whole model of ice age sea level change is a lot younger than you might have expected.

The first geological reports of changes in elevation of the NSW coast were published by David and Etheridge (1890), Etheridge et al. (1896), and David and Halligan (1908). The evidence is real and includes raised estuarine mudflats at Largs in the Hunter Valley, a buried mangrove system with a dugong and Aboriginal axes at Mascot, and a shift from dune sand to estuarine muds beneath Narrabeen Lagoon. That last site was explored using a hand-boring rig powered by 20 students – those were the days!

Around the beginning of the 20th Century we had good evidence of both positive and negative changes in the relative level of the land and the sea, without dates of course, but clearly geologically recent. And the cause? Well geologists then were so locked into cycles of erosion that no other mechanisms were considered.

Evidence for Pleistocene Ice Ages was well known in the northern hemisphere, and even though abstraction of water from the oceans was part of the model for continental glaciation as early as 1842, no field evidence of any recent change in sea level that might be attributed to glacial conditions was presented until 1924, when the Flandrian transgression was first described in Belgium.

In Australia we were slow to pick this up and as late as 1969, when the compendium of NSW Geology was published by the Geological Society geologists were still locked into the Kosciusko Orogeny to explain everything, but the geomorphologists, particularly Bruce Thom, had abandoned that and accepted that water abstraction from the oceans had occurred during the Ice Ages and that this could explain most of the features of the coast. With an increasing number of carbon-14 dates the sea level graphs became more accurate and people like John Chappell made a huge contribution when he untangled the tectonic changes from the eustatic changes on the Huon Peninsula (PNG) in 1973/4. There have been many more dates produced since then but most just blur the details we would like to know.

Why do we need details? Because all the evidence from climate modelling and tide gauges shows that sea level is rising. We need to know by how much and how should we adjust to it? If we can identify a higher level in the last few thousand years it might give us a realistic measure of the changes to expect in the near future.

I don't have solid answers to these questions but the Collaroy-Narrabeen barrier is one place where we can already see the 'writing on the sea-wall'. Local Government is planning for a 1 m rise by 2100, I doubt this is enough and even if it is, it will still mean enormous private losses.

Bet your life that property insurance companies have already factored that in!

Report by Chris Morton and Peter Mitchell.
Photos: Chris Morton and Peter Mitchell.

Reference:

DAVID T.W.E., and HALLIGAN G.H. 1908. *Evidence of recent submergence of coast at Narrabeen.* Journal and Proceedings of the Royal Society of NSW. 42:229-237

DAVID T.W.E. and ETHERIDGE R. 1890. *The raised beaches of the Hunter River Delta.* Records of Geological Survey NSW 2: 37-52

DOLANSKI J. 1975 *Copper mineralization in the Narrabeen Group, Sydney Basin.* GS1975/377 35pp

ETHERIDGE R., DAVID T.W.E., and GRIMSHAW J.W. 1896. *On the occurrence of a submerged forest with remains of the Dugong, at Shea's Creek, near Sydney.* Journal and Proceedings of the Royal Society of NSW. 30: 158-185

https://theconversation.com/things-warm-up-as-the-east-australian-current-heads-south-31889

Dudley Rock Platform

Leaders: Brian England and Ron Evans.
Date: Wednesday 1st July 2020.
Attendance: 16 members.

After a long pause in activities due to the corona virus and with the easing of Government health and social distancing restrictions, it was decided to recommence field excursions with a half day visit to the Dudley rock platform and its fossil forest. Surprisingly, given the significance of this part of the coastline, this was the Society's first organised visit.

The purpose of our visit, as well as examining one of the best preserved forest remains in the Newcastle Coal Measures, was to establish the correct stratigraphy and nature of the exposed coal seam. Some authors have attributed the coal to the Dudley seam, whereas others (Nashar, 1964 & Boyd, Little and Herbert, 1998) have attributed it to the Victoria Tunnel seam. We hoped our examination of the rock outcrops would solve this confusion.

Members met at the small car park at the end of Bombala Street in Dudley, on the northern boundary of Glenrock State Recreation Area. It was a magnificent sunny winter's morning as we set off down the well-formed track through an open forest of stringybark and spotted gum, passing two lookout platforms which provided an overview of the rock platform below as well as great spots from which to watch passing whales. The track emerged on the south bank of Cross Creek *(photo 1)* at the north end of the rock platform.

Initially the platform comprises interbedded deltaic sandstone and conglomerate typical of the lower part of the Kotara Formation lying at the base of the Adamstown Subgroup. Immediately it was obvious that it would be the Victoria Tunnel coal, not the Dudley coal which lay directly below these rocks. At the top of Dudley Bluff (below the first lookout platform) there is a small outcrop of Redhead Conglomerate, below which lies the lower split of the Fern Valley seam. Sadly the stratigraphy above the rock platform is largely obscured by vegetation, making interpretation difficult.

Beneath a short overhang just south of Cross Creek lies one of the best examples of a water escape structure seen anywhere along this coastline *(photo 2)*.

These structures form when water held under pressure in the pore networks of unconsolidated wet sediments is suddenly expelled through some point of weakness, disrupting the overlying sediment and leading to the temporary formation of a funnel-like water filled void into which the disturbed sediment layers collapse. Where lag conglomerate beds have been intersected the pebbles often settle to the base of the funnel to form a column. Formation of these structures may have been initiated by earth tremors. The overhang also displays spectacular examples of interbedded sand bar and gravel bank deposits *(photo 3)* laid down by the braided river which built up the sediment pile in the Kotara Formation.

1. Cross Creek.

2. Water escape structure.

Further south the Kotara Formation exposed on the rock platform displays superb examples of trough cross bedding *(photo 4)*. In these structures the horizontal traces of the foreset beds are markedly curved and concave down current with the bisectrix indicating direction of current flow. A wide variation in current direction is indicated. These troughs were probably eroded by tidal currents and infilled by sediment deposited by slow-moving (less than 3 cm/sec) delta distributaries (Wulf, 1962).

3. Interbedded sand bar and gravel bank deposits.

4. Trough cross bedding.

5. Honeycomb weathering in sandstone.

Spectacular examples of honeycomb weathering begin to appear on the sandstone beds further south *(photo 5)* and nearby lie superb examples of dimpling *(photo 6)* on sandstone surfaces exposed to regular drying and re-wetting by seawater.

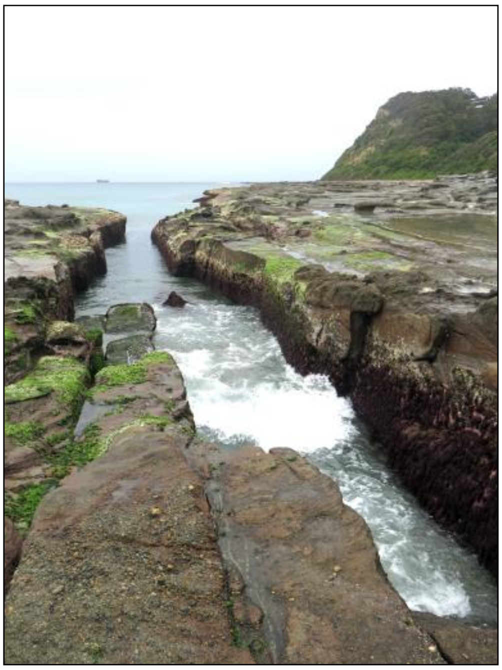
6. Dimpling.

7. A jointed spherical concretion in cross section.

8. Tessellated siderite bed.

The sandstone along this section also contains scattered spherical concretions, some solid *(photo 7)*, others with only a rim of toughened indurated sediment evident. Small lenticular masses of brown siderite here show spectacular tessellation due to shrinkage on dehydration of the original gel-like deposit and later in

9. Breccia bed - note clasts of coal and shale.



10. Channel eroding out along a set of parallel joints.

filled by secondary iron oxides *(photo 8)*. Also of interest here is a sandstone bed showing angular clasts of coal, carbonaceous shale and grey shale torn from the underlying beds associated with the Victoria Tunnel seam and washed into an adjacent lake bed *(photo 9)* by a flood.

A few hundred metres south of Cross Creek the rock platform is cut by a deep channel *(photo 10)* eroded along a set of closely spaced parallel joints trending NW-SE. These joints are evident in the cliff at the head of the channel where a small cave is being eroded under the rock platform.

South of the channel the rock platform drops abruptly by around 0.6 m where the deltaic sandstone has been eroded away to expose the underlying bed of laminated lacustrine shale *(photo 11)*. Within the shale are layers of nodular brown concretionary siderite *(photo 12)*. The second of these layers contains drift fragments of *Dadoxylon* and immediately overlies the shales containing

11. Deltaic sandstone laminated lacustrine shale boundary.

12. Nodular brown concretionary siderite deposit.

13. Petrified stump of *Dadoxylon*.

the fossil forest. These wood fragments probably represent flood debris.

The fossil forest comprises a multitude of stumps *(photo 13)* and trunks *(photo 14)* preserved mainly in siderite. The logs are up to 10 m long and 20 cm thick,

14. Petrified trunk of *Dadoxylon*.

15. Petrified *Dadoxylon* stump with shallow radiating roots attached.

with stumps up to a metre across showing shallow roots around their base *(photo 15)*. Some of the trees have been knocked over. The *Dadoxylon* trees were tall, straight and devoid of low branches, with no knots visible on any of the logs exposed. No fossil leaves are present in any of the enclosing shales. Site evidence shows that these trees grew in a swamp and were felled by a flood, with the logs scattered randomly. There is no apparent tuff component in the surrounding rock and no evidence of burning, unlike the forest preserved in the Reids Mistake Tuff at Reids Mistake Head. So this forest was not destroyed by a volcanic eruption.

At the very southern end of the accessible rock platform black carboniferous shale below the Victoria Tunnel seam is occasionally exposed at sea level at low tide.

16. Victoria Tunnel seam exposed at the base of the cliff due to a very low tide and sand erosion by large seas.

The Victoria Tunnel seam itself is exposed in the lower part of the adjacent cliff *(photo 16)*, showing alternate bands of bright (vitrain) and dull (fusain) coal. Both lie immediately below the shale bed containing the fossil forest but are higher here due to minor folding. These areas are covered by sand at times.

Access further south along the coast is blocked by rockfalls but the continuation of the shale and sandstone beds of the Kotara Formation can be clearly seen. At the southern end these sediments incorporate a wedge of Merewether Conglomerate (Boyd, Little and Herbert, 1998).

Report by Brian England with additions by Chris Morton. Brian Dunn led the initial investigative trip to the area.
Photographs by Brian England and Ron Evans (11, 14, 15, 16)

References:

BOYD, R.; LITTLE,M. & HERBERT, C. (1998). *A new look at the Newcastle Coal Measures. Two contrasting approaches to their formation and sequence stratigraphy*. Field guide for the 32nd Newcastle Symposium on advances in the study of the Sydney Basin. Department of Geology, Newcastle University.

NASHAR, B. (1964). *Geology of the Hunter Valley*. Jacaranda Press.

WULF, R. (1962). *Trough cross bedding*. Journal of Sedimentary Research, 32(3), 472-474.

Mulbring Quarry

Leader: Brian England.
Date: Saturday 15th August 2020.
Attendance: 22 members and 5 visitors.

Mulbring Quarry was last visited by the AGSHV in April 2014.

