'Geo-Log' 2019

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

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President's Introduction.

Hello members and friends.

Firstly, may I ask, where did 2019 go? It seems to have passed by so quickly.

Over the last year our society has conducted a broad and diverse range of exceptional activities, both local and interstate. These activities are subject to long and detailed planning. In many cases planning of 12 to 18 months can take place before the activity is be conducted. However, with all the best laid plans no one can predict the weather.

The dry weather conditions due to the long ongoing drought towards the end of 2019 created some difficulties for our leaders. But fortunately, only one activity (Burraga Swamp) had to be cancelled because of State Forests and National Parks being closed due to bushfires.

There are many people to thank for their efforts in making 2019 a very successful year. Firstly, congratulations to the planning committee who bring together all the ideas from trip leaders and develop them into a cohesive annual program. Also, my fellow executive members and past executive committee members who work tirelessly in making the AGSHV the successful organisation we see today.

Congratulations to Sandy Pfeiffer and Brian and Barbara Dunn for organising and running their first excursions for our society.

Sandy's intimate knowledge of the history and geology of the Mt Airly diamond/gold mines and the Glow Worm Tunnel in the Blue Mountains near Lithgow made for a very informative if not exciting and adventurous 4-day activity.

Brian and Barbara also ran their first activity in what turned out to be very difficult conditions. Their 3-week Safari to Southeast Queensland and Northern New South Wales, in what would normally be very a pleasant time of year, was hampered by very hot dry and windy conditions, a product of the ongoing drought. This resulted in water shortages in some towns, raging bushfires and park closures. This forced changes to the program most days. Nevertheless, Brian and Barbara diligently reassessed each day, and despite all the difficulties delivered an excellent activity.

A big thank you goes out to Dr Peter Mitchell, OAM, our guest leader to Muogamarra Nature Reserve in October last year, and for offering to run another activity to Long Reef ocean rock platform in March 2020. He also generously donated 40 books 'Exploring tidal waters on Australia's temperate coast' that he co-wrote with Phil Colman for us to sell, with the proceeds going towards the production of the Geo-Log.

And let us not forget the social committee for their ongoing organisation of the craft days, soup and slides get together and the end of year Christmas party. And lastly to our trip leaders for their dedication and their great reports that contribute to this Geo-Log that Ron and Brian so professionally produce. As ever the Geo-Log is the equal to professionally produced documents and is eagerly waited for each year.

Planning for 2020/21 is well under way with some great destinations planned, one of which has been long anticipated is a return trip to the Flinders Rangers next July/August. So, stay fit and healthy as I look forward to enjoying your company this coming year.

With best regards,

Chris Morton.

Geology of the Newcastle Region

Presenter: Phil Gilmore.
Date: Thursday 24th January 2019.
Attendance: 47 members.

An interesting Power Point talk was presented to our group by Phil Gilmore at Hexham Bowling Club *(photo 1)*. Phil is Manager of Regional Mapping, Geological Survey of NSW. He is also, the Project Leader of the East Riverina Mapping Project compiling detailed maps of the central Lachlan Orogen around Wagga Wagga and Ardlethan. The following is some of Phil's background that was not given on the day. Phil completed his Bachelor of Science with Honours at the University of Newcastle in 1996 and completed his Masters of Economic Geology, University of Tasmania, 2015. After his Honours, he was an Exploration Geologist, spent time in the UK, was Senior Geologist with the Coal Compensation Board and became Manager for Regional Mapping in 2006. He is also Secretary to the Hunter Valley Branch of the Geological Society of Australia and one of the driving forces of HEDG (Hunter Valley Earth Sciences Discussion Group).

The following is a brief summary of Phil Gilmore's talk. Phil started with the role of the Geological Survey of NSW. He then moved on to giving us some introductory geology covering tectonic plates, orogens and basins and the geological time scale. Rocks in the Newcastle Region are mainly from the Carboniferous, Permian and Early Triassic with influence from the Cretaceous, Eocene and Quaternary.

The Carboniferous saw the deposition in the Tamworth Belt and Hastings Belt along with the Tablelands Complex accretionary wedge in a forearc basin setting accompanied by widespread volcanism

Richard introducing Phil Gilmore before he presented his talk on the Geology of the Newcastle Region.
(Photo Ron Evans)

Phil Gilmore commencing his Power Point talk on the Geology of the Hunter Region.
(Photo Richard Bale)

related to a volcanic arc e.g. Nerong Volcanics at Port Stephens with rhyodacite and Mount View rhyolite. The Carboniferous, in our area, was a time of cold climate conditions as evidenced by the varved shales at Seaham.

The Early Permian saw a change from convergence to rollback continental setting with back-arc basin opening i.e. the Sydney-Gunnedah-Bowen basin forming in the west. This was the time of the Alum Mountain Volcanics forming Alum Mountain at Buladelah and The Buckets at Gloucester. Sediments started being deposited in the Sydney, Gloucester and Cranky Corner Basins. This was also the time of shallow marine fossils found at Mulbring and cold-water Eurydesma fossil shells at Allandale.

Soils formed from early Permian sedimentary rocks have a major influence of wine quality in the Hunter Area e.g. Shiraz wines from soils over shallow marine rocks are calcium rich, slow draining give Blackcurrant flavours = $40 a bottle. Soils over fluvial sandstone are clay rich, don't drain to give Raspberry flavours = $20 a bottle. Deformation of orogenic mountain belts gave rise to the Nambucca Block. East-west shortening and the formation of a series of synclines and anticlines followed by erosion "shearing" away the top section gave the characteristic hills seen to the northwest from Port Stephens.

Late Permian was warmer and a time of heavy forestation and stable long-term coal forming swamps which gave rise to the Newcastle Coal Measures *(figure 1)*. Fossils of *Glossopteris*, *Dadoxylon*, *Phyllotheca* are common. Coal forms from compacted organic material by burial and heating, going from peat to lignite to coal to anthracite.

Tuffs and tuffaceous sandstones are common through the Newcastle Coal Measures with six layers having a Volcanic Explosivity Index of VEI 8 or above equivalent to 6 Yellowstone explosive volcanic eruptions *(figure 2)*.

The Permian Triassic boundary mass extinction event at 252 million years (Ma) ago killed off more than 96 percent of the planet's marine species and 70 percent of its terrestrial life.

The early Triassic Narrabeen Group consisting of fluvio-deltaic sandstones and conglomerate conformably overlay the Newcastle Coal Measures as seen on Mt Sugarloaf. The Cretaceous was the time of the opening of the Tasman Sea which also saw the emplacement of many dykes that are seen along the coast dated around 90 Ma.

The Barrington Tops basalts were due to volcanic activity when eastern Australia drifted northwards over a mantle hotspot during the Cenozoic, Eocene Epoch. Basalts were erupted starting at about 50 Ma till about 27 Ma. Rubies and sapphires can be found in the area.

The Quaternary is having a major influence on the Hunter Region with the formation of dune systems along Stockton Beach. 120,000 years ago, during the last interglacial when it was warmer, sea level was 2-5 m higher with Largs on an estuary similar to Belmont today. 20,000 years ago, during the last Glacial Maximum, when it was colder, sea level was 100 m lower and beach was 25 km to the east towards edge of continental shelf. Sea level has been steady for last 6,500 years allowing rock platforms to form from constant wave action and undercutting of cliff lines. The 1989 5.6 magnitude earthquake is the latest in a series of earthquakes recorded since European times, probably extending much further back in time, showing that the area still has seismic activity.

Phil Gilmore talked about the Maps and Data that are available from The Department of Planning and Environment, Geological Survey of NSW. MinView is an interactive web-based mapping system showing geology, mineral occurrences, geochemistry and other geological observations. Phone Maps has interactive maps of geology and geophysics. DIGS is a searchable on-line database where reports and publications can be downloaded. The release of the Port Macquarie Geotrail in 2018 was of interest to our group. The Survey is now working on new Geotrails for Newcastle, Warrumbungles and Tweed areas.

This activity was another experiment in a new format for our AGSHV group. After our successful 40th Celebration held here at the Hexham Bowling Club and the fact that the room facilities seemed suitable for our needs, it was decided to continue using this venue for our lecture and meeting functions.

After the meeting, we made use of the downstairs Riverside Bistro that serves mainly Asian meals. The timing and coordination proved disappointing as most meals were not freshly prepared but had been kept warm for us. It was felt that having a meal at the Bistro before the meeting would work better in the future.

This meeting has proved to be particularly popular with a total of 47 people attending. After our trial in 2018, again, it seems to have been a good chance for people to come along, who are not normally active members. Again, people said they enjoyed the talk along with the social gathering and a meal.

Slides.

Permission to use Power Point slides presented by Phil Gilmore granted by personal communication, 24/1/2019 and again 18/6/2019.

Hexham Bowling Club acknowledgement.

On behalf of the AGSHV, I would like to thank Hexham Bowling Club, and all their staff for their support in organising our talk. I would also like to thank the catering staff for providing a nice meal.

Report by Richard Bale.
Photographs by Richard Bale and Ron Evans.

AGHSV members in Hexham Bowling Club waiting for Phil Gilmores talk on the Geology of the Hunter Region to commence.

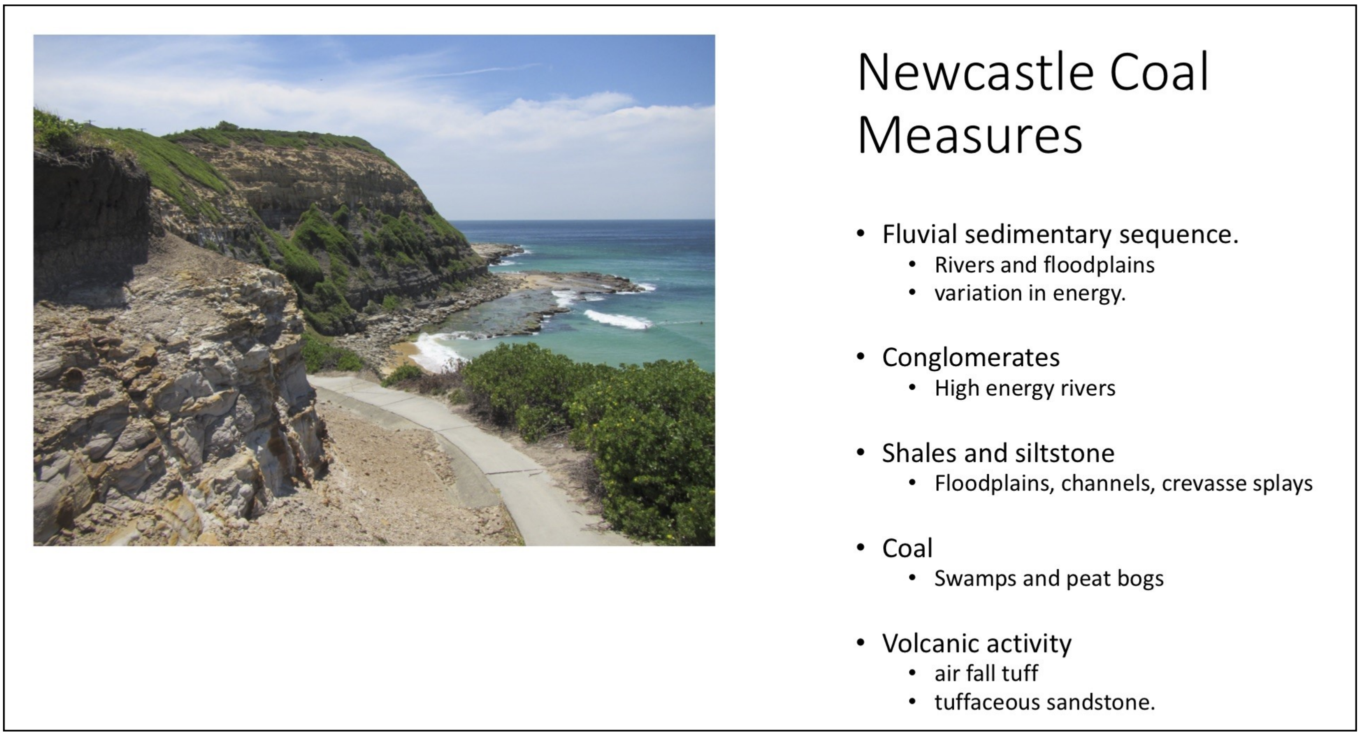


Figure 1. Power Point slide illustrating geological features of the Newcastle Coal measures.

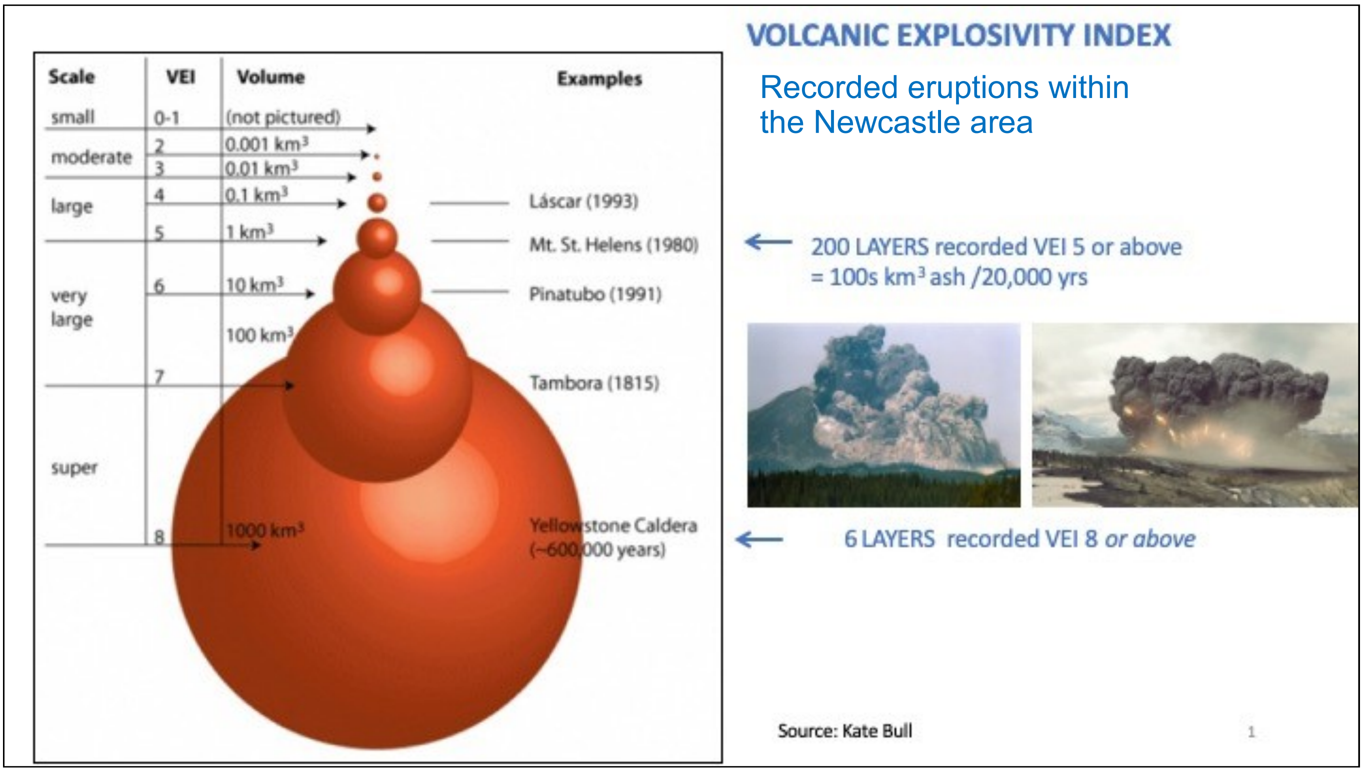


Figure 2. Power Point slide used to illustrate the magnitude of the volcanic eruptions that occurred in the Newcastle area that subsequently led to the deposition of tuffs.

Mining and minerals in the Ural Mountains of Northern Russia

Presenter: Brian England.
Date: Saturday 16th February, 2019.
Attendance: 25 members.

With the advent of high-quality digital imaging, 35 mm slides have been assigned to the technology dustbin that no one wants to empty. But buried amongst the dinosaurs of this outdated technology are valuable records of extraordinary journeys - journeys that were unique and which can never be repeated. The logistics of making digital copies for group presentations are prohibitive and it was decided by the Committee that members be given the opportunity to present old time slide shows of some of their more memorable experiences.

The slide show presented a stunning visual account of an extraordinary journey into the real Russia of the late 1990's, into a part of the North Ural Mountains rarely accessible to outsiders, an area then being mined for piezoelectric quartz for the Russian electronics industry.

Ours was a small international group of Australians, Americans and Canadians led by Gene Skubolov from Saint Petersburg and a small contingent of Russian helpers.

In their search for suitable crystals in the gigantic en-echelon quartz veins traversing folded and faulted Late Precambrian schists and phyllites, numerous large cavities were encountered which contained extraordinary quartz gwindels (twisted crystals) as well as some of the World's finest anatase, brookite and ferroaxinite. One of the axinite pockets we encountered was the size of a bus! My discovery of the best anatase pocket ever found at Dodo caused excitement worldwide.

The region was so remote it could only be reached by huge transport long range helicopters. Local transport between mining camps was using ex-army 8 cylinder diesel amphibian tracked vehicles which regularly broke down and required Russian ingenuity to get going again across the thawed tundra *(photo bottom right)*. The 50 kilometre trip between the main camp at Neroika and the Puiva camp took 7 hours!

Everything we needed for the 10 day trip had to be brought in with us on the choppers. We were continually tricked by the 24 hour daylight, being far enough north at that time of year to be in the land of the midnight sun.

Unfortunately, the Heritage Room at the Hexham Bowling Club could not be totally blacked out so some of the slides, taken under atrocious conditions did not show well. Some of these photos accompany this report.

Report by Brian England.

Preparing to show photos through a slide projector,

Brian preparing to deliver a slide show of his trip to the Ural Mountains of Northern Russia.

The amphibian tracked vehicle needing repairs again!

Airly Mountain, Newnes and Glow Worm Tunnel

Leader: Sandy Pfeiffer.
Date: Monday 11th to Thursday 14th March, 2019.
Attendance: 22 members.

Monday 11th March.

At 8 pm everyone gathered at the camp kitchen of the Lithgow Tourist and Van Park in Bowenfels for a meeting where introductory talks covering the next 3 days' activities were presented.

Airly Mountain Diamond/Gold Mines - Some Information.

History.

- Early 1890's to 1912 – Extensive oil shale mining was carried out in the New Hartley Shale Mine below the north-eastern side of what was called Torbane Mountain *(figure 1)*. This mountain is to the west of the Airly Mountain diamond/gold mines and now named Mount Airly on modern maps and in AGSHV Geo-Log 2017 Lithgow trip report.
  This period was the peak of Airly Village (between Airly and Torbane Mountains), which consisted of many houses, a school and shops etc. Only one house remains today. Some miners constructed cave houses on the east side of Torbane Mountain.
  Around the peak of oil shale mining the miners fossicked for gold and diamonds at the top of Airly Mountain in their spare time (Jefferys 1982 p64).
- 1930's (Great Depression). Shafts and tunnels prospecting for gold and diamonds were driven mostly near the present flying-fox terminal (and elsewhere) at Airly Mountain (MacNevin 1977 p87).
- About 1960 a prospector told Col Ribaux about diamonds at Airly Mountain. So Col and his family started mining gold and diamonds at first in their spare time while employed elsewhere. Over the years at least 260 m of shafts and tunnels were excavated by pick and shovel by the Ribauxs (Fischer 2018). In places the underground passages were so narrow they could barely be negotiated (pers comm Jim Herlihy 2019).
- At the top of mountain, the diamonds and gold were concentrated/recovered from the gravels etc. using equipment often constructed/adapted by the Ribaux family.
  - ◊ 1962 first hut built at mine site.
  - ◊ 1964 flying fox built to convey equipment from Airly Village to top of Airly Mountain.
  - ◊ Late 1960's "Medibank" road constructed to top of mountain via "Pappy's Pass".
  - ◊ 1975 Nissen hut bought from army camp and installed at mine site.
  - ◊ Mid/late 1970's Col mostly working Airly Mountain mines full time assisted by family.
  - ◊ 1981 open cut mine excavated by partner Arrawattta P. L. on west side of mountain exposing previous shafts and tunnels.
- Early 2009 Centennial Coal starts mining the Lithgow Seam in Illawarra Coal Measures below the mountains. Mining to extend from pithead at Torbane, heading west and north.
- March 2011 Mugii Murum-ban State Conservation Area created covering Torbane, Airly and Genowlan mountains.
- 9th December 2018 - Col Ribaux dies at his house at foot of Airly Mountain, aged 81.

Topography.

The topography on the Airly Mountain area comprises steep sided isolated mountains rising some 360 m above the valley floor at the immediate base of the mountains. The mountains typically contain near vertical 60 m high cliff faces, the base of which are some 160 m above the valley floor.

Geology.

Deep Leads - The Simple Story.

The diamonds and gold at Airly Mountain are in "deep leads". Deep leads are formed when ancient gravels containing gold (and in this case diamonds) are deposited in a paleochannel (old stream floor). The deep lead gravels are then covered by extrusive basalt flows, which flow into the valley floors. The hard basalt protects the gravels and surrounding areas from erosion leaving prominent mountains. So what was once a valley floor is now at the top of a mountain!

Stratigraphy at Airly Mountain Area (top/youngest to bottom/oldest).

Basalt: Paleogene Period, Eocene Epoch. There are 2 separate remnant basalt outcrops on Airly Mountain, the southern one yielding the majority of gold and diamonds. This southern basalt has a maximum thickness of 36 m although is much thinner in other places (MacNevin 1977 p86). Basalt also outcrops on Torbane Mountain, the north end of Genowlan Mountain and on Black Mountain (north of Torbane Mountain) - *see figure 1*.

Diamond Bearing Gravels: Eocene Epoch (and older?).

Burra-Moko Head Sandstone Member: middle of Grose Sandstone Formation, part of Narrabeen Group which is Triassic in age.

The Burra-Moko Head Sandstone forms the 60 m high cliffs in the area (NSWNPWS 2015 p5). One source (Temby 2006 p5) states the cliffs are the Banks Wall Sandstone Member but the Burra-Moko Head Sandstone is more likely as the cliffs are not far above the Illawarra Coal measures.

Lower parts of the Triassic Narrabeen Group: underlies the Burra-Moko Head Sandstone with limited outcrop exposed.

Illawarra Coal Measures: These Permian age coal measures unconformably underly the Triassic Narrabeen Group. They includes the oil shale beds once mined in the New Hartley Shale Mine and the coalesced Lithgow/Lidsdale Coal Seams, the lower parts of which are currently being mined by Centennial Coal.

Middle/lower aged Devonian basement rocks exposed in the distant valleys around Airly Mountain unconformably underlies the Permian rocks.

Deep Lead Paleochannels.

Following tectonic uplift of the Sydney Basin commencing 180 to 200 mya (million years ago) and further uplift (Temby 2006 p5), paleochannels were cut into the Burra-Moko Head Sandstone and were infilled with the gold and diamond bearing gravel deposits

The paleochannels at Airly Mountain are in a general N-S direction with a N to S current direction (Temby 2006 p5 & 6). It has been estimated that the paleochannels are from a drainage system 17 to 25 km long with a catchment area of 210 to 270 square kilometres (Temby 2006 p7). The channels at the Airly Mountain mine area are broad and open to the north and narrow/steep sided to the south (MacNevin 1977 p86).

These channels were then covered with the 39 to 41 million year old Eocene basalts. But the story is not that simple. The basalts are interbedded with the gravels, so that while the gravels at the base of the paleochannels may be older than the basalts, they were also deposited at practically the same time as the 39 to 41 million year old basalts (Temby 2006 p6).

Col Ribaux has identified 5 separate channels at Airly Mountain, based on mineralogy and geometry (pers comm. 2018).

The gravels consist of gravelly sand with layers of pure sand and clay (Gibbons et al 1963 p5). The gravels are up to 3 m thick but probably average about 0.5 m (MacNevin 1977 p86). Heavy minerals present consist of gold, zircon, spinel, topaz, tourmaline, sapphire, rutile, garnet, beryl and, of course, diamond (Gibbons et al 1963, p6). In places the gravels are cemented, the resultant material resembling a hard conglomerate.

The Diamonds.

The southern basalt outcrop on Airly Mountain has yielded the majority of diamonds (and gold). The diamonds exhibit a very low degree of fracture and surface abrasion.

They are of octahedral, dodecahedral and macle shape with other shapes present (Gibbons et al 1963 p7 and Temby 2004 p 97). An octahedron is a form comprising eight triangular faces. A dodecahedron has 12 sides with 5 edges per side. A macle is a twinned crystal where two octahedra rotate at 180°on a common plane (twin plane).

Col Ribaux reported that 90 to 95% of the diamonds were of gem quality (Fischer 2018). Diamonds recovered by the Ribaux family and partners have been up to 1.36 to 1.5 carats and down to 0.1 carat and smaller. Rare stones weighing 5.6 carats and over 10 carats have been reported (Temby 2006 p8 & 9). (One carat is 0.2 of a gram. A 1.5 carat diamond would be about 7 mm).

The colour of the diamonds mined is white or a very pale hue, yellow, green, pink, blue and black (Gibbons et al 1963 p7 and Temby 2004 p97).

Diamonds recovered by the Ribaux family and partners have yielded 0.25 to 0.5 carats per cubic metre of gravel treated. Some pockets of yellow clay had yields of 12 carats per cubic metre of material treated with pockets up to 40 carats per cubic metre (Temby 2006 p8).

The Diamond Source.

Some authors (Gibbons et al p7 and MacNevin 1977 p87 3rd last paragraph) suggest that the source of the diamonds is not very distant from Airly Mountain, based on their un-fractured/un-abraded nature. A close -by source is indicated by the relatively small estimated catchment length (17 to 25 km) and area (Temby 2006 p7), which is interpreted as being to the north or northeast of Airly Mountain (Temby 2004 p43).

The diamonds may be from alkali basalt diatremes resulting from subduction zones (Temby 2006 p3). This is opposed to the South African Diamond kimberlite pipe source model. As far as I can ascertain, the definite source of the Airly Mountain diamonds has not been found.

The Gold.

Along with the diamonds, gold has been recovered from the Airly Mountain paleochannel gravels. Recovery of up to 600 mg of gold per cubic metre of gravel has been reported (Temby 2006 p8).

The gold would have been eroded from pre-Permian basement rocks (with possible additional sources such as other alluvial gold).

Some of the cemented gravels from the open cut required crushing before being concentrated/treated but this was not done. Col Ribaux treated some of this material and reported good yields of gold (Temby 2006 p8). Much of this cemented gravel is still lying around the ground. Recent fossicking of mine mullock heaps and concentrate tailings has yielded some gold and diamonds (although the gold was fine and difficult to pan). Modern day fossickers can still find diamonds, sapphires and zircons etc. in the concentrate although they are usually very small.

***Tuesday 12th March - Airly Mountain*.**

Members departed the Caravan Park at 8:30 am in a convoy of six 4WD vehicles in sunny pleasant weather that remained so all day. We drove west along the Great Western Highway before turning north along the Castlereagh Highway. At the township of Capertee we turned right into Glen Davis Road. 8.5 km along this road we turned left into what was Col Ribaux's property (now owned by Centennial Coal Company P.L).

We stopped at Col's house to admire the beautiful amphitheatre of surrounding cliff faces of Airly Mountain *(photo 1)*. Members then wandered around the myriad of mining equipment, old cars, trucks, buses converted into camper vans, bulldozers, caravans, children's go-carts, old aeroplanes etc. that Col had stored there *(photo 2)*. When in the Australian Army, Col was in the Royal Australian Electrical and Mechanical Engineers Corps and was an experienced and ingenious mechanic. He constructed mining and diamond/gold recovery equipment in the fully equipped workshop next to his house, as well as carrying out general mechanical repairs/maintenance *(photo 3)*. He once converted a WW2 Stuart tank into a bulldozer/backhoe for use around the mines at the top of the mountain.

Having put our vehicles into 4WD we entered the Mugii Murum-ban State Conservation Area and proceeded up the steep winding track to the base of the cliffs. Here we entered Pappy's Pass (named in memory of "Pappy" Gil Ribaux - Col's father) constructed through a narrow cleft in the cliff face *(photo 4)*. The Ribaux family constructed the road up to the mines in the late 1960's and is an engineering feat especially considering they had to start at the base of the mountain and often had to laboriously bulldoze the dirt and rock uphill as opposed to the easier method of starting at the top, pushing the dirt downhill.

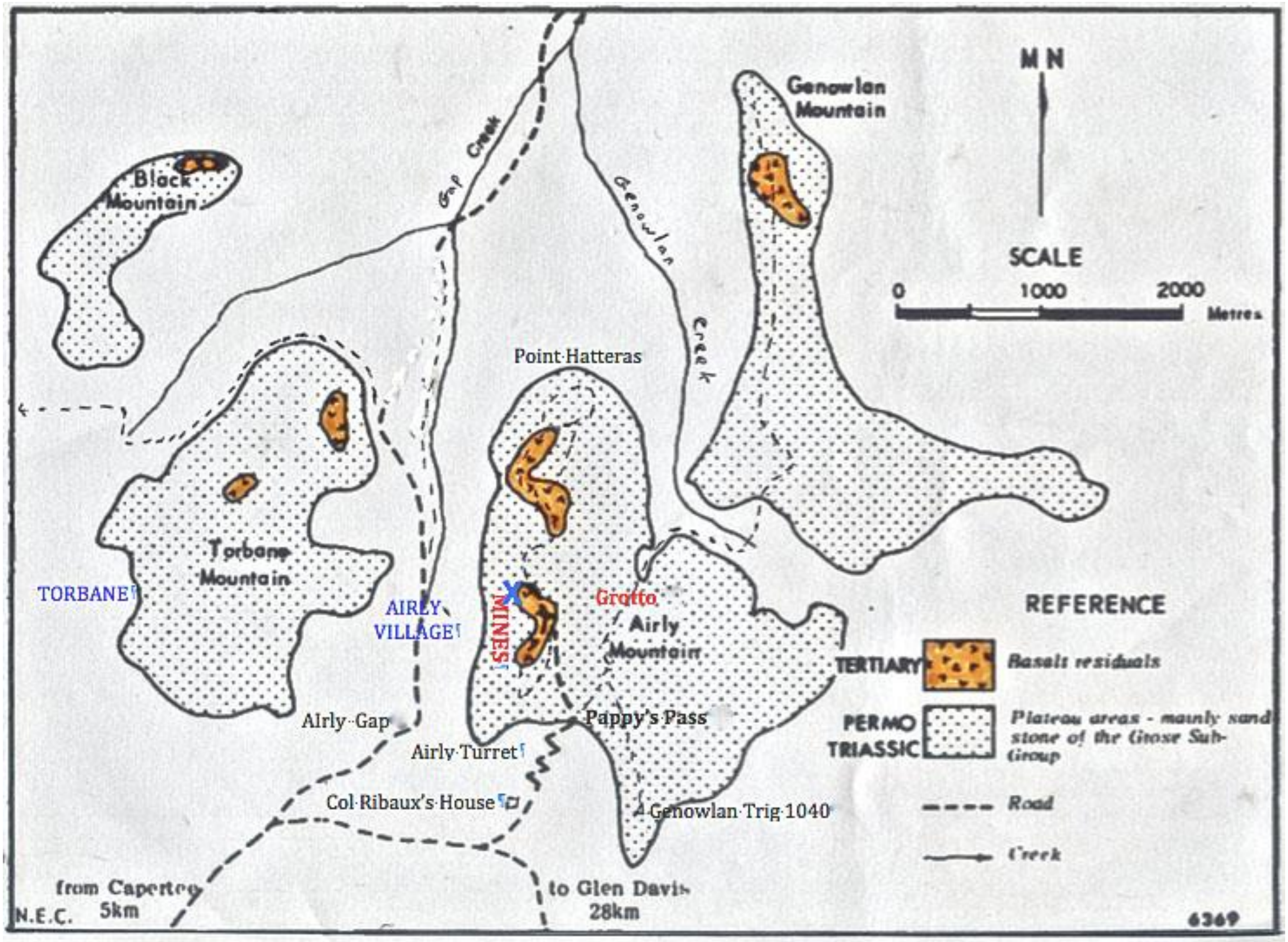
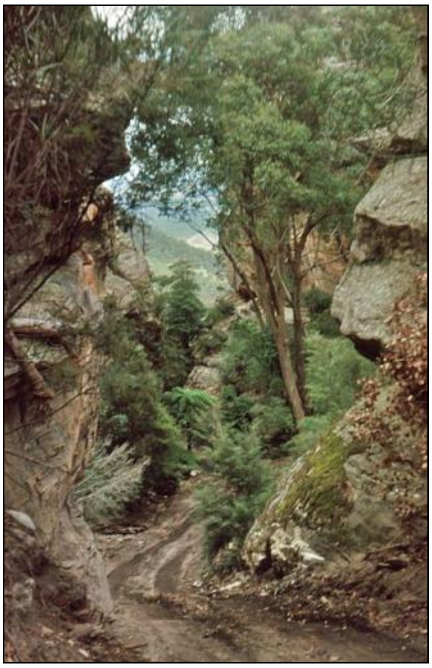


Figure 1 - Geology and Topography of the Airly Mountain Area. The 4 separate mountains/plateaus are shaded with dots, the outcrop mostly being the Triassic aged Burra-Moko Head Sandstone. (Torbane Mountain is also known as "Mount Airly" in modern maps.). Diamond/gold mines are below the basalt (to left of "MINES" shown). **X** indicates position of open cut mine site. Modified from Gibbons et al 1963 and MacNevin 1977.

1. Part of amphitheatre of cliffs surrounding Col Ribaux's house.

2. Example of some of the equipment and trucks around Col Ribaux's house.

3. Col Ribaux's bush workshop next to his house.



4. Looking down Pappy's Pass towards the distant clearing of Col Ribaux's house.

At the top of Pappy's Pass we took the left fork winding up through the "pagodas' of the Triassic sandstone. Reaching the base of the Paleogene basalt we stopped at Katos Adit *(photos 5 and 6)*. When I was here in May 1981, this was a working mine tunneling horizontally into the east side of the mountain and following a deep lead of gold and diamond bearing ancient river gravels. Adits are the easiest method of mining deep leads. Elsewhere on Airly Mountain vertical shafts were dug through the basalt then branched out into near-horizontal drives when the gravels were reached.

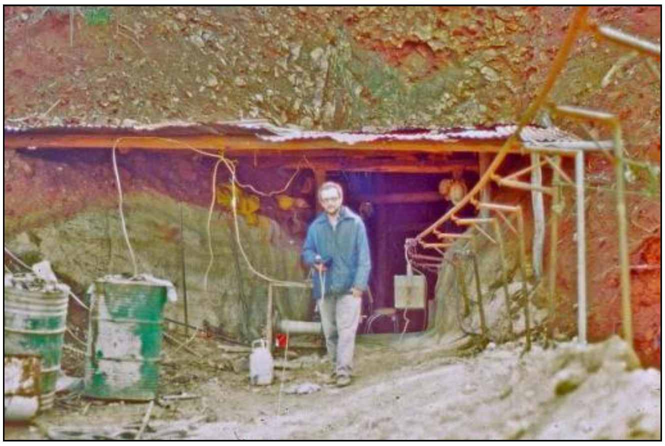
The entrance to Katos adit has been closed off but the group had a chance to see a typical deep lead adit entrance and to see the ingenious monorail system designed and constructed by the Ribauxs *(photo 7)*. Wire cables, pulleys and an electric powered winch were used to move the bucket along the monorail.

Compared to many other Airly Mountain adits and tunnels, Katos Adit is spacious having excavated a lot of basalt to give easier access to the thin stream bed below. When a geology student at the NSW Institute of Technology Jim Herlihy mapped some of the Airly Mountain tunnels in the late 1960's. He recounts in an email to Sandy: "The tunnel I surveyed was minuscule in cross section compared to [Katos Adit] ". "…the tunnel was so small we had to undo the belt and put the battery in the helmet [with a miner's cap lamp] and push the helmet in front of us." "The tunnel followed the deep lead and was so narrow we had to hold our elbows against our sides. We were going downstream and the worst part came when the original creek/stream went over a small waterfall about 80-100 cm high. I had to slide down into what would have been the pool at the bottom of the fall then arch my back upwards to get back up to the stream bed. The thought did cross my mind as to how one would be rescued if one got stuck or something, such as an angry wombat, blocked the tunnel."

The group then drove over the top of the mountain to the open cut mine site on the mountain's western side *(figure 1)*. Here a great view was seen of Airly Gap, Gap Creek valley, the surrounding mountains and the Capertee River valley headwaters further to the north. Members were warned to beware of the "Airly Poison" along the top of the cliff here. As Col Ribaux had said "One drop'll kill ya".

Immediately below us was Airly Village *(photo 8)*. Only Airly House exists where once there was a thriving town serving the New Hartley oil shale mines in the early 1890's to 1912. The 1:25,000 Glen Alice topographic map shows individual lots (where houses/ buildings once were or were planned) and shows where the streets and laneways of the village once were. The Society's April 2017 Lithgow trip passed Airly House on its way to see the miners' cave houses further to the north as reported by Brian England in the 2017 Geo-Log.

Immediately to the east of the lookout down to Airly Village is the site of an open cut mine that has been backfilled but part of its eastern wall is still visible *(photo 9)*. While the group observed the remains of the open cut mine Sandy showed them a photo of it that he took in 1981 just after its excavation. This photo had two interesting aspects. One is that it showed a previous shaft and tunnels exposed in the excavation wall. The open cut was excavated in an area where diamond and gold were more abundant and where there were a lot of underground mines. Open cut mining was a cheaper method of reaching the deep lead gravels than the previous underground mining methods, even though a lot of basalt overburden had to be removed.



5. May 1981. Katos Adit showing monorail system to carry excavated rock out of adit.

6. May 1981. Inside a deep lead -Katos Adit. Grey and brown coloured basalt with dark brown river gravel layer below.

7. Katos Adit today showing detail of monorail system to carry excavated rock out of adit. Photo Ron Evans.

The other interesting aspect was that the photo (looking east) was taken near the cliff edge while standing on sandstone outcrop. The gravels at the base of the basalt were some 10 m below the photographer's feet. This was a good demonstration of how steeply the ancient streams had cut into the sandstone and how deep they are.

The open cut mine site was a good spot to have morning tea while enjoying the view from the cliff top *(photo 10)*.

After morning tea, participants then looked at the remains of the flying fox the Ribauxs installed in the about 1964. This ran from the top of the cliff to near Airly House below and was used to carry equipment and supplies up to the mines before the track up the mountain was built. The winch (run by an army BSA motor bike engine) and the wires are still there. There are two wires, one to support the load, the other to pull the load up. Each wire would have been in the order of 600 m long raising the load some 250 m in height. The wires could support a 200 to 250 kg load (Fischer 2018).

Col Ribaux once told Sandy the story of the day he was using the flying fox to winch a bathtub up the mountain. A visitor to Airly House (unaware of the flying fox) could not believe her eyes when she looked up to see this weird apparition of a bathtub floating through the sky.

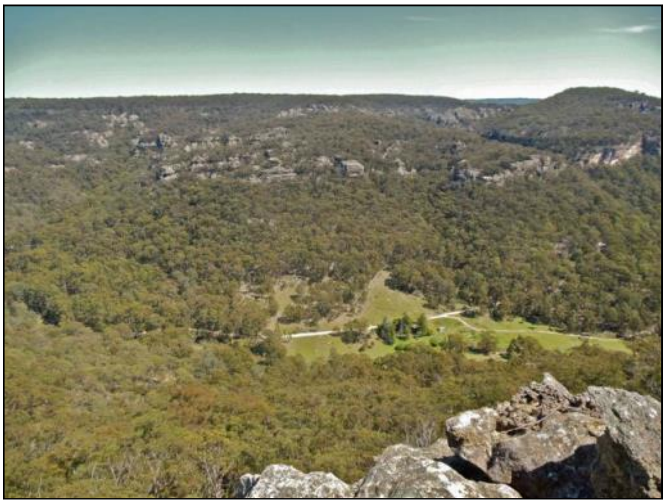
Immediately to the north of the flying fox some participants inspected an outcrop of the river gravels. These were cemented together and resembled a coarse conglomerate.

The group then saw the first hut built in 1962 complete with bunks, a fireplace and an old fridge. This is a good example of traditional Australian bush craft being constructed of rough tree branches/trunks tied together with fencing wire and lined with galvanized corrugated iron sheeting (except one wall was the back of an old bus). Near this hut are 2 "bush basher" cars and the site where another shed once covered concentrating equipment (*photo 11)*. This shed has been removed and only a concrete block remains.

Walking past the large dam that stored water for the concentrating equipment, the group saw the more luxurious Nissen army hut bought by Col's brother in about 1975. This gave participants an opportunity to use the toilet facilities - a typical outdoor bush dunny but with no redbacks evident. The scene in this area has changed greatly since 1981 *(photo 12)*.

We then walked a short distance to see some of the old concentrating equipment left by the Ribaux family including a home made puddling machine used to separate gold from clay *(photo 13)*. Some of this equipment may one day end up in a mining museum next to 19th century stamping batteries etc. We also saw an old Morris Commercial truck that once had a trommel used to screen out large gravels *(photo 14)*. The smaller heavy gravels were then concentrated to later recover diamonds and gold. The trommel had been removed from the truck but it still had its home made loading hopper (to feed the trommel) which consisted of the tray from a dump truck mounted above the bonnet and cabin.

There were 44-gallon drums of concentrated heavy gravels next to the Morris truck that had been



8. View to west (from open cut mine site) of Torbane Mountain (aka Mount Airly). Airly House is among the pine trees in the clearing below. Airly Gap is to the left.

9. December 1981. Open cut mine (view to east from near cliff edge). The deep lead gravels can be seen just above the water filled previous tunnel at lower left of photo (at the base of the basalt). Note the previous shaft on the right of photo (and man on top for scale).

10. Morning tea with a view at Café Airly (open cut mine site).

11. May 1981. Shed containing concentrating equipment (above the open cut mine). All that remains today is the brown concrete block behind the yellow garbage bin.

12. December 1981. Concentrating equipment near the Nissen hut (in background). Note trommel behind the shed and the long grey sluice box for collecting gold or diamonds next to the white pipe.

13. Sandy next to a home made puddling machine used to separate gold (and other heavy minerals) from clay.
Photo Ron Evans.

tipped onto the ground so that fossickers could look for small diamonds/sapphires/zircons etc. that had been missed by the original miners. Sandy was of the opinion that this concentrate had most probably been gone over by fossickers so often that the chances of finding something would be very small. However, after only a few minutes searching, Shayne found an Airly Mountain diamond! It was only 2 mm diameter, needing a hand lens to properly identify it, but it had good specimen/ memento value.

We then drove past the communication tower to near the southwest corner of Airly Mountain to see Hornes Adit. This is one of the earliest mines on the mountain and was re-opened by the Ribauxs. Although its entrance has now been closed, the contact between the most southern outcrop of basalt and the sandstone could be seen. From near this point we had a good view of Airly Turret with its many pagodas and a view towards Airly Gap, Capertee, Pearsons Lookout and Blackmans Crown. North/south trending open joint planes were seen to the north *(photos 15 and 16).*

After lunch *(photo 17)* we then drove to the north end of Airly Mountain passing its northern outcrop of Paleogene basalt. From near Point Hatteras we looked across the Genowlan Creek valley to the magnificent cliff faces of Genowlan Mountain *(photo 18).* This view is comparable to any seen around the tourist traps of Katoomba. Although not obvious from our viewpoint, the northern half of Genowlan Mountain is a narrow spur, the top being only about 600 m wide or less. This mountain also has an outcrop of basalt *(see Figure 1).* Col Ribaux had done some exploratory digs around here but no serious mining has been conducted.

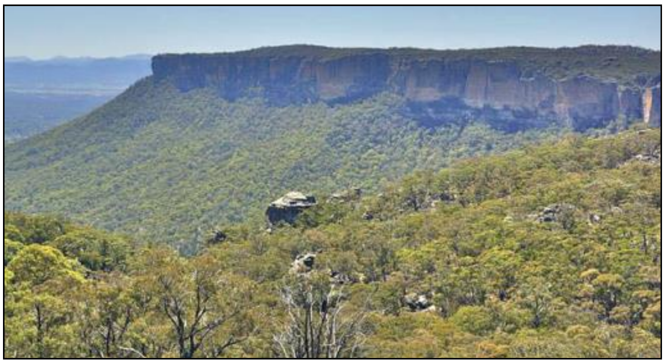
Heading back south we stopped at a saddle between the 2 outcrops of the Airly Mountain basalt. A short walk down to the east took us to a small sub-tropical rain forest glen with picturesque tree ferns, trees with vines and moss covered walls *(photo 19).* Garden gnomes had mysteriously taken up residence here. Some of the group climbed down a narrow chasm where steel ladders had been installed.

The convoy then drove back to the top of Pappy's Pass and took the fork towards the east side of Airly Mountain. Driving down the mountain we stopped at The Grotto and had to crawl along a rock ledge (assisted by some rickety railing installed by Col Ribaux) to enter the lower part of The Grotto. This is a deep narrow canyon eroded into the sandstone with many overhanging beds and caves above the curving stream floor *(photo 20).* Some members continued upstream to a gully with rainforest type vegetation (trees, tree ferns, ferns and moss) ending in a 6m high waterfall that separates the lower and upper parts of The Grotto *(photo 21).* There used to be a steel ladder here leading to the upper Grotto but the NPWS removed it. (We did not have time to drive then walk into the upper parts of The Grotto).

14. The Morris Commercial truck as it was in May 1981, complete with trommel (rotating drum with screens inside). Note further concentrating equipment in foreground.

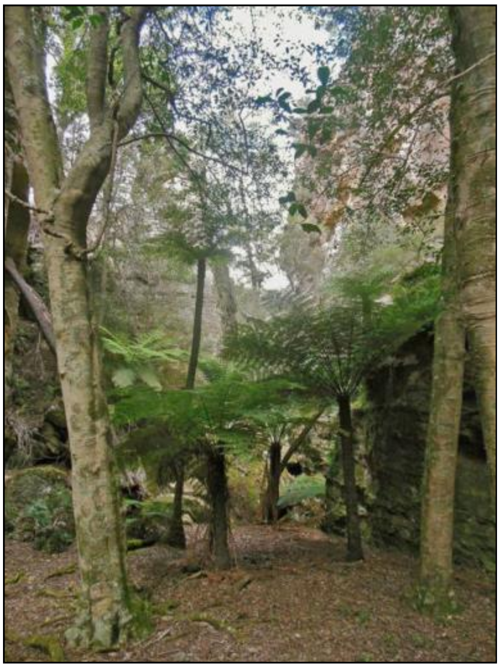
17. Lunch in a clearing above Hornes Adit.

15. Airly Turret (to left). View is towards the south. Glen Davis Road from Capertee is visible on the right. Photo taken October 2014.

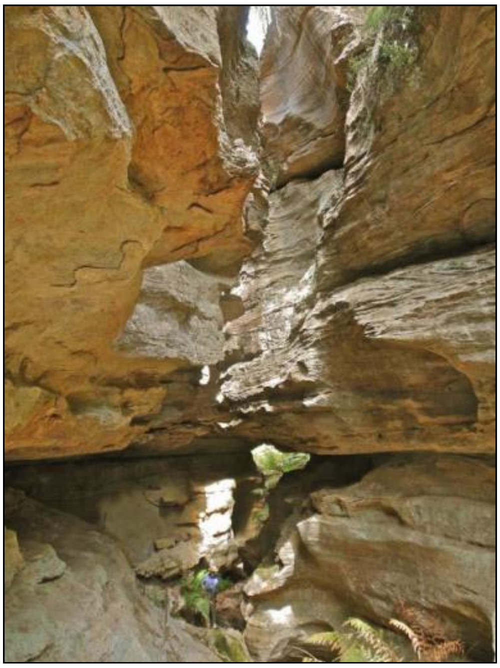


18. Genowlan Mountain from near Point Hatteras.

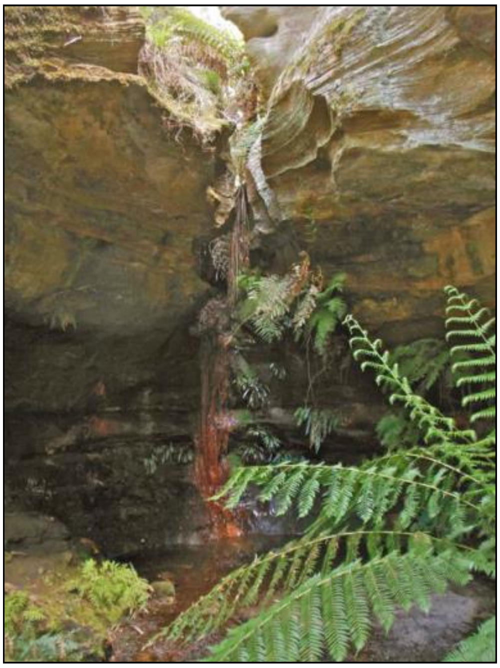
16. Quadcopter picture of Airly Mountain taken from above Airly Turret, looking north. Torbane Mountain on left, Genowlan Mountain cliffs on right. Red arrow is where people are sitting on the pagoda in photo 15. Hornes Adit is between red and blue arrows. Note N-S trending open joint planes. Photo by Peter Hilleard.



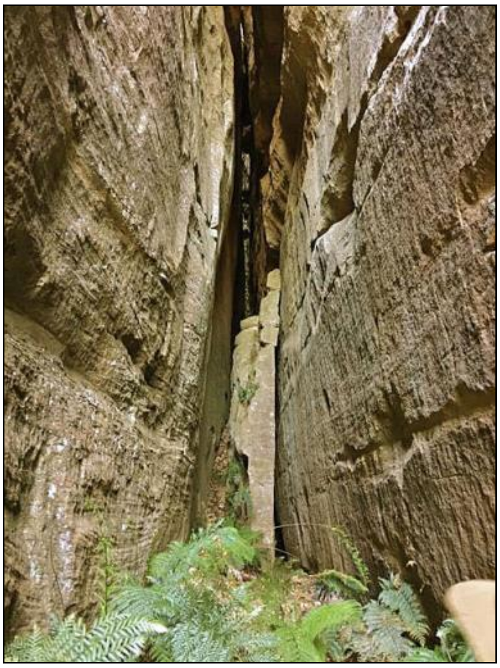
19. Ferny glen along the road from Point Hatteras.



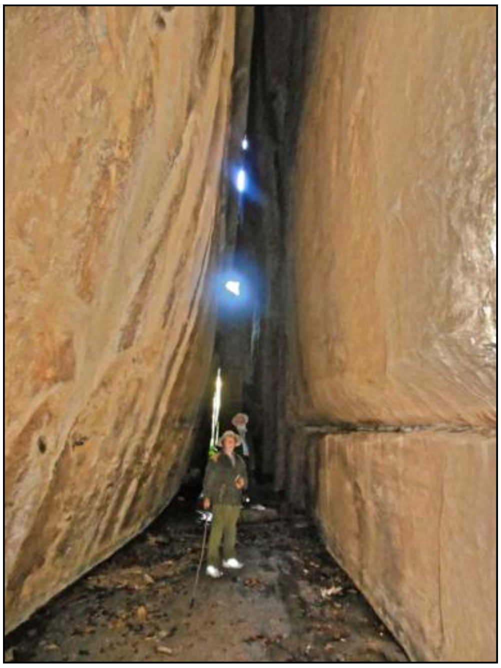
20. The Grotto (lower part).



21. Waterfall separating lower and upper parts of The Grotto.



22. The Ultimate Chasm looking south from near its entrance behind photographer. Note fallen slice of sandstone at base and fallen boulders jammed into the top of chasm.



23. The Ultimate Chasm (October 2016) looking north from near its termination. Note thin siltstone band on right (east) not present on left.

24. Fun and games at Airly Mountain. One of our vehicles bogged in the loose sand. Photo by Roz Kerr.

25. Fun and games at Airly Mountain. Bogged vehicle pulled up by Sandy's winch. Photo by Roz Kerr.

Leaving The Grotto we walked from where the cars were parked through the bush and along a stream bed to the Ultimate Chasm eroded into sandstone along N-S trending joint planes. It is very narrow (mostly about 2m or less) and at one point, where a large slice of sandstone had fallen into the chasm base, we had to squeeze sideways to get through *(photo 22)*. The chasm is at least 10 m high and fallen boulders jammed into its top, along with the narrowness, restrict sunlight from illuminating its base.

The Ultimate Chasm ends abruptly at its southern end in a solid narrow wall. Near here an interesting feature was noted in that a thin band of siltstone was present on the eastern side of the chasm but was not present on the western face *(photo 23)*. This could have been caused by: 1) faulting, or 2) the band just happening to lens out in the short space between the 2 faces. The latter seems more likely as the band lenses out to the north and south (thus not very persistent) and no signs of faulting could not be seen in the solid rock at the end of the chasm.

The time now being about 4.15 pm it was decided to head back up the mountain to Pappys Pass then to Lithgow. But the day had more fun in store. The track used to consist of some protruding boulders and rock shelves that Sandy had negotiated in previous years with a bit of 4WD driving skill. However the NPWS had recently "done up" the track that consisted of covering it with a thick layer of loose un-compacted silty clayey sand with some rock pieces. This caused Sandy's lead vehicle to become bogged near the top of a steep section and he only made it over the top after his third attempt, traveling at speed to avoid the wheels over-spinning. It was like trying to drive up a steep sand dune so Chris advised the following 5 vehicles to let some air out of their tyres to increase traction. Even so, two of the cars became bogged and had to be pulled over the top by the winch on Sandy's car *(photos 24 and 25)*.

We made it to Pappys Pass without further incident and stopped at Col Ribaux's house to re-inflate tyres and get a final opportunity to photograph the

26. Airly Mountain from Pearsons Lookout, facing north. Col Ribaux's house is at the lower left side of the distant large shaded patch. Airly Gap is to the left of the photo.

surrounding cliff faces in full sunlight. Just south of Capertee we stopped at Pearsons Lookout with a view of the distant Capertee Valley, Pantoneys Crown mesa and Airly Mountain *(photo 26)*.

We returned to the caravan park at about 6.30 pm. So ended a long but enjoyable day's activity. Given more time Sandy could have shown participants other features (such as Jurrasic Park, the upper part of The Grotto, more of Point Hatteras, other mines and more of Col Ribaux's gold recovery equipment) but we did see the best parts of Airly Mountain.

Newnes - Some Information.

History.

- **Late 1890's** - Deposits of oil shale discovered in Wolgan and Capertee Valleys. Several attempts made to work these deposits (until Commonwealth Oil Corporation took over) (Eardley et. al., 2015, p13). Some sources state that oil shale was known here as early as 1865 (Eardley p123) and mined in 1873 (Lishmund, 1971, p64).
- **1900** - George Anderson drove an adit into oil shale/torbanite at Newnes (Knapman, 2010, p16).
- **1905** - Commonwealth Oil Corporation begins operations at Newnes after completion of new site including installation of retorts (total cost of 1.8 million pounds). The site was initially only worked for a few months (Knapman, 1019, p16).
- **April 1906 to Nov 1907** - 50 km long standard railway constructed from Newnes Junction (west of Bell) to Newnes (Deane et. al., 1979, p21). At the Newnes refinery site the railway branched out into tracks at various levels up the hillside to service the different parts of the refinery on the south side of the Wolgan River. The railway also crossed the river to serve the oil shale mines and brick kilns on the north side of the river.
- **June 1911** - Retorting started at Newnes by COC. *(See figure 2)*. Technical problems brought operations to a temporary stop 4 months later (oil shale mined was too rich for retorts designed for poorer Scottish oil shales) (NSW National Parks and Wildlife Service, 1996, p14 & Knapman, 2010, p203). First refined oil dispatched August 1911 (Eardley et. al., 2015, p191).
- **By 1911** - Newnes mines producing up to 67,000 tons of shale per year (NSW National Parks and Wildlife Service 1996, p13).
- **1914** - Operations recommenced by John Fell with modified retorts to handle richer shale. Newnes again becomes an important industrial centre. Some production going until 1922 but only at 20,000 to 30,000 tons per year (NSW National Parks and Wildlife Service 1996, p14).
- **January 1923** - Closure of Newnes refining works due to cost of production and industrial disputes (NSW National Parks and Wildlife Service 1996, p14; Taylor undated, p6 & Knapman, 2010, p203).
- **1924** - Fell built a new refinery at Granville, presumably using Newnes oil shale or crude oil? (Taylor, undated, p6 & Lishmund, 1971, p 11).
- **1927** - Retort accident closed the Granville refinery and left Newnes to almost become a ghost town (it once had a township of about 2,000 people at its peak - NSW National Parks and Wildlife Service 1996, p9).
- **1923 to 1931** - the plant lies idle (NSW National Parks and Wildlife Service 1996, p15).
- **1931 to 1932** - A 9 month reactivation of activities to provide coal miners with work during the Depression (Eardley et. al., 2015); NSW National Parks and Wildlife Service 1996, p15). In November 1931 Newnes retorted 3,000 gallons of crude oil daily (Eardley et. al., 2015, p198). Works closed in 1932 due to lack of capital and government assistance (Taylor, undated, p6). Operations stopped in 1934 (NSW National Parks and Wildlife Service 1996, p15).
- **1939** - Retorts, refining equipment and (later) the electrical power plant at Newnes dismantled and sent to Glen Davis (Knapman, 2010, p36, p148 & p203 & NSW National Parks and Wildlife Service 1996, p13).

Miscellaneous.

- Initial mining at Newnes was on the north side of Wolgan River intending to join underground works at Glen Davis but these mines abandoned. Mining later moved to south side of river, east of the works, the centre of mining in later years (Eardley et. al., 2015, p13).
- c1911?? - COC decide to join Newnes and Glen Davis by tunnel but abandoned it after 1.5 miles (Knapman, 2010, p16).
- By 1913 - most of refining equipment at Torbane dismantled and re-erected at Newnes (Taylor, undated, p4).
- July 1913 (to 1918?) - New Hartley Mines oil shale railed to Newnes for retorting.
- c1939 - Electrical power house at Newnes overhauled to supply power to Glen Davis until powerhouse finished at Glen Davis in 1940's (Knapman, 2010, p38).
- 1941 - Oil pipeline (5cm diam.) installed from Glen Davis refinery to Newnes Junction (65km) via Pipeline Trail, Newnes & old railway line (Taylor, undated, 2010, p53- Knapman, 2010, p37).
- Lack of funding/investment, industrial disputes and competition from imported overseas oil were the main reasons for the on again/off again nature of the various activities at Newnes.
- The **Newnes Hotel** (built 1907) was dismantled and re-erected away from the river in 1987 to avoid

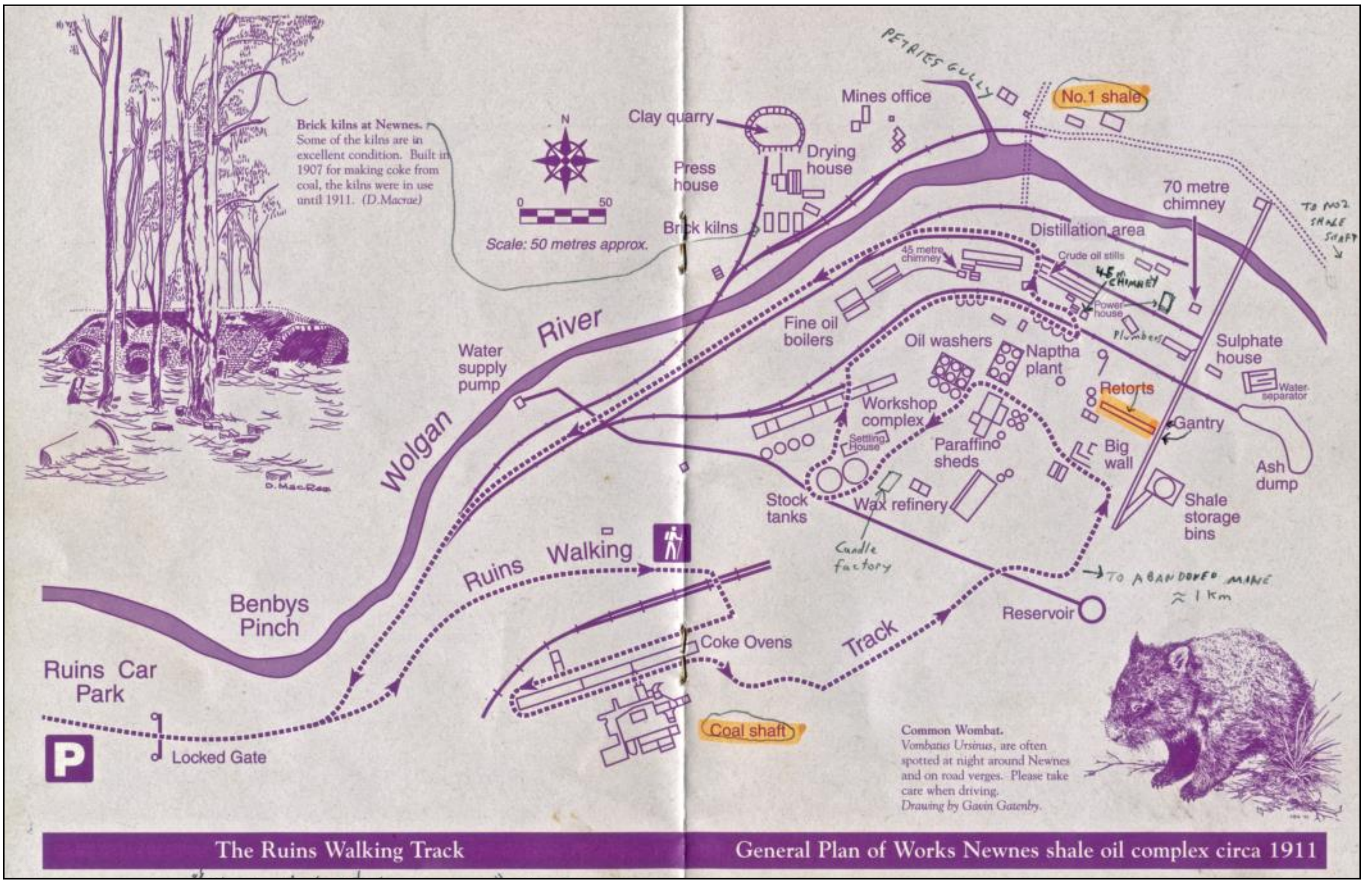


Figure 2. The oil shale refining works in 1911. Dotted line denotes the walking track. From: NSW National Parks and Wildlife Service. *Walking Track Guide, Newnes & the Glow Worm Tunnel* – 1996

flooding. It is the last surviving building of the mining era. It became un-licenced in 1988 (Eardley et.al., 2015, p205).

- Coal mined at Newnes was good coking coal. Coke made at Newnes was used to heat its retorts/boilers and also sold to ironworks/smelters in Lithgow and Cobar (Eardley et.al., 2015) "beehive" coke ovens were built in 2 rows of 60. Coke was initially the main product exported along the railway until the Cobar smelters at Cobar closed in about 1911 (Eardley et.al., 2015, p152 & 155). 90 beehive ovens remain, 13 of which are in good condition (NSW National Parks and Wildlife Service 1996 p6).
- Products of oil shale can include crude oil, kerosene, gas, naphtha, paraffin, wax (used in candles), various lubricants and petrol (Lishmund, 1971).

Geology.

- See Figure 3, p19.
- Read Brian England's "What is Oil Shale, that strange rock that burns?" (Geo-Log 2017, p22).
- Oil shale or "kerosene shale" usually has a low density, a greasy feel, silky sheen and a conchoidal fracture (like a broken piece of thick glass). Most oil shale burns easily when lit by a match, giving off a thick, black oily smoke (Lishmund, 1971, p6).
- Coal and oil shale mined belongs to the Permian aged Illawarra Coal Measures.
- At Newnes the oil shale seam is approximately 60m below the top of the coal measures. The seam is 45 to 63 cm thick, dipping to the northeast at about 55 m per 1.6 km (Lishmund, 1971, p63).
- The "Wolgan coal seam" mined at Glen Davis is 60 feet below the oil shale seam (Knapman, 2010, p245). This would be the same/similar situation at Newnes.

Wednesday 13th March. Newnes.

Members departed the Caravan Park at 9.00 am, in overcast weather that remained so for the rest of the day. We followed yesterday's route except at Lidsdale we turned right into Wolgan Road towards Newnes. Past Lidsdale we turned right into Blackfellows Hand Trail and stopped at Blackfellows Hand Cave car park. After a short walk up the hill we looked around the cave that was formed by an overhanging high cliff face containing many interesting Aboriginal rock paintings at the base of the rock wall *(photos 27 & 28)*.

Returning to Wolgan Road we headed east, driving down the precipitous Wolgan Gap and through the Wolgan Valley with its scenic sandstone cliffs either side of us. We passed Donkey Mountain, which forms an "island" in the middle of the valley. At the township of Newnes we had a brief comfort stop at the Newnes

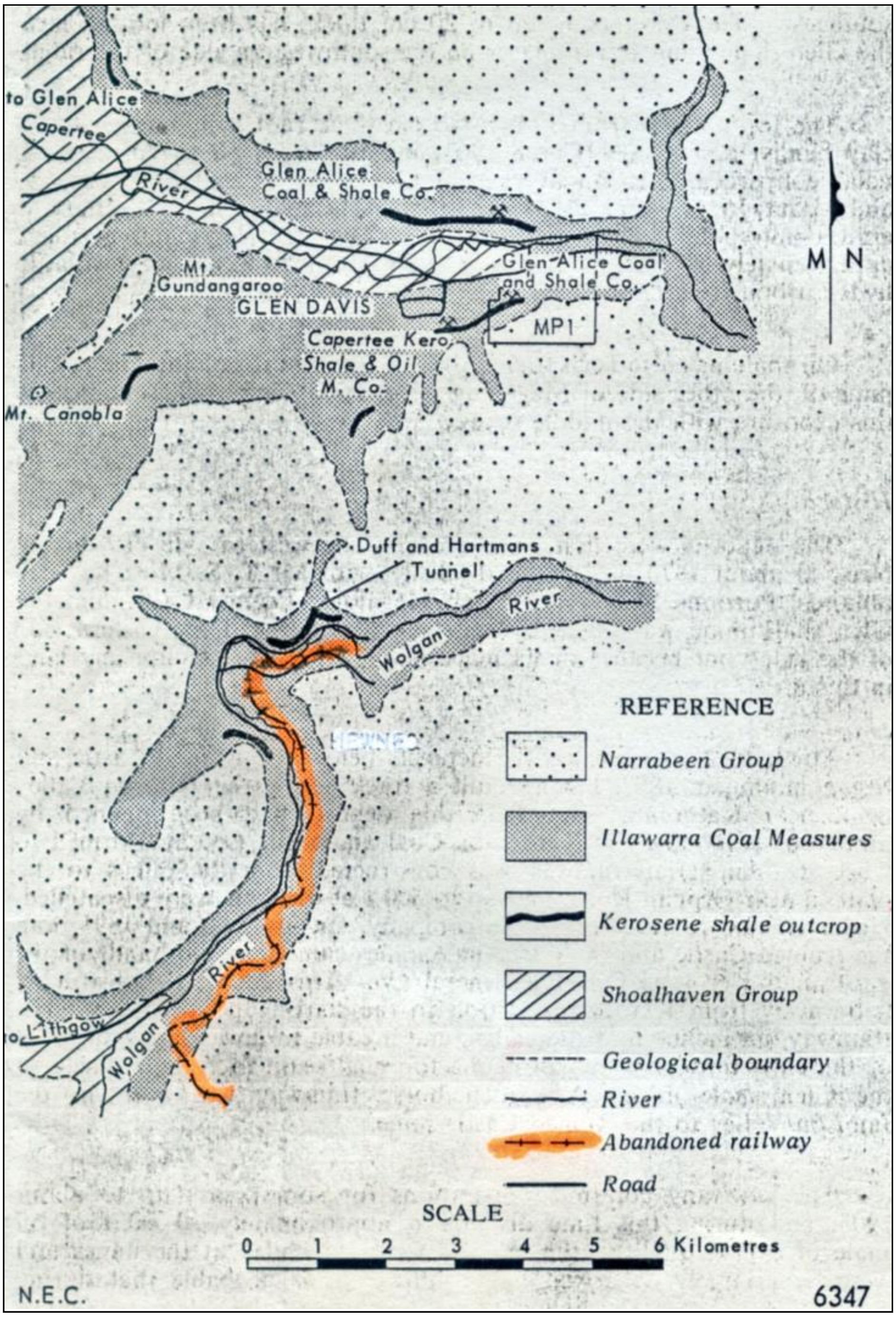
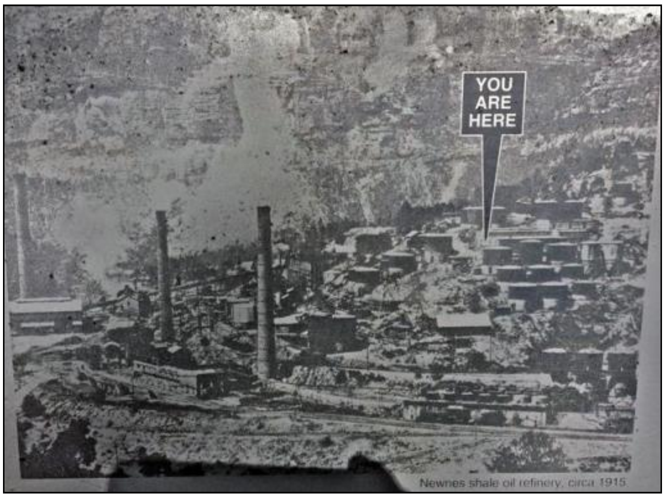


Figure 3. Geological map of Newnes and Glen Davis area. Modified from: Lishmund - The Mineral Industry of New south Wales, No. 30 - 19710. *Oil Shale.*

27. The group at Blackfellows Hand Cave.

28. Aboriginal paintings at Blackfellows Hand Cave.

29. Newnes railway station. Participants in foreground looking at one of Sandy's books with photos of the station as it was in about 1915.