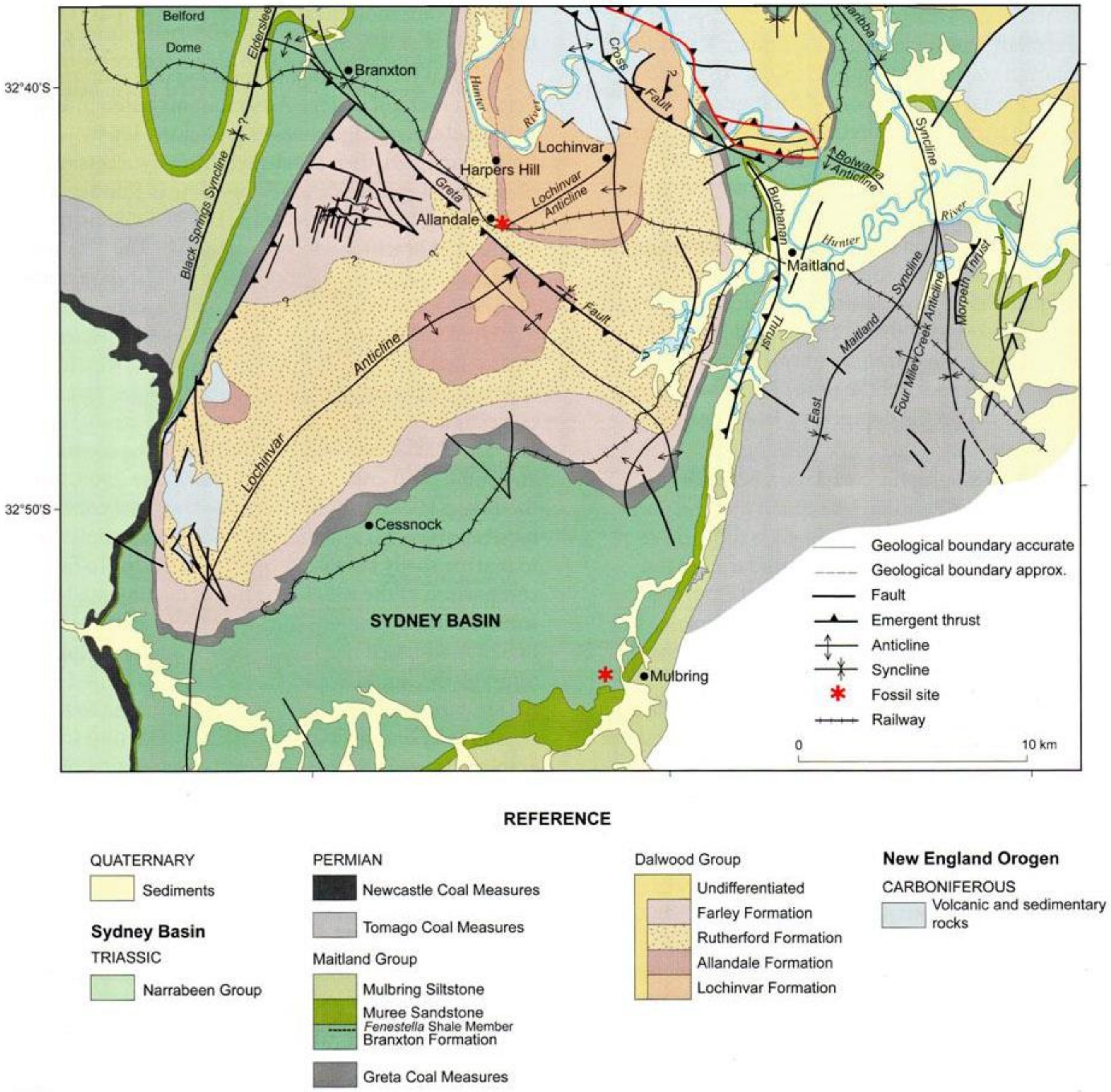
The following information is taken from the report in Geo-Log 2014.

Introduction.

The now-disused Mulbring quarry is on private land and was once used as a source of road base by Cessnock Council. It was first noted as a fossil locality by Branagan and Packham (1967).

Despite the wealth of fossils found at the quarry, very few specimens from there have been described in the scientific literature, and the stratigraphy and depositional environment of the strata at the site have only recently been documented in an unpublished thesis (Vanderlaan 2007 and recently summarized by Percival et.al. 2012). Access to this site is strictly at the discretion of the landholders, and their permission must be obtained prior to entry.

Regional geology map showing the site of Mulbring Quarry.



(From Percival, Meakin, Sherwin, Vanderlaan and Flintoff (2012))

Stratigraphic Column of the Permian Period, Hunter Valley.

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

Stratigraphy.

In Mulbring quarry, the Fenestella Shale Member of the Branxton Formation, the lowermost unit of the Maitland Group, is exposed.

The Fenestella Shale Member is 30-60 m thick and consists of interbedded yellowish brown micaceous shale and siltstone, with sparse bands of very thin calcareous mudstone (Booker 1957).

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

Fossil Fauna.

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

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

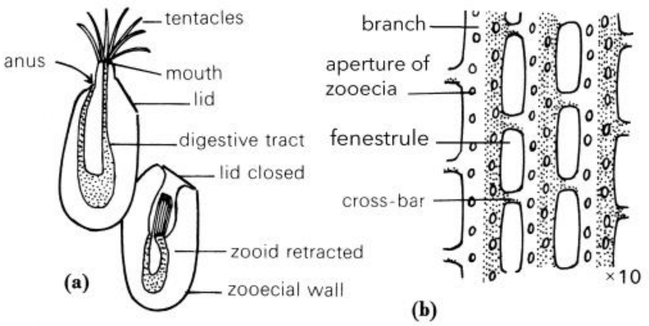
A large proportion of the fossils found are predominantly complete and unfragmented. Brachiopods and bivalve molluscs exhibit high levels of articulation (segments are found still attached together), indicating a low-energy environment on the marine shelf, below wave base for much of the time. There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

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

Common Fossils found at Mulbring Quarry.

Bryozoans.

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

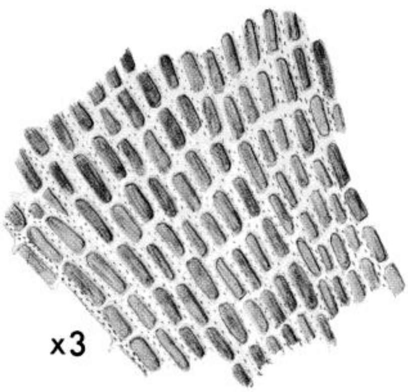


(From Rhonda M. Black (1970) P. 229)

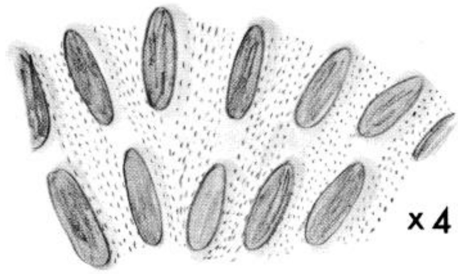
(a) Two zooecia showing the position of zooids (animals) when open and closed.

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

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



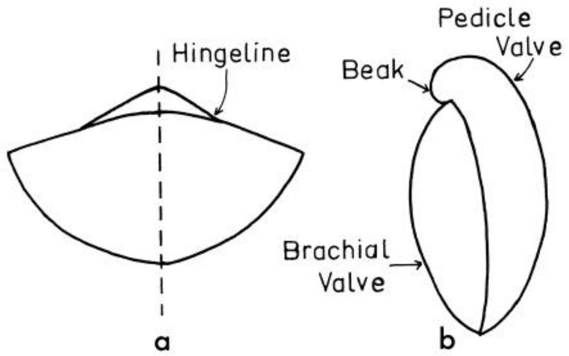
Fenestella sp. Note two rows of zooecia per branch.
(From Nashar (1964) P. 20)



Polypora sp. Note many rows of Zooecia per branch.
(From Nashar (1964) P. 20)

Brachiopods.

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

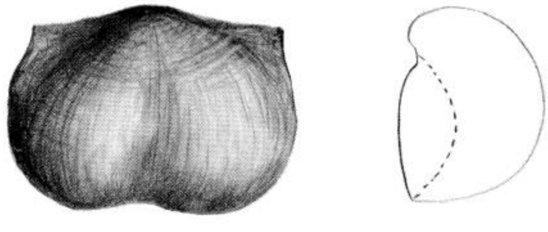


a. Bilaterally Symmetry b. Unequal valves
(From Nashar (1964) P. 21)

Common Brachiopods found in the Mulbring Quarry include Spirifers such as *Notospirifer sp., Ingelarella, Trigonotreta sp.* and *Echinalosia* (a productid).

Ingelarella.

Spirifer sp.
Ribbed valves with hingeline longer than shell height.



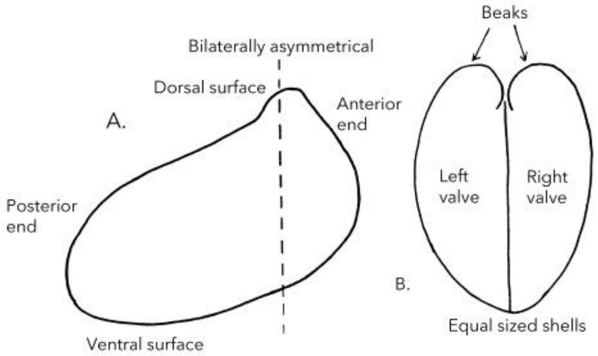
The Productid *Dictyoclostus*. Note small brachial valve.
(From Nashar (1964) P. 21, 22)

Molluscs.

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

a) Bivalves.

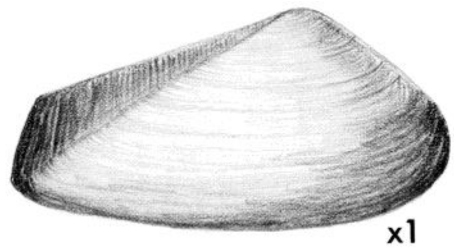
These organisms have a laterally compressed body that lives between two calcareous valves that have equal valves but are bilaterally asymmetrical.



(From Nashar (1964) P. 24)

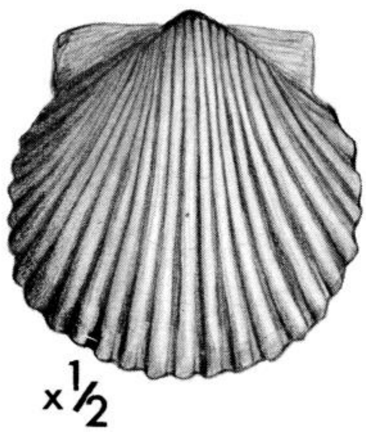
The group is entirely aquatic most living a sedentary life in shallow waters.

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



Myonia sp. Note straight shell on dorsal surface.

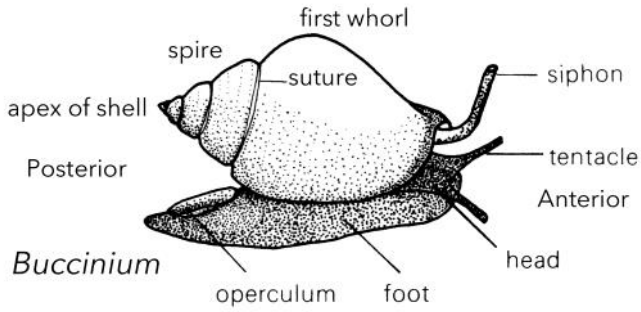
(From Nashar (1964) P. 25)



Deltopecten sp. (From Nashar (1964) P. 20)

b) Gastropods.

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



(From Rhonda M. Black (1970) P.60)

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

Keenea sp. may be found at Mulbring Quarry.

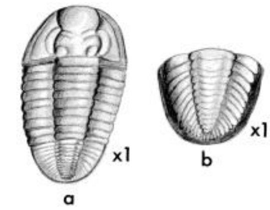
(From Nashar (1964) P. 26)

Other Fossils.

Corals:
Solitary Rugose corals such as *Zaphrentis* may be found.

(From Nashar (1964) P. 176)

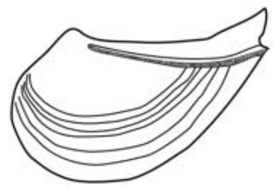
Trilobites:
Moulds of the trilobite *Doublatia inflata* have been found, either as a whole specimen or in parts.