30. Newnes oil shale refinery circa 1915. The arrow points to the paraffin sheds. Photo is of one of the NPWS information boards along the walk.

31. Some of the more intact beehive coke ovens.

32. One of the partly dismantled beehive coke ovens. The horizontal layers of bricks above formed the top of a rectangular brick structure that once entirely covered top and sides of the oven domes.

33. Diamond python at The Big Wall.

Hotel, the last surviving intact building of a township that once had a population of about 2,000 people. We then forded the Wolgan River and stopped at the old Newnes railway station for morning tea *(photo 29)*. All that remains is the sandstone walled platform and a steam train's water tank, where once stood the station building, goods shed, and the Newnes post office.

Driving along the route of the abandoned railway line we stopped at the Ruins Car Park and started up the Ruins Walking Track that passes through the vast complex of the old oil shale refinery *(figure 2 & photo 30)*.

The first stop along the walk was at the line of 90 remaining beehive coke ovens *(see Miscellaneous section above & photos 31 & 32)*.

Next to the coke ovens we saw the remains of the mine shaft buildings, the coal mined being used to feed the ovens. Continuing along the walking track we stopped at the top of the Big Wall, a 15 m high brick retaining wall. The refinery complex had been built on the side of a steep hill so this and other walls were needed to overcome initial slope stability problems.

34. Remains of the paraffin sheds.

35. Circular brick foundations for one of the many large steel storage tanks.

Next to the wall and just below us we saw a diamond python that had climbed a tree from the base of the wall *(photo 33)*.

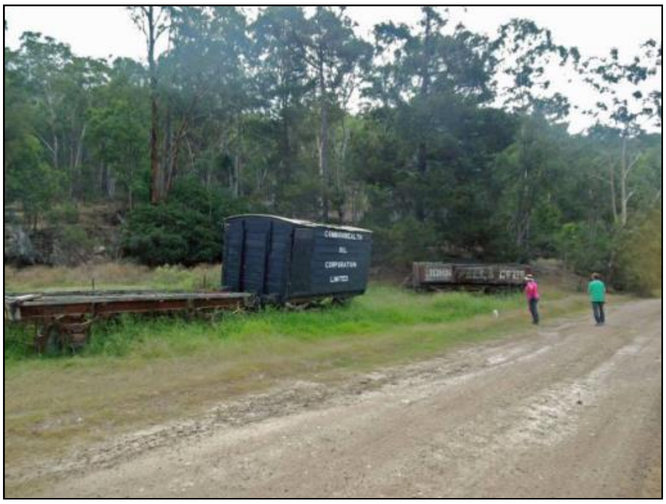
We then stopped the stately ruins of the paraffin sheds *(photos 30 and 34)*. This brick building is where heavy oil was converted into paraffin then into wax to make candles at the adjacent candle factory. Winding downhill we passed circular brick foundations that once supported the many steel storage tanks *(photo 35)*.

At the base of the hill some of us walked off the track to where the shale retorts were. Unlike Glen Davis nothing of the retorts is left as they were moved to Glen Davis in 1939. We then passed through the distillation area where there once were two 45 m high chimneys and one 70 m chimney *(photo 30)*. Still evident were brick lined flues that took gases from the distillation benches to the 45 m chimneys. We then followed the railway track back to the car park and drove to the station for lunch.

After lunch the 22 participants descended upon the Newnes Hotel and bought out its entire stock of ice creams and most of its cold soft drinks. As the hotel has

36. Relaxing on the verandah of the Newnes Hotel.

37. The bar of the Newnes Hotel.



38. Old railway carriages near the Newnes Hotel.

been un-licensed since 1988 no alcoholic beverages could be consumed but it was pleasant sitting on the verandah looking the view of the river and cliffs *(photo 36)*. Bibliophiles Brian and Sandy bought the hotel's last

2 remaining copies of the book *Shale and Shays*. The hotel contains an informative museum with many artifacts, old photos and maps. It was originally sited next to the river near the ford but was moved to its present position after being undermined and nearly washed away by floods in 1986. It has been faithfully restored including the bar that now serves as a shop counter *(photo 37)*. Outside the hotel and along the street are other artifacts including some old railway carriages, a reflection of the years when the Commonwealth Oil Corporation and John Fell & Co operated the refinery *(photo 38)*.

After a brief stop at the Wolgan Valley Lookout (at the top of Wolgan Gap) we returned to the caravan park by 4.20 pm. That evening we had our group dinner at the Lithgow Worker's Club. The caravan park's office manager, Daniel (a friendly, polite, and helpful red headed youth) offered to drive us to the club in a minibus and picked us up after dinner to return us to the caravan park. Thus ended the second day's activities.

Wolgan Valley Railway - Some Information.

- The single-track standard gauge railway was constructed to service the oil shale mines and refinery at Newnes. The line was used to transport refinery products and coke to Sydney and elsewhere. It was a privately constructed, owned and operated railway.
- Henry Deane (1847 - 1924) supervised survey of the line and was the Chief Engineer for its construction.
- Length of the line is 51.7 km from Newnes Junction to the start of the works at Newnes (Deane, 1979, p13). The total length of track would be longer than this, considering sidings (crossing loops) and triangles along the line and the maze of tracks at the refinery works.
- The line joined the Main Western Line at Newnes Junction, west of Bell.
- The line rises 106.4 m from Newnes Junction to the Summit then falls 684 m to the works at Newnes in the Wolgan River Valley.
- The steepest grade is 1 vertical in 25 horizontal (much steeper than most modern tracks are allowed).
- The railway includes two unlined tunnels through sandstone. Tunnel 1 is 110.6 m long and Tunnel 2 (with the glow worms) is 402 m long.
- Having to negotiate the mountainous topography required very tight curves, some involving S-bends past Tunnel 1 *(figure 4)*. The design and construction could be considered to be a great engineering feat.
- Past Tunnel 2 the line enters the Wolgan River Valley running precariously along the top of the talus slope with the near vertical cliffs towering immediately above the track.
- The first regular passenger service on 4 February 1910 took 3 hours to travel the 49.7 km from Newnes Station to Newnes Junction (Eardley et.al., 2016, p186).
- A total of 4 "Shay" locomotives were imported from the USA to work on the line (Eardley et.al., 2015, p161 to 164). These were chosen as the most suitable to handle the tight curves and steep grades on the line (Deane, 1979, p21 to 25) . Unlike most locomotives, they each had 3 vertical (not horizontal) cylinders that were unusually connected to horizontal drive shafts (Deane, 1979, p21).

Wolgan Valley Railway - History.

- 1906 April - Construction starts (Deane, 1979, p21) commissioned by the Commonwealth Oil Corporation.
- 1907 November - Construction all but completed (Deane, 1979, p21).
- 1934 - Operations at Newnes oil shale mine cease (NSW National Parks and Wildlife Service 1996 p15).
- late 1930's - Rails still laid but had not been used for some years (Eardley et.al., 2015, p203).
- World War II - Rails cut up and used for beach defenses in Europe (NSW National Parks and Wildlife Service, 1996, p15).

Glow Worms - Some Facts.
(NSW National Parks and Wildlife Service 1996 p15)

- Glow "worms" are larvae stage of adult flies called fungus gnats.
- The worms reach a length of about 30 mm and grow over a period of months.
- They naturally live in caves or any dark damp place, so a pitch-black, wet, abandoned railway tunnel has made an ideal habitat for them.
- The worms spin hanging threads of silk with sticky droplets to trap insects such as mosquitoes which are attracted by the light produced by the worms.
- The amount of the blue bioluminescence produced by the worms is controlled by the amount oxygen they supply to the enlarged tips of their 4 excretory tubes.
- They are disturbed by noise and light and may stop glowing. If this occurs turn off your lights, keep quiet, wait a minute and they will resume glowing.
- The adult flies also glow, are about 8 mm long and live for up to 4 days.
- Touching the glow worms will kill them. You can look at them close up with your light but do not touch.

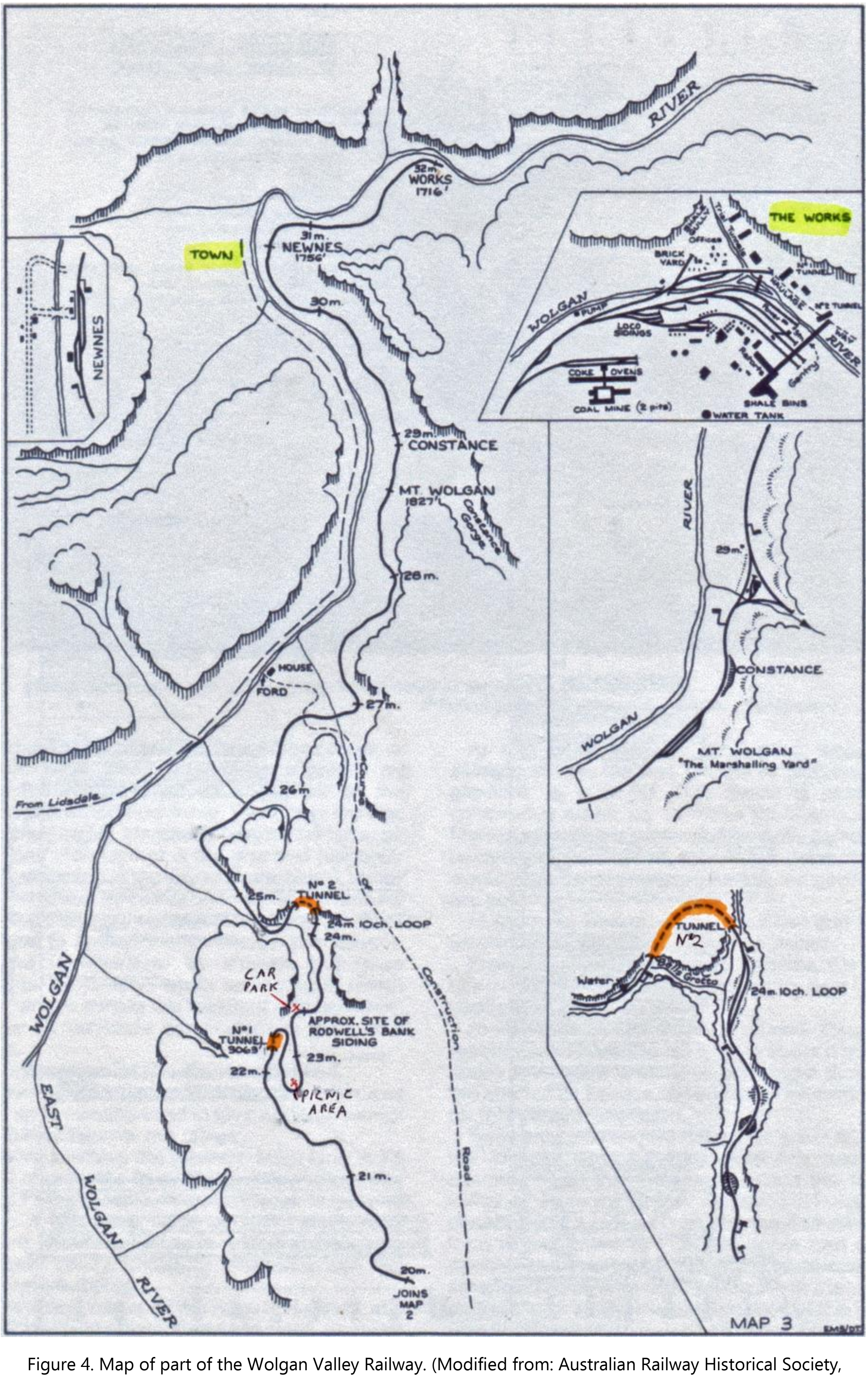
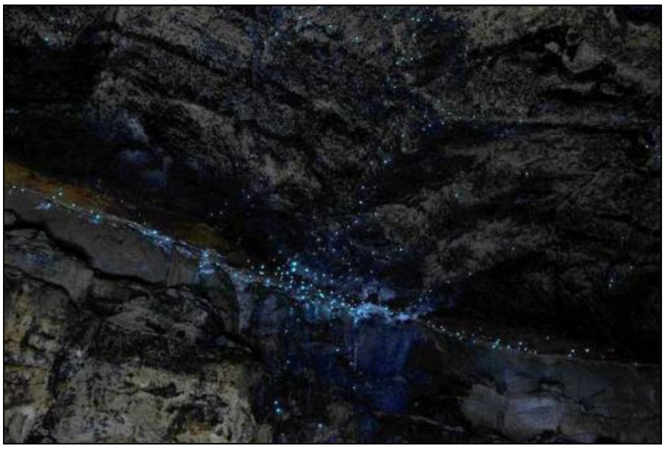


Figure 4. Map of part of the Wolgan Valley Railway. (Modified from: Australian Railway Historical Society, New South Wales Division, *The Wolgan Valley Railway – Its Construction*, 1979.) No 2 Tunnel (with the glow worms) is also shown in lower right inset. Mileages (e.g. "21 m") are distances in miles along the track from Newnes Junction.

39. Northern portal of No. 1 Tunnel (January 2009 photo).

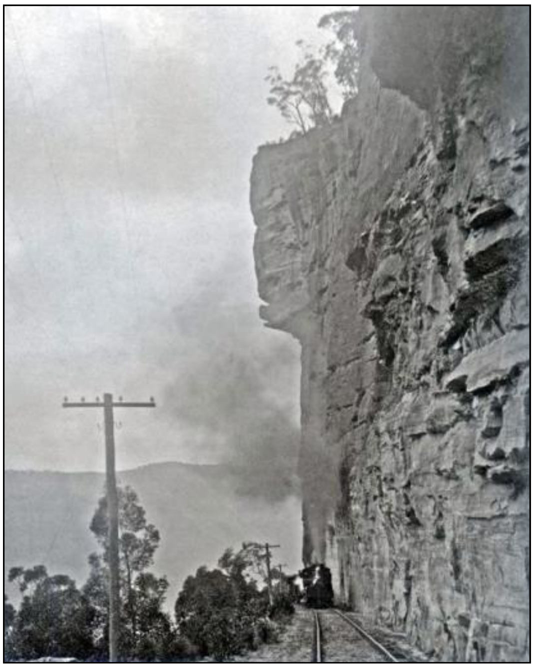
40. From inside No. 1 Tunnel, southern end.

41. Glow worms inside No. 2 Tunnel (from Lithgow Tourist Information).



42. Glow worms inside No. 2 Tunnel (from Lithgow Tourist Information).

43. Tree fern forest from Newnes end of No. 2 (Glowworm) Tunnel.



44. Circa 1912 photo of the track running along the top of the talus slope with the Wolgan Valley cliffs above. From *The Wolgan Valley Railway – Its Construction*, 1979, Australian Railway Historical Society NSW Division. (Photographer unknown; D. O'Brien collection.)

45. View of Wolgan Valley and Donkey Mountain from the railway line at the top of the valley's talus slope. The Lidsdale - Newnes Road is on the other side of Donkey Mountain.

46. Bells Grotto adjacent to No. 2 Tunnel.

47. "The Lost Suburb". Photo by Barry Collier.

Thursday 14th March - Glow Worm Tunnel.

Members departed the Caravan Park at 9.00 am in drizzling rain which later cleared to a mostly sunny day. Instead of driving through the central part of Lithgow we took a circuitous route through the back streets after Google Maps sent us up the wrong street. Quickly recovering from this we made it to the north east corner of Lithgow, past the State (coal) Mine Heritage Park and north along Glow Worm Tunnel Road.

After about 1.5 hour's travel we arrived at the southern portal of No. 1 Tunnel, mostly driving along a pot-holed gravel road. Just before this tunnel it became obvious we were now following the Wolgan Valley Railway's alignment as we passed through its cuttings and over its embankments. No. 1 Tunnel is 110 m long, unlined and on a tight curve *(photos 39 & 40)*. Walking through the tunnel gave the group a chance to see almost un-weathered Narrabeen sandstone with its many planar and curvilinear ironstone bands. Regular indentations in the floor showed where the railway sleepers had been before they were removed.

Just past the northern portal of No. 1 Tunnel we stopped at a lookout over the Tunnel Creek valley with its many Narrabeen sandstone pagodas and cliffs. The lookout is on the top of a cliff from which could be seen the road/railway track some 50 m immediately below. To accommodate the railway's need to make a steep descent in the confined space of the valley, the track forms an "S" bend here, almost like a zigzag. At No. 1 Tunnel the track makes a 180° turn, heading from north to south. Then at the picnic area it makes another 180° turn, heading back towards the north, shortly passing No. 1 Tunnel 50 m above *(see Figure 4)*.

At the picnic area we stopped for morning tea amongst the pagodas, one of which had been cut in half for the railway's construction. Driving the short distance to the Glow Worm Tunnel Car Park we started the pleasant 1 km walk to No. 2 Tunnel, continuing along the railway alignment. Tunnel No. 2 is 402 m long and on a curve, thus being in complete darkness for most of its length. It has water flowing through it that had eroded into the original track formation floor of dirt and rubble, so walking through the tunnel by torchlight we had to be careful not to stumble on the eroded irregularities on the floor or to walk into a pool of water. This effort was well worth it as we were rewarded with the fascinating sight of hundreds of glow worms shining like stars in the sky *(photos 41 & 42)*.

Exiting the tunnel we entered a beautiful forest of tree ferns *(photo 43)*. Past the tunnel the railway alignment/walking track enters a steep sided very narrow gully that eventually broke out into the Wolgan Valley. Here the abandoned railway runs precariously along the top of a talus slope at the base of high vertical cliff faces *(photo 44)* where we had a panoramic view of the Wolgan Valley that we had driven along the day before *(photo 45)*.

Returning to the No. 2 Tunnel, some participants preferred to go back to the car park via the tunnel and see the glowworms again. Others preferred to walk through Bells Grotto (adjacent to the tunnel) and rejoin the track on the car park side of the tunnel *(figure 4 and photo 46)*.

After lunch at the picnic area the group headed back towards Lithgow. At Barry's suggestion, on the way back, a stop was made at "The Lost Suburb" as Barry called it *(photo 47)* reached by turning right at the top of the hill just before going down into Lithgow. This consists of many Narrabeen sandstone pagodas and cliffs and is a smaller version of the Lost City further to the north.

The remaining participants (some had left for home early in the day or after seeing the glow worm tunnel) stayed Thursday night at the Lithgow Caravan Park and left Friday morning to either go home or to continue onto the Society's Molong Caves and Gulgong trips.

Report by Sandy Pfeiffer.
Photographs by Sandy Pfeiffer (or his family) unless noted otherwise.

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Mt. Canobolas, Borenore and Wellington Caves Trip

Leaders: Janece McDonald & Lawrie Henderson.
Date: Thursday 15th - 17th March, 2019.
Attendance: 14 members.

Fourteen AGSHV members arrived at Molong Caravan Park on Friday 15th March, 2019. Molong was established in 1822 and was originally a police and military outpost. Copper Hill located north of Molong was the first copper mine in Australia. The Packham Pear was cultivated here by Charles Packham in 1896. Molong is rich in history with a National Trust listed broad main street. Many of the heritage buildings underwent restorations during the 1988 Bicentenary (many built from local stone). The Railway Station was completed in 1886 and became the terminus of the main western line from Sydney from 1886-1893.

The group met at the camp kitchen for a BBQ and a trip overview by leaders Janece McDonald and Lawrie Henderson *(photo 1).*

Day 1: 16th March, 2019.

After breakfast, the group headed towards Mt Canobolas along the Mitchell Highway, noting outcrops of karst upon exiting Molong along the railway cutting. First stop was at Yuranigh's Grave, approximately 3 km from Molong. The gravesite of Yuranigh, Sir Thomas Mitchell's Aboriginal assistant, is the only known site in Australia where Aboriginal and European burial practices coexist. Yuranigh accompanied Sir Thomas Mitchell on his 1845 expedition to Queensland and was held in high regard by Mitchell. He was killed on the southern outskirts of Molong in 1850 and interred under local traditional custom. The carved trees at the corners of his grave to denote that he was a man of distinction. Mitchell paid for Yuranigh's (European) headstone and the railing *(photo 2).*

The group proceeded along the Mitchell Highway, stopping at Fairbridge Memorial Park which houses a memorial to Kingsley Fairbridge. Kingsley Fairbridge, a South African and a Rhodes Scholar established the Fairbridge Farm complex, opposite the park in 1938. He brought children from the slums of London and later Australia, to farm schools in Australia and Canada. He believed that the children could have a fresh start and learn farming skills to assist in the development of new countries. The scheme operated until 1973 at Molong and for a little longer in Pinjarra in Western Australia. It is now known that many of these children were abused. Former ABC Managing Director, David Hill told of sexual abuse at the Royal Commission into Child abuse. Mr Hill was one of about 7,000 poor and orphaned children sent to Australia between 1913 and the mid-1970s. About half of them were sent to farms run by the Fairbridge Society. Interestingly, AGSHV member, Ian Rogers who grew up at Orange and attended Orange High School, went to school with several of the boys from Fairbridge and recalls staying at one of the Fairbridge "hostel" houses on a weekend visit. Each house had a house mother and/or house father responsible for twelve children.

The next stop was at Borenore, a small village just off the Escort Way. This stop was a park adjacent to the Borenore railway station *(photo 3).* Here the group inspected large Borenore marble blocks, observing the numerous crinoid and coral fossils, typical of a Devonian reef *(photo 4).* An interpretative sign told of marble quarrying by Frank Rusconni at Borenore where he established his renowned quarry. Frank was born in Araluen (near Braidwood), NSW in 1874 and trained and worked in Europe. The distinctive Borenore marble can be found in many important buildings such as the Sydney Central Railway station.

The group travelled to the summit of Mt Canobolas and enjoyed a much-deserved morning tea. Lawrie gave a talk about the geology of the region *(photo 5).*

Gondwana was a supercontinent that existed

1. Group enjoying BBQ tea at the Molong caravan Park camp kitchen.

2. Yuranigh's grave showing the carved tree in his honour.

3. Borenore Railway station on the Broken Hill line, built in 1885, now unused but still intact.

from the Neoproterozoic (about 550 million years ago) until the Jurassic (about 180 million years ago). It was a remnant of an even larger continent called Rodinia. During the Carboniferous (about 350 million years ago), it merged with Laurasia to form a larger supercontinent called Pangaea. Gondwana (and Pangaea) gradually broke up during the Mesozoic Era, about 180 million years ago. The remnants of Gondwana make up about two thirds of today's continental area, including South America, Africa, Antarctica, Australia, and the Indian Subcontinent.

The Tasman Line (to the west of Broken Hill) defines the eastern margin of Australia at that time and the Ross Delamerian Belt (Delamerian Orogen) follows this line and continues along the coast of Antarctica *(figure 1)*. Eastern Australia, as we know it, was in deep ocean at the time. Weathering and erosion of the highlands of the Delamerian Orogen deposited sedimentary fans in what is now the Tasman Sea. A modern analogy would be the Ganges and Brahmaputra Rivers depositing sediments from the eroding Himalayas in alluvial fans in the Bay of Bengal. Another is the northward moving sand of Australia's east coast reaching the north east "bend" in the coastline at Sandy Cape on Frazer Island and falling into the abyss, forming an alluvial fan and contributing to the sediments of the Lord Howe Rise.

4. Devonian reef fossils in the Borenore marble at Borenore village.

5. Morning tea atop Mt Canobolas.

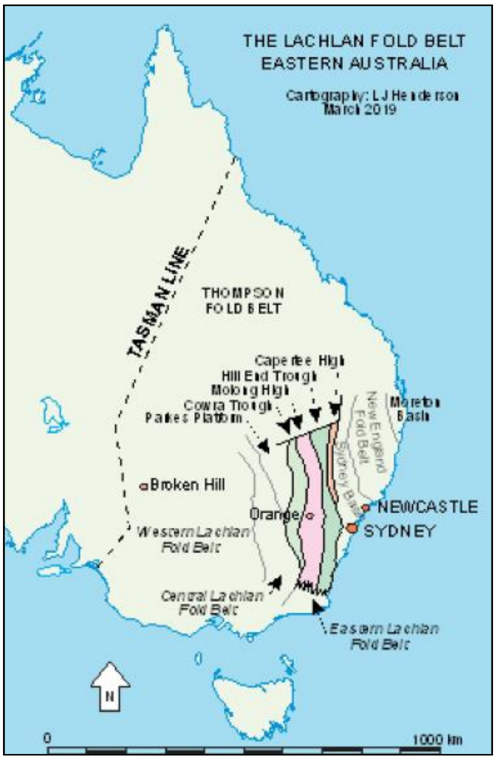


Figure 1. Lachlan fold belt Eastern Australia.

The subduction rate of the Proto Pacific Plate, plunging under the continental plate, was greater than the convergence of the plates. Therefore the hinge of the subducting plate moved seawards over time. This rollback resulted in a back arc basin accumulating sediments from the eroding Delamerian Orogen. The sea became shallower and between 450 and 420 million years ago the back arc basin began to close. Folding and faulting occurred in the sediments and in places supported fringing coral reefs. The folding resulted in the north-south trending highs and troughs we see today. From the original 2000 to 3000 kilometres of deposition of the Lachlan Fold Belt, it has been compressed to about 1000 kilometres wide today and up to 40 kilometres thick. By about 385 million years, dry land had begun to appear as the Lachlan Orogen began to form and was eroding by 380 million years. The hinge of the subducting Pacific Plate today forms the eastern `side of the Kermadec Trench. The subducting plate is responsible for the volcanic islands of Fiji, Kermadec Islands, New Zealand, etc.

During the Paleogene period in eastern Australia, widespread volcanic activity occurred, leading to the formation of chains of volcanoes and extrusive as well as intrusive volcanic material. These are linked to a long lasting mantle plume that intruded the base of the Australian Plate as it moved northward under the influence of plate tectonics. The oldest of these volcanics, at about 23 million years old is at Main Range in Queensland, decreasing in age to about 11 million years at Mount Canobolas. As Australia has moved north, plume activity has continued, resulting in younger volcanoes further south. Bass Strait/north west Tasmania is considered to be the next point of plume activity. The map below shows another hot spot activity north west and east of the Mt Canobolas hot spot as well. A modern analogy is the Hawaiian Island chain with current active volcanic activity and a new volcano forming under the sea as the oceanic plate passes over the hot spot *(figure 2)*. The Mount Canobolas volcano was a shield volcano and would have looked like Mauna Loa in Hawaii today. This volcano has a radius of 60 kilometres and a maximum slope of 12 degrees. It is 4169 metres above sea level and is 9170 metres above the ocean floor.

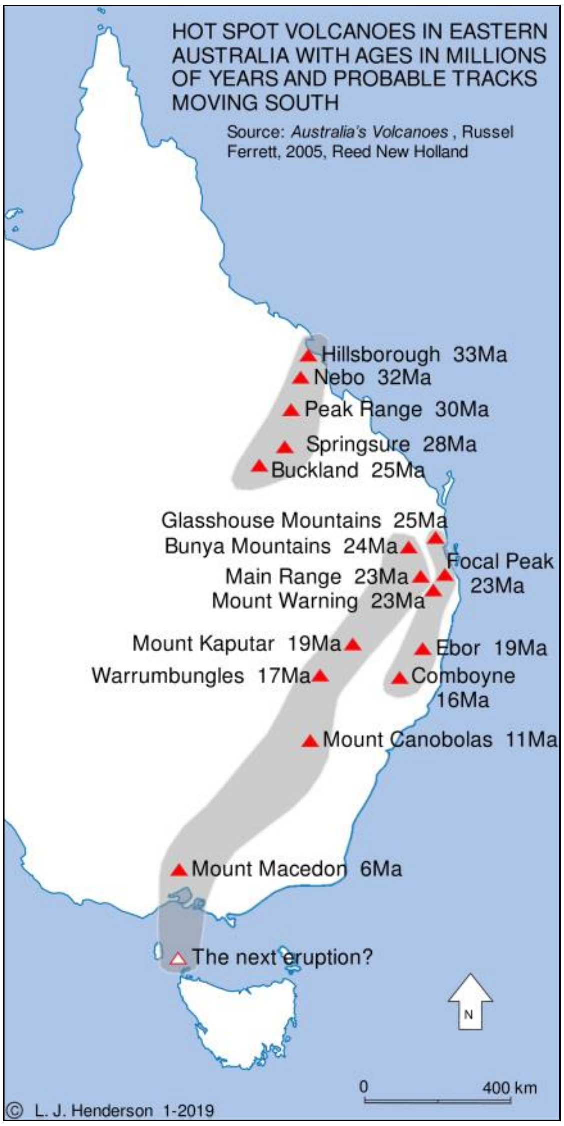


Figure 2. Hot Spot Volcanoes in Eastern Australia.

Prior to the formation of the Mount Canobolas volcano, the Lachlan Fold Belt was a level plain, eroded from the folded Ordovician basement rocks. Tectonic events from the Silurian to the early Carboniferous produced the north-south folding seen in the rocks today. The Fold Belt had been penetrated by granitoid intrusions during the Carboniferous Period (eg. Bathurst batholith), and about 13 million years ago, during the late Paleogene (Miocene epoch), the first volcanic activity began and continued virtually uninterrupted for the next 2 million years.

Looking at time scales, if we condense the 500 million years of Lachlan Fold Belt evolution into one year, then Mt Canobolas erupted only a week ago.

The volcanic rocks of the Canobolas Complex range from moderately rich in silica (early eruptions) to very poor (later eruptions). The feldspars contain sodium and potassium rather than calcium. The lavas vary from several types of trachyte to andesitic basalts and basalts. Large quantities of agglomerate and tuff formed during explosive eruptions and the last (non-explosive) eruptions were basalt. This highly fluid lava travelled up to about 50 kilometres in all directions and gradually built up the shield volcano (see volcanic distribution map below). The Mount Canobolas vent was the last to erupt and as the main volcanic vents erupted at different times, evolution of the magma chamber between events changed the chemistry of the lava. Consequently, seven main types of lava are recognised in the Mount Canobolas complex.

Originally, the volcano would have been much higher, but as it became extinct and cooled, subsidence has caused the mountain to contract. The summit is now 1397 metres above sea level and about 500 metres above the surrounding plain (see image 9). Over fifty volcanic cones, vents, dykes, domes and plugs have been recognised in a 30 kilometre radius. Currently, the Mount Canobolas volcanic province covers about 825 square kilometres. The north west trending Canobolas Divide separates the northern flowing streams from the south flowing streams. The streams flowing north are part of the Macquarie River catchment and flow to the Darling River, while the south flowing streams are part of the Lachlan River catchment and ultimately flow to the Murray River *(figures 3 & 4)*.

Climate at the summit is temperate with warm to hot summers and cool to cold winters. Minimum and maximum temperatures in January range from 3°C to 37°C and in July, -7°C to 18°C. The mean annual rainfall of 920 mm falls mainly in winter with contributions from occasional thunderstorms during summer. Snow falls are often seen in winter.

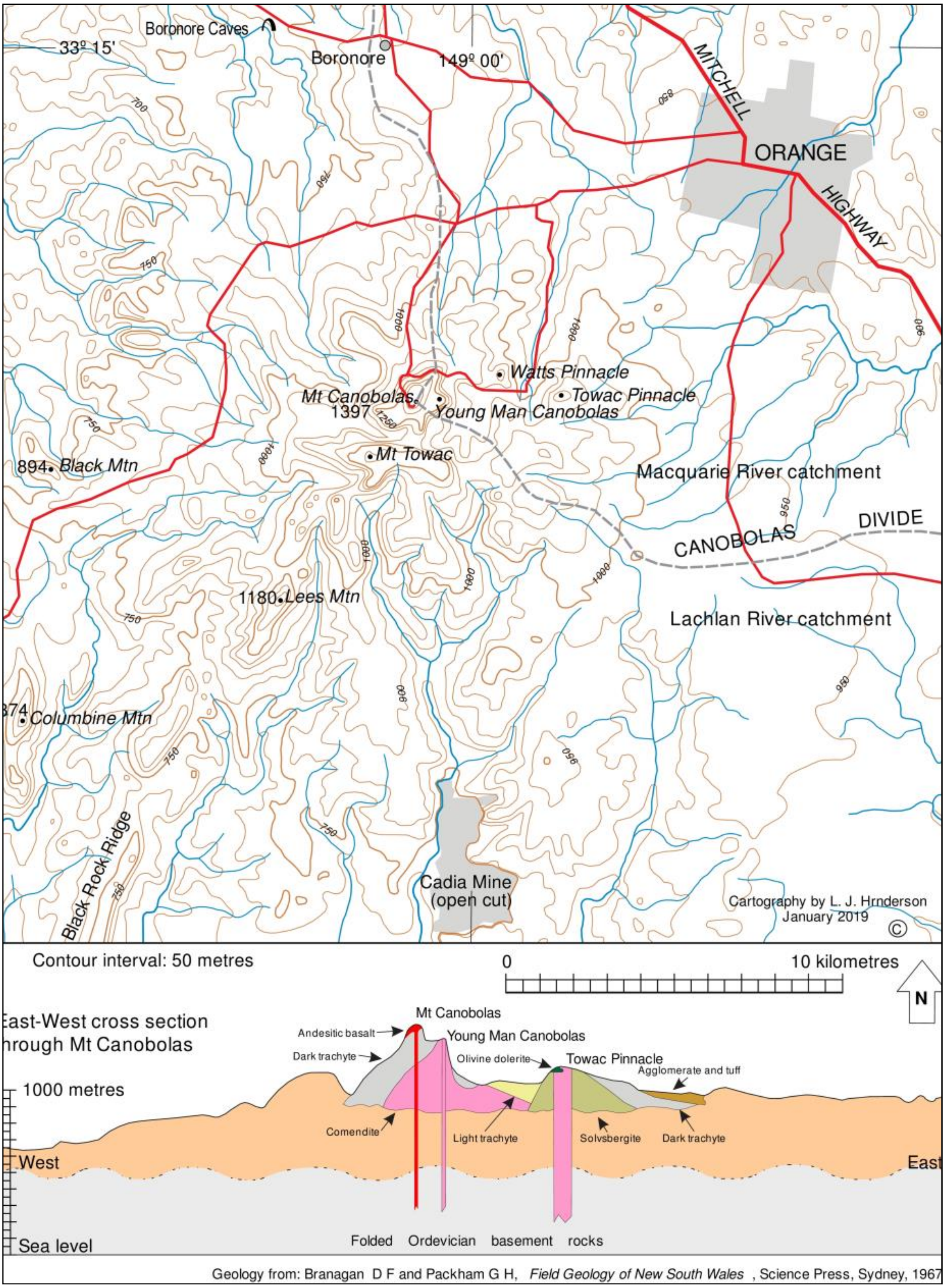


Figure 3. Mount Canobolas and cross-section showing geology.

Erosion of the rocks since the extinction of the volcano has produced a variety of soil types. Soils on the higher slopes are thin and skeletal, mainly derived from trachyte, while those on the lower slopes and gullies are deeper and richer, consisting of red earths and krasnozems. Vineyards and orchards dominate the lower slopes and pine plantations occupy the more elevated areas. Native plants occupy the non-agricultural and forestry land.

Red earths are associated with old land surfaces and are of low inherent fertility, markedly deficient in phosphorus, nitrogen and trace elements, but responding well to good management. Krasnozems are deep friable red clay soils, often strongly acid and are found mainly on the volcanic rocks.

Rock Types found at Mt. Canobolas Volcanic Complex (Source: Orange Regional Museum) Additions in blue.

Rhyolite	This is a fine grained igneous (volcanic) rock. It is usually pink or grey in colour and contains crystals, usually (sometimes) too small to see with the naked eye. It is formed from (lava cooling on the surface or sometimes) magma that has slightly cooled before reaching the surface.
Trachyte	A fine grained igneous (volcanic) rock. It is often light coloured and (may) contain distinct crystals that give the rock a coarse feel.
Obsidian	An igneous (volcanic) rock showing no crystalline form due to rapid cooling. This results in a volcanic glass with a smooth surface. The rock is usually black, but brown, tan or green forms can occasionally be found.
Basalt	This is a ~~non~~ crystalline smooth, ~~brown~~ (black)-coloured igneous (volcanic) rock. It forms from extrusive lavas and covers more of the Earth's surface than any other rock.
Tuff	An igneous (volcanic) rock derived from volcanic ash. As the ash settles after an eruption it is compacted to form a solid rock. It is usually soft, with crystals and can show a variety of colours.
Andesite	An igneous (volcanic) rock, usually light to dark grey in colour. ~~The rock usually does not contain crystals.~~

In 1827, Major Thomas Mitchell arrived in Sydney to become the Surveyor-General of the colony of New South Wales. He was born Thomas Livingstone Mitchell in Grangemouth, Stirlingshire in Scotland in 1792 and after serving as a surveyor in the army, came to New South Wales to become Surveyor-General, a position he held for 27 years. He was responsible for the placement of roads, bridges and towns throughout the colony and led four expeditions of exploration. He carried out most of the surveys of Eastern Australia, one of which led to the opening of new grazing lands in southern Victoria. He explored northern and western New South Wales in 1831 and 1835 and in that year, he climbed Mount Canobolas, where he produced a rough geological map of the area. He was later promoted to Lieutenant Colonel and died in Sydney on the 5 October, 1855, aged 63 years. He is buried at Camperdown Cemetery, Newtown in Sydney. Mitchell was the first European to ascend Mount Canobolas and there is a plaque at the summit commemorating the event. The name Canobolas comes from two Aboriginal words, gaahna bula. This means "two shoulders" which refers to the summits of Mount Canobolas and Young Man Canobolas.

After morning tea, the group (most) walked from the summit of Old Man Canobolas to the summit of Young Man Canobolas, a 2 km return trip. The landscape had been burnt by a severe bushfire almost two years ago and was showing signs of regeneration, although the understorey was badly infested by weeds. A dyke was evident approximately 500 m along the walk.

The group travelled down the mountain, noting outcrops of trachyte and views of both Old Man and Young Man Canobolas, before going along the Escort Way to Borenore Karst Conservation Reserve. Borenore Karst Conservation Reserve lies within the Borenore Limestone belt, which runs for 6 km along Boree Creek.

During the Ordovician, Silurian, and Devonian carbonate deposition took place in the Lachlan Fold Belt and the western portion (Tamworth Trough) of the New England Fold Belt. The limestone went through a period of exposure and erosion to about 12 million years ago (Tertiary) when it was covered by basalt lava flows from the nearby extinct volcano complex. This caused the limestone to be metamorphosed to produce high quality marble. Boree Creek has incised its way through the basalt to its present level exposing some of the old land forms, modifying others and creating new ones. Geology observed today includes folded and faulted sandstone, shales, limestone and volcanic outcrops. Typical karst surface features such as grikes, small dolines, rillenkaren and sinking streams are evident

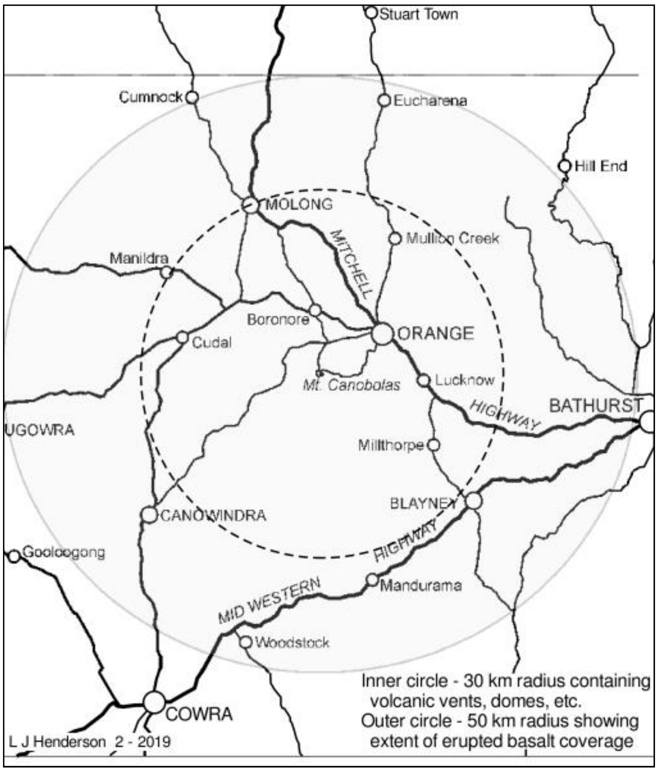


Figure 4. The extent of lava distribution at Mt Canobolas.

6. Lunch at Borenore Karst Conservation Reserve-keeping an eye out for the hungry kookaburra.

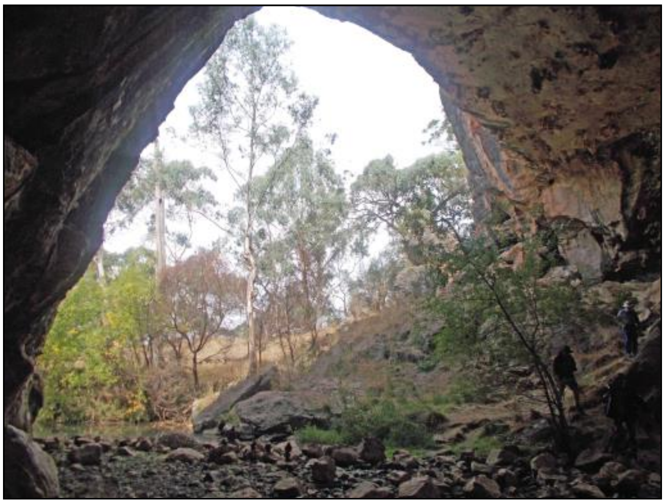
in the landscape.

The group lunched in the Borenore Karst Conservation picnic area *(photo 6)*. After lunch the group walked the 600 m Arch loop track, entering the Arch Cave from the south. This natural bridge is the remainder of a much bigger cave which has eroded over time as a result of incision via Boree Creek. *(photos 7 & 8)*. In summer the water sometimes vanishes completely underground due to insufficient flow and Boree creek being a typical karst sinking stream. The creek level was low with no evidence of flow at this time *(photo 9)*.

Obvious are the multiple episodes of turbulent flows due to the number of scallops of various sizes in the marble *(photo 10)*. Scallop lengths are inversely proportional to the velocity of the water that formed them and a diagram of their formation is shown *(figure 5)*. The faster the water flow, the smaller the resulting scallops.

Upstream is to the left at point 1, the water flow separates from the main current at the upstream edge of the scallop starting the formation of an eddy. Within the eddy at point 2 the water flow type changes from laminar to turbulent. Water swirls in an eddy at point 3, entirely within the scallop. Lastly, at point 4 the water flow exits the downstream (shallower) edge of the scallop to continue the process downstream. Since these scallops indicate water flow direction and velocity, they

7. The group in front of the Arch, approaching from the south.



8. A view of the Arch from inside Arch cave.

can help determine palaeoflow conditions in cave systems.

The group scrambled through Arch Cave, noting more scalloping and fossils (primarily crinoids and corals) in the marble. Some explored the upper (oldest part of the) cave. This cave is not extensive but shows evidence of past hydrologic activity via very small scallops at the entrance and speleothems such as stalagmites, stalactites, straws and columns *(photo 11)*.

The group returned to Molong via Boree and stopped to inspect the Monument honouring Major Thomas Mitchell's 2nd, 3rd and 4th expeditions to the Darling River, Western Victoria and to central Queensland (1835-1845) *(photo 12)*. On return to the caravan park members enjoyed free time walking around the historic town of Molong and enjoying a coffee or ice cream.

<u>Day 2</u>: 17th March, 2019

The Molong Museum opened for the group and we enjoyed a "trip down memory lane" and learnt much about Molong's rich history. The Molong Museum building was constructed in 1856 as the Golden Fleece Hotel and displays an extensive collection of local history and heritage items, including a room devoted to

9. A view of Boree creek in the Arch Cave.

10. Scalloping on the Borenore marble, resulting from turbulent flow.

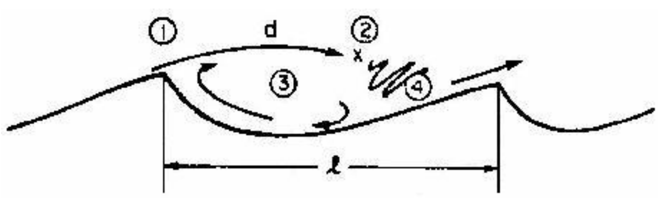


Figure 5. Diagram explaining scallop formation by turbulent flow.

11. Speleothems in the upper older level of Arch Cave.

12. The group inspecting the monument to Major Mitchell's 2nd, 3rd and 4th expeditions.

child migration and Molong's Fairbridge Farm. The Museum has an extensive collection of local rocks, fossils and bones found in the Molong quarry *(photo 13)* as well as a large selection of local indigenous artefacts.

In the afternoon the group proceeded to Wellington Caves via Banjo Paterson Way, which forms the "Animals on Bikes" tourist route which continues on to Dubbo. The group left the Banjo Paterson Way at Yoevil travelling towards Wellington and onto the Caves Complex.

The Wellington Caves are located west of the dividing range and now classified as dry as only occasional rains provide recharge to the caves. Their existence indicates that this region was far more southward of the South pole and the climate was much wetter. Some of the caves display river passages, which are the last remains of a cave river.

The group was fortunate to have as its tour guide, Dr Michael (Mike) Augee *(photo 14)*, a palaeontologist residing at Wellington Caves. Mike runs a palaeontology laboratory where he studies fossils bone remnants found in the Wellington caves, primarily from The Phosphate Mine and Cathedral Cave. Small vertebrates studied include pygmy possums, rodents and bats. The most common fossil parts found are teeth and skeletal bones, including parts of skulls, jaw bones etc. Most are unarticulated due to the effects of transport into the cave deposits.

Mike explained to the group the history of fossil discovery in the caves, indicating the entrance to Bone Cave. Bone Cave is only open to scientists and was discovered in 1830 by George Rankin, who accidentally fell into its entrance. Rankin found piles of bones, many of them were of enormous size and could not be matched with any known Australian animal. In the same year he and Thomas Mitchell, Surveyor General, collected more than 1000 specimens. The extinct species found include marsupial lions *(thylacoleo)*, *diprotodon,* giant kangaroos, a seven metre-long carnivorous goanna *(meglania)*, other reptiles, and birds.

13. Fossils found in Molong quarry on display in Molong Museum.

14. Dr Mike Augee addressing the group prior to entrance into Cathedral Cave.

16. Phosphorite deposits found in the Phosphate mine.

Two caves were explored by the group, the Phosphate Mine and Cathedral Cave. The Phosphate Mine consisting of approximately 300 m of conduit pathways, with a maximum width of 16 m, was a partially sediment-filled cave before being mined between 1912 and 1918. During this time approximately 6,000 tonnes of phosphate rock was extracted. The Phosphate Mine Beds were deposited by the slumping of *Macroderma* guano, re-mobilised older cave sediments and some large surface-derived bones into still ponds that regularly dried out. In addition, phosphorites were deposited at Canowindra and at Wellington during the Pliocene *(photos 15 & 16)*.

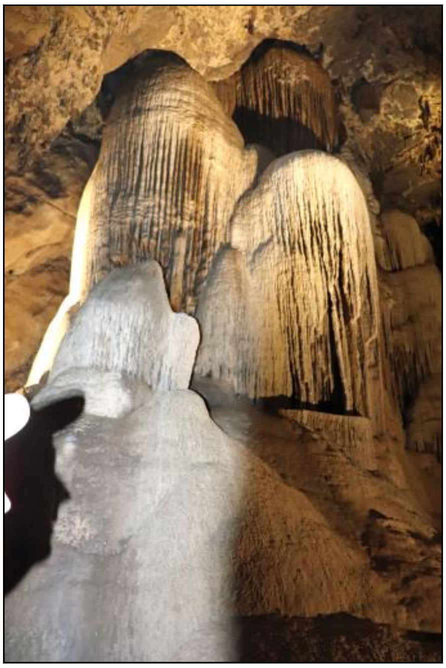
This mine intersects significant deposits of bone-bearing strata. These fossil bones have been the focus of palaeontological studies at Wellington. The mine was rehabilitated during 1995-1996 and made safe for tourism. During this process whole sequences of strata and significant stratigraphic boundaries were found The indication is that the Cainozoic record shows three distinct sequences separated by unconformities and that the record may extend back to the Paleogene.

This cave is home to numerous bats, among them a threatened Bent-Wing Bat. Bats entered Australia during the Miocene and became a significant source of phosphatic cave deposits. A troglobiontic crab living in the caves is considered to be a living fossil. Red entrance facies were deposited in caves during the Pleistocene, along with animals caught by pit-traps, or brought in by predators (such as owls or the ghost bat). Osborne (1987) suggested that the red sediments were derived from soil material made available for transport by wind as a result of increasing aridity.

Cathedral cave is the largest natural cave in the Wellington complex and formed by nonphreatic solution in massive limestone of the Devonian Garra Formation. The cave comprises a steeply sloping entrance which expands into a huge main chamber (45 m long and 20-25 m wide). The main Chamber of Cathedral Cave is developed along an unconformable boundary between massive limestone-mudstone and tightly-folded thinly-bedded limestone consisting of graded beds rich in faecal pellets. The stratigraphic significance of this boundary remains unclear and attempts at extracting conodonts from either of the facies have proved unsuccessful. An interpretation is that it is the result of slumping onto a Devonian reef *(photo 17)*. In this chamber a flowstone covered pillar (15m high with 32 m circumference at the bottom), known as the Altar dominates *(photo 18)*. Despite this single pillar there are few speleothems. At the end of the chamber a vertical drop of about 6 m reveals a pond

15. Mike Augee explaining the history of the Phosphate Mine, just inside the mine entrance.

17. Tightly-folded thinly-bedded limestone possibly the result of slumping onto a Devonian reef.



18. Altar Rock, a huge speleothem measuring 32 m in circumference and 15 m high.

which responds to rainfall and the level of the nearby Bell River. The groundwater level here is 24 m below the ground surface.

Faunal fossils found in Cathedral cave include 38 marsupial taxa, rodents, the ghost bat *(Macroderma gigas)* and mollusca. Ten of these marsupial taxa are now extinct and one *(Sarcophilus harrisii)* is now confined to Tasmania. The presence of limestone boulders, rocks and fragmented nature of bone and lack of any complete skeletal remains indicates high disturbance and re-deposition.

The reserve contains numerous other caves, approximately 26 in all of varying sizes and depth. Recent discoveries by the members of the Sydney University Speleology Club found the water-filled River Cave and Water Cave.

After lunch a Palaeontology lecture and laboratory workshop was given by Dr Mike Augee to an enthralled and engaged group of AGSHV members. Mike gave a lively lecture and showed the group how to identify the bone fragments, dentition and other fossils such as snails. The group enthusiastically sieved and sifted through the red sediments to discover fossil teeth, partial jaws and snail shells (mollusca) *(photo 19)*.

Mike's research is centred on the collection and identification of micro invertebrate fossils found in the red earth predominantly from the Phosphate mine. Whilst the mean ages of the micro invertebrates based on dating is about one million years (Miocene), ages of other bones range from approximately 30,000 years up to four million years (Pleistocene period).

A vote of thanks was given to Mike for giving this group such an opportunity and the benefit of his extensive knowledge and enthusiasm.

Later in the afternoon members walked the

19. Elaine Collier diligently sifting and identifying fossil micro vertebrates.

20. A 'herd' of fossil marine snails observed on the Fossil walk.

Wellington Caves Reserve Fossil Trail. Here there is a selection of marine invertebrate animals whose shells and skeletons have been replaced with brown silica material were observed and described by an accompanying pamphlet. The majority of the fossils are corals (both solitary rugose and the colonial tabulate species). Other fossils found were marine snails *(photo 20),* crinoids, brachiopods and nautiloids.

<u>Day 3</u>: *18th March, 2019.*

The next morning the group packed up and headed to Burrendong Dam and the Burrendong Botanic Garden and Arboretum. Burrendong Dam is a rock-fill embankment, clay core dam across the Macquarie River upstream of Wellington. The dam's purpose includes flood mitigation, irrigation, water supply, hydro-electric power generation and environmental flows to the Macquarie Marshes. It has a capacity of more than 1,600,000 megalitres and supplies water to communities from Wellington to Cobar via the Macquarie River. Due to the extreme drought conditions, current water levels were at 7% capacity *(photo 21)*.

The group moved onto Burrendong Botanic Garden Arboretum. This complex was established in 1964, and has one of the largest collections of Australian plants in cultivation. Over 50,000 flowering plants, shrubs and trees from more than 2,000 species growing on 164 hectares overlooking the Lake Burrendong and include many rare and endangered species. The Arboretum's mission is to preserve and promote Australia's unique flora.

Several of the group did self-guided walk to Fern Gully, a lush rainforest area with an outstanding collection of Australian ferns. After lunch the group headed to Gulgong for the next leg of the field trip.

21. A view of Burrendong Dam from the wall. The dam was at 7% capacity at this time.

The intrepid leaders, Janece McDonald & Lawrence Henderson with Dippy, a full scale model of a local diprotodon.

Report by Janece McDonald and Lawrie Henderson.
Photographs by Janece McDonald and Lawrie Henderson.
Cartography Lawrence J Henderson.

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Gulgong

Leader: Brian England.
Date: Wednesday 20th March 2019.
Attendance: 14 members.

A brief history of Gulgong.

The Gulgong Goldfield was gazetted in 1866 but the early finds were almost negligible. Then on 14th April 1870 shepherd Tom Saunders found a rich reef at the future town site on Red Hill and a major rush ensued. Within weeks 500 people were on the field. In 1870 the town of Gulgong was surveyed and then officially gazetted in 1872. By then 20,000 people had moved into the area. Henry Lawson's family arrived in 1871 and the town became the background for much of his writings. Thomas Browne (aka Rolf Boldrewood) was the Police Magistrate between 1871 and 1881 and spent his spare time there writing Robbery Under Arms.

Officially 15.74 tonnes of gold were mined in the Gulgong Goldfield, both from the quartz reef on Red Hill and the surrounding alluvial and deep lead deposits derived from its erosion. This includes production up to 1940.

Gulgong's narrow streets have retained much of their gold rush appearance and ambience. Very little has changed, although the town has now become a thriving agricultural and commercial centre with a population of around 2200. Most Australians know Gulgong as the town on the ten dollar note.

Our Gulgong Experience.

Members stayed two nights in the Gulgong Tourist Park (formerly the Henry Lawson Caravan Park) which had only recently changed ownership and was undergoing much needed renovations.

There were two main reasons for spending a day in Gulgong on the way home from the Lithgow-Wellington trip. The first was the recently established Holtermann Museum which, despite information to the contrary, we found was not yet open to the public! Fortunately, the second major attraction, the Gulgong Pioneer Museum, was open.

The Gulgong Pioneers Museum is renowned as one of the four most important folk museums in New South Wales. It had its beginnings as a historical display in the Gulgong CWA rooms in 1961. Then following a gift of a thousand pounds by the Late W.H. Lewis, a committee was formed and was able to buy the old Times Bakery building in Herbert Street, where the folk museum became established. Since then an ongoing program of restoration, extensions, and improvement has made the Museum what it is today. A nearby block of land was donated by former Mayor Harry Gudgeon, on the condition that an old-time blacksmiths shop be set up on it. The first visitor was admitted on Easter Sunday 1962, with the official opening performed by Mr. Eric Dunlop on Easter Saturday 1964.

The Museum *(photo 1)* traces the history of Gulgong and surrounding districts from the early pioneering days, through the gold rush years, to the present day. It contains thousands of exhibits including natural history, geology *(photo 2)*, agriculture, firefighting *(photo 3)*, gold mining, printing *(photo 4)*, transport, business, domestic tools and utensils, period clothing, a stunning old doll collection *(photo 5)* and Aboriginal artefacts, as well as the historic buildings which house the collections.

The group met at the Museum entrance in Herbert Street at 9 am and spent two hours exploring the seemingly endless array of exhibits throughout the veritable rabbit warren of rooms. However, the main point of interest to most was the display of rocks and fossils in the C.R. Dempsey memorial geology section. Sadly, many of the specimens on display were mislabelled, a common feature of many country museums. However, a large display of fossils from the nearby Talbragar Fish Beds is one of the best available to the general public and is both well-displayed and

1. Gulgong Pioneers Museum, corner Bayly and Herbert streets.

2. The C.R. Dempsey Memorial Geology Section in the Gulgong Pioneers Museum.

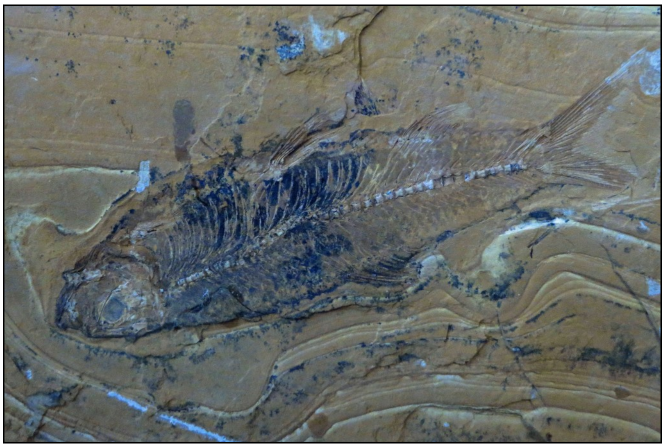
3. The firefighting exhibit in the Gulgong Pioneers Museum.

4. The fully operational print shop in the Gulgong Pioneers Museum.

correctly labelled. Most had been donated by the consortium of Museums that had excavated part of the site in 2006 in a search for fossil insects.

The Talbragar Fish Beds were discovered in 1889 by a Mr. A. Lowe and publicised in the same year by Geological Surveyor William Anderson. The outcrop is very small, covering an area of 1.6 hectares and the fossils are of Late Jurassic age (around 145 Ma). The site is famous internationally for the exquisitely preserved little fossil fish *Leptolepis talbragarensis (photo 6)*, one of the World's earliest examples of a modern fish. The name was changed to *Cavenderichthys talbragarensis* when it was realised that *Leptolepis* was actually a saltwater not freshwater fossil species. The other prominent fossil from Talbragar is the plant *Podozamites jurassica (photo 7)* famous for its perceived similarity to the recently discovered Wollemi pine. But while it is related to the Kauri pine, it has no direct relationship to the genus

5. The Doll collection in the Gulgong Pioneers Museum.



6. The Jurassic fish *Cavenderichthys talbragarensis* from the Talbragar Fish Beds.

Wollemia [See Beatie, R and Martin S. (2007). Insects of the Talbragar fossil bed. Australian Age of Dinosaurs, issue 5].

The group then wandered up to a nearby café for coffee, on the way passing an interesting-looking antique shop which had a rather novel stool outside made from a tractor seat. They almost had a sale until the stool was turned over to reveal the label "Made in China".

After coffee the group drove up to the Gulgong Gold Experience on Red Hill, the highest point in town. This was the site of the original gold discovery by Tom Saunders. Saunders' gold find was alluvial/eluvial gold and the wooden headframe on top of the hill is an exact replica of the one built to service the Black Lead. Hard rock (quartz) mining came much later when the deep quartz reef which had shed the surface gold was worked underground. The cement footings on site are the

7. The Jurassic plant *Podozamites jurassica* from the Talbragar Fish Beds.

8. The old stamp battery on Red Hill.

remains of the Red Hill Gold Mining Company operations which ceased in 1934. Nearby are the remains of a stamp battery *(photo 8)* and a line of water-filled troughs for tourist gold planning.

A metal pyramid *(photo 9)* at the entrance to the gold museum showed the actual volume of gold mined in the Gulgong district.

1870 - 1875:	12,240 kg
1875 - 1940:	3,499 kg
Total weight:	15,739 kg
Volume of gold:	0.81 cubic metres
Value in 2016:	$943,848,500

Inside we found a large display room covered with information and old photographs from the gold rush days. From there a modern tunnel ran towards the base of the shaft and the exit stairs to the surface where a reconstructed mine dump contained several large

9. The pyramid outside the Gulgong Gold Experience showing the volume of gold produced by the Gulgong Goldfield.

blocks of white quartz, sadly without any visible gold! After a late pub lunch at the historic Prince of Wales Hotel, some wandered the streets exploring the town's quaint historic buildings, while others visited the Henry Lawson Centre before wandering back to the caravan park.

The day concluded with delicious Chinese cuisine at the Gulgong RSL Club.

Report and photographs by Brian England.

Brisbane Water and Boudi National Parks

Leaders: Barry Collier, Brian England, Winston Pratt.
Date: Sunday 14th April 2019.
Attendance: 16 members.

The purpose of this excursion was to view and investigate two widely different and World-Class examples of weathering exposed in the Triassic sandstones of the Sydney Basin.

The group assembled at 10 am at the start of the Van Dahl's Walking Trail leading to the north of Patonga Drive 1.8 kilometres west of Pearl Beach in the south-central part of Brisbane Water National Park.

The first area visited comprised three separate and widely-separated sites along Patonga Drive. Here exposed rock platforms composed of Hawkesbury Sandstone display areas of superb tessellated pavement so perfect in their geometry and variable in design it is hard to believe they are completely natural phenomena.

The first and smallest of the three platforms lay a few hundred metres to the east of the Warah Trig Road overlooking the rugged valley of Green Point Creek *(photo 1)*. The second was found along the northern side of Patonga Road further to the west. At this second site the group was stunned by the regularity of the patterns, with a 'chrysanthemum-like arrangement' of the blocks repeated across the exposed area like an Escher drawing *(photo 2)*. There was even a spiral grouping *(photo 3)* and around the edge of the platform parallel elongate blocks point towards the centre of the tessellated area *(photo 4)*. Never seen on previous visits at the western edge of the platform was a crude Aboriginal engraving of a man and several very old survey marks. The third locality occurs on the south side of Patonga Drive and again the patterns are astounding *(photo 5)*.

This particular horizon in the Hawkesbury Sandstone is very uniform in grainsize, unusually high in clay content, and shows no structural disturbances such as cross bedding, which would halt the propagation of the crack networks. The apparent shallow depth of the cracks suggests this phenomenon may be a surface effect. There was some discussion on the origin of the patterns, the general conclusion pointing towards dehydration and shrinkage.

After a picnic lunch at the entrance to Van Dahls Track the group drove off to Putty Beach in nearby Boudi National Park. Those without National Parks passes were forced to do battle with the ticket machine at the park entrance to pay the $8 day-use fee.

Once assembled in the car park at the north end of the access road we ambled off down to the beach, crossed a small creek, and then took the stairway to the top of the northern headland which led to the start of the coastal boardwalk along the edge of the cliff line.

1. Tessellated pavement off Warah Trig road.

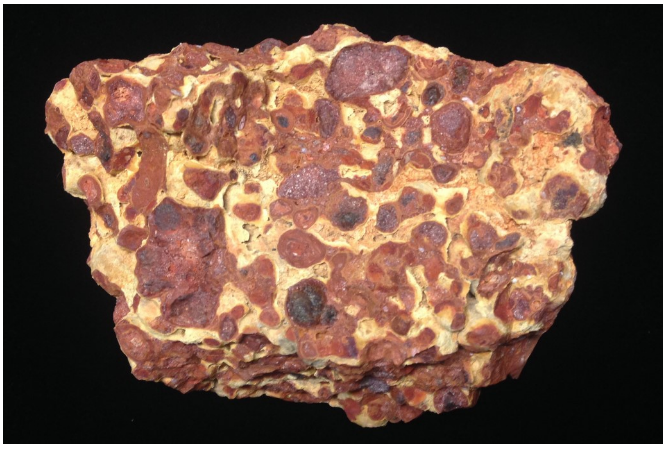
2. Regular geometric pattern in the pavement at site 2.

3. Spiral pattern in the pavement at site 2.

With only limited time available the group only went as far as Bullimah Beach, at the turning point looking north to the southern face of Gerrin Point where there is a text-book example of a sand-filled

4. Elongated blocks of tessellated pavement on the edge of site 2.

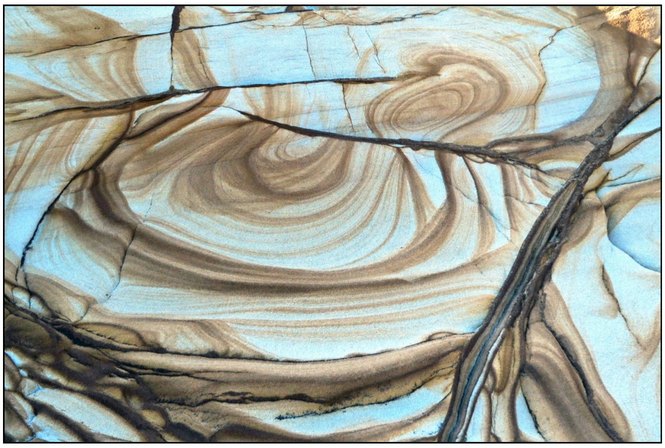
5. Tessellated pavement south-side of Patonga Road, site 3.



7. Laterite specimen.

8. Leached iron-stained sandstone on headland north of Putty Beach.

6. Sand-filled stream channel cutting tidal flat shales.



9. Spectacular Liesegang banding in sandstone.

stream channel cutting through thinly bedded tidal flat shales *(photo 6)*. We then backtracked to the top of the cliffs and began to explore and photograph the extraordinary weathering patterns in sandstones within the Triassic rocks of the Terrigal Formation (formerly the Gosford Formation) at the top of the Narrabeen Group. This site was last visited in January 2010 on a very hot and windy day (Collier and England, Geo-Log 2010).

The hills behind the coastal cliffs are capped by an iron-rich laterite *(photo 7),* a residual rock formed by weathering of the Triassic sediments during an earlier period of high rainfall during which the surface rocks were heavily leached. This laterite capping has been the source of the iron oxides/hydroxides that formed the spectacular Liesegang banding in the sandstone beds below. The sandstone immediately below the laterite is heavily iron stained. As weathering and erosion proceeded the water table gradually fell so that iron was leached from the heavily iron stained sandstone layer along cracks and joints, resulting in cores of brown sandstone cut by lacy networks of white heavily leached sandstone *(photo 8)*. Penetration of iron-charged groundwater into the sandstone below the leached zone has formed World-class examples of Liesegang banding *(photo 9)* covering large areas of the cliff face. The banding formed as iron-rich groundwater migrated along joints in the sandstone and then soaked into the porous rock, leaving behind an iron-stained layer as the rock dried out. This was a seasonal event resulting over time in a succession of concentric stains. Liesegang banding can only form in rocks with an open pore network and this explains the relative rarity of the phenomenon (Collier and England, Geo-Log 2010).

Below these spectacular weathering patterns is a thick bed of laminated blue-grey lake lacustrine shale, which probably prevented further downward migration of groundwater. Down near the high tide mark the sandstone beds show well-developed trough cross bedding.

Many features typical of fluvial deposition environments can also be seen at this site, including pebble lag beds, cross bedding accentuated by differential weathering, and areas of siderite boxwork deposited by iron-charged river water in then-active distributary channels. Some of these boxworks have been broken up and redistributed by sudden high energy inflows.

The group gradually dispersed around 4:30 pm, with some of the photographers staying on to record some spectacular images.

Report and photographs by Brian England.

Wamberal Point to Norah Head Excursion

Leaders: Winston Pratt and Chris Morton.
Date: Saturday 18th May, 2019.
Attendance: 13 members.

Travelling from areas as far afield as the Upper Hunter and south to Umina, thirteen of our members met at Foresters Beach on the Central Coast, on what could only be described as a perfect autumn morning. Although, it did seem uncharacteristically warm for what would be expected for this time of year.

Previous excursions conducted by the AGSHV have examined the Late Permian outcrops up to the Permian - Triassic boundary at Frazer Park north of Norah Head, and the Terrigal Formation of the Gosford Subgroup to the south between Terrigal and Broken Bay, where changes in sea level have affected the coastline of NSW for more than 100,000 years.

The object of this excursion was to examine the Clifton Sub-Group previously not visited by our society between Wamberal Point (Foresters Beach) and Norah Head, where the constant energy of the sea has exposed many rock sequences. This subgroup of rocks belongs to the lower part of the widespread Narrabeen Group, and is of Early Triassic Age (250 to 240 Ma). These exposures are in general dipping slightly to the south-southwest.

The Narrabeen Group is widespread over the Sydney Basin and comprises three Subgroups, the Clifton, Gosford, and Grose Subgroups together with some other formations. *(figure 1)* (Australian Stratigraphic Database, 2019).

Geology - Clifton Subgroup.

The Dooralong Shale is composed of medium to coarse-grained crossbedded channel sandstone intercalated with overbank sediments of siltstone, claystone and fine to medium-grained sandstone. Grey-green to black overbank sediments are commonly micro -crossbedded and contain abundant fossil leaves, stems, carbonaceous debris and rare desiccation cracks. (Uren, 1980).