Typical trilobite.

(From Nashar (1964) P. 27)

Rostoconchs:
Generally small (2cm) mollusc that had a pseudobivalved shell (no hinge).

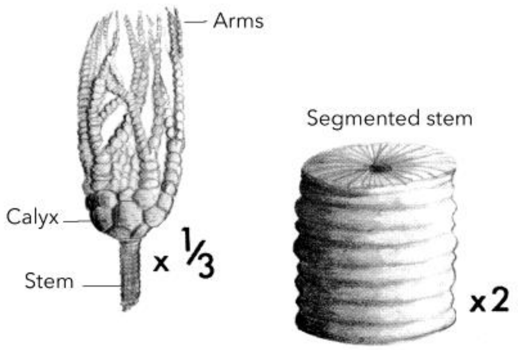


(en.wikipedia.org>Rostroconchia)

Crinoids:

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

One specimen of a minor Echinoderm, the Blastoid *Calycoblastus casei* Brown has been found.



(From Nashar (1964) P. 19)

Palaeoenvironment.

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

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

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

Excursion Details.

Members and visitors met in Mulbring Park. Brian welcomed members and visitors and thanked the large group for attending. He then gave a brief geological outline of the environment that was thought to have existed in the area at the time of deposition and explained how the environment determined the species of fossils found.

Ron then briefly explained why most of the fossils to be found in the Mulbring Quarry were moulds because the original hard material (calcareous shells for example) had been dissolved away by groundwater.

All present then drove into the quarry which is located on private property (via a gate unlocked by the owner), parked and spread out to fossick *(Photo 1)*.

Brian and Ron walked around to the members and visitors identifying fossils and answering questions as they looked for fossils. Many fine specimens had been found *(see photos pages 28 & 29)*.

Attendees were treated to a visit by the quarry owner towards the end of the visit. He showed considerable interest in what we had found.

Looking for and collecting fossils ceased around 12 noon with participants making their own way home.

Report By Ron Evans.
Photographs by Ron Evans.

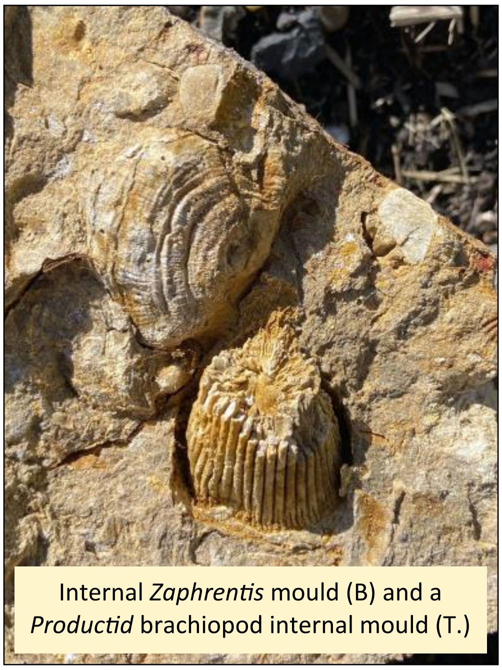
1. AGSHV members and visitors in Mulbring quarry getting organized to look for fossils.

Fossil fossicking in the now disused Mulbring quarry.

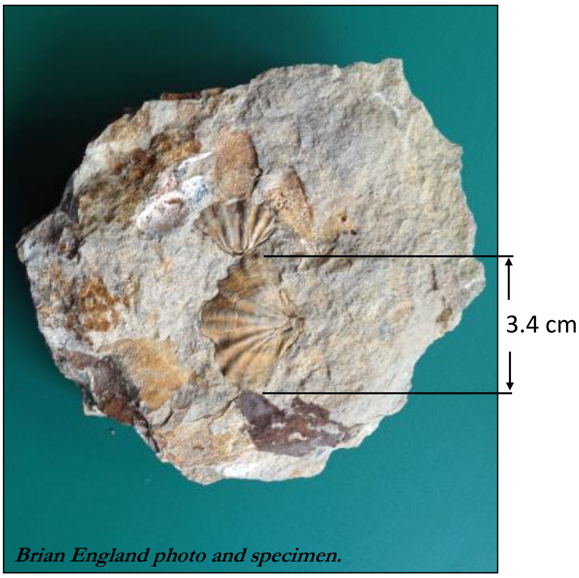
Internal (L) and external (R) moulds of a brachiopod.

Fenestella Zoarium.

Polypora mould.

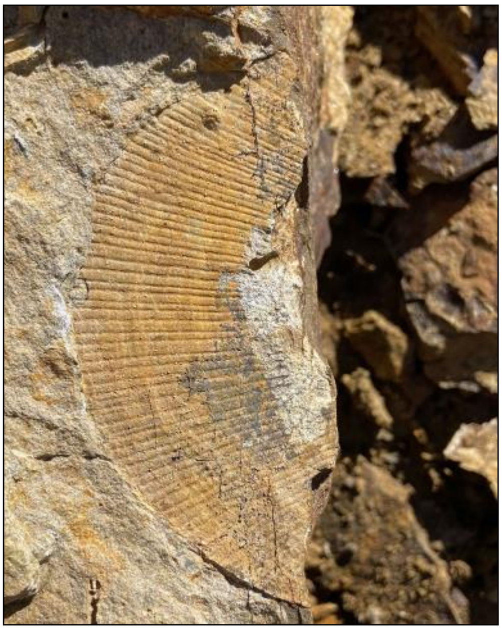


Internal *Zaphrentis* mould (B) and a *Productid* brachiopod internal mould (T.)



Mulbring siltstone containing fossils of *Fenestella*, Spirifid Brachiopods, a bivalve Mollusc and *Zaphrentis.*

Collection of broken fragments of fan-shaped *Fenestella* colonies (zoaria).



Ventral edge of a *Deltopecten* (scallop)

Stenopora bryozoan displaying zooecia along its branches. Small gastropod (spiral) under branch in colony.

Mould of a Crinoid stem with an attached root.

Split slab of sandstone displaying a *Myonia* (bivalve) fossil.

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En.wikipedia.org>Rostroconchia.

Booral to Bulahdelah

Leaders: Ron Evans and Brian England.
Date: Wednesday 16th September 2020.
Attendance: 18 members.

Introduction.

During the 30 km drive east from Booral to Bulahdelah NSW, rocks of Carboniferous age (359 to 299 Ma), faults and the Girvan Anticline are traversed before reaching Permian aged rocks (299 to 252 Ma) within the Myall Syncline near Bulahdelah.

The purpose of this excursion was to drive the west to east section across the Girvan Anticline provided by the Booral to Bulahdelah road. This prominent north-plunging anticlinal fold lies between the Stroud-Gloucester Syncline in the west and the Myall Syncline in the east. This transect provides a complete section across an uninterrupted sequence of marine, volcanic and terrestrial rocks ranging in age from the Late Carboniferous McInnes Formation (323.2 -298.9 Ma) through to the Early Carboniferous Wootton Beds (358.9-298.9 Ma), whose outcrop centres around the fold axis, then the reverse sequence east of the fold axis to the west limb of the Myall Syncline.

These rock sequences were originally laid down horizontally and the folding resulted from east-west compression during the Hunter-Bowen Orogeny as a result of subduction to the east. Note that the oldest beds lie in the centre of the anticline. If this were a syncline the youngest beds would be at the centre. Note also that the inferred axis of the anticline is not central to the structure but offset to the east due to the much steeper dips on that side. This also affects the relative thickness of the beds either side of the axis, the steeper the dip the thinner the intersection the beds make with the land surface. This is evident on the geological section in *Figure 1* and more on *Figure 3*.

As well as representing the changing geological environments shown in *Table 1*, the various formations clearly demonstrate a strong relationship between rock type and topography. The best example in this traverse is the Nerong Volcanics, which because of their resistance to erosion, form a very prominent forested ridge which clearly outlines the shape of the plunging Girvan Anticline in aerial photographs *(Figure 2)*. Softer less resistant sandstones tend to form the low undulating areas and valley floors.

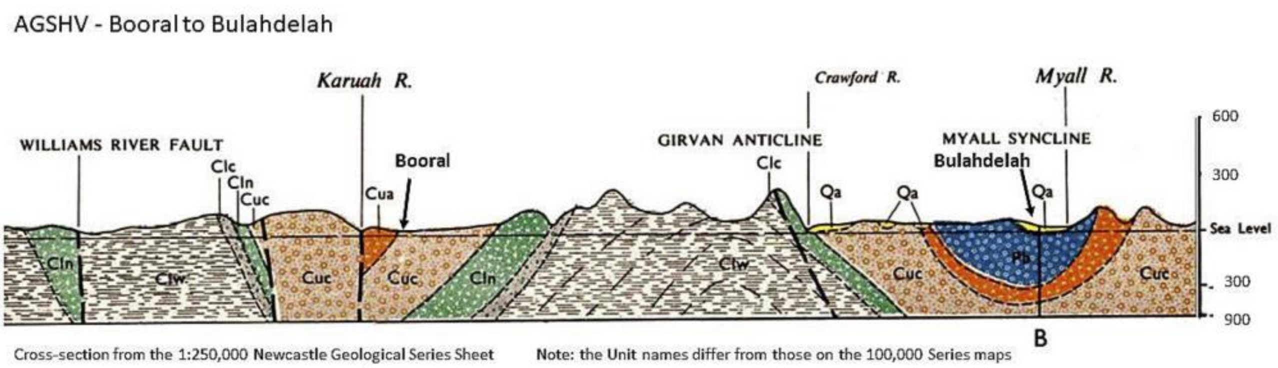
Faulting can also result in differences in landform development within one particular rock type or bed which causes it to react differently to erosion at one or more places along the outcrop. This is the case with the Nerong Volcanics, which cannot be seen in outcrop on the west side of the Girvan Anticline because a fault at that point on the road has resulted in deeper weathering and erosion leading to the formation of a low saddle which the road engineers made good use of when crossing the range.

The physical nature of the rock in a particular formation will strongly influence its appearance in outcrop. Because of their dense and uniform texture, granites and related rocks typically form rounded boulders, developed by weathering inwards from intersecting joint sets and removal of the weathering products by erosion. But this morphology can also be formed during erosion of some sedimentary rocks where their texture is densely packed and uniform, and the beds are thick without interrupting structures such as cross bedding. This is the case with the sandstone in the Booral Formation exposed in the road gutters at *Stop 1*. The outcrop of this rock on the adjacent hill slope is made up of well rounded boulders.

Sediments in the formations west (and east) of the Nerong Volcanics, being younger in age and laid down in close proximity, were derived from the weathering and erosion of these volcanics. They represent a gradually changing depositional environment during a major marine transgression (sea level rise) from shallow marine shelf (Karuah Formation), through shallow marine platform (Booral Formation) where continuing transgression submerged the volcanic source, to terrestrial (alluvial fan) sedimentation (McInnes Formation). During the early part of this transgression (Karuah Formation) heavy mineral beach sands were deposited which now form magnetite sandstone beds. Unfortunately none of these have been intersected by road works but are exposed nearby on private land. The Nerong Volcanics themselves formed at the very peak of an earlier marine transgression in a shallow Marine environment.

The sequence below (older than) the Nerong Volcanics began with deposition of turbidic (submarine mass flow) sandstone and conglomerate on a shallow marine outer shelf, probably after flowing down submarine canyons under the force of gravity. These are the Wooton Beds exposed at *Stop 4* through to 9. At stop 6 in particular, the beds are very thick and clearly show the upward fining Bouma sequence of bedding textures, with what appear to be well-rounded drop stones up to 30 cm across. The environment then changed from shallow marine to near shore alluvial with a widely fluctuating shoreline (Conger Formation) as the transgression continued. At this stage volcanic activity was already contributing to the sediment pile and it was onto these sediments that the ignimbrites of the Nerong Volcanics were ultimately erupted. These Volcanics then provided the source of sediment which contributed to the deposition of the overlying sequence.