The Dooralong Shale was deposited on a coastal outwash plain which graded distally (south-westwards) into an estuarine environment. (Uren, 1980).

The Munmorah Conglomerate was formed by coarse detritus from the nearby New England Fold Belt being transported and deposited as a large alluvial fan complex. This detritus prograded south-westwards over the sandy and silty coastal outwash sediments of the Dooralong Shale.

Middle Triassic		Hawkesby sandstone
Early Triassic	Gosford Sub-group	Terrigal Formation
	Clifton Sub-group	Patonga Formation
		Tuggerah Formation
		Munmorah Conglomerate
		Dooralong Shale
Late Permian		Vales Point Coal

Figure 1. Stratigraphy of the Lower Triassic strata of the northeast Sydney

The Tuggerah Formation overlies the Munmorah Conglomerate and is exposed in the headland and cliff areas at Norah Head, Noraville, Soldiers Point, Jenny Dixon Beach and Cabbage Tree Harbour. The formation also outcrops in the rock platforms at The Entrance, Blue Bay and Toowoon Point. The rock unit generally consists of a lithic sandstone, with minor constituents of red-brown and grey-green claystone, siltstone and minor conglomerate and pebbly bands.

The Patonga Claystone comprises the uppermost portion of the Clifton Sub-Group. This sequence crops out from Lake Macquarie in the north and thickens toward its southern outcrop limits near Wamberal and Wyong.

The Patonga Claystone, together with the underlying Tuggerah Formation form distinctive 'red beds' consisting of interbedded sandstones, siltstones and claystones. These sediments were deposited in alluvial, tidal lagoon and shallow marine environments.

It should be noted that the surface rocks on top of the headland at Snapper Point in the Munmorah State Conservation area are represented by Munmorah Conglomerate. However, due to a south-westerly dip, Munmorah Conglomerates at Norah and Soldiers Point outcrop on the wave cut platform at sea level with Tuggerah Formation forming the cliff-face and headlands.

Wamberal Point.

After introductions and briefings on the day's proceedings, we left the car park at Foresters Beach where we walked down a steep asphalt path that leads down to a set of stairs onto the beach, where we headed south for about 750 metres to Wamberal Point.

Wamberal Point displays the topmost sequence of the Patonga Claystone. The escarpment and rock platform are characterised by the Patonga Claystone, a red bed facies in the Narrabeen Group of the Sydney Basin. From a geotechnical point of view this rock unit has the unfavorable characteristics of low shear strength which causes instability of cut slopes, high expansion and contraction in response to water content and its slaking-prone behavior. *Slaking is the process in which earth materials disintegrate and crumble when exposed to moisture (*Nunt-jauwong, 2006).

The Patonga Claystone is an early Triassic red bed sequence which forms the uppermost beds of the Clifton Sub-Group of the Narrabeen Group in the Central Coast area of the Sydney Basin. The unit crops out over an area of approximately 150 km^2 in the Wyong and Gosford region and has an average thickness of 137 m. Despite its name, the unit contains very little claystone. It consists primarily of red brown siltstone with lesser amounts of sandstone and mudstone.

The derivation of the name Patonga Claystone is somewhat confusing, as it does not outcrop at Patonga:

> Nunt-jauwong. S. (2006) notes that "*the first description of the unit now known as the Patonga Claystone is represented by the definition of the type section for the Collaroy Claystone by Hanlon et al. (1953) based on the strata encountered in the Windeyer's Hawkesbury River Bore at depth of 237 to 373 metres. Later correlations, however, recognized that this section was a stratigraphically lower unit to the claystone exposed at Collaroy, and the name Patonga Claystone was given to the unit in the Hawkesbury Bore by J. Stuntz." (McElroy, 1969).*

Nunt-jauwong. S. (2006) also notes that the Patonga Claystone (Red Beds) consists essentially of four different rock types or lithofacies. The Red Beds are a function of post depositional alteration in oxidising conditions:

i) Red brown mudstone. This is the most common rock type in the Patonga Claystone, and has variable proportions of clay and silt size particles.

ii) Fine to medium grained sandstone. The colour of this sandstone varies from grey to green. The sand grains consist mainly of quartz and green rock fragments.

iii) Grey to green mudstone - siltstone. This lithofacies is slightly coarser grained than the red brown mudstone described above. It characteristically has a gradational boundary with the grey green fine-grained sandstone, and may contain 'clasts' of red brown mudstone.

iv) Finely interbedded siltstone/sandstone. This lithofacies or *mixture of rock types is usually grey to green in colour.'*

v) *The coarser grained materials (sandstone) in the Patonga Claystone are generally grey-green (Fe_2O_3) while the finer grained materials are red brown (Fe_3O_4) in colour. The rock colour can thus be explained, at least partly, in terms of porosity and ground water flow.*

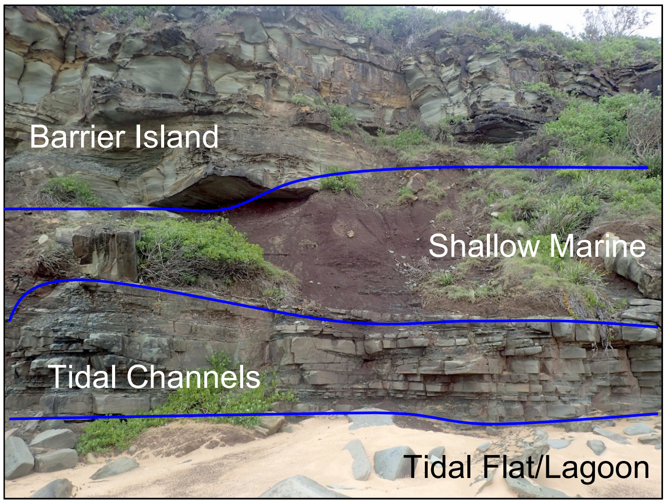
vi) *The post depositional colour change resulted from circulating fluids, i.e. in high porosity rock, water can circulate easily, which reduced ferric iron ($Fe3^{+}$, red in colour) in the sediments to ferrous iron ($Fe2^{+}$green-grey in colour)*

The top of the sand body was intertidal. Trough-crossbeds indicate a longshore current to the east implying an east-west orientated shoreline *(photo 1).*

Along the cliff line at various levels the claystone has been eroded and is undercutting the sandstone above, contributing to large block failure. Numerous boulder sized angular blocks of sandstone are scattered along the toe of the cliff, these have been derived from localised collapse of the undercut sandstone beds.

Interpretation: Herbert (1993) considers that sedimentary features in this area are consistent with a marine shoreline environment. Trough crossbedded sandstone is considered indicative of a barrier-island *(figure 2).*

The northern end of the wave cut rock platform at sea level displays grey-green fine-grained sandstones, with some sections displaying red to grey-green mottling (reduction in process), along with ripple marks, desiccation cracks, bioturbation, en-echelon fractures and a shear zone *(photo 2).* These structures are



1. The Patonga Claystone at North side at Wamberal point showing facies relationship.

fundamental features within shear-zone architectures, and are related to early stages of the shear-zone evolution.

Deformation of brittle upper crust results in the formation of both fault and shear zones. These zones of brittle deformation often contain characteristic deformation structures which allows for the most easily observed and most recognisable brittle shear sense indicator. These can form from a range of features. Here we can observe an historic zone of deformation, the most common of these faults to develop in a shear zone.

From Wamberal Point we drove north for 21 kilometres to Young Street Reserve above the Rock

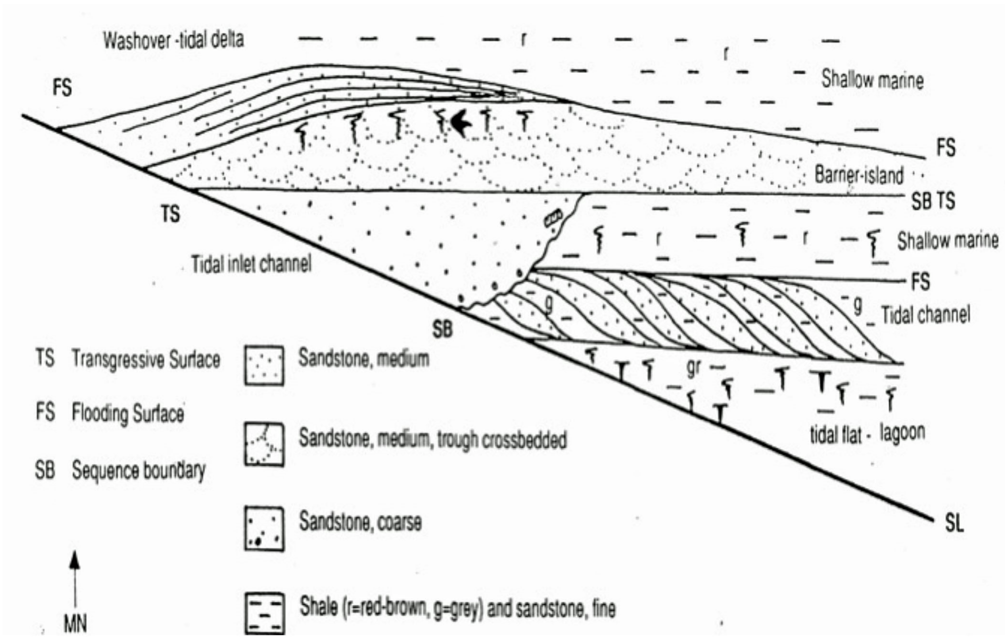
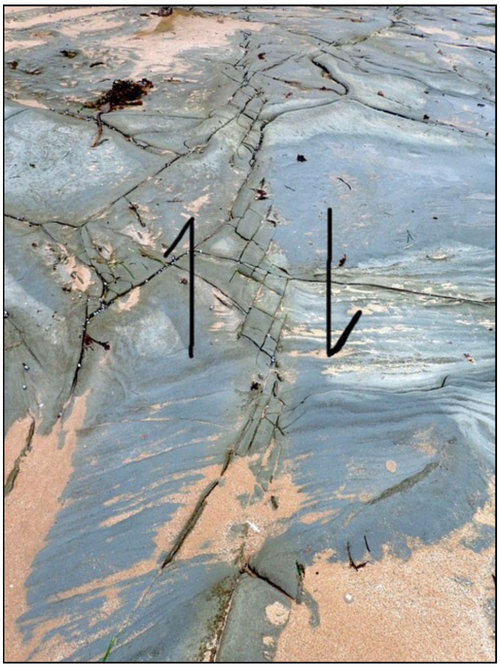


Figure 2. The topmost Patonga Claystone at Wamberal Point, is depicted diagrammatically to show facies relationships. (Not to scale) Note stratal dip has been restored to horizontal for clarity (SL is present sea level). Palaeocurrent data from Uren (1974) was derived from barrier-island sandstone only. The erosional surface under the main sandstone may be a local channel related to the development of tidal inlet (photo 3 & 4), but if it has more regional significance it may represent a relative sea level fall and could, therefore, be regarded as a sequence boundary. Herbert (1993).



2. Showing common orientations of fractures to develop in a shear zone, together with rare Domino fragmentation.
Arrows show stress direction.

Pool at Cabbage Tree Harbour (Norah Head). Given the time we decided to have an early leisurely lunch, before continuing on to Soldiers Pont.

After lunch we drove the two minutes down to Soldiers Point. The Soldiers Point headland affords spectacular views south along the coastline to Sydney and north to Newcastle, with the Norah Head Lighthouse prominent in the foreground, which is our next stop.

Soldiers Point.

The wave cut platform at Soldiers Point is composed of Munmorah Conglomerate which is overlain by Tuggerah Formation forming the cliff-face. The rock platform is dominated by prominent sub-vertical parallel joints. However it should be noted that the dominant joints on the Soldiers Point rock platform have a NE/SW strike, where as, a short distance away at Norah Head the dominant joints seem to have a NW/SE strike opposite that of Soldiers Point. *(photo 3)*. The reason for this is ambiguous and controversal, the specific origin of the stresses that created these joints sets are unclear and were not within the scope of this activity.

Two basaltic dykes some 20 metres apart running in a NE/SW direction can be seen at Soldiers Point.

The most easterly dyke has weathered out below the wavecut rock platform, whilst the other dyke is quite spectacular. It cuts through the Tuggerah Formation rising to the top of the 10 to 15 metre high headland *(photos 4, 5 & 6)*. Interestingly, the dyke pinches out, and terminates within metres of its northern end, where

3. Soldiers Point. The blue dotted line represents dykes. Note separation between mainland and what is now an island. (Google Earth).

4. Weathered dyke on the southern side of Soldiers Point rock platform.
Photo Ron Evans.

as the southern end has been eroded away by the ocean leaving a long noticable channel with blocks of remanent basalt in the rock platform. In addition, weathering along the cliff line due to groundwater seepage, wave/wind action of joints within the massive sandstones comprising the Tuggerah Formation caused very large rock falls from exposed parts of the headland. Examples of such large rock falls can be seen on the beach areas below the headlands.

Continuing on past north eastern end of the exposed dyke, the Tuggerah Formation is exposed in the striking 20 metre high cliff-face *(photo 7)*. Many aspects of sediments delivered by a meandering river system over tens of thousands of years can be examined. The

5. Looking north - the exposed dyke at Soldiers Point displays horizontal poorly developed columnar jointing and baked margins. Where the dyke abutted the vertical Tuggerah Formation, crossbedding and other sedimentary structures are preserved. The fallen slab of sandstone exposing the dyke has a chilled margin.

6. Southerly view of the dyke. Note the fallen blocks of sandstone, the result of extensive jointing seen beside the dyke.

cliff-face principally consists of lithic sandstone, with minor claystones, siltstones and pebbly bands and red banding towards the top of the escarpment.

Additionally, buried in the sand at the bottom of the natural access ramp that was utilised by fishermen in the 1940's/50's to gain vehicle access the rock platform and beaches are small blocks of laterite *(photo 8)*.

These remanent laterite blocks that are partly exposed at the bottom of the cliff-face have tumbled down from above. These rocks are a reminder of sedimentary profiles that have long disappeared from the headland.

7. Cliff composed of pebbly sandstone Soldiers Point seen from the rock platform.
Note the dark dyke on the left of the cliff.

8. Sample of Laterite, a rock is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidizing and leaching conditions. It forms in tropical and subtropical regions where the climate has wet and dry seasons to promote vertical movement up and down of ground water.

Norah Head:

After exploring the rock platforms at Soldiers Point it was time to make our way to Norah Head, our last stop for the day.

After a short drive we arrived at Norah Head Lighthouse car park, where we gathered at the nearby Merchant Marine Monument which has nice views out to sea. Here a large ships anchor leans against a basalt monument with a plaque. The plaque commemorates the merchant mariners who lost their lives during World War II. It is a fitting way to commemorate the area's strong maritime history and also to remember those who died. The east coast of Australia saw significant enemy action during the war, with mines laid by German raiders and attacks by Japanese submarines.

The short stroll along the concrete pathway down past the lighthouse, to a set of wooden stairs that leads to the rock platform is lined on one side by stunted coastal native plants that somewhat restrict the view out to sea, and the other side by the original living quarters that housed the lighthouse staff. Beyond the cottages where a white painted fence stands we arrived at our next destination, Norah Head Lighthouse *(photo 9)*, which was built in 1903. So, before we descended to the rock platform to examine the geology, we indulged ourselves with a guided tour of Norah Head Lighthouse.

Calls for construction of a lighthouse at Norah Head (then "Bungaree Norah Point") were made as early as 1861 due to many wrecks occurring in the area. A notable supporter at the end of the 19th century was local landholder Edward Hargraves from Noraville. However, these efforts were fruitless for many years. The first formal recommendation to construct the lighthouse was made by the Newcastle Marine Board, just prior to its abolition in 1897.

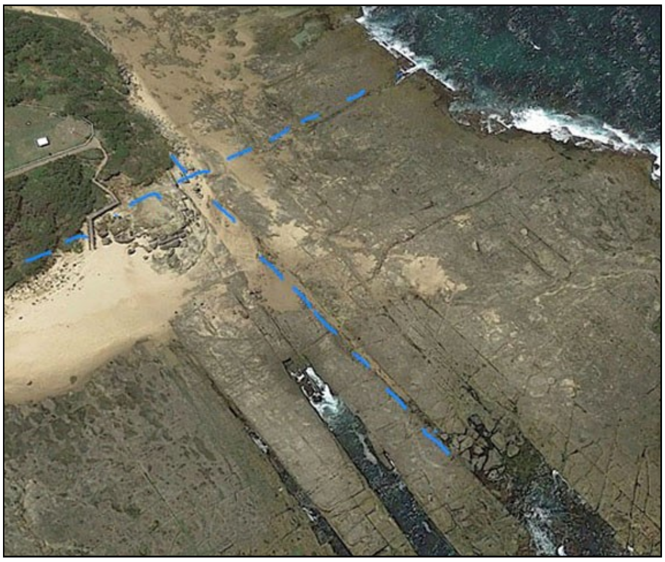
Construction commenced in 1901. Materials were brought by boat and unloaded on a wharf near the lighthouse constructed at Cabbage Tree Harbour for that purpose.

Officially displayed for the first time in 1903, the original vaporised kerosene burner was upgraded in 1923, electrified in 1961 and automated and de-manned in 1994, after more than 90 years of being staffed.

The concrete block tower is 27.5 metres (90 ft) high, topped by a bluestone gallery. On top of the gallery is the original Chance Bros. lantern. This lantern holds the original housing of the 1st order bivalve dioptric Fresnel lens with 700 prisms which cost £5,000 for the optical apparatus,

The entrance door is made of cedar set with sidelights and fanlight with an etching on the door glass saying 'Olim Periculum Nunc Salus', Latin for 'Once Perilous, Now Safe'. (Wikipedia)

9. Norah Head Lighthouse.



10. The blue dotted lines represent NW/SE and NE/SW trending dykes at Norah Head. Note conjugate joints lower right corner (Google Earth).

All the materials used in the construction of the circular tower section of the lighthouse were processed in England, and then transported to Bungaree Norah Point by ship for assembly.

A short walk down through the well maintained grounds brought us to a point overlooking the coastal rock platform. From here we could see two prominent dykes *(photo 10)*. One, an alkaline dyke trending NW/SE, is cut by another (a olivine/tholeite dyke) trending NE/SW and dated at 90 Ma (Embleton, et.al.,1985). The NW/SE dyke is older than the NE/SW dyke *(photo 11)*. It was once thought that these dykes may have been associated with the development of the Tasman Rift. However recent studies suggest that dykes older than 85 Ma may not have this association (Och et.al., 2014).

The Munmorah Conglomerate on the Norah Head rock platform on one side of a two metre wide eroded joint-controlled trench is cut by NW/SE trending joints along with minor secondary NE/SW jointing. However there is a prominent height difference between the rock platform on either side of this trench suggesting the trench may represent an eroded fault and not a joint.

The cliff-face behind the rock platform represented by conglomeratic sandstones is Tuggerah Formation. The rock unit generally consists of lithic sandstone, with minor constituents of red-brown and grey-green claystone, siltstone and minor conglomerate and pebbly bands. Where significant siltstone/claystone bands occur within the Tuggerah Formation, at the level of the wave/tide zone, extensive undercutting of the cliff area can occur and so lead to very vulnerable overhangs which are capable of sudden failure. (Roberts 2016).

11. NE-SW dyke at Norah Head running across the rock platform and through the distant cliff.

Report : Chris Morton.
Photography by Chris Morton and Ron Evans (photos 4, 7, 9 & 11).

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Munibung Hill Walk

Leader: Barry Collier.
Date: Saturday 29th June 2019.
Attendance: 16 members.

Introduction.

Munibung Hill rises 169 m ASL and is generally a north-south trending hill.

The rocks making up the hill are part of the Moon Island Beach Subgroup, the uppermost Sub-Group of the Permian age Newcastle Coal Measures *(figure 1)*.

Rocks found in the Moon Island Subgroup are polymictic conglomerate, sandstone, shale, coal and tuff.

The dominant rock present on Munibung Hill is Teralba Conglomerate *(figure 2)*.

The Newcastle Coal Measures were formed from sediments deposited in a high energy terrestrial setting that resulted in increased amounts of coarse sediment being deposited leading to a high proportion of conglomerate within the coal measures.

Increased tectonic activity and erosion of the adjacent fold belts situated to the north and north-east were the source of the coarse sediments.

The Newcastle Coal Measures have been divided into four Subgroups. From youngest to oldest they are the Moon Island beach Subgroup, Boolaroo Subgroup, Adamstown Subgroup and Lambton Subgroup *(figures 1 & 2)*.

Various sites around Munibung Hill have been quarried for gravel over many years, but none recently.

The oldest is Hawkins Quarry situated on the south western side of Munibung Hill. Gravel quarried was used for roadworks and in the construction of Williamtown Air Base and Speers Point Memorial Pool Complex in 1963. It's not been used from about 1981.

Two Council Quarries also operated on the western side of the hill with the entrance off the present day Hopkins Street *(figure 3)*.

The Walk.

The walk had been postponed for a week because of weather conditions on the previous Saturday. In hindsight, a wonderful decision as I don't think we could have chosen a better day weatherwise on the morning of the walk.

We began our walk at the end of Farm Street Speers Point and walked easterly past residential land, then ascended a prominent ridge in a generally southerly direction through beautiful, wet sclerophyll forest growing in the valley of Hawkins Creek. We passed through what may have been a small quarry, then a large former quarry to a lookout at the end of the ridge.

The lookout is above the former quarry. However, due to concerns about falling rocks by neighbours, Council has planted trees around the edge of the lookout spoiling scenic photos, but the views through the trees were great.

We then followed the crest of the ridge almost to a telephone tower, then more or less, followed the contour around the head of Hawkins Creek, then along the top of Hawkins Quarry which provided some great views south over Lake Macquarie.

Near the western end of the quarry, we walked up to the crest of an east-west ridge and followed it easterly to the firetrail which accesses the phone tower. Along that ridge we had great views to the west and north, including the most recent Council Quarry, which has recently been bulldozed for a proposed residential development. We then followed firetrails for about 1 km to the summit of Munibung Hill, where morning tea was enjoyed, with marvellous 360° views.

After morning tea, we headed generally south towards the start of the walk. About 100 metres from the starting point, we detoured to the base Hawkins Quarry above which we had walked. The sheer quarry wall provided some interesting geological formations such as the two sets of vertical joints in its face.

From there, it was back to the starting point in Farm Street before about half of the group headed to Speers Point Park for lunch.

My thanks goes to Wendy and Craig Patric who provided invaluable assistance in the preparation of the walk

Report by Barry Collier and Ron Evans.
Photographs by Barry Collier.

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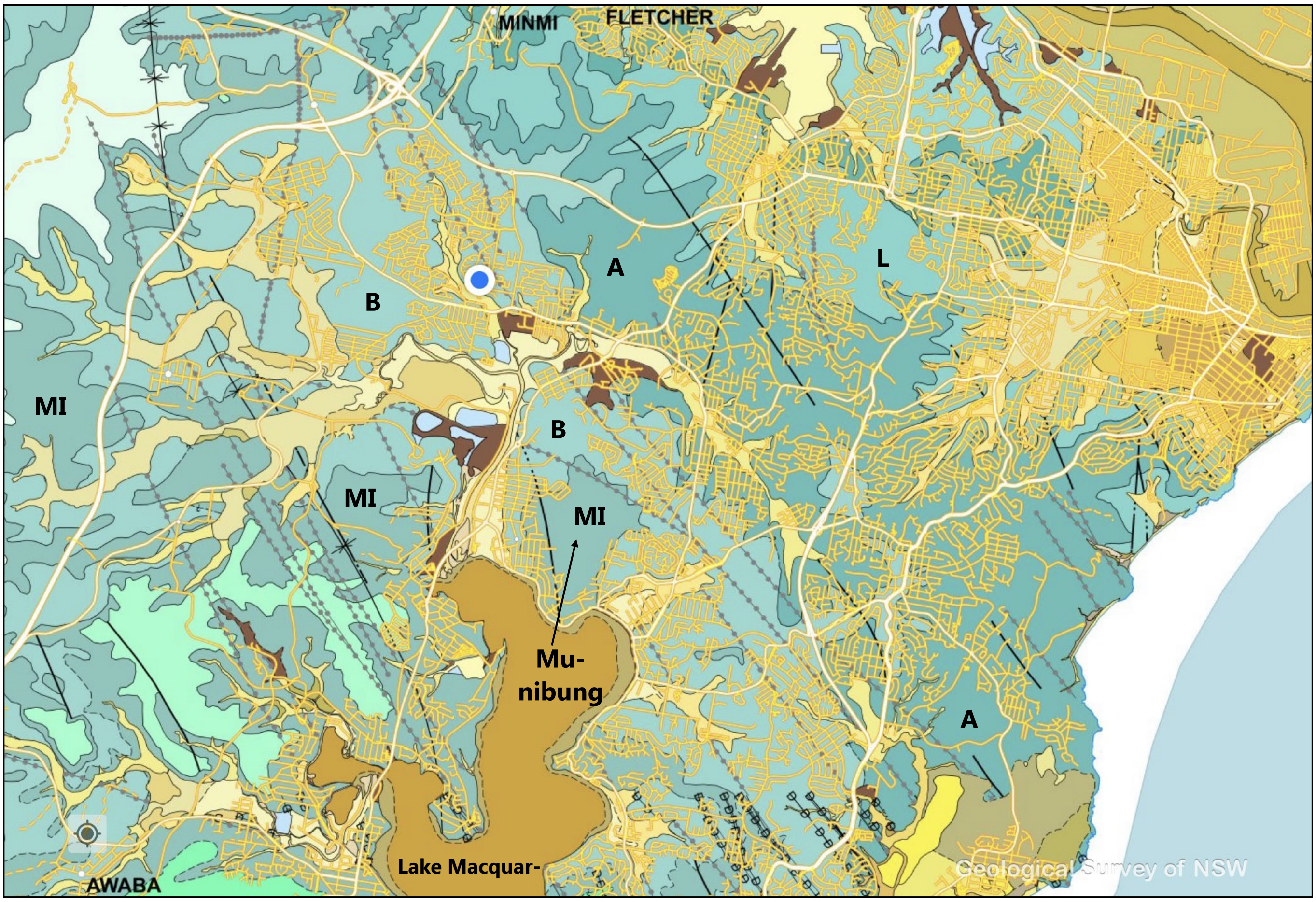


Figure 1: Newcastle Coal Measures showing its four Subgroups.

Key: MIB = Moon Island Beach Subgroup.
A = Adamstown Subgroup
B = Boolaroo Subgroup
L = Lambton Subgroup

Figure 3. Munibung Hill.

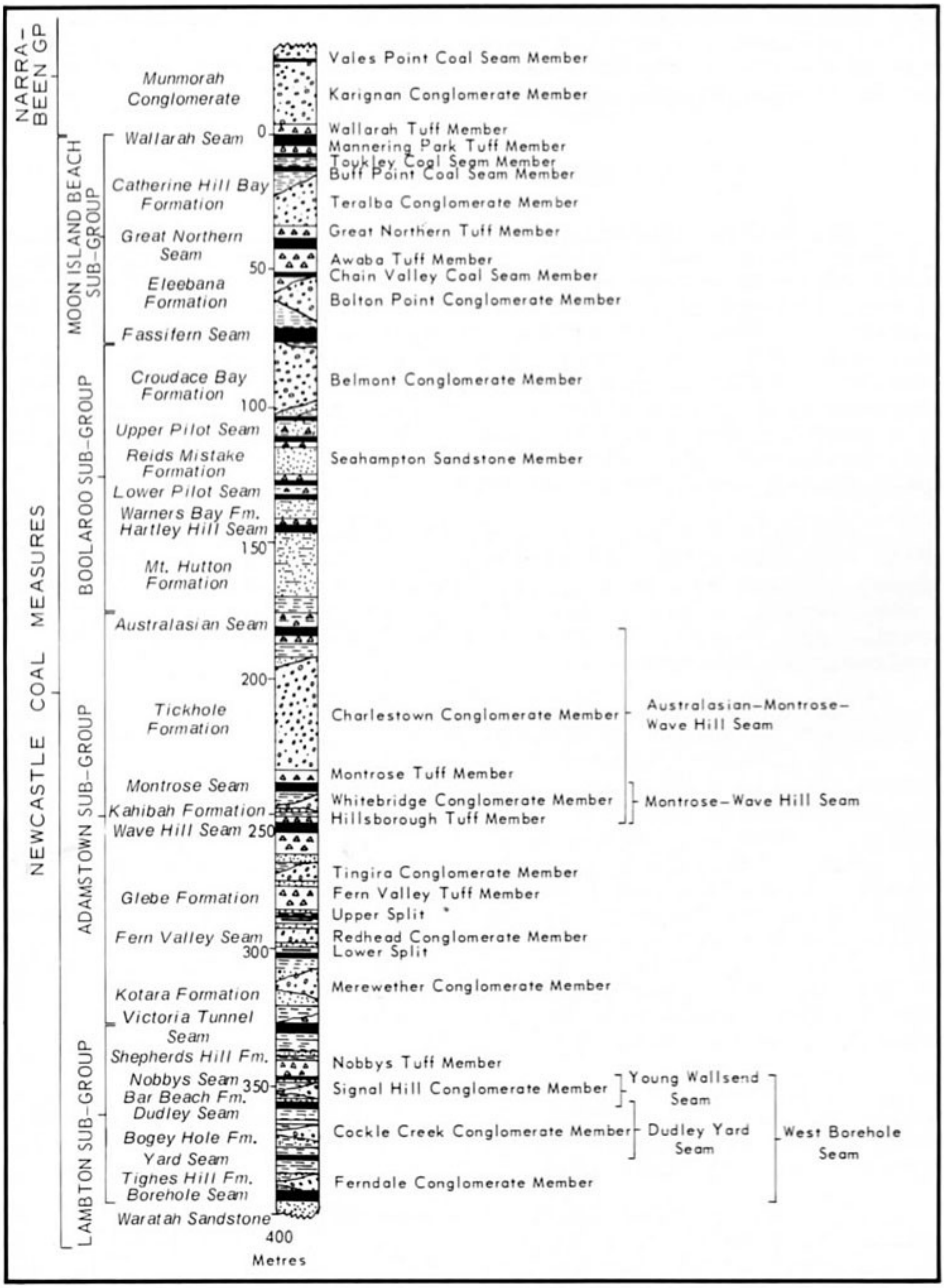


Figure 2: Stratigraphic Column of the Newcastle Coal Measures.

South-east view from our morning tea stop looking towards Warners Bay and Valentine.

View south of Lake Macquarie over Speers Point from the top of Hawkins Quarry.

Enjoying morning tea on the top of Munibung Hill.

The now abandoned Hawkins Quarry.

Green Point Rock Platform

Leader: Barry Collier.
Date: Saturday 27th July 2019.
Attendance: 16 members.

There are a number of very interesting sites in the Central Coast/Lower Hunter area that can't be placed with certainty on the club program because they are so dependent on weather conditions that can't be forecast months, or even weeks in advance. One of those is Green Point at Pearl Beach, which can only be viewed at low tide with calm seas.

When the Pilchers Hill outing was cancelled, I realised conditions were right for Green Point and so it was planned for that afternoon.

There is a public reserve on the end of the Green Point headland, the Paul Landa Reserve. The rock platform surrounding it was reached by walking onto the beach from our parking area near a cafe and then around the shoreline *(photo 1)*.

The headland is composed of sandstone in the Terrigal Formation, as is the case with Boudi NP, Avoca and Terrigal, but all of those areas consist of yellowish rock with numerous Liesegang Rings.

Green Point consists of white sandstone *(photo 2)* with virtually no Liesegang Rings. The sides of the headland consist of a series of erosion caves and overhangs, with amazing honeycomb weathering *(photo 3)* and, as the exposed rocks are dark grey, the white overhangs and caves stand out even more. Brian England couldn't believe that in a 2 hour outing, he took more than 100 photos.

Apart from the amazing caves and overhangs, there are some very interesting rock platforms around or below high tide level and some great views, particularly towards Lion Island *(photo 4)*. There are some absolutely fascinating large boulders, with extraordinary weathering formations on their surface.

1. Rock platform at Green Point. Note the honeycomb weathering in the sandstone boulders.

About 400 metres from the end of the headland, the rocks suddenly return to the normal yellowish colour, with lots of Liesegang Rings and the shoreline returns to what is normal for the Terrigal Formation.

Report by Barry Collier.
Photographs by Barry Collier.

2. White sandstone in Green Point Headland, part of the Terrigal Formation.

3. Large erosion caves within the headland. Note the coarse honeycomb weathering inside the left cave.

4. Lion Island.

Peak Hill

Leader: Brian England.
Date: Monday 5th to Tuesday 6th August, 2019.
Attendance: 22 members.

Monday 5th August.

Just north of Peak Hill attendees passed through the old gold mining town of Tomingley, recently revived by the opening of a huge open cut mine. Only the immense waste dumps are visible from the road, although just south of town an access road for machinery had been excavated under the Highway. Exploration drilling just to the south of the present pit has apparently outlined another large gold resource. Drill rigs were still operating in the fields east of the Highway, the ground around them covered by neat rows of white sample bags containing percussion drill chips.

Tomingley was initially a cattle property before being proclaimed a goldfield in June 1882. But early efforts at mining were severely hindered by low rainfall and a resultant shortage of water. Before the current operations, the old McPhail gold mine headframe and dumps beside the Highway were a landmark to travellers between Dubbo and Peak Hill. Tomingley was not included in the program due to an absence of any information on the geology of the deposit.

After travelling via Dubbo all participants had arrived at the Peak Hill Caravan Park in time to meet for a delicious Chinese meal at 6:30 pm at the Peak Hill Ex-Services and Citizens Club in Caswell Street, just a short walk south of the Caravan Park.

1. Scrap metal figure just inside the entrance to the Open Cut Experience.

Before returning to camp most people visited the Big Fish Fossil Hut adjacent to the Park. Normally costing $3, entry was free for Park residents. This small rectangular well-lit room houses a small but very impressive display of fossils representing ancient life that existed across eastern Australia over the past 700 million years, from the earliest marine life to the skull of a tiny ancestor of T-Rex. The display includes some of the major invertebrate groups including trilobites and ammonites, through to the rise of the fishes, amphibians and dinosaurs. The dinosaur case includes a giant sauropod dinosaur rib similar to those recently found in Queensland. The star of the collection is a cast of the largest fossil fish on display anywhere in Australia – *Xiphactinus*. At 4.5 metres long it lived during the Cretaceous, the age of the dinosaurs. Most of the specimens on display are casts but it is impossible to tell these from the real thing, so meticulous was the preparation carried out by owner Michael Durrant in his studio near Young. The pieces on display are part of an incredible 15,000 specimen cast collection. The Big Fish Fossil Hut was opened on 6th October 2009 and is open 8am till 9pm seven days a week.

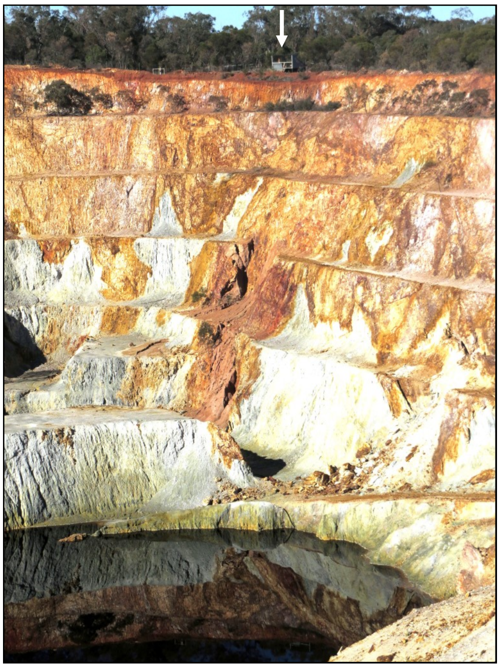
Tuesday 6th August.

Society members met in the car park at the entrance to the Open Cut Gold Mine Experience at 9 am. Here there was ample room to park both cars and caravans. Just inside the gate we were confronted by a group of statues cleverly made from bits of scrap metal *(photo 1)*. Unfortunately people headed off in small groups to explore in different directions, so not everyone heard the explanations of the geology given by their leader as they went around the workings. The tour was meant to begin at the display in the entry shelter, then move to the displays in the covered viewing platform overlooking the Proprietary Pit *(photos 2 & 5)* where the history and geology of the Peak Hill mine were explained *(photo 3)*. However, most people eventually saw everything, but in a different order.

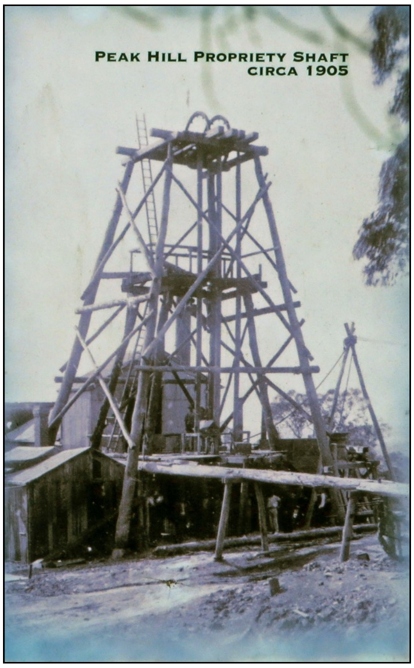
Geology of Peak Hill.

The gold deposit occurs within Late Ordovician andesitic lavas and volcanogenic rocks within the Goonumbla Volcanics (Squire, et.al., 2007). These rocks are very similar to the rock sequences hosting very large porphyry-type copper-gold deposits elsewhere in New South Wales, including North Parkes to the southwest of Peak Hill, and it is probable that similar mineralisation underlies the Peak Hill deposit. At Peak Hill the rocks have undergone significant shearing, brecciation and intense hydrothermal alteration, obliterating original lithologies (Chapman, et.al., 2009).

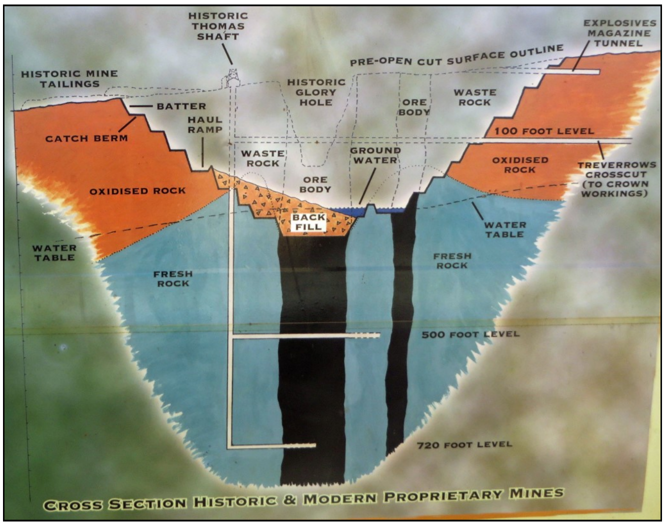
The ore is unusual in that it contains small amount of tellurium and the gold telluride calaverite has



2. Western wall of the Proprietary pit. Note the viewing platform (↓).



4. The old Proprietary mine (from display board).



3. Section through the Proprietary pit.

been reported (Allibone, 1998). Recently up to 4.5% Te has been found in the goethite forming the main gangue mineral. The gold occurs enclosed in goethite and contains traces of bismuth and silver. The ore is of supergene origin.

History of Gold Mining at Peak Hill.

Alluvial gold was discovered in a total of 9 shallow leads on the western side of Peak Hill in 1889. Hastily constructed dams were built across gullies, permitting washing of the upper parts of the leads by cradling. In 1889 the Mining Warden reported that on Peak Hill every ravine and gully contained payable gold. Some gullies were only worked to a few feet width and 2 to 3 feet in depth, the whole thickness then washed. But no rush occurred until the discovery of the "Golden Hole" by a syndicate of new chums after a local diviner advised the men where to sink a shaft! On September 11th 1890 they bottomed on wash from which 7.25 ounces of coarse gold were picked.

Mining eventually progressed to open cut (the old "Glory Hole") and underground workings, with skips from the mine carrying ore being tipped into a Gates rock crusher before being fed into wooden vats containing cyanide solution. The cyanide dissolved the gold which was then precipitated on zinc shavings. Recovery from this process was only 60% of the gold contained in the ore. Thousands of tonnes of the waste from this process were later removed to be used as road base, building material, etc.

The Cornish Lancaster boiler (circa 1890) just inside the entrance gate to the Gold Mine Experience was used to produce steam to power the winder, crushers and stamp battery for the Peak Hill Proprietary mine *(photo 4)*. The mine reached a depth of 120 feet with a cutting 16 feet in length across the lode. The Peak Hill Proprietary closed in 1917 after a long struggle with declining reserves and rising costs of labour, cyanide and zinc shavings. The mine owners, Transvaal and Rhodesian Estates, removed and sold off the remaining machinery.

Production between 1889 and 1919 was 2.34 tonnes of gold and 25.5 tonnes of copper (Markham and Basden, 1974). The original works and processing site plus the old glory hole fell within the boundary of the new open pits.

Alkane Exploration Limited commenced open cut mining of the oxidised zone in 1996 and produced a further 153,655 ounces of gold up to mine closure in 2002. The ore was blasted from the pits using ANFO. Low grade ore (0.5 to 1 g/tonne) was sent to a heap leach without crushing. High grade ore was passed through primary and secondary crushers then agglomerated with water and cement added to produce pellets which were sent to heap leach piles. The leach solution was passed through carbon adsorption columns and the gold-loaded carbon then sent to a gold stripping column; the gold being recovered using hot cyanide solution. The pregnant solution was then sent to a bank of electrolytic cells. The resultant gold sponge was then placed in a furnace to produce gold bullion (around 80% gold) which was sent to the Perth Mint for refining to 99.99% Au.

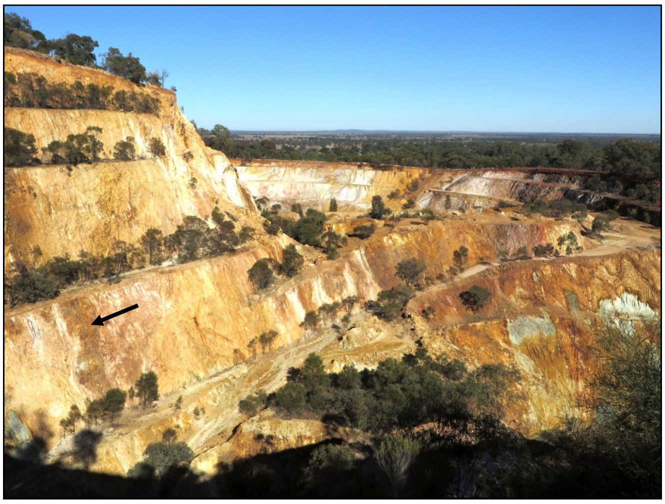
Modern mining was confined to the oxidised zone, which extended to a depth of at least 100 metres and forms a very irregular boundary with the underlying primary ore. The ore zone occurs as vertical pipe-like bodies, the unworked sections appearing brown in the walls of the open pits.

The mine employed a staff of only 50 people during its operation. An underground resource of 11.3 million tonnes remains unmined.

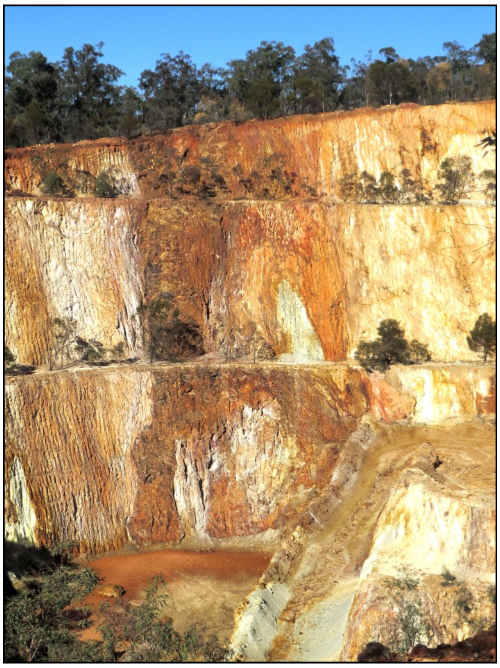
Rehabilitation.

Several decades of exploration and mining activity caused significant disturbance around Peak Hill. Commencing in 1996, Alkane undertook rehabilitation of all the vegetation outside the open pits. Two semi-trailers of compacted car bodies were removed for recycling and rubbish and noxious weeds were also targeted. The tree limbs scattered around disturbed areas assist in the establishment of new seedlings by providing protection from winds and grazing animals while the fallen timber provides habitat for invertebrates, reptiles, small mammals and birds.

Between 1997 and 1998 Alkane had removed 100,000 tonnes of gold-bearing sands dating from ore milling in the period 1890-1917 from around the north and west sides of the hill. The sale of these sands to Tailings Treatment Limited at Tomingley provided the cash to rehabilitate the area.



5. View west over Parkers (right foreground) and Proprietary pits. Note remnant orebody.



6. Eastern wall of the Great Eastern pit showing the exposed orebody (brown).

Exploring the Peak Hill Gold Mine Experience.

Most people eventually walked the Peak Hill Bush Walk Trail which skirts the western rim of the Proprietary pit then the northern side of Parkers *(map page 58).*

The Proprietary pit was mined between April 1996 and June 2001 with the removal of 3 million tonnes of ore and 2.5 million tonnes of waste rock for a return of 95,000 ounces of gold. This pit contained the largest orebody on Peak Hill. The western side has been back filled with waste rock to improve stability after cracks appeared in the pit wall. There is still a significant resource at the base of the pit which at present is uneconomic. Despite reaching a depth of 100 metres the open cut floor is still 100 metres above the 1890-1917 workings. Remnants of historic alluvial mining can be seen in the brown soil profile near the crest of the

7. View west over the Crown pit towards Peak Hill

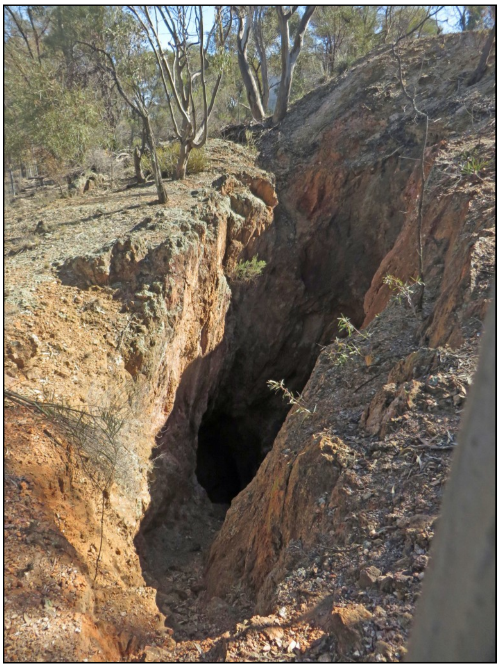
pit. Tunnelling commenced close to the exposed eroding surface of the ore bodies and followed ancient valleys which lay buried down slope and run beneath the town. Much of the rock in the pit walls is oxidised (weathered). Pyrite, the major component of the primary ore has been changed to iron oxides (mainly goethite) and sulphuric acid. The iron oxides produce the reds, browns and yellows while the blue/green patches of rock are unweathered and still contain pyrite. The main orebody in the Proprietary was 400 m long and up to 80 m wide and extended to a depth of 100 m.

From the Parkers lookout good views were available to the west over both pits, with interesting structures visible in the western *(photo 5)* and southern walls of Parkers, the latter showing a remnant of the oxidised goethite orebody and associated quartz veins. Further around the circuit, a short spur track led off to the northern side of the Great Eastern pit where another excellent exposure of the orebody was visible in the pit wall *(photo 6)*.

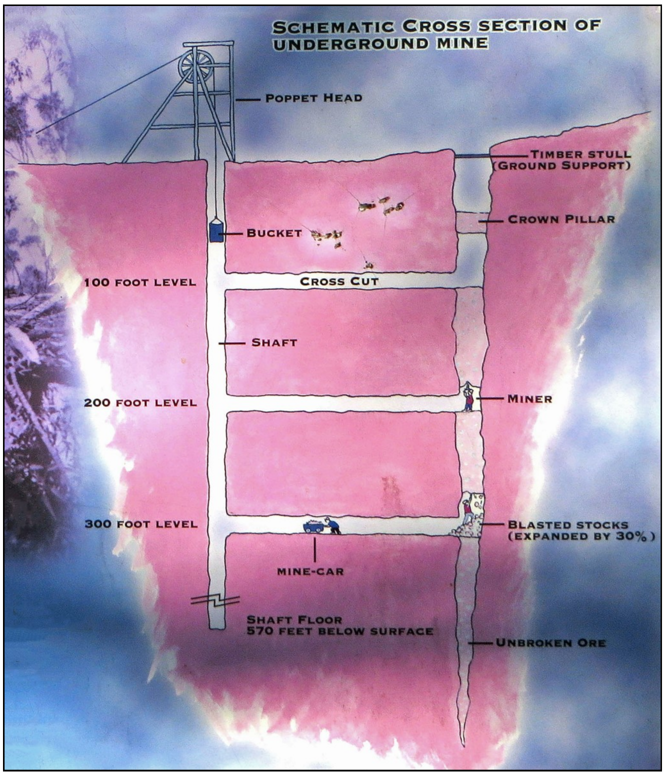
The Great Eastern cut was mined between April 2000 and November 2001 with 360,000 tonnes of ore and 490,000 tonnes of rock removed for a return of 11,000 ounces of gold. The ore and rock were removed via a ramp which can be seen winding its way up from the base of the pit.

A short rough walking track through the forest off the main route led towards the town reservoir on top of the hill where the Gold Mine Discovery Trail could be joined near a point overlooking the Crown pit *(photo 7)*. This pit was developed by Alkane between March and October 2002. Only 100,000 tonnes of ore and 100,000 tonnes of waste rock were mined for a return of 3,000 ounces of gold. The waste rock was used to partially fill the adjacent Bobby Burns pit and stabilise the north wall to safeguard the reservoir road. The last of the ore was excavated from the isolated depression visible in the floor of the pit. This is called a goodbye cut as it was considered a bonus since it was not part of scheduled production.

A little further on a series of steel bridges crossed the very deep and narrow slots of the Golden Crown Historical Workings *(photo 8)* and passed very close to the old 570-foot main shaft, where a horse whim was used to raise the ore and waste rock as well as lower and raise men and equipment *(photo 9)*. Steam engines were used later in the history of the workings. In the 1890's miners at the Crown chased rich bonanza grade ore usually in narrow shoots which meant that underground mining, rather than open cut, had to be used. The ore and waste rock were blasted using dynamite, with the blast holes drilled by hammer and tap. The ore raised from these workings was crushed and treated in wooden vats with sodium cyanide solution to dissolve the gold which was then precipitated onto zinc shavings. These were placed in an acid bath the remove the zinc, the sludge then smelted to produce gold bars. The gold in the deeper pyrite-rich ore was too refractory to treat on site and some of this was sent to Lithgow for direct



8. One of the deep slots resulting from mining narrow veins in the Crown Historical Workings.



9. Cross section of the Crown Historic Workings (from information board).

smelting. Horizontal timber studs (stulls) were used to stop the walls of the narrow stopes caving in and these are still visible in some of the slots.

In 1906 Thomas Smith and party working between the Old Crown and Three Acre leases put down a shaft to 250 feet and struck an ore shoot 30 feet long and from a few inches to a foot in width. Several parcels of ore were treated at the Sulphide Corporation, Cockle Creek and yielded an average of 9 ounces 8 pennyweights per ton of ore. By 1907 ore was being sent to the Great Cobar Company's Lithgow works, the final parcel yielding 18 ounces per ton. In 1908 one parcel of ore treated at Lithgow returned 19 ounces per ton. A new shaft was sunk to aid ventilation and facilitate ore handling. The width of the reef was 8 feet. At lower levels the reef contained up top 5% copper.

The last of the new pits on the walk is the Bobby Burns pit, mined between March 2001 and May 2002. From this hole 430,000 tonnes of ore and 320,000 tonnes of waste rock were removed for a return of 14,000 ounces of gold. At the edge of the pit lies a large boulder of siliceous ore consisting of quartz and iron oxides plus microscopic particles of gold. This came from the surface outcrop and could not be blasted. It weighs 30 tonnes and contains two ounces of gold!

Report by Brian England.
Photographs by Brian England and Ron Evans (Proprietary pit below).

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Peak Hill Gold mine walking trails.

View south over the abandoned Propriety pit.

Geology and Mineralisation in the Cobar Trough and Adjacent Areas

Leaders: Brian England and Ed Zbik.
Date: Tuesday 6th to Monday 12th August, 2019.
Attendance: 22 members.

Preamble.

This was a repeat of an excursion run by the Mineralogical Society of New South Wales last June and organised by Ed Zbik, a member of both the Mineralogical Society and the Amateur Geological Society of the Hunter Valley. Ed was almost wholly responsible for chasing up the contacts for both the Mineralogical Society field trip and the Geological Society field trip documented below. We owe Ed a great debt of gratitude for his time and persistence in ensuring we had access to the sites we visited. Before both trips, Both Brian England and Ed Zbik had achieved the Mineralogical Society of New South Wales Certificate of Compliance which demonstrates superior knowledge of work safety practice on mine and quarry sites. This qualification was a very significant factor in being able to convince mine management that we were competent to take excursions onto working mine sites and active leases.

Another principal factor leading to the running of the Cobar excursion was that the Railway Ballast Quarry 59 kilometres east of Cobar was visited by Brian England and David Atkinson on their return from the Tibooburra Safari back in 2017. They were so impressed that it seemed imperative to bring Society members out to this extraordinary locality.

Background Information.

Climate:

The Cobar district has a hot persistently dry semi-arid (Köppen classification) climate with an average rainfall of 400 mm per year. Note that average evaporation is 2400 mm a year! Temperatures are typically mild in Winter and hot in summer when temperatures exceed 40°C for short periods between December and January.

Flora:

Vegetation communities are mainly composed of Red Box and Mulga woodlands on the ridges with Bimble Box species in the drainage flats. White Cyprus Pine is scattered throughout the district. There is a dense understorey of shrub species including Ironwood, Yarran, Wilga, Turpentine, Emu Bush, Hopbush and Punty Bush. Groundcover is more abundant in the drainage flats due to the extra runoff received from the surrounding ridges.

The region is home to an endemic orchid species *Pterostylis cobarensis* which is listed as vulnerable under the EPBC Act. It is a terrestrial orchid growing to 40 cm in height with between 7 and 11 narrow leaves forming a ring around the base of the plant. The 1.2 cm flowers are transparent with brown and green markings and can be seen flowering between September and November.

Fauna:

There are around 470 native animal species in the Cobar district. Birds are the most common and include emus, pigeons, honeyeaters, parrots and birds of prey. Following large rain events, the Newey Reservoir is host to an abundance of bird life. Reptiles are the next most common and include shinglebacks, lace monitors, sand goannas, plus western and eastern brown snakes. Mammals include echidnas.

A brief summary of the geology of the area visited.

The area between Nyngan and Cobar, north to Bourke, and south beyond the Lachlan River is underlain by Ordovician marine sandstone, siltstone and mudstone of the Girilambone Group laid down by turbidity currents on the continental slope and sea floor. Low energy deep water cherts are interbedded with these rocks.

The sandstone beds have been compressed and metamorphosed to a fine-grained quartzite which now forms the higher ridges to the north of Cobar. Less resistant sandstones form ridges along the Barrier Highway between Nyngan and Hermidale.

Basalts erupted from sea mounts or associated with sea floor spreading also occur in the Ordovician sequence.

Around 440 Ma the Girilambone Group were folded, faulted and regionally metamorphosed by widespread compression in the Benambran Orogeny. Strongly folded examples of these rocks can be seen in the abandoned Railway Ballast Quarry on the southern side of the Barrier Highway 59 kilometres east of Cobar.

Widespread crustal extension across eastern Australia in the Late Silurian to Early Devonian (420-410 Ma) led to the opening of basins, including the Cobar Basin (a 250 km by 50 km rift valley) and the Mount Hope Trough in the areas we visited. These became filled with sediments including conglomerate, sandstone, siltstone and mudstone. Shallow water limestone reefs developed on continental shelves to the west.

Volcanism associated with this basin opening included explosive eruptions along basin margins, producing ash fall tuffs, ash flows (ignimbrites) and less violent lava eruptions. A spectacular ignimbrite containing large crystals of feldspar and quartz can be seen in the road cutting on the south side of the Barrier

Highway a few kilometres to the west of the Florida Rest Area near Mount Boppy 48.7 kilometres east of Cobar.

The basins formed in the Silurian-Devonian were subsequently deformed during a compressional phase in the Middle Devonian (385 Ma) and the outcrop in the New Cobar pit on Fort Bourke Hill shows the resultant dip of strata in the Cobar Super Group. During this deformation the copper-gold deposits of the Cobar district were formed in association with faults which allowed deep crustal fluids to penetrate the upper crust and carry up metal sulphides.

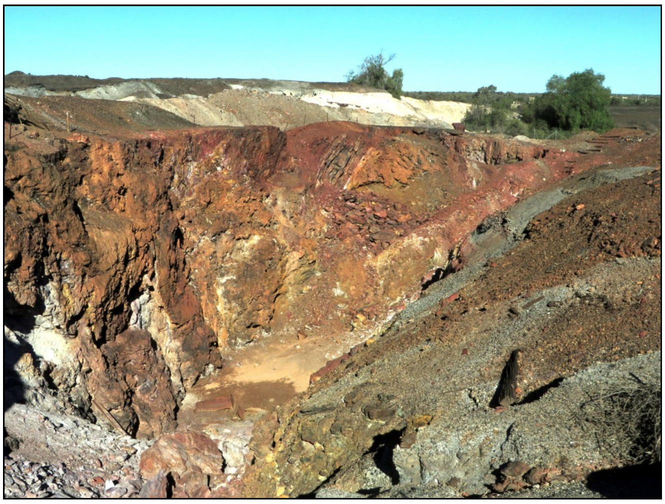
Distinct suites of granites were emplaced during the Silurian and Devonian.

The prominent ranges at Mount Grenfell are made up of quartz-rich fluvial sandstones of the Mulga Downs Group deposited during the Devonian (410-360 Ma). This was a high energy depositional environment, probably a braided river or delta front. The resulting sedimentary rocks have since been folded to produce open folds characterised by shallow-dipping beds.

The view from Fort Bourke Hill looks out over the Cobar peneplain, a low undulating plain with rolling downs, flat plains punctuated by stony ridges and ranges of folded Ordovician sediments. The low rainfall the area receives results in creeks where water flowing from ridges onto the peneplain only rarely enters major rivers, such as the Lachlan.

The mineral deposits in the Cobar Field are typically polymetallic, ranging from Au-Cu-Pb-Zn at the Peak, Au-Cu at New Cobar and Chesney, and Cu-minor Au at Great Cobar and Gladstone. Gold mineralisation occurs in discrete lenses within the base metal zones and is apparently restricted to two shear zones - the Great Chesney Fault and the Peak Shear System. All the Cobar deposits are structurally controlled and were

1. The Great Cobar Museum and Heritage Centre with the Mullock Tank in the foreground.



2. Great Cobar open cut.

probably emplaced during deformation and inversion of the Cobar Basin in the Early Devonian (402-385 Ma).

The deposits occur within high strain zones, usually in areas of intense cleavage, shears and faults. In detail, mineralisation is localised within dilations formed along competency contrast contacts, for example sandstone/slate contacts. The deposits are steeply dipping and pipe-like with short strike lengths, narrow widths (10-30 m) but very significant vertical extent. In general, the Cobar deposits are characterised by multiple lenses with relatively complex geometries.

This has been compiled from several sources, but principally from: STEGMAN, C. and POCOCK, J. (1996). *The Cobar Goldfield - A geological perspective.* In: COOK, W.G. et.al. The Cobar Mineral Field - a 1996 perspective. The Australasian Institute of Mining and Metallurgy, Melbourne, Spectrum Series 3/96, pages 229 -264.

Tuesday 6th August.

The Cobar excursion followed immediately after the Peak Hill field trip, the same group of people making their own way via Narromine to Cobar, passing through countryside showing the effects of the prolonged drought affecting vast areas of the state. Everyone arrived at the Cobar Caravan Park with enough daylight remaining to set up camp before dinner. Most self-catered while a few walked down to the Great Western Hotel.

Wednesday 7th August.

Most of the group spent the morning in the Great Cobar Museum and Heritage Centre located in the former administration building of the Great Cobar mine *(photo 1)* at the eastern edge of town overlooking the large open pit, now partly filled with water. This pit, often called the mullock tank, was not part of the Great Cobar mine but acted as a quarry providing rock to backfill the underground mine stopes to continually build up the floor level so the miners could keep working the copper ore above. It was dug by hand with pick and shovel to a depth of 430 metres.

The Great Cobar mine opened in 1871 and at its peak 14 smelters were in operation, serviced by a 64-metre chimney. It employed over 2000 men. Between 1876 and 1919 the mine produced 114,809 tonnes of copper and 9670 kg of gold plus 46,700 kg of silver (Stegman and Stegman, 1996). The actual Great Cobar open cut, not visited on this trip, is located several hundred metres to the south at the southern end of the huge slag dump *(photo 2)*. The fortunes of the mine collapsed after World War I when the world wide demand for copper dropped. It ceased operations in March 1919.

The history behind the Great Cobar Museum and Heritage Centre.

The building was designed to be the new administration offices for the Great Cobar Copper Mine and was completed in 1912, the first pay going out from the building on Saturday 23rd March of that year. The men lined up at the pay office window which still exists at the back of the building. But this era lasted only 7 years and when the mine closed in 1919 the building was abandoned and left derelict. Many people were leaving the town and many of the buildings were moved to other places. Houses were taken away by train and tenders were put out for the sale, scrapping or demolition of the mine infrastructure. Bits of Cobar were transferred to Newcastle, Sydney, Wollongong, Dubbo and Wagga. This building was saved from a similar fate by Mayor Patrick Condon. After he died in 1930 his widow sold it to Elizabeth Bannister and it was converted to living quarters which became known as Bannister's Flats.

4. Two of the Bessemer converters in operation at the Great Cobar Smelter.

The flats were occupied by couples and families of various size and ages. Notice of vacancies spread by word of mouth and were quickly taken up despite the lack of amenities. Water had to be hauled to the upstairs flats in a bucket on a rope and the toilets were in the back yard. All washing and bathing was done in an outdoor communal washhouse. There was no cooling and residents slept on the balcony on warm nights under a dampened sheet. The flats had stoves for cooking and heating. Food was kept cool in ice chests with the blocks of ice coming out from Nyngan on the train. The ice had to be carried home from the freezing works in East Cobar and then lugged upstairs. Kids enjoyed sliding down the bannisters or sliding down the stairs in a metal tub! The flats were small and inconvenient but offered a cheap option when accommodation was scarce. The building became empty again in the 1960's

3. One of the Bessemer converters rescued from the slag dump.

5. The headframe of the Chesney No. 2 shaft.

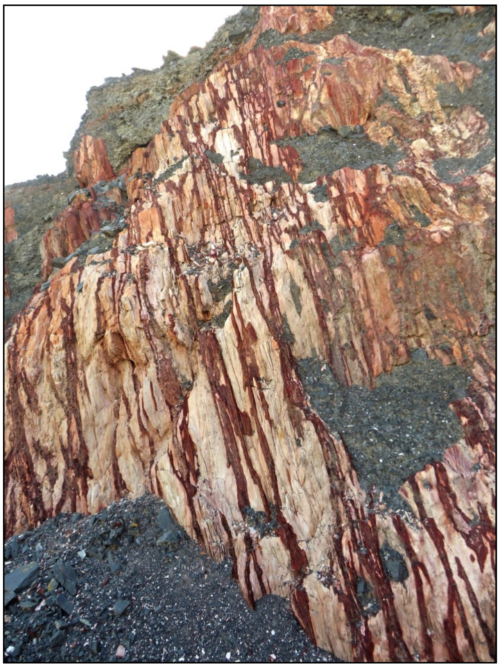
when Mrs. Bannister moved to Sydney. Many locals remember playing in the deserted rooms and swimming in the adjacent open cut. It was a favourite pastime to go up to the haunted house at night and scare the bejesus out of friends.

A new life came in the 1960's when the CSA mine used the building as a boarding house for some of the contractors. By then plans were being made to convert it into the Cobar Mining and Pastoral Museum and it has been the Great Cobar Heritage Centre since 1969.

People were left free to explore the Museum at their own pace. Some who had seen the displays on previous visits headed off to Mount Grenfell Historic Site as they had to head for home the following Monday when the visit to Mt. Grenfell had been scheduled. The only requirement was that everyone assemble at the car park adjacent to the refurbished Chesney No.2 shaft south of Cobar on the Kidman Way at 2 pm precisely, wearing all the required personal protective equipment in preparation for our surface visit to the Peak Gold mines leases. Hard hats, yellow vests or shirts, steel-cap boots and safety glasses would be mandatory.

Beyond the entrance foyer, which houses a small gift and book shop, is room after room of very informative historical displays, with the top floor (up the original wooden staircase) devoted almost entirely to geology and mining plus a comprehensive history of the local wool industry. The local copper/gold mines, including Endeavour (Elura), CSA and Peak Gold mines (operators of the New Cobar, Chesney and Peak mines) had contributed fascinating displays of their operations, including videos of their ore processing operations. Sadly, we arrived just a few days before the huge Endeavour mine was about to close due to depletion of ore reserves. Also housed in an upstairs room was a large display of local rocks and minerals.

6. Historic workings near the Chesney No. 2 shaft. Note the remnants of the timber working platform.



7. Leached orebody outcrop in the old open cut at the Chesney mine.

Accessed through a door at one side of the entry foyer we found a large outdoor display of old farming and mining machinery, including two of the Bessemer converters *(photos 3 & 4)* recently recovered from the slag dump south of the Museum. These were used to convert the smelted copper sulphide matte to blister copper which was cast into rectangular anodes for electrolytic refining. It was called blister copper because of the blisters formed on the surface of the molten metal as the sulphur escaped as sulphur dioxide.

Everyone arrived at the Chesney mine all kitted out well before 2 pm. The Manager of Peak Gold Mines, Neal Valk, had arranged for their Environmental Officer, Laura Barnes, to act as guide for the afternoon. Before proceeding through the gate, Laura handed out safety glasses to those who had none. We were then led up past the headframe of the No. 2 shaft *(photo 5)*, now used as the main ventilation shaft for the New Cobar

8. View down across the New Cobar open cut on Fort Bourke Hill.

underground workings. In groups of four we were then led a few hundred metres up the western side of a backfilled open cut to a point looking down into the spectacular depths of some of the historic workings *(photo 6)*. The remnants of a timber platform used by miners to work overhand on the orebody above them were clearly visible. Open cut workings like this were common along the mineralised zone between the Great Cobar mine and Peak Gold mine 8 kilometres to the south back in the early years of the Cobar Goldfield.

While waiting their turn, others in our group were able to examine the north wall of the partly back filled open cut where there is an excellent exposure of the upper leached zone of the orebody, the Great Cobar Slate host rock having been leached white and veined with secondary iron oxides (goethite) *(photo 7)*. This open cut also provided good fresh exposures of the Great Cobar Slate, a light to medium grey strongly cleaved rock, in places laced with veins of white quartz. Due to time constraints we did not explore the historic ruins on the eastern side of the ridge as I knew from a visit with the Mineralogical Society a few weeks before that there was very little of geological interest there.

After farewelling Laura back in the carpark, we drove a few hundred metres back towards Cobar and parked beside Kidman Way, then began walking south along a track to the top of the rise. Here, enclosed by a wire fence, we found the rehabilitated dumps of the Gladstone mine to which we had been given unrestricted access by Peak Gold Mines. All we had to do was work out the intricate locking mechanism on the gate, which we eventually did. Then an hour or so was spent closely examining the contoured rows of mine mullock spread out down the slope. This configuration, borrowed from farm planning, was designed to restrict water runoff and resulting heavy metal contamination of the adjacent scrubland, with a small dam at the base of the area to catch any runoff that did occur after heavy rain. All shafts had been back filled and marked by a small mound of mullock, each enclosed by a fence and labelled as a historic shaft with an assigned number. The prime purpose here was to locate the rest of a specimen of suspected atacamite crystals found during the Mineralogical Society field trip the previous June. The search was unsuccessful but we did find good examples of fibrous malachite and massive cuprite.

Recently rehabilitated by Peak Gold Mines, the Gladstone mine was one of the principal early copper mines on the Cobar Field. Producing 2000 tonnes of copper from 33,340 tonnes of ore between 1908 and 1920, mainly from secondary (oxidised zone) ores. The orebody was in the form of a brecciated quartz vein. Above the water table (in the oxidised zone) azurite, malachite and cuprite occurred with hematite and limonite (goethite). Below the oxidised zone the supergene enriched zone yielded several small but very rich patches of chalcocite/chalcopyrite. This passed into low grade primary chalcopyrite ore at depth. No gold was present in this deposit.