BOORAL to BULAHDELAH - SIMPLIFIED CROSS-SECTION.



Carboniferous	Cua	Alum Mountain Volcanics - Rhyolite, conglomerate, basalt, dacite, andesite, ignimbrite, tuff
	Cuc	Johnsons Creek, McInnes & Karuah Formation - Sandstone, conglomerate, mudstone, chert, tuff
	Cln	Nerong Volcanics - Rhyolite, dacite, andesite, ignimbrite, agglomerate, conglomerate, sandstone, mudstone
	Clc	Conger Formation - Sandstone, siltstone
	Clw	Wooton beds - Sandstone, siltstone, claystone, shale, limestone, lavas
Permian	Pb	Bulahdelah Formation - Sand, shale
Quaternary	Qa	Marine and freshwater deposits - Gravel, sand, silt, clays, "waterloo rock"

NOTE: The Unit Symbols used above are different to those used on the more detailed Geological Map of Stata from Booral to Bulahdelah showing the route followed *(Figure 3).*

Figure 1.

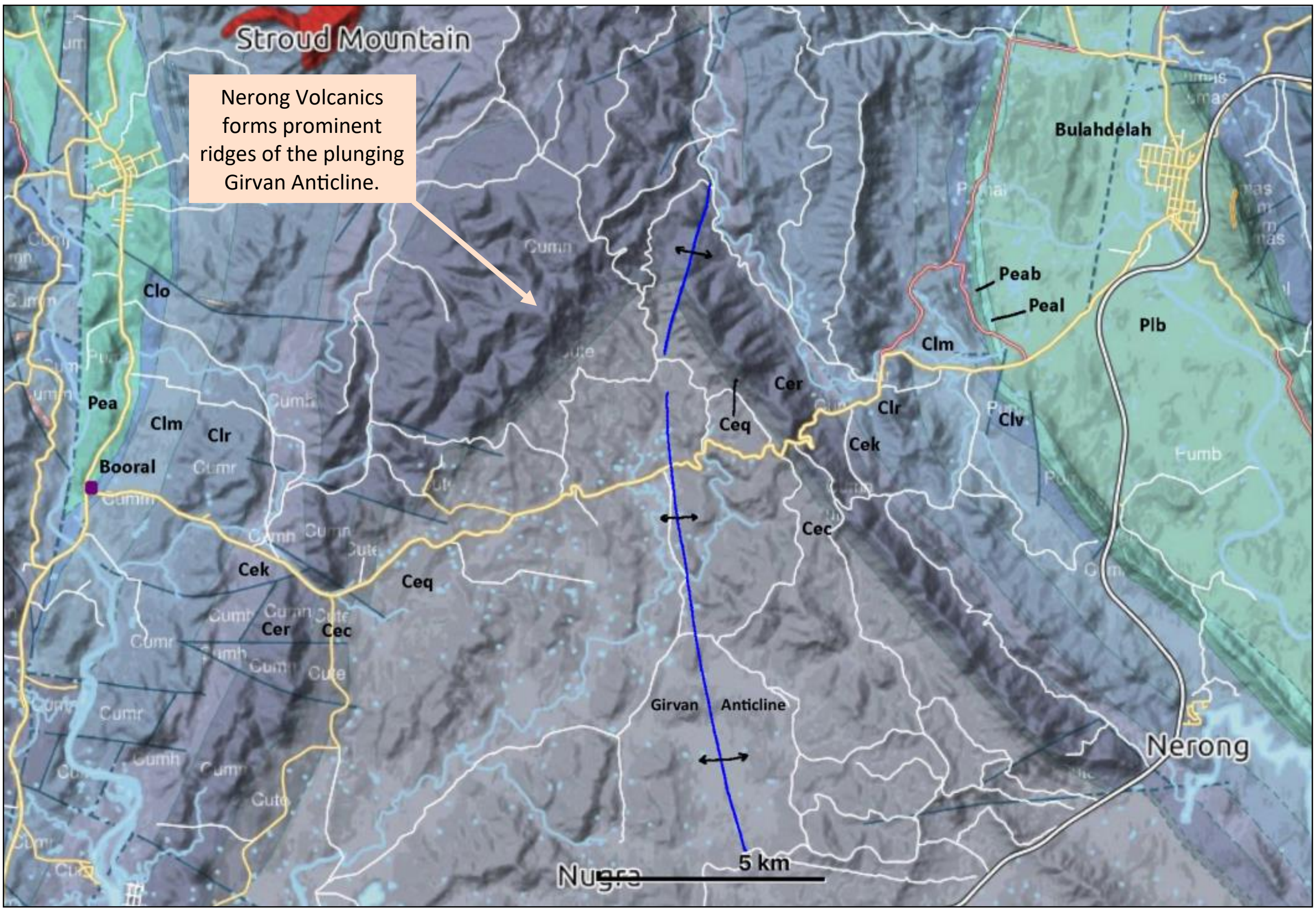
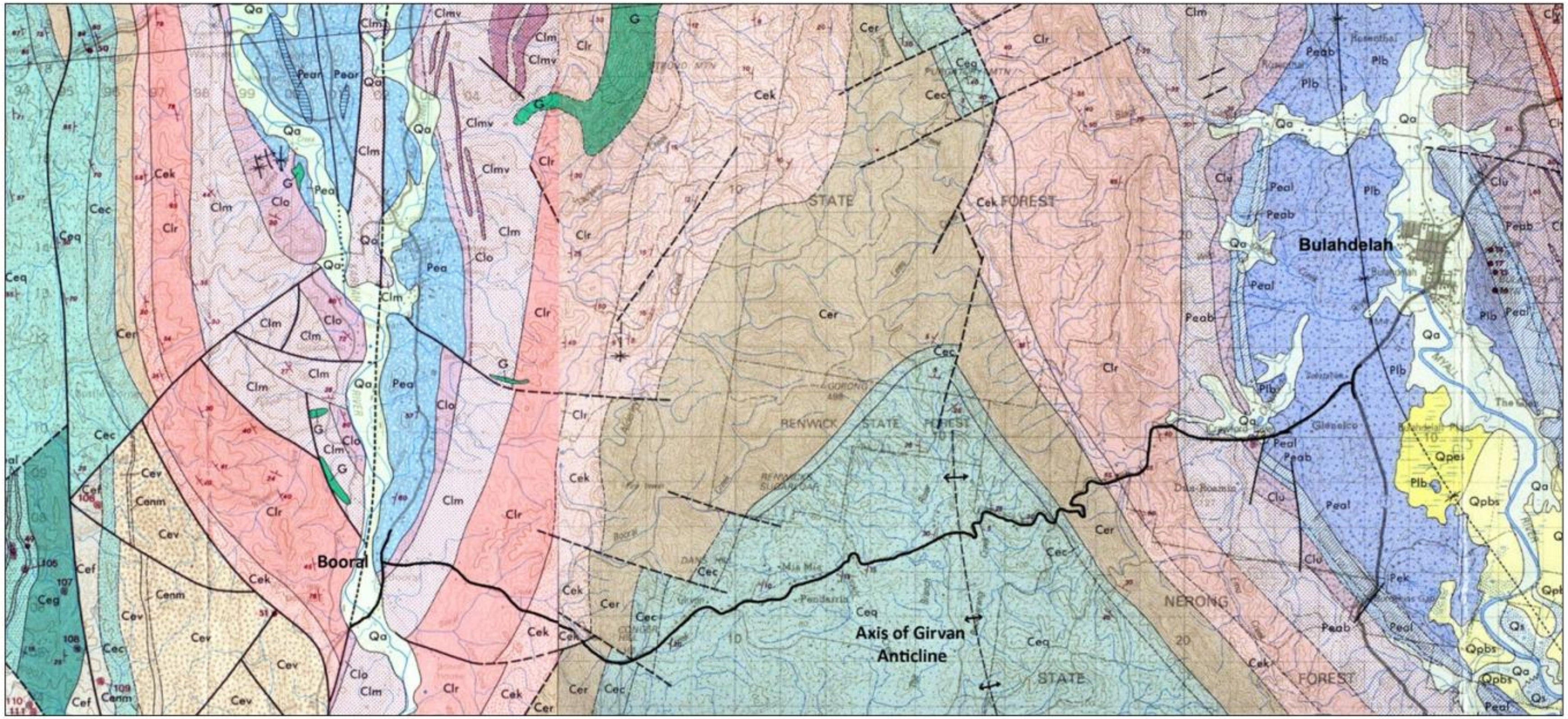


Figure 2.

GEOLOGICAL MAP of the STRATA from BOORAL to BULAHDELAH.



Bulahdelah Formation - Plb

Lakes Road Rhyolite member - Peal

Burdekins Gap Basalt member - Peab

Alum Mountain Volcanics - Pea

Johnsons Creek Conglomerate - Clo

Muirs Creek Conglomerate - Clv

McInnes Formation - Clm

Booral Formation - Clr

Karuah Formation - Cek

Nerong Volcanics - Cer

Conger Formation - Cec

Wooton Beds - Ceq

Key:

P = Permian C = Carboniferous

Strata listed from **youngest** to **oldest**

Bulahdelah Beds 283.5 to 227.09 Ma

and

Wooton beds 358.9 to 298.9 Ma

Figure 3.

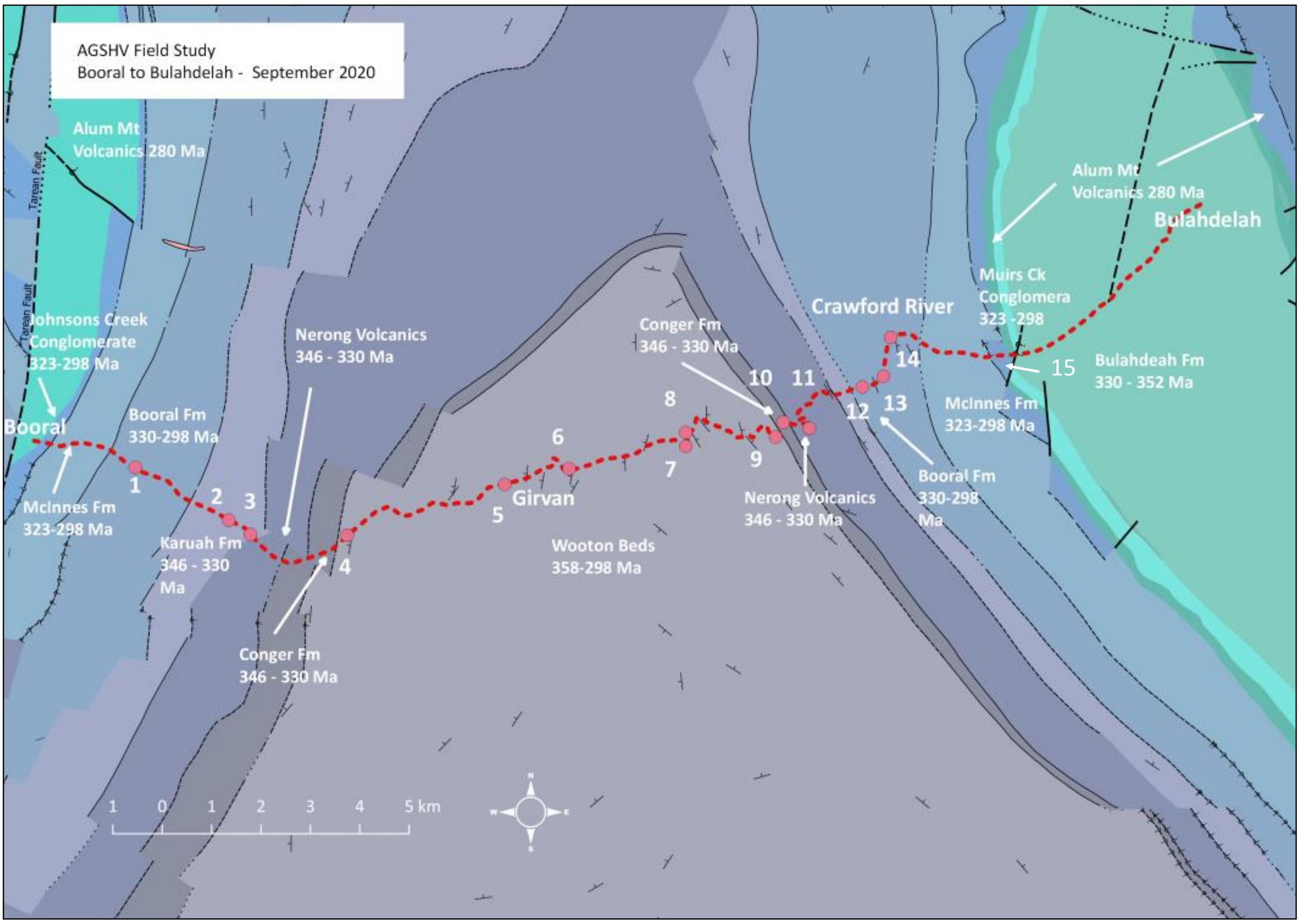


Figure 4. Map showing the location of stops made - these are GPS waypoints.
(Rick Miller)

Note: The McInnes Formation was not visible in outcrop on the west side of the Girvan Anticline due to recent sediment cover, but the Muirs Creek Conglomerate member was found exposed in the abandoned Crawford quarries 25.2 km from Booral during the excursion thanks to member Roz Kerr who had visited the site many years previously.