9. The processing plant at the Manuka silver mine.

10. Group photo at the Manuka processing plant.

11. Wilfley tables for gravity separation at the Manuka processing plant.

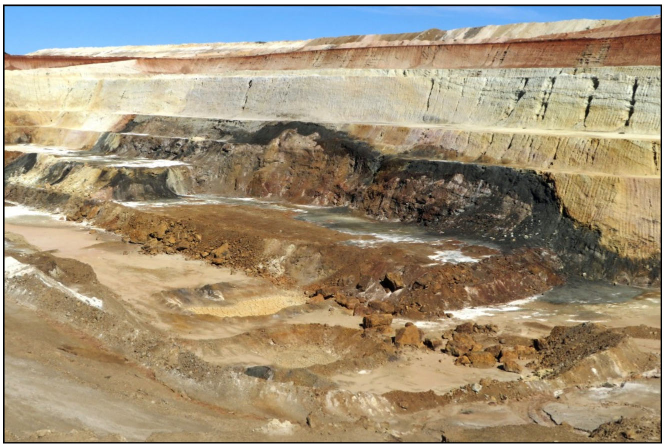
At 4:30 pm we drove back towards Cobar and then up the sealed road to the lookout on Fort Bourke Hill where an enclosed viewing platform allowed us to peer down into the depths of the New Cobar Open Cut *(photo 8)*. A series of display boards in the enclosure provided details on this mine and others in the Cobar Basin. Much of this information has been reproduced in this report. It was cold with a very strong wind making the conditions even more uncomfortable and the light was very poor for photographs.

The New Cobar mine lies on the western margin of Fort Bourke Hill which is an erosional remnant hardened by quartz veining and silicification. It began as a small open cut in the late 1890's. Between 2001-2 the pit was extended to a depth of 150 m, 200 m wide and 380 m long. It is classed as a medium size open cut. To enlarge the pit a total of 3.6 million tonnes of rock was removed and stockpiled on the western flank of Fort Bourke Hill.

The pit exposes the upper and lower oxidised zones in saprolite (dated at around 189 Ma) and the supergene zone just above fresh rock and primary ore, which is sediment-hosted and shear-zone controlled. The lode comprises a stockwork of pyrrhotite-chalcopyrite-gold veins that overprint an older quartz-magnetite vein stockwork lying wholly within the Devonian Great Cobar Slate. Both stockworks have gradational margins. The mineralisation is hosted by a splay fault and adjoins a flexure on the Fort Bourke Fault (McQueen, undated). The prominent quartz vein visible in the wall of the pit marks the position of the Great Chesney Fault, a prominent feature which extends south to the Chesney and New Occidental mines. The access tunnels alongside the vein were dug from the late 1800's to the early 1900's to access gold and copper ore.

Underground mining at New Cobar began in

12. Site manager in the casting room at the Manuka processing plant.



13. Stratigraphy of the Manuka deposit revealed in the Boundary pit.

2004 via a decline accessed by a 5.5 x 5 m portal at the base of the pit. This allows access for a single truck, with passing cubbies off the main decline. Around 200 loads of ore are brought to the surface from the decline each week and placed on New Cobar's ROM (Run of Mine) pad. There it is crushed and then trucked south at the rate of 500 tonnes per week to the Peak mine where the processing plant is located.

Thursday 8th August.

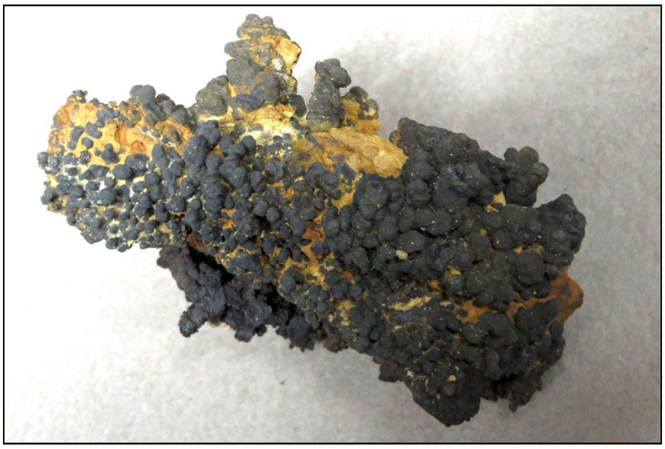
The group assembled in six vehicles at the Cobar sign at the start of Kidman Way on the eastern side of town for an 8 am start in convoy down to the Manuka silver mine 90 kilometres south of Cobar.

At the Manuka Road turnoff, we made sure everyone had caught up before beginning the 22 kilometre of dirt road to the Manuka mine. With the numbers of wildlife (kangaroos and emus) well down compared to last June, the main problem for drivers was the copious amounts of dust thrown up from the very dry powdery road surface.

We arrived at the Manuka (formerly Wonawinta) property at 9:20 am to find the gate had been left open for our visit. Driving on past the homestead and mine camp we found site the manager John going about his daily checks around the processing plant. Our visit had been given the go ahead by Manuka mine Management a week prior. John ushered us into one of the meeting rooms in the small office complex and gave a brief site induction and safety talk before giving us the OK to explore this vast mining site.

The Manuka mine is the largest and most recently developed silver mine in Australia with a resource estimated at 52 million ounces of silver (Harris, et.al., 2017) at an average grade of 96 g/tonne and 236,000 tonnes of lead. Initially Geopeko Ltd./Norgold Ltd. detected a number of anomalies on Wonawinta Station during a regional geochemical survey in the 1980's and subsequent drilling by Cobar Consolidated Resources outlined the large near-surface supergene silver resource, with the first mining commencing in 2011 (Gilmore, 2016). The mine was further developed by Black Oak

14. Goethite gossan from the Boundary pit showing chalcophanite microcrystals lining shrinkage cracks. Specimen is 11 cm across.



15. Colloform manganese oxide sample from the Boundary pit. 8 cm.

Minerals before being taken over by Southern Cross Goldfields, then in 2015 by Manuka Resources. The 180,000 t/pa processing plant *(photo 9)* began operation in August 2012 after an investment of $60 million.

Much of the plant was sourced from other operations, including one ball mill for fine grinding coming from the Ardlethan Tin mine and Wilfley tables and spirals for gravity separation sourced from heavy mineral beach sand operations. Neither the tables nor the spirals had yet been used. The plant began with a 72% recovery rate using carbon in leach technology with the silver recovered from the carbon using hot sodium cyanide solution and crude silver dore produced on site. This plant is also used to process gold ore from the Mount Boppy gold mine near Canbelego, where mining of this historic deposit recommenced in March 2015. The site generates its own power and there is an on-site reverse osmosis plant for producing drinking water.

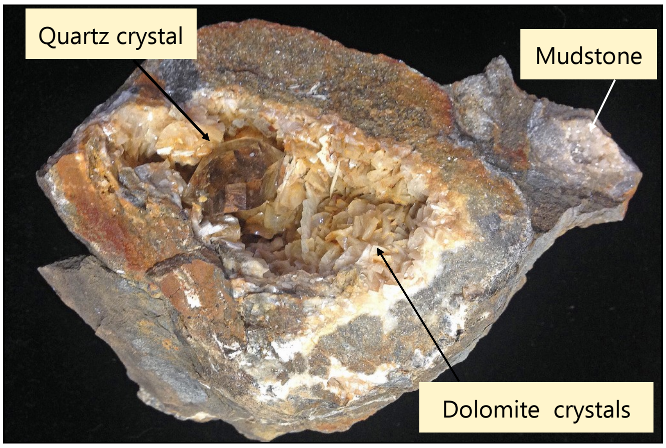
Our visit began with a very comprehensive tour of the plant *(photo 10)*, from fine grinding in the ball mill currently loaded with Mount Boppy ore, to gravity separation *(photo 11)*, CIP leach tanks, metal recovery columns, filter beds, and finally the gold/silver room where the molten metal is poured into moulds to produce bars *(photo 12)*. The last monthly production run before the operation was put on hold due to low silver prices was 6 tonnes of silver! John proudly showed us a group photo of the mine staff posing behind the large stack of silver bars wrapped in black plastic ready for shipment.

16. The Main pit largely hidden from view.

17. Smoky quartz crystal from the Main pit at the Manuka mine. Specimen 5 cm.

18. The best smoky quartz crystal from a previous visit still embedded in clay. Specimen 8 cm.

19. Quartz crystal on white barite crystals. Specimen 5 cm.

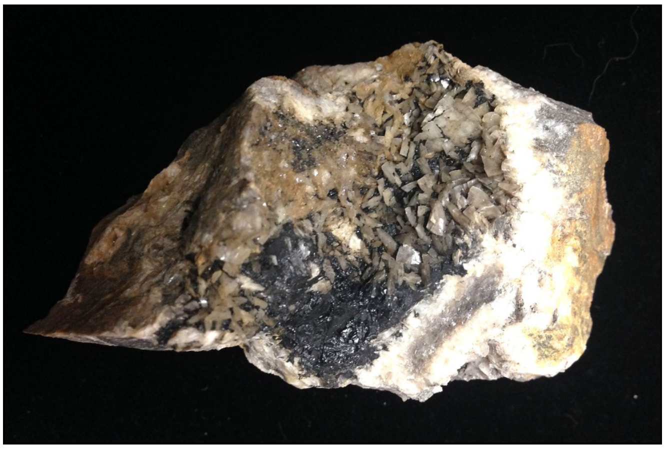


20. Crystal of smoky quartz in situ in a dolomite lined cavity in dolostone nodule with some of the host mudstone attached. Specimen is 10 cm.

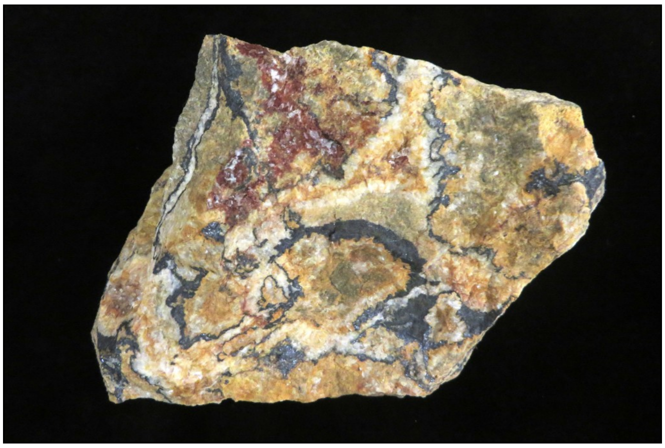
We were extremely fortunate in being the last group allowed on site before re-starting of the plant in just a few weeks, after the price of silver had begun to climb. There are large stockpiles of both silver and gold ore on site and more gold ore would be coming in from Mount Boppy once the pit there had been de-watered sufficiently for extraction to re-commence. Although the plant had been kept in operating order for the three years since shutdown, a considerable amount of work would be required to get it back into full production and prior to that the tailings dam would need to be raised 1.5 m to allow safe storage of new tailings. Also, heavy storms in February and March had done serious damage to mine infrastructure, especially access roads to and into the main pits.

It was well over an hour before we left the plant and already I had picked up a very nice smoky quartz crystal from the road base. Now everyone had smoky quartz crystals in their thoughts as John led us off via a side tack to the western end of the Boundary pit, the smallest of the operating pits. This had been a good source of smaller crystals on previous visits. We had intended to pause for morning coffee amongst the forest of tall eucalypts along the way but the wind was so strong and cold that this idea had to be abandoned. But at least the wind kept the annoying flies away.

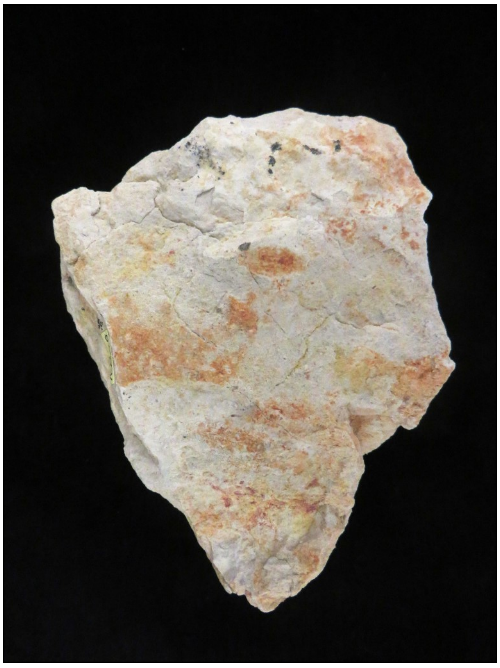
Initially we drove to a point overlooking the main Boundary pit where the different layers in the deposit could be seen clearly *(photo 13)*, from the overlying dark brown regolith (soil), through the leach zone, the dark oxidised zone comprising mainly iron oxides, to the light coloured saprolite ore horizon below, the yellowish areas having the highest silver values. We then moved on to the smaller western extension of the pit where we had some success looking for quartz crystals. Also found here were interesting examples of gossanous material from the oxidised zone with syneresis (dehydration) cracks lined with brilliant but tiny crystals of hematite *(photo 14)* and examples of black colloform manganese oxides *(photo 15)*. But now hunger was getting the better of us and in desperate search for a sheltered spot we pulled the vehicles into the edge of



21. Black bitumen associated with gypsum, coating a dolomite crystal cavity lining. Specimen is 7 cm.



22. Colloform galena-sphalerite-dolomite in dolostone breccia. Specimen is 11 cm.



23. Massive saprolite ore. Specimen is 12 cm.

the access ramp for a late morning coffee/early lunch. Meanwhile John drove off to check the access roads into the main pit.

Only 20 minutes was allowed for lunch and at 1 pm John returned to guide the vehicles down into the main pit *(photo 16)* where he left us parked in the large cleared area above the pit floor where the Mineralogical Society group had found the best specimens last June.

The rest of the day was spent here searching over the exposed surfaces quite successfully for the smoky quartz crystals the mine had become internationally famous for *(photo 17)*. There was also an abundance of dark brown dolostone boulders around the edge of the area, blasted ready for removal to expose the underlying silver-rich saprolite layer.

This had been my third visit to the Manuka mine. On previous visits I had concentrated on collecting the quartz crystals, picking up over 400 specimens on each visit but keeping only the very best *(e.g. photo 18)*. However this time I concentrated on breaking up selected dolostone boulders which showed an abundance of crystal-lined cavities in a search for micromount specimens, minute crystals that are best examined under a binocular microscope at between 10 and 30 times magnification.

The most interesting and productive boulders comprised hollow ovoid bodies of dense dolostone up to an observed 30 cm diameter scattered through a dark grey foliated mudstone. The location of this rock type in the mine stratigraphy is unknown but it may be from mudstone bands known to occur within the dolomitic layers in the Booth Limestone. The initial search produced spectacular specimens of dolomite and barite crystal lined cavities , some with smoky quartz crystals remaining in situ *(photos 19 & 20)*. In most of the cavities exposed, fully-formed quartz crystals showing a variety of weird shapes and groupings simply fell out, having no point of attachment to the cavity walls. This immediately led to the conclusion that the quartz crystals grew suspended in watery fluid as the penultimate (prior to calcite) mineral to crystallise out. The size and shape of the crystals and groups appears to have been controlled by the size and shape of the cavity, with the crystal(s) growing to conform to the shape of the space available.

Around 30 kg of potentially productive material was loaded into the back of the Forester, with David at times wondering if he would have to catch a bus back home from Cobar! A few weeks after returning home this had proved an excellent strategy. Carefully breaking down the dolostone to expose all the cavities present revealed astonishing micromount specimens of quartz, dolomite, calcite, barite and siderite, all exquisitely crystallised.

People began to leave the mine around 2:30 pm, while I continued assaulting dolostone boulders till 3:45, determined to collect what I could on what would probably be my last ever visit.

Some took the "back road" when returning to

Cobar, continuing directly on at the T-intersection. The first 32 km of this road was dirt and a bit rough and corrugated in places, but then good bitumen the rest of the way. Again virtually no wildlife was seen, although there were a few goat herds, but at least they had a bit more road sense that the emus and kangaroos!

Geology of the Manuka mine.

The Manuka deposits are located on the Winduck Shelf in the Cobar Basin, lying within the Palaeozoic Lachlan Fold Belt. The Booth Limestone Member is the principal host for the mineralisation and forms part of the Gundaroo Sandstone within the Early Devonian Winduck Group, representing a period of reef and platform sedimentation. The ore horizons are located in dolostone, which is overlain by black pyritic shales. In the mine area these sediments were deposited on the underlying Thule Granite dated at 427 Ma (Harris, et.al., 2017).

The mineralogy of the deposit comprises galena, sphalerite, dolomite, barite, calcite, quartz, bitumen and gypsum, the latter two commonly associated in cavities in the dolostone *(photo 21)*. The sulphides are rarely seen but have been observed as colloform layers in areas of coarse dolostone breccia infilled by secondary dolomite *(photo 22)*. The silver is probably present in the saprolite ore as a greenish-yellow silver halide, perhaps bromargyrite (AgBr) (Brown, et.al., 2017). Mercury has also been produced from the deposit, probably occurring as the sulphide cinnabar. The principal ore horizon lies within massive saprolite claystone beds *(photo 23)* formed by intense acid leaching of the dolostone by acid released from the weathering of pyrite (Harris, et.al., 2017). The dolostone protore is not considered ore grade.

The association of gypsum with bitumen was one factor leading to the dolostone-hosted primary sulphide precursor of the saprolite ore being classed as Mississippi Valley Type (MVT) in part. In MVT deposits the low temperature mineralising solutions which scavenged the metals are similar to oil field brines in chemistry, being typically high in sulphate, CH_4, organic compounds and hydrocarbon droplets. The deposits are typically hosted in dolomites (dolostone) associated with coral reefs. Hence the crinoidal reef limestone exposed in the main pit at Manuka and nearby. Tectonic processes have channelled the brines through the carbonate host along faults, breccia zones, folds and collapse structures. Most MVT deposits are associated with fossil carbonate platforms in foreland basins. Fluid pathways are typically gravity driven from a tectonically elevated region down through a topographically lower host carbonate horizon (Robb, 2005). The Manuka deposit has been subjected to repeated tectonic episodes which is reflected in the complex mineral paragenesis and multiple episodes of quartz crystallisation.

Friday 9th August.

The group again left in convoy from the big Cobar sign on the eastern edge of town at 8 am, heading south on Kidman Way but then turning east along the Nymagee Road. It had dawned cold and cloudy with occasional light falls of rain appearing as we approached Nymagee.

When the Nymagee copper mine was in full production in the early 1900's the town had a population of 2200, half of whom were Chinese migrants. The old town is now only a shadow of its former self, with a current population of 100 (2016 census) and an Hotel, Post Office, Police Station and a few houses the only structures remaining. Nymagee is home to "Clancy of the Overflow" written by Banjo Paterson.

At the Pub we turned left into Graham Street and drove up to the gate at the entry to the Nymagee mine lease area. The Mine Geologist from the Hera gold mine 5 km to the south had left the gate open for our visit, which was prearranged with the Management of Aurelia Metals (formerly YTC - Yunnan Tin Company - Resources). We drove up he hill past the scant remains of the Mine Manager's house, now just a pile of bricks to the right of the track, and parked on the north side of the northernmost open cut where there was a flat area large enough to park all 6 vehicles away from any access track. It was immediately obvious that a significant amount of test drilling had been undertaken since my last visit in June to further test mineralisation at depth below the historic workings. There were no rigs on sight at the time of our visit though. The Nymagee copper/ gold project is 95% owned by Aurelia Metals who purchased the mine from CBH Resources in 2009. Mineralisation is known to be open at the northern end of the lease and at depth below the old workings, with a current reserve estimate of 8.1 million tonnes.

On the 5th of June 2019 the Australian Mining Journal announced that Aurelia Metals had placed the Nymagee Project on hold. Recent testing had shown that contaminants, particularly talc and the iron sulphide pyrrhotite, may render scoping study base metal recoveries unachievable. The deposit was envisaged to be another "Cobar giant" with the mineralisation bearing a strong resemblance to the massive CSA deposit north of Cobar. The more recent drilling program was part of further exploration and scoping work and Aurelia Metals may revisit potential mining in the future. When eventually mined, the Nymagee ore could be processed at the current Hera mine operation.

History of the Nymagee Copper Mine.

Copper was found at Nymagee by Henry Manley and his mate Bryson in September 1876 while minding sheep near a small hill. A month later Manley applied for a conditional purchase of 80 acres. One of the major shareholders in the Great Cobar mine, Russell Barton, was so impressed with the outcrop that he bought it in 1880 for 1200 Pounds and formed the Nymagee Copper Mining Company in March that year. Captain John Wills was appointed Manager and three shafts were commenced on the West Lode and one on the East Lode. Four Reverberatory furnaces were built for smelting of the rich carbonate and chalcocite ores that had been found to extend to a depth of 48 metres.

By February 1885 the mine employed 109 miners and 200 woodcutters and carters and by 1885 was consuming 52,000 tons of wood annually to fuel the 11 furnaces, two calciners and the boilers for the steam engines used to power the mine machinery. The town of Nymagee developed at the foot of the ridge around that time. The mine was successful till 1893 when it closed due to low copper prices. It was re-opened and worked on tribute in 1895 and was then purchased by the Great Cobar Company in 1896. The new Management installed a blast furnace and subsequently established partial pyritic smelting practice; a very energy efficient smelting technique developed by Robert Carl Sticht at the Mount Lyell mine in Tasmania in which heat for smelting is provided by oxidation of the pyrite in the ore. The reverberatory furnaces were retained for matte roasting to remove the sulphur as sulphur dioxide. In December 1906 the operation was sold to a group of British investors who formed the Nymagee Copper Limited Company. Smelting recommenced in October 1907 and in August 1908 the nearby Crowl Creel and Shuttleton mines were brought into production to provide siliceous ore (as flux) to blend with the Nymagee ores.

Lower copper prices, cost of transport and failure to convince the Government to build a branch line from Hermidale to Nymagee, made the mine unprofitable and it closed in 1908. The mine lay idle till 1912 when it was taken up by the Mouramba Copper Mine Limited. With the workings dewatered and new plant installed, smelting began again at the end of 1913. However, shortly after operations were again suspended due to drought and the uncertainty in the international copper market after the declaration of war in September 1914. Mining recommenced in 1915 after the copper price rebounded and continued till 1917 when the mine closed for the last time (McQueen and Davies, 2016; McQueen, 2017).

Geology of the Nymagee mine area.

The Nymagee copper deposit is comparable in size to others on the Cobar Field. Production during its working life amounted to 24,800 tonnes of copper from 428,986 tonnes of ore (Gilligan, 1974). Lead, zinc and silver were not produced even though substantial quantities of these metals occurred in the ore. These metals probably reported to the slag during smelting.

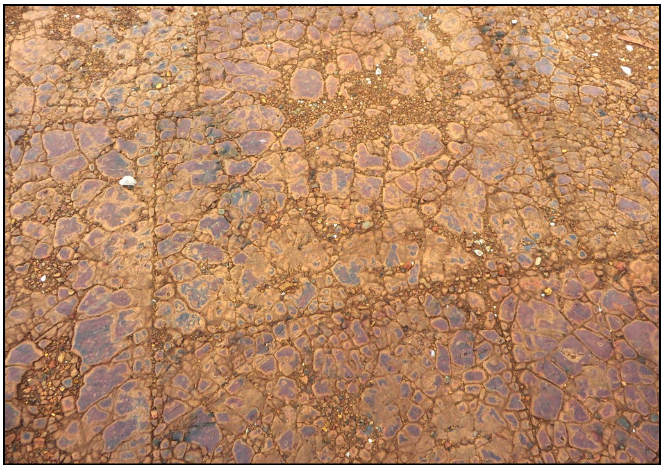
Mineralisation occurs in a west-facing and dipping deep water turbidite sequence of siltstone and sandstone belonging to the Early Devonian Lower

24. Historic shaft beside the open cut at the Nymagee copper mine.

25. Row of concrete tanks used in the mid 1950's to extract copper from mine water by the cementation process. Note the piles of scrap iron used for precipitation.

26. Ruins of the smelter at the Nymagee Coppermine.

27. Examining the Blackstone oil engine (right) and the Ingersoll Rand compressor (left).



30. A section of the old slag floor at the site of the Nymagee copper smelter.

28. Bosh ring from the blast furnace filled with broken up slag.

31. Lava-like patterns in cooled slag.

32. Oxidation patterns in slag.

29. Crinoid stems on the weathered surface of local limestone.

33. Mould of a slag pot in the slag dump at the Nymagee smelter.

Amphitheatre Group. The siltstone has a well-developed slaty cleavage due to the mine sequence lying on the western limb of a large anticlinal fold.

The mineralisation is very similar in rock associations and mineralogy to Cobar-type deposits, hosted at Nymagee by strongly cleaved turbidic sedimentary rocks in zones of high strain. It has been suggested that the orebodies are sediment-hosted syngenetic in origin and have been strongly remobilised physically or hydrothermally.

There are three main zones of mineralisation in an area 750 m along strike by 250 m wide. These zones are conformable, or nearly so, with bedding in the enclosing sediments. The East Zone is Cu-rich while the west zone is Zn-Pb rich. The Main Zone contains both ore types. Samples of galena (PbS) can be found on the

34. Scrap steel scavenged from the blast furnace site,

35. Sheltering from an icy wind.

36. Ellen and Ron having lunch at the Nymagee copper mine.

dumps of the Whip shaft. The principal primary copper mineral was chalcopyrite associated with lesser pyrrhotite. The deposit had a surface oxidised zone extending to a depth of 48 m in which the basic copper carbonates azurite and malachite formed the main ore minerals. Below this was a supergene enriched zone extending to below 37 m, from which most of the ore was produced. Below that lie largely untouched primary sulphides which may provide a major resource in the future. Iron oxides (hematite and goethite) are abundant on the surface as gossans, representing the surface weathered expressions of the underlying orebodies (Suppel and Gilligan, 1993).

The Society's exploration of the Nymagee mine area.

The original intention was to explore the mine dumps on the ridge to the north but as most of the group had already headed off south towards the smelter ruins, that plan was shelved till after lunch.

Two large and very deep open cuts extend along the western side of the ridge, with copper mineralisation still visible in the walls. Access to these workings is prevented by very secure wire fences so photography of these impressive mine remnants was not possible. A line of shafts along the western side of the cuts *(photo 24)* were probably used for ore haulage since no access ramps into the cuts were visible. Several outcrops of hard dark brown limonitic gossan also occur along the edge of the open cuts, just outside the fence line. Nothing of mineralogical interest was found in any of these outcrops, virtually everything apart from iron having been leached from them.

Just south of the large main shaft opening, now covered by a metal grate, we found a line of small concrete troughs *(photo 25)* once used to extract copper metal from mine leachate by the cementation process in which the copper was precipitated out on scrap iron, piles of which were found alongside the troughs *(also photo 25)*. Cementation was a popular means of extracting copper at minimal cost from abandoned copper mines in the period 1949-1965.

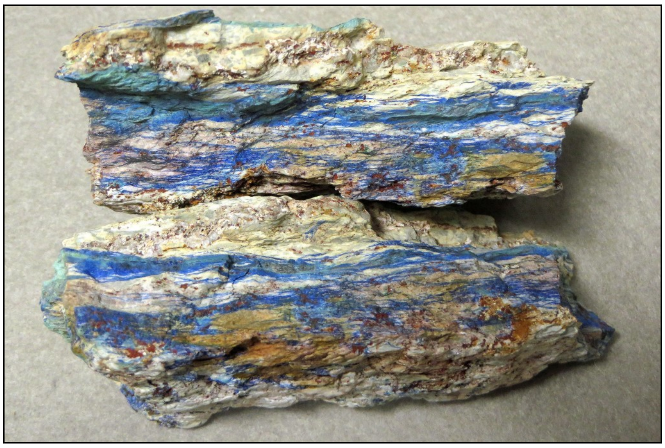
Over the years the historic smelter site had been reduced to a pile of bricks and scrap iron *(photo 26)* but on the immediate southern side of the ruins came a real technological surprise. Probably too heavy and bulky to be reclaimed as scrap, two huge machines stood intact adjacent to the northern wall of a large concrete and brick-lined pit *(photo 27)*. One, a diesel/fuel oil Blackstone single cylinder engine made in Stamford, England, had been positioned to drive a nearby Ingersoll-Rand compressor used to provide the air blast for the blast furnace located just a few metres to the west *(photo 28)*. These historic dinosaurs caused much on site discussion. Scattered cobbles of locally sourced limestone used as a flux in the smelting process showed spectacular crinoid stems and ossicles on weathered surfaces *(photo 29)*. Out over the flat surface of the huge slag dump along the western side of the mine area lay

37. Slump bedding in chert from the Whip Shaft, Nymagee mine. 10 cm.

38. Outcrop of distal turbidite beds near the Whip shaft, Nymagee mine.

39. Close up of turbidite outcrop showing distinct C and D Bouma beds.

40. Flute marks on a bedding plane in the turbidites.



41. Azurite veins in slate from the Blue shaft at the Nymagee mine. Specimen is 9 cm.

more surprises. At most of the early metal smelters it was common practice to use the first slag pours to cast a series of adjacent square or rectangular blocks on a levelled surface to provide a hard working floor and this was certainly done at Nymagee *(photo 30)*. Later, the slag pots were simply wheeled to the edge of the slag dump in hand-pushed trolleys and tipped over the edge while the slag was still molten, resulting in spectacular patterns resembling those seen on the surface of cooled basaltic lava (pahoehoe) *(photo 31)*. Occasionally the slag had solidified in the pot before it could be tipped out, resulting in conical moulds of slag pots scattered throughout the solidified molten material *(Photo 33)*. After over 100 years of natural weathering in this semi-arid climate the slag on the surface of the dump shows intricate oxidation patterns along dehydration crack networks *(photo 32)*.

Out on the flat in the centre of the slag dump some distance from the smelter site, we found a huge rusting metal sculpture unintentionally created by dumping steelwork scavenged from the blast furnace structure, probably in preparation for intended recycling that never eventuated *(photo 34)*. Here some members took meagre shelter from the icy wind in part of the circular steel shell of the blast furnace *(photo 35)*.

After lunch *(photo 36)* back at the vehicles, we walked to the north along the track to the dumps of the Whip shaft where a large variety of rock types associated with the copper mineralisation could be examined. These included an astonishing example of slumped bedding in a banded chert *(photo 37)*, small pieces of massive fine-grained galena/sphalerite, and very heavy pieces of dark brown limonite gossan rich in cerussite, the lead carbonate, from the oxidised zone of the orebody.

However, Ron came up with the most interesting find here, a small outcrop of sea floor turbidites just to the west of the Whip shaft dump *(photo 38)*. The outcrop was well-banded *(photo 39)* with only the C and D units of the Bouma sequence represented, suggesting deposition was distal from the source of the turbidity flow. The fine sandy basal C unit showed well preserved ripples and cross bedding structures while the upper D unit comprised finely laminated mud deposited from settling of fine suspended material. This sequence was repeated several times over the vertically-dipping outcrop. Nearby outcrops showed very strong purple manganese oxide staining. Also present in these rocks were clearly-defined raised subconical flute marks, one end typically bulbous, the other flaring out and merging with the bedding plane *(photo 40)*. These were formed by subsequent sediment filling of erosional scours on the surface of the bed.

From the Whip shaft we continued up the track to the small dump of the back-filled Blue shaft where blocks of schistose slate were broken up to reveal cross sections of quartz veins containing bright blue azurite and green malachite, the two secondary copper carbonates which were the main copper ores in the early days of mining. Some of the slate adjacent to the quartz veining was stained blue by subparallel anastomosing azurite veinlets *(photo 41)*. There was no point in continuing on to the top of the ridge to the Higgins shaft, sunk at the north end of the Main Lode Zone, as nothing of interest had been found on the dumps there on previous visits.

The group left Nymagee at around 2:30 pm, making sure the gate was securely fastened behind the last vehicle. The day had remained mostly cloudy with a bitterly cold wind but no rain, perfect conditions for photography. It was too late to make the scheduled visit to the nearby Crowl Creek and Shuttleton mines so everyone was back in Cobar at 3:30 pm, in time for coffee.

Saturday 10th August.

We left Cobar at 8 am, again heading down Kidman Way, but this time towards Mount Hope 160 km to the south. The day had begun cloudy and very cold, with a strong wind adding a significant chill factor. A planned morning coffee stop at the historic Gilgunnia Rest Area was thwarted by rain, whose prevalence and intensity increased the further south we drove. Barry was summarily sacked as Society weatherman by general consensus, although we found out later that night that Cobar city had remained dry all day!

Only scattered hills of volcanic rocks of the Late Silurian/Early Devonian Mount Hope Group (Cobar Special 1:500,000 Metallogenic Map) broke the monotony of the flat country between Cobar and Mount Hope.

We reached the Pub at Mount Hope at 10 am in moderately heavy rain, with no sign of the bad weather lifting. Drowning our disappointment with coffee inside the Pub, we spent time studying the old mine photographs on the walls, periodically aiming our backs at the roaring fire in the pot belly stove in one corner.

It was still raining lightly but showing some promise of clearing when we decided to leave the comfort of the Pub and head south on Kidman Way for another 3.5 km, parking at the side of the Highway as the Great Central mine came into view on top of the ridge to the west. We kitted ourselves out with safety vests before climbing over the fence and heading up the slope towards the spectacular ruins of the old copper mine. At this point the weather began to miraculously clear, with even the sun breaking through briefly. Permission to enter had been gained from the lease owner.

History of the Great Central Copper Mine.

The mine was opened in 1878 under the name McDowells after its discoverer. The first official record made by the Geological Surveyor L.H.G Young in 1880 stated that no well-defined lode had been located, the deposit comprising a series of quartz veins containing copper carbonates traversing brecciated porphyry. The greatest depth reached by early shafts was 240 feet, at which level copper sulphides took the place of the carbonate ores. Only the rich carbonate ore shoots were mined, with the underground workings being haphazard as a result (Carne, 1908).

The oxidised ores were hand-picked, the richer ore going directly to the smelters and the balance to the crushers. The crushed ore was beneficiated using a modified version of the Handcock jig. Ironstone flux for smelting was obtained from the mine and fireclay from nearby deposits. The smelters comprised three reverberatory furnaces, two for reducing the carbonate ore and one for refining. Water was provided from a large dam 1.6 km south of the mine and a few smaller closer dams.

The mine was taken over in 1900 by the Option and Development Company, which installed a completely new plant at a cost of 16,000 Pounds. But this operation ceased in 1902 after the 500-foot main shaft had not revealed the expected orebody. As a result, the new treatment plant was never used. It was dismantled and carted away, but the extensive foundations made of local stone still litter the eastern

42. The "Great Central Manor" near the Great Central copper mine

43. Some of the stone foundation ruins at the Great Central mine. Large stone structure (top right) may have supported a water tank.

44. Headframe and main shaft of the Great Central mine.

45. View down the Main shaft of the Great Central mine.

side of the ridge today. Another example of putting the cart before the horse, which was repeated many times across Australia around that time. Total copper production was 2200 tonnes (Carne, 1908).

Leaching was carried out on material quarried from an area of stockwork veins and disseminations in the breccia by McLernon in the early 1970's. The remains of this operation are still evident, including the large open cut on top of the ridge west of the old Main shaft, the leach heap, and powder and detonator magazines.

Geology of the Great Central Mine.