Car convey of AGSHV members parked beside the road at Stop 1.

The Days Activity.

By 9:40 am members had assembled at the Booral Bakery, some arriving early enough to grab a coffee and one of the locally made delicacies on offer. Recent changes in COVID restrictions meant that of the original 23 members who nominated for the activity, some had to be asked not to come so that our numbers remained below 20, a very unfortunate situation facing the leaders. In addition, car pooling was not encouraged which meant that 8 vehicles had to travel in convoy and find parking close to the points of interest without disrupting traffic or posing a danger to participants. It was a perfect sunny spring morning with temperatures in the mid 20's.

Figure 4 shows the route taken and the location of stops made.

Table 1 gives a detailed description of the stratigraphy encountered along the road.

Stop 1: Booral Formation.

Easy parking for the convoy. A hill on the right (south) was littered with sandstone boulders. Good exposures of sandstone were found in the table drain on the right side (south) of the road.

Table 1: Details of stratigraphy along the route.

FORMATION/AGE	LITRHOLOGFY	DEPOSITIONAL ENVIRONMENT	*DISTANCE from BOORAL*	OUTCROP LITHOLOGY	GEOMORPHOLOGY
McInnes Formation - Clm 323.2 – 298.9 Ma (Late Carboniferous)	Thick bedded grey lithic sandstone, minor conglomerate, siltstone, coal and carbonaceous shale.	Transitional marine to terrestrial.	*Boundary at 1.5 km*	No outcrop.	Soil covered floodplain.
Booral Formation – Clr 330.9 – 298.9 Ma (Late Carboniferous)	Thin bedded siliceous mudstone with thicker interbeds of feldspathic sandstone.	Shallow low energy marine platform. Continuation of the marine transgression that submerged the volcanic source.	**STOP 1** Outcrop at 2.2 km *Boundary at 3.5 km*	Very tough fine sandstone with conglomerate bands.	Prominent ridge on south side of road. The sandstone weathers to round boulders. WHY?
Karuah Formation – Cek 346.7 – 330.9 Ma (Early Carboniferous)	Pink cross-stratified thin to thick lithic sandstone plus conglomerate derived from the Nerong Volcanics, minor mudstone. Magnetite sandstone beds 1-5 m thick.	Shallow marine shelf, the early part of a major marine transgression.	**STOP 2** Outcrop at 4.4 km at private property sign. **STOP 3** Outcrop at 4.7 km *Boundary at 5 km is a fault boundary and disconformity.*	Conglomerate. Sandstone.	Hilly terrain.
Nerong Volcanics – Cer 346.7 – 330.9 Ma (Early Carboniferous) **Note:** Equivalent to the Gilmour Volcanics.	Rhyodacitic ignimbrite. Minor dacite and rhyolitic pitchstone. Minor interbeds of sandstone and conglomerate.	Shallow marine. Peak of major marine transgression. Erupted onto extensive area of emergent Conger Formation.	*Boundary at 5.7 km at Branch lane – indefinite.*	No outcrop.	Hilly terrain.
Conger Formation – Cec 346.7 – 330.9 Ma (Early Carboniferous)	Fine to coarse lithic sandstone, interbedded boulder conglomerate, mudstone and thin andesitic to rhyodacitic ignimbrite.	Volcanoclastic shallow marine to near shore alluvial. Active volcanic foreland with widely fluctuating shoreline.	*Boundary at 6.9 km at yellow road sign.*	No outcrop.	Hilly terrain.
Wooton Formation – Ceq 358.9 – 298.9 Ma (Early Carboniferous)	Thin bedded sandstone and siltstone plus turbidic sandstone and conglomerate.	Shallow marine outer shelf. Several sea level changes indicated.	**STOP 4** Outcrop at 7.1 km **STOP 5** Outcrop at 10.8 km. **STOP 6** Outcrop at 12.6 km **STOP 7** Outcrop at 15.1 km **STOP 8** Outcrop at 15.5 km **STOP 9** Outcrop at 17.8 km *Boundary at 18.2 km*	Mudstone/shale. Note changes in dip – WHY? Weathered conglomerate. Mudstone/sandstone beds. Mudstone/sandstone beds. Distinct mudstone beds. What does the dip indicate? Conglomerate/ mudstone.	Gently undulating valley floor. ↓ (Core of Girvan Anticline). Become hilly with winding road.

FORMATION/AGE	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	*DISTANCE from BOORAL*	OUTCROP LITHOLOGY	GEOMORPHOLOGY
Conger Formation – Cec	As above.	As above.	**STOP 10** Outcrop at 18.2 km *Boundary at 18.5 km*	Thick sandstone bed with overlying shale. Note the change in dip – Why?	Very hilly eastern limb of Girvan Anticline.
Nerong Volcanics – Cer	As above.	As above.	**STOP 11** Outcrop at 18.6 km (Pull-out on left) *Boundary at 20.8 km*	Rhyolitic ignimbrite with abundant free quartz. Note drill holes – Why?	Prominent N-S trending ridge – road very windy. Base of ridge corresponds to the boundary.
Karuah Formation – Cek	As above.	As above.	*Boundary at 21.2 km*	No outcrop.	Flat valley floor covered by alluvium .
Booral Formation – Clr	As above.	As above.	**STOP 12** Outcrop at 22.6 km **STOP 13** Outcrop at 23.1 km *Boundary at 23.5 km*	Dipping mudstone beds. Note the dip and direction.	Undulating valley floor away from the stream .
McInnes Formation – Clm	As above.	As above.	**STOP 14** Outcrop at 23.9 km. *Boundary at 24.9 km*	Sandstone.	Undulating valley floor away from the stream.
Muirs Creek Conglomerate - Cumc 323.2 to 298,0 Ma (Late Carboniferous)	Massive boulder to cobble conglomerate containing clasts of acid volcanics and lenses of cross bedded sandstone and coal.	Terrestrial - alluvial fan.	**STOP 15** Quarry located at 25.2 km.	Conglomerate	Small ridge on the western edge of undulating valley floor.
From STOP 15 to Bulahdelah Early Permian Bulahdelah Formation covered by Holocene floodplain deposits and Pleistocene estuarine deposits are traversed. The axis of the Myall Syncline is just west of Bulahdelah.					

Feldspathic sandstone exposed in the southern gutter acting like pavers preventing erosion.

Boulders composed of texturally uniform feldspathic sandstone observed on the southern hillside beside Stop 1.

Stop 2: Karuah Formation.

No obvious outcrop of rock. However conglomerate boulders were found where an access road entered private property.

Conglomerate boulders. Pebbles of grey chert were seen indicating the volcanic origin of the matrix.

Stop 3 was not stopped at - the sandstone that outcropped had been examined at *Stop 2* by walking east to where it was found in a low road cutting.

Stop 5: Wooton Formation.

Driving from *Stop 3* to *Stop 4*, the road passed through the Nerong Volcanics. However, no outcrops were observed as the road followed a valley eroded through the Nerong Volcanics along a fault which enabled erosive forces to more readily erode the hard volcanic rocks.

At *Stop 5* it was obvious that the Wootton Beds were outcropping as dipping beds of mudstone/shale were exposed the southern road cutting.

They were observed to dip north-west as they were located on the western limb of the northward plunging Girvan Anticline.

North-west dipping beds of mudstone/shale observed in the road cutting.

Brian then demonstrated how a Brunton Compass was used to measure dip and strike of a bed and explained that many measurements were needed to accurately determine dip and strike of an outcrop.

Brunton Compass aligned along the strike of the bed.

Dip (angle down from the horizontal) and strike (compass direction) as demonstrated by one measurement.

Driving on towards the crest of the Girvan Anticline, the north-west dip of the beds became more obvious.

Wooton beds obviously dipping north near the crest of the Girvan Anticline.

As the road dropped down the eastern limb of the Girvan Anticline it became windy and unsafe for the convoy to pull over. However, the Wooton beds could be seen to dip east. As the Conger Formation was approached, the road climbed to a ridge where it was safe to park.

<u>Stop 10</u>: Conger Formation.

Rocks of the Conger Formation outcropped in road cuttings on the northern side of the road.

It was immediately apparent that the rocks were much different to the mudstones previously examined in the Wooton Formation.

At the bottom of the hill an outcrop of cobble to boulder conglomerate was found. This deposit would have most likely been the result of a high energy alluvial fan deposit.

Coarse conglomerate outcrop near base of Conger Fm. Note how the beds dip to the east.

Rocks outcropping near the top of the hill were lithic sandstones exhibiting a variety of structures indicating conditions at time of deposition.

Graded bedding was observed in some outcrops with a narrow band of cobbles at their base.

Other sections contained convoluted laminations.

Both of these structures indicated deposition by turbidity currents as the structures were indicative of Bouma sequence deposits (turbidites) *(see diagram next page)*.

The conditions of deposition must have been very varied because of the disrupted nature of the structures observed.

Beds at the top of the cutting dipped to the east indicating that the axis of the Girvan Anticline had been crossed.

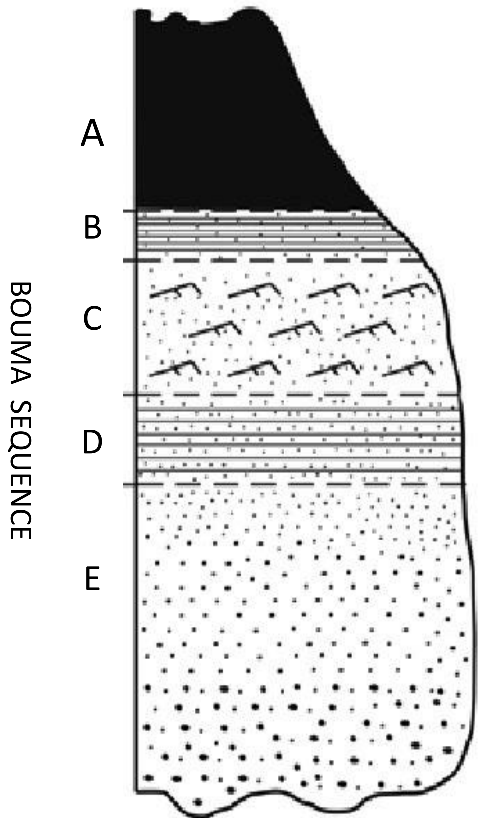
Brian indicating the extent of a graded bed of sandstone.

Base of coarse sandstone showing grading.

Bouma sequences. A graded bed starting a Bouma sequence at the bottom fines up before being eroded by the cobble base of a second sequence.

- - - - *Erosion surface*

DIAGRAM of a BOUMA SEQUENCE formed by a LOW DENSITY TURBIDITY CURRENT .



LOW ENERGY

MUDSTONES
Laminated to homogeneous. Suspension fallout.

VERY FINE SANDSTONE or MUDSTONE
Horizontal lamination. Suspension fallout - very weak flow regime traction.

SANDSTONES
Ripple or cross-lamination. Lower flow regime traction.

SANDSTONES
Horizontal lamination. Upper flow regime plane bed traction.

SANDSTONES
Massive to graded bedding in lower section. Upper flow regime - rapid settlement from turbulent suspension.

HIGH ENERGY

Bouma sequences E, D and C. The rock is situated in the coarse lower graded section E followed by D (lamination) and C (cross-lamination).
This sequence has been disrupted by scouring of coarse material (arrow).

Rhyodacitic ignimbrite.

Stop 11: Nerong Volcanics.

These harder erosion resistant rocks form a very distinct range of hills over which the road passes.

After parking, an outcrop of rhyodacitic ignimbrite exposed in the road cutting was examined. The crystalline nature of the rock was obvious when a fresh specimen was examined *(see photo opposite)*.

An interesting find was the presence of several bore-core holes in the outcrop. These may have been made to obtain orientated rock samples used to determine paleomagnetism (record of Earth's magnetic field when the rock was formed). This gives a record of in the past behaviour of Earth's magnetic field (eg reversals) plus past location of tectonic plates from declination measurements. One bore hole still contained a rock core.

Moving on, we made a brief stop at *Stop 13* to note the eastward dip of the beds before proceeding to *Stop 14*.

Stop 14: Booral Formation.

A quite extensive road cutting on the southern side of the road beside the Crawford River exposed steeply dipping beds of mudstone, part of the Booral

Stop 11, an outcrop of rhyodacitic ignimbrite within the Nerong Volcanics.

Dip slope in Muirs Creek Conglomerate on the western wall of the abandoned Crawford quarry.

Rock core still present in a bore hole within the ignimbrite.

Muirs Creek Conglomerate. Note the plutonic rock clast top center.

Mudstones of the Booral Fm dipping east.

Formation.

The steep eastward dip of the beds clearly illustrated the asymmetrical nature of the Girvan Anticline, namely a steeper dip on the eastern side as compared to the western side.

Stop 15: Muirs Creek Conglomerate member.

The abandoned Crawford quarry is situated on the western side of the Myall Syncline against the eastern side of a small ridge. Holocene floodplain deposits cover the valley floor to the east.

After parking beside the road at *Stop 15*, the abandoned Crawford quarry could be seen on its southern side next to a small ridge.

Some pieces of conglomerate were found next to the fence. However, the more adventurous climbed over the fence to examine the quarry and conglomerate more closely.

A smooth wall (dip slope) of polymictic conglomerate was observed on the western side of the quarry while fine examples of conglomerate were lying about. Samples found were basically a rhyolitic pebble to cobble conglomerate with some plutonic and metamorphic clasts. The rock formed from piedmont fan deposits.

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

References:

Australian Geology Travel Maps and NSW Geology Maps. *Apps for smartphone or tablet.*

www.researchgate.net/figure/Bouma-sequence.

Wybung Head Excursion

Leaders: Chris Morton and Brian England with assistance from Barry Collier.
Date: Saturday 17th October 2020.
Attendance: 20 members, 3 guests.

Timing of the terrestrial end-Permian extinction event in the Sydney Basin.

The Society has visited Snapper Point in Lake Munmorah State Conservation Area (MSCA) several times in the past to examine the geology, geomorphology (especially the sea caves) and the Permian/Triassic boundary at 252 Ma, which has generally been linked with Siberian Trap magmatism when Australia was part of the single continental landmass called Pangaea (Burgess, et.al., 2017). This latest visit was to re-examine the P/T boundary at Snapper Point and compare that exposure with the one at nearby Wybung Head to the south on the other side of Frazer Beach in the light of two recent papers published in the scientific literature, namely Vajda, et.al. (2020) and Fielding, et al. (2019). These authors have called the P/T boundary the End Permian Mass Extinction Event (EPE).

Fielding et al. noted that past studies of the EPE, the largest of all mass extinction events in the history of life on Earth, have not resolved the precise timing of the terrestrial EPE in the Permian southern high latitudes. They have now constrained the EPE in the Sydney Basin by two U-Pb high precision determinations of 252.6 and 252.3 Ma. They conclude that the terrestrial EPE occurred around 370 Krs before the onset of the marine EPE determined at Meishan in China. Using palynological, carbon isotope and palaeobotanical data gleaned from strata spanning the EPE at Snapper Point and Wybung Head, Vajda et al. showed that the Permian temperate coal-forming forests vanished abruptly, followed by the accumulation of a 1m thick bed of mudstone low in organic matter which they called the "dead zone" containing fungal spores and charcoal. The first trace of vegetation revival occurs 1.6 metres above the EPE at Wybung Head. Hence the section at Wybung Head wholly records the most catastrophic event in the history of life on Earth! The paper by Vajda et.al. is worth reading in its entirety as it contains a very sobering message for our future as deforestation continues at an alarming rate.

The opportunity to visit this part of the coastline is very dependant on weather conditions and tides. With this in mind the group met in the Frazer Beach car park at 12:30 pm for a picnic lunch beside the picturesque little creek draining out into the bay beneath the beach. This allowed ample time to explore the rock platforms

1. Selective erosion of concentrations of a sandy matrix in the conglomerate.

on either side of the low tide of 0.25 m at 3:30 pm. The sky was partly cloudy with a cooling breeze that made the forecast warm 27 degrees more comfortable. Importantly, before setting out we discussed the aspects of coastal safety. It is sobering to learn that in just 8 years, 16 people have drowned in this area. Legend has it that Wybung in the local Aboriginal language means 'dangerous sea'.

The group set out northwards along Frazer Beach towards the Snapper Point headland and its narrow rock platform composed of Karignan Conglomerate, deposited by yet another of the large braided rivers that brought copious amounts of sediment from the New England Fold Belt which lay to the east (Veevers, 1984) during the Late Permian. On the rock platform, we found three unusual roughly circular erosion features *(photo 1)* which may be concretionary in part or a result of selective erosion of concentrations of a sandy matrix in the conglomerate. We found an easy pathway up to the Snapper Point car park passing patches of wind stunted ground-hugging flannel flowers in full bloom, from a distance looking like patches of snow amongst the green grass and brown earth.

From the car park, there is a spectacular view down into an enormous sea cave at the end of a deep, long wide chasm formed by the progressive collapse of the cave roof as the cave migrated inland *(photo 2)*. Formation of this cave and inlet is a result of marine erosion along a small fault that is evident in the cliff face above the cave entrance *(photo 3)*.

More importantly, this outcrop displays an excellent section through the EPE stratigraphy, including the Karignan Conglomerate in which the inlet and cave formed, the Vales Point coal seam, EPE, then the Dooralong Shale and above that the lower shale beds of the Munmorah Conglomerate. However this outcrop is not accessible so the group walked around to the south side of the headland to a point adjacent to the memorial cairn where the same sequence, although weathered, can be studied directly.

While the Snapper Point cave appears to be only accessible by sea, the beach inside the cave was mined for decorative pebbles in the 1950's by a Mr Frisby. The resourceful Mr Frisby built a gantry on the south side of the inlet 25 metres from the cliff top adjacent to the cave, with a steel cable anchored into the cave wall. During low tide, a bobcat was lowered via the steel cable down into the cave some 100 metres from the gantry, followed by a skip which was hauled back up when full of gravel for loading onto trucks *(photo 4)*. As the tide

2. Sea cave at Snapper Point showing EPE, Vales Point coal, Karignan & Munmorah Conglomerates.

3. Small fault cutting through the roof of the sea cave - note displacement of the Vales Point coal seam.

4. Bobcat and skip used by Mr Frisby to collect pebbles from the sea cave at Snapper Point.

5. Brown oxide indurated joints erode more slowly than the surface of the rock platform to form small ridges.

6. The white lines show the direction and persistence (length) of four important joint sets. (Peter Mitchell)

rose, both the bobcat and skip were hauled back to the clifftop. The pebbles/gravel were used as aggregate for decorative concrete in the Bankstown Civic Centre, in the facade of Wynyard Station and buildings as far away as Broken Hill (Butler, 1982). *(for further information on this operation, see Geo-Log, March 2014).*

The headland and chasm at Snapper Point also provided an opportunity to discuss the joint systems characteristic of this part of the Permian coastline. Many of the joints, including those on the rock platforms on the north side of Wybung Head, show concentrations of brown iron oxides within the joints, penetrating up to 5 cm into the adjacent conglomerate, making the joints more resistant to erosion so that they stand proud of the surface by several cm, so that they are easy to see *(photo 5)*. This is probably the result of recent weathering processes, with iron leached from the conglomerate and redeposited in the joints by groundwater. Other sources of iron may have been a near-surface laterite profile. Or, the iron deposition could have also been due to pore water circulating through the conglomerate as the joints formed. *"Only an examination of the joints at depth will confirm which process was operative". (Guest, Peter Mitchell*

7. Prominent feature in the form of a bed of cross bedded sandstone in the lower cliff face.

10. Eroding concretion in trough cross bedded sandstone bed.

OAM onsite comments).

8. Pebble lithology in Karignan Conglomerate.

9. Well-rounded coal clast in sandstone bed.

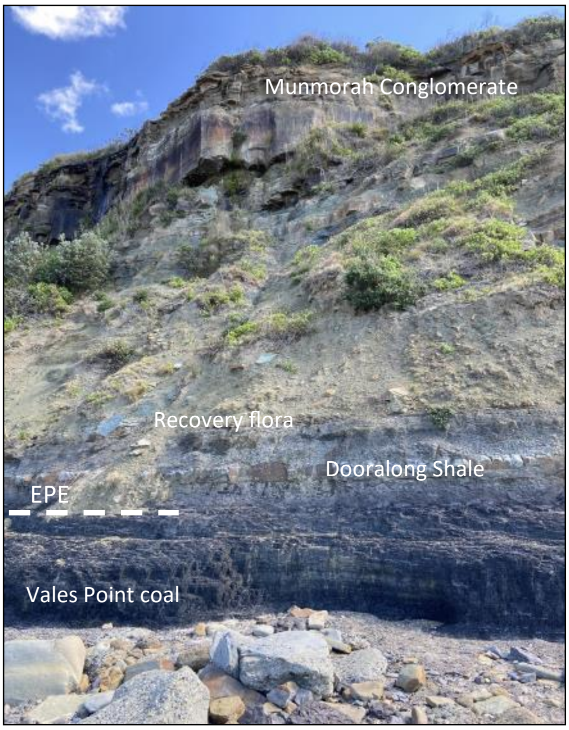
After a good deal of discussion between members, Peter went on to make further comment on the joint systems at Snapper Point and Wybung Head.

Without taking measurements, it is possible to recognise four sets of joints *(photo 6)*, all of which are close to vertical. The most persistent set strikes NW/SE with an orthogonal partner striking NE/SW but with less persistence. In addition, there are two mid-length conjugate sets. The four sets interact to define the orientation of the coastal cliffs here.

Returning to Frazer Beach, we walked south to the rock platforms hugging the coastal cliffs north of Wybung Head. The most prominent rock here is again the Karignan Conglomerate. On approach to the rock platform, there is a prominent feature in the form of a bed of cross-bedded sandstone in the lower cliff face *(photo 7)* probably representing a sandy distributary stream channel bed. Unfortunately, the stratigraphy above the sandstone, including the Vales Point coal and EPE, is covered by scree and thick vegetation here. It is worth noting that the rocks exposed from here to the southern side of Wybung Head are the last surface expression of Permian sediments before they emerge again at Wollongong on the South Coast.

The Karignan Conglomerate is composed mostly of beds of clast-supported planar cross-bedded poorly sorted conglomerate with isolated clasts reaching 30 cm! The pebbles (clasts) show a wide range in lithology including red, green and black jasper, black hornfels, silicified shale, sandstone, white vein quartz and a variety of volcanic rocks *(photo 8)*. The pebbles in some beds show a distinct imbrication.

There are occasional thin interbedded sandstone lenses which can be quite extensive laterally. Many of the sandstones display trough cross-bedding, suggesting a tidal influence during deposition. Within one sandstone lens, a single well-rounded pebble of black coal was observed *(photo 9)*, along with thin layers of scattered plant fragments. Rare concretions that formed within the sediment pile are also present *(photo 10)*.



11. Stratigraphy, Wybung Head (according to Vajda et. al.)

12. Normal fault displacing the Vales Point coal seam and overlying Dooralong Shale.

Continuing on past Little Bumpy and Big Bumpy we came to the cliff section studied by Vajda et al. and Fielding et al. Here there was no obscuring scree or vegetation with the full local stratigraphy exposed *(photo 11*. At this very outcrop Vadja et. al. identified the strata of the EPE, from a brecciated coal/shale bed at the eroded top of the Vales Point coal, up through the EPE, then shales showing evidence of wildfires, the Dooralong Shale, then an interval of algal abundance and finally the floral recovery zone before passing into the shales below the Munmorah Conglomerate.

The lower part of the sequence is cut by a small normal fault *(photo 12)*. This is perhaps the most geologically significant location on the entire coastline.

A friable grey siltstone on the rock platform immediately below the Vales Point coal contains

13. Flattened section of a *Vertebraria* root. Horizontal and two central longitudinal groves can be seen.

14. Vertical section of a *Vertebraria* root. Air chambers were present between the black carbonized remains.

15. Cross sections of *Vertebraria* root. Dividing membrane tissue can be seen surrounding the specimen on the right.

16. Shallow syncline to the right of Wybung Head within the Munmorah Conglomerate.

17. Vales Point coal seam is being eroded away undercutting the harder sandstone bed above, part of the Munmorah Conglomerate.

18. Erosion on the surface of the Vales Point coal is obvious when looked at closely.

excellent examples of *Vertebraria* (the root system of the Permian *Glossopteris* flora) in both transverse and longitudinal sections *(photo 13 & photo 14)*, allowing close examination of the root structure. The fossils clearly show the diametrically paired septa (which in life were air-filled) plus parts of the rarely preserved thin encasing epidermal tissue. Some transverse sections show the paired septa and segments of the horizontal dividing membranes*(photo 15)*.

Looking south, the coastal cliff at the back of Gravelly Beach consisting of Munmorah Conglomerate is well exposed and shows a shallow dip to the west as part of a broad shallow syncline *(photo 16)*.

Adjacent to the south end of Gravelly Beach erosion of the Vales Point coal has created a deep horizontal slot in the cliff face above the Karignan Conglomerate *(photo 17)* which has also been hollowed out in part. Here the Vales Point coal is directly overlain by a thick bed of partly cross-bedded sandstone, presumably part of the Munmorah Conglomerate. The brecciated coal/shale, overlying dead zone, Dooralong Shale and floral recovery zone exposed in the section at the north end of Gravelly Beach are missing, presumably eroded away by the distributary stream that deposited the sandstone bed *(photo 18)*.

Access further south was prevented by rockfalls.

After returning to our vehicles at Frazer Beach car parking area we drove towards Wybung Head and pulled in at the Wybung Trig Station, the highest point in the MSCA. This lookout gives a 360 degree view of the area. From here we could see far out to sea, and south over the three lakes that make up the Tuggerah Lakes system, then west to the Watagan Mountains and north to Stockton Beach. Another prominent feature is Bird Island which was used by the RAAF and RAN for bombing practice in WW11. It is now a bird sanctuary.

This was a convenient spot to talk about the formation of the coastal barrier dune system that now separates Tuggerah Lake from the sea. The dunes are the final defence against erosion by providing a barrier of sand against waves during storms. As well as limiting the landward passage of storm waves, wind and salt spray, the dunes act as a barrier to coastal inundation during abnormal high tides and importantly are an ecological transition zone between marine and terrestrial environments.

During the last ice age, sea level fell to around 130 m below present-day levels, leaving the Pleistocene sand barriers stranded inland, and transforming part of the continental shelf into a coastal plain. For most of NSW, the coastline was several tens of kilometres seaward of its present position. Coastal rivers flowed out onto the shelf and delivered sediment to the coastal plain. Coastal headlands were less prominent than today, facilitating longshore sediment transport.

A warming climate in the last glacial period caused the sea level to rise until about 6,500 years ago. It was close to its present position. This rapid rise in sea level, in conjunction with a prevailing south-easterly

19. Wybung Head.

20. Munmorah Conglomerate exposed beside the track to Wybung Head.

21. Cross bedding within Munmorah Conglomerate.

swell, promoted the onshore and longshore movement of large amounts of sediment to form an outer Holocene barrier. Further development of these most recent barriers ceased around 2000 years ago when transport of sand from the continental shelf ceased (Kidd, 2001).

Also discussed were the perched Pleistocene dunes found on many of the local headlands. During the last ice age, retreating seas exposed extensive areas of sand which were blown by the wind onto some headlands along the coast. This sand is now held in place by vegetation and in places is up to 30 m deep.

Our last stop for the day was Wybung Head *(photo 19)* itself, accessed via a weather-worn gravel track from the Wybung Head parking area that led down through coastal heathland past an impressive wall of Triassic Munmorah Conglomerate *(photo 20)* here appearing as beds of cross-bedded pebbly sandstone *(photo 21)* displaying colourful Liesegang banding *(photo 22)*.

Wybung Head itself is a narrow flat-topped sandstone peninsula ringed on three sides by cliffs. It provides spectacular 270 degree views north and south along this ruggedly beautiful coastline. From this vantage point there is clear evidence of coastal cliff line regression. On the narrow rock platform below lies a jumble of sandstone blocks which have parted from the cliffs along joints *(photo 23)*.

The enormous amount of information we tried to absorb, combined with the stunning wildflower display, the spectacular coastal scenery, remarkable geology of

22. Liesegang Rings within a sandy phase of the Munmorah Conglomerate.

23. Fallen sandstone joint blocks from a regressive cliff.

international significance and great company, including that of our guest, geologist Peter Mitchell OAM, made for a very successful day.

Report by Chris Morton.
Edited and abridged by Brian England.

Photos by Chris Morton (1, 4, 6, 12, 20, 23) and Ron Evans (2, 3, 5, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 22) and Brian England (9, 21).

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Quarry Beach & Quarry Head

Leader: Brian England.
Date: Saturday 14th November 2020.
Attendance: 13 members, 1 visitor.

Originally scheduled for Friday 13th this excursion was postponed till the following day due to storms being forecast in the afternoon. This proved to be a wise move as Caves Beach was hammered by a severe storm around the time of low tide on the Friday.

Although Society members had been to Quarry Beach several times, this was the first organised visit to the site for all Society members. The site was originally brought to our attention by members John and Alison Hyslop who live nearby. They described a strange feature on the rock platform which demanded investigation.

Those attending met at the road barrier at the south end of Spoon Rocks Road, Caves Beach, where some had a picnic lunch before the excursion began. A surprise attendee was Peter Mitchell OAM, who had been invited but had advised that a previous appointment meant that he could not be with us on Saturday. Fortunately that appointment had finished earlier than expected.

The group walked down the old 4WD track, taking the left fork which led down to the north end of Quarry Beach and the Mawson Breakwall, passing on the way the almost unrecognisable overgrown quarry from which the rock for the breakwall was extracted.

The track down to the beach had been severely eroded since my last visit and now resembled a ragged ditch requiring some care to negotiate. At the end of the track finely bedded unfossiliferous shales below the Belmont Conglomerate lie exposed, while around the corner to the north is a wall of this conglomerate crowded with tafoni *(photo 1)* caused by differential erosion of irregularities in the conglomerate texture. It is this conglomerate that was quarried to construct the breakwall.

This illegal breakwall was constructed by Mr Mawson, a Swansea hotel keeper and businessman who provided the impetus to develop Caves Beach. He then involved a Japanese consortium in a mining venture called Silver Valley Minerals in a failed attempt to mine and export coal from the Wallarah seam at the top of the Moon Island Beach Subgroup outcropping in dense bush along the ridge line a short distance inland. The breakwall, built to provide an anchorage for colliers, stands a little worse for wear as a reminder of this failed venture back in the 1970's. Scattered areas of broken coal beside the access trail suggest that at least some initial mining (or perhaps only exploration) did indeed take place. Originally a road had been laid along the breakwall but this was washed away by storms many years ago and access to the Spoon Rocks is now difficult *(Lake Macquarie History website - by maps.com)*.

2. Fossil tree stump on rock platform adjacent to Mawson Breakwall showing enclosing tuff mound.

Because of its dark muddy colour the first rock platform south of the breakwall was initially thought to comprise sediments of the Warners Bay Formation which immediately underlies the Reids Mistake Tuff. However the abundance of (previously sand-covered) fossil tree stumps observed during this excursion and their identical mode of preservation to those at Reids Mistake Head a few kilometres to the north indicate that they are in fact part of the same fossil forest. The appearance of the fossil forest here suggests that the ash surge which buried it swept into a section of muddy swamp, mixing in with the mud as it slowed. The tree stumps here *(photo 2)* are much larger in diameter than those at Reids Mistake Head but are covered by similar mounds of hardened tuff *(photo 3)*. Also present are siderite-replaced logs and concretions *(photo 4)*, both probable indicators of a coastal lagoon or swamp environment.

Further down Quarry Beach a small isolated headland

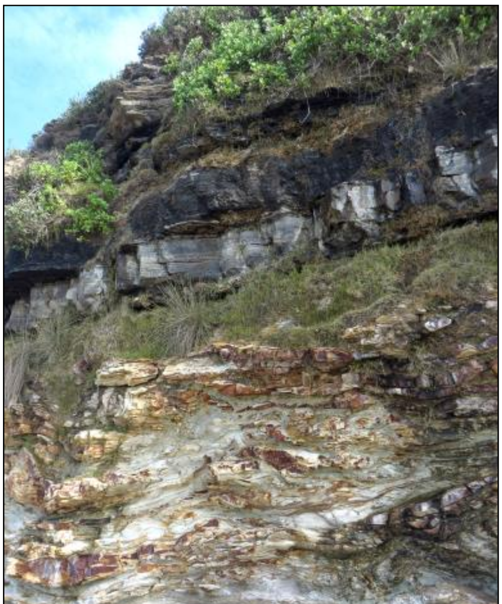
1. Belmont Conglomerate outcrop near the Mawson Breakwall showing abundant tafoni.

3. Mound of hardened tuff covering a fossil tree stump on rock platform adjacent to Mawson Breakwall.

4. Siderite concretion in tuff in rock platform adjacent to the Mawson Breakwall.

exposes an excellent section through the local stratigraphy comprising the upper part of the Boolaroo Subgroup consisting of the upper part of the Reids Mistake Tuff, the bed of grey silicified shale immediately underling the Upper Pilot Seam and the lower shaley part of the Belmont Conglomerate at the top *(photo 5)*. The silicified shale bed is very distinctive *(photo 6)* and is a good local marker bed. The Belmont Conglomerate has been quarried out here.

The intermediate part of the Reids Mistake Tuff begins to outcrop again on the rock platform adjacent to the small headland *(photo 7)* and after a short break forms the more extensive rock platform exposed at low tide further south. The tuff beds here show the turbulence typical of a base surge tuff surge *(photo 8)* while the eroded surface is worn smooth and shows the very fine grain size and cherty appearance that is typical of the Reids Mistake Tuff. Small scale intricate folding *(photo 9)* is abundant. Several superb examples of fossil tree stumps enclosed within hardened tuff mounds are exposed here *(photo 10)*. Many of the trunks have a core of siderite, surrounded by silica (chalcedony) and are



5. Stratigraphic section exposed on the small headland on Quarry Beach.

6. Block of silicified shale from the bed immediately below the Upper Pilot seam.

encased by a peculiar pelletal texture which may be fossil bark (Peter Mitchell). At the south end of the platform is a rare example of a tilted tree trunk enclosed within a tuff mound and covered by successive layers of cherty tuff showing very pronounced differential compaction over the trunk *(photo 11)*.

At the southern boundary of the fossil forest the rock platform steps up abruptly onto a bed of massive, coarser and much less disturbed sandstone around a metre thick. This sandstone contains very few distinct bedding structures, apart from occasional signs of turbulence during deposition. Interestingly it does not form part of the stratigraphy visible in the little headland just to the north.

But spread across this raised platform are perhaps the most enigmatic structures seen anywhere along the coastline. Lenses of siderite are quite common in fluvial sediments and still form today in river beds and lagoons where iron-charged water enters a coastal (brackish) reducing environment and is forced to drop the iron as an iron carbonate gel precursor to siderite. But here the originally continuous siderite lenses show directional crumpling *(photo 12)*, stretching *(photo 13)* and towards the northeast of the platform appear to have been torn apart and rolled into separate rod-like bodies up to 14 metres in length *(photo 14)*. Many of these rods show cuneiform extremities and some also show spectacular dehydration crack networks which extend into the enclosing sandstone. These siderite bodies are distributed throughout the full thick-

7. Outcropping of Reids Mistake Tuff forming the rock platform adjacent to the small headland on Quarry Beach.

8. Contorted base-surge beds in the Reids Mistake Tuff on the rock platform south of the small headland on Quarry Beach.

9. Small scale deformation in base-surge beds in the Reids Mistake Tuff on the rock platform south of small headland on Quarry Beach.

10. Fossil tree stump in tuff mound on rock platform.

11. Tilted fossil tree stump draped by layers of tuff.

12. Siderite lens showing directional crumpling. Flow direction is from left to right. Belmont Conglomerate forms the cliff line.

13. Stretched siderite lens. Flow direction is from left to right.

14. Siderite rod showing cuniform end.

15. Fossil wood fragment replaced in silica in siderite rod.

ness of the sandstone bed and all lie exactly in parallel with an orientation of 030 degrees. The position of the siderite bodies has no relationship to any joint sets and show no branching indicative of intersecting joints. They comprise dense fine crystalline (recrystallised) granular siderite altering to dense texture-less goethite on exposed surfaces. Calcite is a minor intermixed component. They show no bedding or accretionary structures but there are occasional small enclosed tuff bodies and fossil wood fragments replaced by siderite and/or chalcedony *(photo 15)*. Similar fossil wood fragments are common throughout the sandstone but become noticeably less abundant towards the north and northwest.

A number of directional features shown by the siderite bodies indicate that the phenomenon which caused their breakup, shape modification and distribution came from the present-day southeast, ie from a direction normal to their orientation. These features include imbrication *(photo 16)* and tilted stacking *(photo 17)* of siderite rods in vertical sections of the

16. Imbrication shown by adjacent siderite logs in vertical section in a sandstone bed. Flow is from left to right.

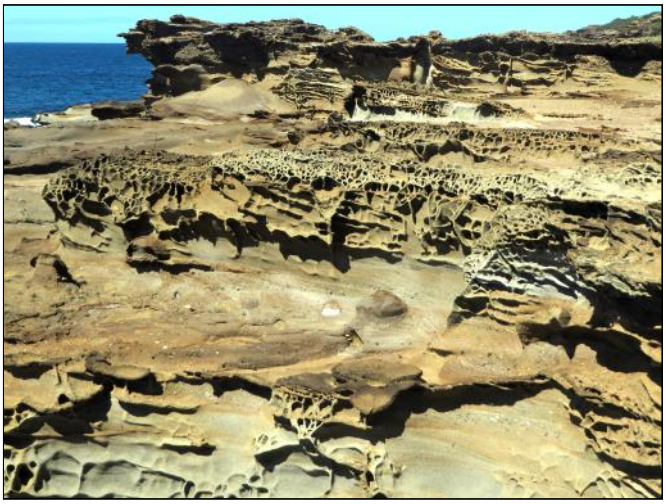
17. Tilted stack of siderite logs in vertical section within a sandstone bed. Flow is from left to right.

18. Crumpling of siderite lens conforming with bedding deformation.

sandstone bed, stretching *(see photo 13)*, crumple ridges conforming to bedding deformation in the adjacent sandstone *(photo 18)* and directional distortion of the remaining untorn siderite lenses exposed on exhumed surfaces. These features

19. Joint block of Belmont Conglomerate partly detached from coastal cliff along joints at northern end of Quarries Head.

20. Interbedded gravel bed and point bar deposit in vertical section through the Belmont Conglomerate.



21. Honeycomb weathering developed in sandy point bar beds within Belmont Conglomerate.

together with the dense generally structureless nature of the sandstone compared to the highly contorted underlying tuff and the presence and distribution of wood fragments derived from the underling fossil forest (?) strongly suggest that this sandstone unit lying on top of the Reids Mistake Tuff originated as a mass flow (perhaps a lahar) which occurred during or soon after the formation of the original gel-like siderite lenses. A search of the available literature throws little light on this geological enigma. However Biek (2002) talks briefly of siderite bodies deposited as a gel-like material in the bottom of shallow lagoons which later became rolled into rods by wave action.

Beyond the siderite structures the rock platform steps up again to the upper surface of the silicified shale bed immediately below the Upper Pilot seam. This bed also contains fossil tree trunks preserved in growth position and the surface of the bed displays well defined transverse sections of collapsed *Vertebraria*.

Further progress south along the coast is prevented by massive rock falls from the high sea cliffs of Belmont Conglomerate. The large size of the fallen blocks is due to the wide spacing between the two intersecting joint sets visible in the cliff face. Undercutting by wave action of the underlying soft shale and coal leads to the separation and collapse of huge joint blocks weighing hundreds of tonnes as they lose support and crash down onto the rock platform. On the north side of Quarries Head one huge block has only partly come away, leaving a narrow deep chasm between it and the cliff face *(photo 19)* .

We returned to the coastal 4WD track above the beach via the stairway which leads to an impressive coastal lookout at the edge of the old Mawson quarry. After a little over a kilometre the track terminates on top of Quarries Head overlooking Pinny Beach to the south. This section exposes a continuation of the Belmont Conglomerate which hugs the coastal cliffs from here down to Middle Camp Inlet, with the overlying Teralba and Bolton Point Conglomerates (both in the Moon Island Beach Subgroup) outcropping a few hundred metres inland (Gosford - Lake Macquarie geology 100K map).

The first feature encountered is "split rock" a huge block of conglomerate slowly breaking away from the cliff along a north-south trending joint on the northern side of the headland. This is the same block seen from sea level at the south end of Quarry Beach *(see photo 19)*. Beyond this the Belmont Conglomerate is exposed on a series of rough uneven benches separated by low cliffs. This exposure provides a different aspect compared to Caves Beach where only vertical sections are visible. The outcrop comprises repeated sequences of interlocking sand bar and gravel bank deposits typical of the Belmont Conglomerate *(photo 20)* . The sandy layers show spectacular honeycomb weathering *(photo 21)* and differential erosion has produced a rough and spectacular coastline. The sandstone beds also show good examples of cross bedding, truncated cross beds and pebble lag *(photo 22)* and large logs of the form species *Dadoxylon* replaced by both siderite and chalcedony are common *(photo 23)* . These very likely represent driftwood dropped in distributary stream channels as water flow ebbed.

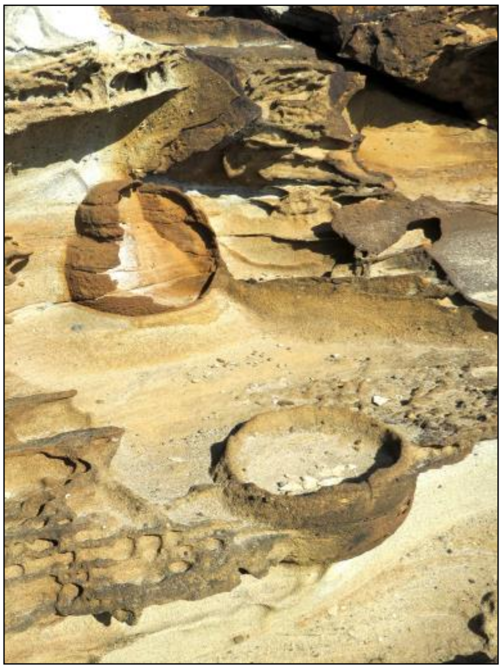
Joints in the conglomerate have been infilled by brown iron oxides (limonite) and groundwater leaching along some bedding planes has resulted in the development of calcite speleothems in areas sheltered from weathering and erosion.

But the most visually stunning features in the Belmont Conglomerate on Quarries Head are the abundant calcareous

22. Truncated cross beds and pebble lag in point bar beds in Belmont Conglomerate.

23. Fossil log replaced by both silica (chalcedony) and siderite.

24. Concretion rimmed by limonite.



25. Limonite-rimmed concretion eroded to form a "washing basin".

26. Eroded calcareous -rimmed concretions forming raised bowls.

concretionary structures, often rimmed by brown limonite, developed specifically in the sandy point bar deposits. These take many forms including simple circular outlines of resistant limonite *(photo 24)*, partly eroded "washing basins" *(photo 25)*, slightly raised bowls *(photo 26)*, solid oblate spheroids and groups of circular depressions in the sandstone, some with rims standing proud due to limonite induration *(photo 27)*. In most of the concretions the centres have been much softer compared to the rims allowing central depressions to form through marine erosion. However in one isolated outcrop the reverse is true, resulting in grotesquely eroded structures *(photo 28)*. All the concretions formed within the sediment pile as shown by the continuation of sedimentary bedding through them *(photo 29)*. There are also roughly cylindrical limonitic

27. Circular depressions in trough cross bedded sandstone layer formed by erosion of concretions.

28. Grotesquely-eroded calcareous concretions.

29. Limonite concretion showing continuation of bedding through it from the surrounding point bar sandstone.

concretions up to 2 metres in length which resemble fossil logs but show no woody textures.

The track back north over the headland provides spectacular views to the south over Pinny Beach and more coastal cliffs of Belmont Conglomerate.

Report and photos by Brian England.

Reference:

BIEK, R. (2002). *Concretions and nodules in North Dakota*. North Dakota Geological Survey.

View down onto the Quarry Beach rock platform and its concretions from the Quarry Lookout.
Photo Ron Evans.

Publication Acknowledgements.

Geo-Log 2020 is the usual collaborative publication with reports from trip leaders who organise and conduct activities. Various members also provided photographs for inclusion in Geo-Log 2020.

Activities conducted during the year were restricted due to Covid-19 and when they did take place, were conducted within Covid-19 protocols.

A special thanks to Geo-Log editor Brian England (Life Member) for the onerous job of checking the geological content and seeking out errors in the reports submitted for inclusion in Geo-Log 2020. He was ably assisted with some editing by Ron Evans.

Life Member Ron Evans compiled Geo-Log 2020 and organised its publication by Lakemac Print, Speers Point.

Ron Evans.