The deposits are hosted in the Regina Volcanics comprising rhyolitic to dacitic lavas interbedded with crystal tuffs, sediments and vitric tuff forming part of the Mount Hope Group within the Cobar Supergroup deposited in the Mount Hope Trough, which was formed along with the adjacent Cobar Basin by rifting at the start of the Early Devonian. Initial terrestrial sedimentation took place in the western part of the trough followed by widespread submarine felsic volcanism associated with minor turbidite deposition.

Mineralisation probably represents a stockwork vein system of the type commonly found in felsic volcanic rocks below massive sulphide deposits. The stockworks predate deformation and are confined to altered parts of the Regina Volcanics and breccia. It is perhaps stratabound, at least in part. The breccia zone in the Great Central area (largely mined out by the 1970's open cut) could indicate a very explosive volcanic environment during the deposition of the Regina Volcanics. Alteration patterns in the Regina Volcanics are similar to those in the host rocks associated with many volcanogenic massive sulphide (VMS) deposits (Supple and Gilligan, 1993).

The Society's exploration of the Great Central Mine area.

As we strolled up the bare slope towards the tree line of eucalypt and Cyprus pine below the ridge on

46. Specimens of porphyry stained with azurite. Typical of the carbonate ore from the Blue shaft at the Great Central mine. The largest is 6 cm across.

47. The runaway boiler at the Great Central mine.

48. Cyprus headframe of the Hodges Main shaft at the Great Central mine.

which the ruins are located, we came upon many small piles of stones and bricks marking the sites of former miner's huts. One small ruin was associated with a low pile of finely crushed carbonate ore and this may have been the site of a small experimental beneficiation plant.

At the tree line we found what might be called the Great Central Manor, a rectangular stone-lined pit with a single entrance on the western side *(photo 42)*. There would have had a stout pole at the northern and southern ends supporting a central beam over which a sheet of canvas would have been draped to keep out sun and rain. Structures of this type were common in the early copper fields of northern South Australia. A small flat area adjacent to the south side of the pit would have been the foundation for a tent or hut.

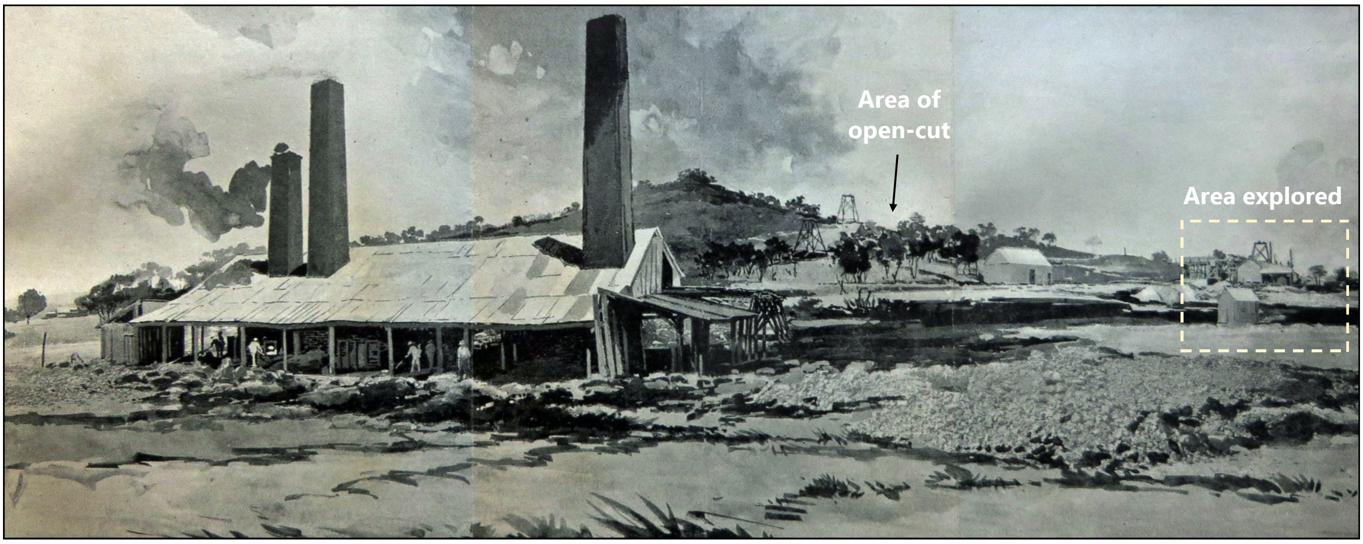
Near the top of the ridge extensive stone foundations began to appear along its eastern side, remnants of the last futile and very expensive attempt to resurrect the mine *(photo 43)*. Sadly, no plans have yet been found to enable identification of the various foundations. However some are reasonably obvious such as the winder house, boiler house with stone flue to a chimney, and the main shaft complete with a recently added simple iron headframe*(photo 44)*. A small concrete plinth just west of the Main shaft had the date 22/5/70 scratched into it, which may indicate when the steel headframe was added. The Main shaft had been covered but gaps around the edge enabled a close look at the timbering and a ladderway down its eastern wall *(photo 45)*. The purpose of the large stone structure and adjacent pit at the southern end of the ruins remains a mystery, but with a little applied imagination it may have supported a very large water tank *(see photo 43)* feeding a water wheel to provide power for crushing machinery.

Immediately west of a collapsed wire fence above the Main shaft is the Blue shaft, surrounded by dumps containing scattered blocks of porphyry breccia stained bright blue with azurite *(photo 46)*. The shaft is very irregular in shape, which would have made it difficult to use any type of mechanical haulage.

Only scant remains of the actual infrastructure occur scattered around the site, including a large boiler *(photo 47)* which had rolled down the eastern side of the ridge to land amongst a copse of eucalypts.

What we had already seen was fascinating enough but the best of the ruins lay just around the southern end of the ridge. Here we came upon the historic timber headframe of the Hodges main shaft (circa 1885) constructed from rough-hewn Cyprus logs *(photo 48)*. That it is still standing is a tribute to the miners who built it. Although much of the original structures, including all the buildings, had long gone, there is sufficient left to make this site one of extreme historical significance. Amongst the small forest of weathered Cyprus posts, piles of bricks and broken concrete, other amazing structures include the small square drystone chimney *(photo 49)* so well constructed that it shows no sign of falling apart. A square hole at its western base undoubtedly connected to a stone flue leading to the

49. Left to right: Headframe of Hodges main shaft, square water tank that fed the rectangular wooden Hancock jig situated below the drystone chimney and water tank.

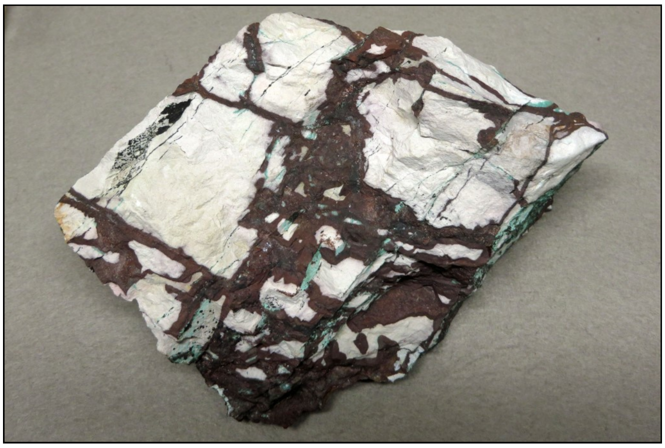


50. Photograph from Carne (1899) showing the area of Hodges Main shaft viewed from the west.

boiler house which provided steam to power the rock breakers located nearby. These were used to pulverise the soft weathered azurite-stained porphyry ore which was then fed into a modified Handcock jig built of rough-sawn local timber. The remarkably well-preserved remains of this simple ore dressing machine are still in place *(see photo 49)*, with the cubic steel water feed tank still precariously perched above it *(see photo 49)* on a partially collapsed Cyprus log frame.

The jigging process was simple. Finely crushed lower grade ore from the rock crushers suspended in water was fed through a number of cells in a long tank in which horizontal screens were pulsed vertically. The lighter unwanted material (mainly clay) floated and was washed over a barrier to the waste dump while the heavier ore particles sank to the bottom of the tank to be scraped out and sent to the smelters a few hundred metres to the west.

So little remains of the small smelter apart from its dumps of slag that it was not visited due to time constraints. The recent open cut, which consumed many of the historic shafts along the top of the ridge west of the Main shaft, were also left out of the itinerary due to the improbability of finding anything of geological or historical interest. Historic photographs of the mine are rare but *photo 50* is an enlargement of part of a photograph from Carne (1899) showing the area of Hodges Main shaft and associated plant viewed from the west.



51. Networks of malachite/iron oxide veins in sandstone from the Mount Hope copper mine. Specimen is 10 cm.

52. "Master Rock Collector" Brian showing 'lesser mortals' how to collect fresh rock samples.

53. Coarse rhyolitic ignimbrite rom the Florida Volcanics.

The weather was looking even more promising as we headed back to the vehicles but there was still a very nasty cold wind so we retreated to the public shelter shed just north of the Pub for lunch.

After lunch we all drove to the summit of Mount Hope (opposite the Pub) to have a brief look over the historic remains of the Mount Hope copper mine. But very little remains here, only the huge black slag dump which extends down to the edge of Kidman Way, a rusting domed work shed, water tank, and scattered concrete foundations of unknown purpose. Of greatest interest perhaps was the line of concrete tanks inside a wire enclosure that were used to extract copper from mine water by the cementation process back in the 1950's. The old open cut had been backfilled using dump material in early 2017. Prior to that the mine had been very popular amongst mineral collectors as during its working life it had provided exceptional specimens of the bright blue copper carbonate, azurite. But little of interest remains these days on what is left of the mine dumps. Even so, some interesting rocks were found including a boulder covered in azurite which had rolled down into the bush, veins of chalcopyrite/bornite altering to malachite and spectacular networks of malachite/iron oxide veinlets in fine white sandstone *(photo 51)*. The actual smelter site was obscured by dense scrub so was not investigated.

We departed Mount Hope at 2 pm for our return to Cobar, the sky clearing to scattered white clouds by the time we arrived back in the Caravan Park at 4 pm.

Geology of the Mount Hope Mine.

Mineralisation occurs a silicified lens of strongly sheared shale and sandstone of the Broken Range Group, which is younger than the sediments containing the Cobar-type deposits at Cobar and Nymagee. However, the structure and lithological setting of the Mount Hope deposit is very similar to the Cobar-type deposits. Primary mineralisation occurs in a network of veins containing mainly chalcopyrite with very little pyrite or pyrrhotite. Quartz veining is not associated with the ore but occurs along the margins and in the nearby country rock. Some of these veins contain abundant cavities lined with colourless quartz crystals.

The deposit was discovered in 1878. Almost 7000 tonnes of copper were produced, mainly from oxidised and supergene ores between 1881 and 1919. Leaching operations during World War I and between 1949 and 1965, plus intermittent operations in later years, have obscured much of the mineralogy (Supple and Gilligan, 1993).

Sunday 11th August.

The group left in a convoy of six vehicles at 9 am and headed east along the Barrier Highway to a point 49 km from Cobar where there is an excellent roadside outcrop of the Devonian Florida Volcanics. The weather had started out overcast and cold, and the temperature did not exceed 11°C for the whole day!

The rock in the road cutting is a very coarse-grained rhyolitic ignimbrite composed of large broken crystals of colourless quartz and white feldspar. It outcrops beside a wide right-hand bend in the Highway and also forms the prominent ridge to the south of the road. The outcrop was recently broken up by

54. Folded cherts of the Ordovician Ballast Beds in the south wall of the Railway Ballast quarry.

55. The thrust ramp separating the folded cherts from undisturbed beds in the Railway Ballast quarry.

56. Apparent kink fold in the east wall of the Railway Ballast quarry.

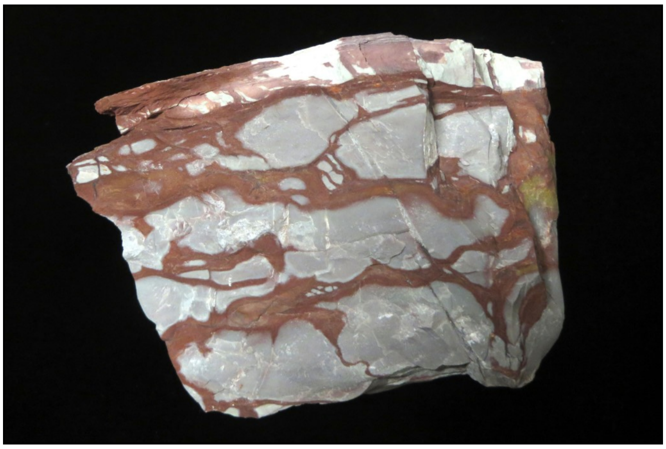
57. Lobe-like structures on bedding plane in chert in the Railway Ballast quarry.

58. Nodular bedding in chert in the southeast corner of the Railway Ballast quarry.

roadworks, making the collection *(photo 52)* and examination of fresh specimens *(photo 53)* easy. This ignimbrite is part of the volcanic sequence associated with the opening of basins (including the Cobar Basin and Mount Hope Trough) during crustal extension that occurred across eastern Australia in the Late Silurian to Early Devonian. Explosive eruptions produced ash fall tuffs associated with less violent lava flows.

We then moved on to the abandoned Railway Ballast Quarry located immediately south of the Barrier Highway 59 km east of Cobar. The location of the quarry is well hidden from the Highway and easily missed, especially when travelling at Highway speeds, being only fleetingly visible through the forest. It is marked by a high bank of gravel in from the Highway. A well-defined track on the western side of the gravel bank leads down onto the wide quarry floor where there is ample vehicle parking.

The quarry provides one of the very few



59. Nodular chert bodies in iron-stained sediment. Railway Ballast quarry. Specimen is 11 cm.

60. Liesegang banding in chert.

exposures of the Late Ordovician - Early Silurian(?) contorted and regionally metamorphosed thinly bedded turbidite sequence of the Ballast Beds lying at the base of the Girilambone Group, which was deposited along the eastern margin of the Australian Craton (Percival, 1985). The sequence includes the Whinfell Chert, thought to be a chemical or biochemical precipitate deposited at considerable depth under very quiet marine conditions (Felton, 1981). The cherty bands are composed of chalcedonic silica with fine detrital quartz and some clay. Radiolaria are present along with poorly-preserved graptolites. The beds were folded in the Early Silurian, as a consequence of along-strike movements of terranes during the Benambran Orogeny around 440 Ma (Gilmore, 2016).

The quarry is the type locality and section for the Ballast Beds, named in 1913 by E.C. Andrews because the rock was used as ballast for the nearby Parkes to Broken Hill Railway (Percival, 1985). The locality was identified as a geoheritage site by Ian Percival in 1974.

The most obvious feature that confronts visitors as they enter the quarry is the magnificent exposure of folded chert beds in the south wall *(photo 54)* and elsewhere in the quarry. Just to the east of the folded chert beds is the exposed slickensided surface of a major

61. Rounded quartz and volcanic rock pebbles in conglomerate from the summit of Mount Boppy.

62. Timber headframe over the Conqueror Brown shaft at the start of the Peak mine Golden Walk.

thrust ramp (fault) *(photo 55)* separating the folded rocks to the west from flat bedded undeformed chert beds to the east. Within the largely undeformed beds along the eastern wall is a well-defined kink fold *(photo 56)* caused by localised shearing forces. On the quarry bench below and to the south of the kink fold is a bed of lobe-like structures *(photo 57)* whose origin remains uncertain. They have been variously interpreted as interference ripples on a bedding plane, compaction/loading features or mullions resulting from most probably multiple deformation (Phil Gilmore, Pers. Com.), or load structures representing in plan the wavy nodular bedding present in a higher-level outcrop a short distance away in the south wall *(photo 58)*. Felton (1981) suggested another possible explanation; a result of periodic disturbance caused by bottom currents or

63. The 1897 Barrass and Conley 10 head stamper and steam engine on the Golden Walk at the Peak mine.

64. Headframe of the currently operating Peak gold mine.

tremors in the substrate of the sediment. The true origin of these enigmatic features is still under discussion.

There are also many examples of complex and spectacular weathering patterns scattered throughout the quarry. One 10 cm thick chert band at the east side of the quarry is composed of ovoid stretched chert nodules with the internodular areas filled by bright red iron-oxide rich sediment *(photo 59)*, perhaps the result of a sudden oxidation event in the waters of the Cobar Basin during sediment deposition. The chert in some nearby beds shows Liesegang banding *(photo 60)*.

Lunch was held on the floor of the quarry, after which most of the group returned to Cobar as more rain appeared imminent. Those travelling with Barry and Elaine Collier chose to explore the summit of Mount Boppy, accessed by a very narrow and steep sealed road leading off the Canbelego Road. The gate was found closed but unlocked and since the only sign on it read "Please close the gate" the decision was made to drive up rather than walk. After about one kilometre the road ended at an enclosure encircling the communications tower which was sending out loud vibrations in the strong wind.

Trees obscured much of the potential view but during occasional brief bursts of sunlight we could see the dumps of the Mount Boppy gold mine off in the middle distance to the south.

The main objective was to find what this prominent pair of hills were made of and as soon as we alighted from the car it became very obvious. In the road cuttings were sections through thick beds of fluvial sandstone with extensive lag deposits of well-rounded white quartz pebbles reaching around 5 cm diameter, with only occasional clasts of fine-grained grey volcanic rocks . Horizontal tension cracks in the sandstone had been filled with white quartz, remobilised from the quartz component of the sandstone during deformation *(photo 61)*. We now knew why these little hills stood so prominently above the surrounding plain. On the Cobar special 1:500,000 Metallogenic map the outcrop area of this rock is only small and the exposed layers of white quartz pebbles have provided very effective armour plating to protect it from weathering and erosion.

As we returned back towards Cobar the showers returned briefly, having held off long enough to explore the quarry and Mount Boppy without getting wet. On the eastern outskirts of Cobar, a brief diversion was made to Devils Rock a few kilometres to the north near the Old Reservoir. We were so impressed by its appearance and doubtful origin that we did not even get out of the car before heading back to town.

With the weather again lifting, some of the group drove south along Kidman Way, turning into the Peak gold mine after 8.5 km. After parking in the visitor car park adjacent to the historic timber headframe of the Conqueror Brown shaft *(photo 62)*, they took the Golden Walk set up several years ago by Peak Gold Mines. The Conqueror was the deepest of the early shafts on the Peak Lode, reaching a depth of 267 feet, with internal workings to 301 feet. The Heyday of the Peak mine was during 1896-1912, but minor work by tributers and treatment of tailings continued up till the early 1950's.

The Golden Walk passes several clearly marked historic sites, all protected by a high wire mesh fence. The most spectacular of the ruins is the remains of the 1897 Barrass and Conley 10 head stamper battery and steam engine *(photo 63)*, still remarkably preserved despite having never had a shed built over it. The walk ends at a raised platform overlooking the modern headframe of the current Peak mine *(photo 64)*, where badly faded information boards once explained the history and current operations. But Peak Gold Mines is about to refurbish the walk and update the information presented to visitors. It then only remained to return to the Caravan Park, with some making preparations to return home.

Monday 12th August.

Totally out of character with the weather we had experienced over the last week, the day dawned cloudless with no wind, and remained that way for the rest of the day! Those who remained in Cobar assembled outside the Caravan Park at 9 am and then headed west on the Barrier Highway, turning north after 40 km towards the Mount Grenfell Historic Site, another 30 km along a dirt road.

At the picnic area we found tables and toilets, which we made use of before setting off to explore the rock art site three kilometres from the gate *(photo 65)*. There, beneath rocky overhangs along the western side of a wide rocky gorge *(photo 66)*, are three groups of ancient Aboriginal art depicting human figures *(photo 67)*, animals *(photo 68)*, medicines, waterways, land and dreaming stories *(photo 69)* depicted in red, yellow and white ochre pigments applied with a crude brush or fingers. Hand stencils are also present made by filling the mouth with pigment and blowing it over a hand placed against the rock. The galleries have been protected by wire screens painted to match the surrounding rock, with small "portholes" at significant

65. Start of the 3 km walking trail to the Aboriginal Art site.

66. "The Gorge" at Mt Grenfell Historic Site. Artwork is located in overhangs along the right side.

67. Human figures in the art caves at Mount Grenfell Historic Site.

68. Human figures in the art caves at Mount Grenfell Historic Site.

69. Artwork in the caves at the Mount Grenfell Historic Site.

spots to allow easy photography. These screens were put in place to prevent feral goats rubbing against the art works. Silastic drip lines have also been added along the rims of the overhangs to present rainwater running down over the art.

The Ngiyampaa People are dryland people who once inhabited the arid plains and rocky hill country of Central Western New South Wales in an area bordered by the Lachlan, Darling-Barwon and Bogan Rivers. The

70. Outcrop of quartz-pebble conglomerate beside the walking track.

71. Infilled mud cracks in sandstone bed on steps of the Art Gallery Walk. Mount Grenfell Historic Site.

semi-permanent waterhole below the galleries was an important meeting place for generations of this Aboriginal group. After European settlement, the Ngiyampaa People were moved to stations northwest of Wiradjuri Country and in the 1930's many were relocated to Murrin Bridge near Lake Cargelligo. On 17th July 2004, Mount Grenfell was handed back to the traditional owners and is now jointly managed by the Ngiyampaa People and National Parks New South Wales (McQueen and Davies, 2016).

The Mount Grenfell region is composed of quartz-rich sandstones of the Mulga Downs Group deposited during the Devonian between 410 and 360 Ma. The poorly sorted mix of rock fragments and sand in some beds, such as pebbles scattered in sandstone, indicate a high energy depositional environment, probably a braided river or delta front (Gilmore, 2016). The resistance of the quartz-rich rocks to weathering and erosion has resulted in them remaining as topographic highs. The rocks have been folded into wide open folds with flat-lying to gently-dipping beds. Cross bedding, conglomerate beds composed mainly of white quartz pebbles *(photo 70)*, infilled mud cracks *(photo 71)* and spectacular examples of ripple marks showing a range of morphologies *(photo 72)* are evident throughout the area.

72. Ripple marks on sandstone beds forming part of the Art Gallery Walk. Mount Grenfell Historic Site.

73. Rock outcrop on the Ngiyampaa Loop Trail. Mount

74. Pancake weathering in sandstone of the Mulga Downs Group. Mount Grenfell Historic Site.

After exploring the art sites, some of the group attempted the 3.5 km Ngiyampaa Loop Trail which led to the northeast up along a rocky ridge past spectacular rock outcrops *(photo 73)* to a viewing point overlooking the surrounding plains towards the distant headframe of the Endeavour mine. The trail had been little used and was difficult to locate in places but the installation of yellow posts, each visible from the other, ensured no-one got lost.

Exploring around the rim of the canyon on returning to the art sites, we found areas of spectacular "pancake" weathering *(photo 74)* and some unusual trees. After lunch in the picnic area our much-diminished group returned to Cobar to prepare to leave for home or set out on other adventures the following day.

A farewell dinner was held at the Cobar Bowling Club that evening to bring to an end an extraordinarily successful journey into the geology and mineral deposits of the Cobar Trough.

Report by Brian England.

Photographs by Brian England, Ron Evans (5, 6, 8, 24, 26, 27, 34, 45, 47, 54, 65, 71 & 72) and Chris Morton (52).

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Muogamarra Nature Reserve

Organiser: Chris Morton.
Date: Saturday 19th October 2019.
Attendance: 21 members and 4 visitors.

Guest leader:

Dr Peter Mitchell. OAM, honorary Associate Professor of Physical Geography at Macquarie University

Introduction.

The planning of this activity began in 2017 when Barry Collier made an off the cuff remark that a Peter Mitchell *(photo 1)*, who also happened to be a geologist, ran interpretive tours in Muogamarra Nature Reserve. Barry wondered if he could be persuaded into running an activity for our society.

So, with that in mind, contact was initiated through Chase Alive Discovery Centre within Kur-ring-gai Chase National Park. Peter in reply, said he would be delighted to run an outing for us. However, this proved somewhat problematic as arrangements had to be made to suit both our busy schedules. One request to Peter was could he send me a brief biography for introduction purposes. Peter's reply was somewhat brief and understated, which summed up this remarkable man.

"One-time rock doctor who built the Snowy Mountains scheme (with a little help), then scoured the Northern Territory looking for gold and copper. Somehow stumbled into academia and spent two lifetimes at Macquarie in the School of Earth Sciences, teaching geomorphology, soil science and land management.

Now a geriatric who annoys local government and State agencies on environmental management issues so much that they gave him a medal. Meanwhile keeps his hand in consulting for archaeologists and talking to interested members of the public about weird places like Muogamarra. PM."

Peter's true achievements are so much more prestigous:

Citizen of the Year 2015 - Dr Peter Mitchell OAM.

"Dr Peter Mitchell OAM is a highly respected environmental scientist with a local, national and international reputation.

He has committed decades of service to the community, through education and promoting public awareness of the natural environment, conservation and our local heritage.

Peter is best known to the Ryde community through his work as a Member of the City of Ryde Heritage Advisory Committee and his part in locating the grave site of Woollaware Bennelong, one of the most significant figures in Australian history. He assisted in the assembly of the educational website findingbennelong.co and also helped catalogue all local heritage items.

He combines his passions for Bennelong, geomorphology, and all things 'Ryde', as a popular guest speaker at historical associations, environmental groups, schools and clubs giving expert insights on the Ryde local area and the importance of Bennelong in our nation's history. He also holds field days and advises Ryde and other Councils on a range of environmental issues.

Peter was Gladesville District Probus Club President in 2013 and 2014 and among other initiatives was instrumental in the acquisition of an automated external defibrillator for the Putney Tennyson Bowling Club.

People say that if Dr Peter is around and there is job to be done – be it mowing the lawn, fixing a complex piece of machinery, or volunteering at his granddaughter's school - then the job will get done. From 1974 Peter held various academic positions at Macquarie University and other teaching institutions. He retired in 1998 as Associate Professor and Head of Department of Physical Geography at Macquarie and was awarded the Order of Australia medal in 2013". *(City of Ryde media release)*

1. Dr Peter Mitchell leading members of the AGSHV in Muogamarra Nature Reserve.

Geological Setting of Muogamarra Nature Reserve:

Hawkesbury Sandstone is the most extensive rock unit within Muogamarra Nature Reserve and forms the extensive plateau surface within the reserve and the dramatic cliff-lines along the Hawkesbury River. Soil types reflect the topography with deep yellow earths on broad ridges and shallower sandy soils on narrower ridge tops and on valley slopes.

The Narrabeen Group of sedimentary rocks underlies the Hawkesbury Sandstone and only minor outcrops occur along the Hawkesbury River at the lowest elevations within the park and reserve. Soils derived from this series are relatively deep clay soils.

Two volcanic diatremes occur in Muogamarra Nature Reserve at Peats Crater and Peats Bight. These crater-like depressions were filled with igneous breccia which has since been largely eroded. A volcanic dyke, 2-3 m wide which may be of different age, connects the two craters and extends from Barrenjoey Head to at least Bar Island, a distance of about 18 km. Another dyke cuts west from Muogamarra into Ku-ring-gai Chase National Park. The volcanic rocks of the diatremes weather to form a deep red soil with a higher nutrient content than the surrounding areas. (NPWS. Plan of Management)

Peter's handout notes go on to say:

Petes Crater has a relief of 200 m and cuts through the entire thickness of the Hawkesbury Sandstone with the ridge crests being close to the interface with the Ashfield Shale. Some shale beds occur near the top of the sequence but these are considered to be within the Hawkesbury Sandstone. Just above the sea level at the rivers edge, lithic quartz sandstone of the Newport Formation in the Gosford Sub-Group outcrops.

History of Muogamarra Nature Reserve.

In 1836 George Peat was granted 50 acres (20 ha) on the Hawkesbury River at what is now Peats Bight. He built huts and a wharf there, and farmed his land. A dairy farm was then built nearby at Peats Crater.

Muogamarra was founded by John Duncan Tipper in 1934 when he leased 600 acres (240 ha) to protect the flora, fauna and aboriginal sites, due to his concern at the loss of Hawkesbury Sandstone forest. He named the site 'Muogamarra', which he believed was an aboriginal Awabakal word meaning "preserve for the future."

This area was at the northern end of what is now the nature reserve. Over time Tipper expanded his lease to 2,050 acres (830 ha). In 1954 the land was given up by Tipper and gazetted as Muogamarra Sanctuary.

In March 1969 the 750 acre (300 ha) Sir Edward Hallstrom Faunal Reserve, which was dedicated in 1961, now makes up the southern part of the nature reserve.

This area was the work of Allen Strom and Sir Edward Hallstrom. The two areas were amalgamated into what is now Muogamarra Nature Reserve, under the control of the NSW National Parks and Wildlife Servic. (Wikipedia)

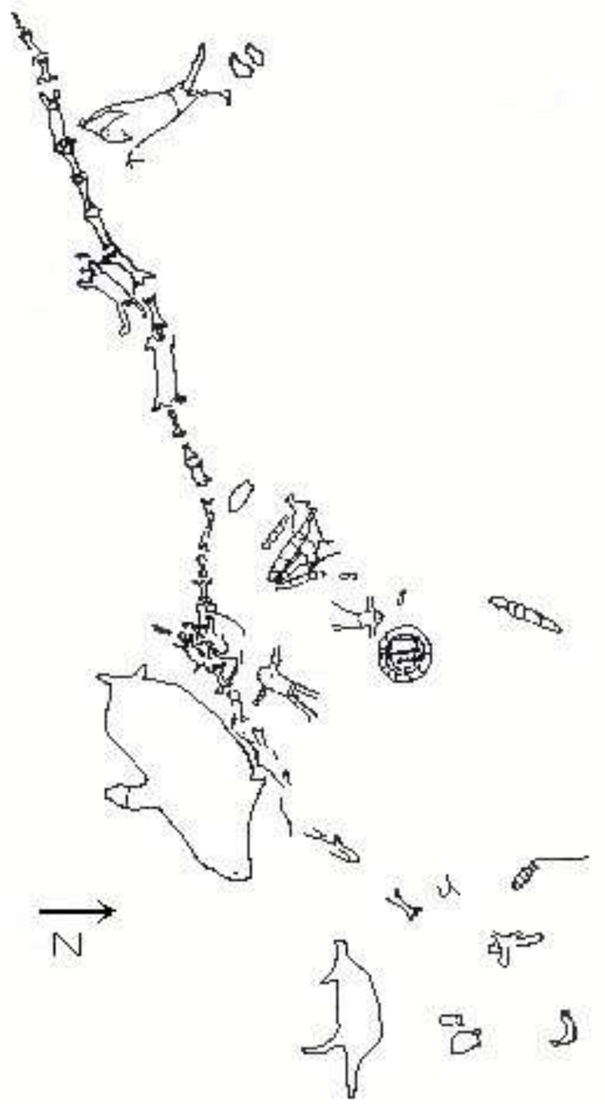

Figure 1. Aboriginal rock engravings on a sandstone rock platform at our meeting place.

The Outing.

We arrived at Muogamarra at 9 am on a beautiful cloudless spring morning that promised to be very warm, with a gusty south westerly change in the afternoon. Peter Mitchell was manning what is normally a locked gate to this very special area. Its access is restricted to just six weeks of the year during spring when it is open to the public. Peter directed us to a sandstone rock platform a kilometre further on where we gathered around and waited for everyone to arrive.

This was an ideal spot to meet, as the rock platform contained many aboriginal engravings. These engravings are stark testimony of aboriginal association with the land in the Sydney area for at least the last 30,000 years *(figure 1).* This area was also the site used as a school for the children that belonged to the road gangs that built the Pacific Highway in 1927-1930. A tent school was set up for about 14 children and only operated for around 4 months.

Another prominent feature here was a large weathered out concretion. The concretion stands around 600-700 mm high and a metre wide, with the centre naturally weathered out, making it an ideal natural basin *(photo 2)*. There are many European engravings around the basin that I presume would date back to the early school days.

After greetings and formalities we drove on to the Field Study Centre around 2 km along a dirt track, where we parked the cars and enjoyed morning tea in the rotunda. From here we walked west along a well-formed shaded track that was most likely formed by John Tipper to the spectacular Western Lookout *(photo 3).* This lookout affords expansive views that encompass the Hawkesbury River and incised stream cut valleys and the verdant plateaus. Below this vantage point are the twin diatremes.

Peter describes these in his handout as:

"These diatremes are considered by some as the most interesting volcanic features in the Sydney Basin. There are more than 200 of these in the Sydney Basin and they are much more common here than in almost all other parts of the world. Popularly known as 'volcanic necks' or named as 'craters', diatremes located in sandstone country do form spectacular landscape features of deep circular valleys incised below the plateau surface. The 'crater' at Peats Bight in Muogamarra Nature Reserve is an excellent example. Downstream of the main crater through the gorge which follows the line of a dyke there is a second diatreme, but the only evidence of it is the valley shape and a very small outcrop of weathered breccia in the creek bed near the saltmarsh."

The European history has not been documented well. There are dates of land sales along with names but with scant detail. It seems early timber getters harvested the rainforest timbers around the 1820s which opened up the area to grazing. It was in 1836 when George Peat acquired 50 acres that included some areas of the craters and the gorge. Peat's main objective seemed to have been control of the access to the river, where he could run his ferry service and regulate any shipping that may wish to off load goods. Others such as George Sullivan cleared the eastern section of the crater by the 1840s.

The date of construction of a road into the craters remain uncertain, however it may have predated the main Peats Ferry Road which was surveyed in 1848 and completed in 1853. The construction would have been carried out by convict gangs. A dairy farm run by the Woods family was operating in the second crater in the 1880s.

Returning via the circuit track to where we left our cars allowed our members to enjoy the few spring wildflowers that seemed to be suffering from the long dry spell and the seven-year drought that we are enduring at the moment. When we arrived back at the vehicles it was too early for lunch, so we grabbed our lunch packs from our cars and continued on to John Tippers Cabin. Peter related the story of John Duncan Tipper (1886-1970), conservationist and electrical

2. Weathered-out concretion forming a natural basin.

3. Society members surveying Peats Crater at western lookout.

4. Waratah flower.

5. Soil type relates to parent rock and weathering process.

6. Fossilised termite burrows dug in sediment before lithification.

7. Deeply eroded joints within sandstone.

8. Sandstone slab has been lifted and/or supported by tree roots growing underneath.

engineer, who was born on 4th August 1886 at West Maitland, New South Wales. The cabin was the old NSW Government House gatehouse. Tipper relocated the cabin to the reserve to use as an office. Further details and history regarding John Duncan Tipper can be found @ http://adb.anu.edu.au/biography/tipper-john-duncan-1186

Interestingly, Peter showed the group a waratah plant *(Telopea speciosissima)* that seemed to be out of its natural environment and posed the question, why is this so *(photo 4)?* This question allowed our leader to discuss John Tippers conservation credentials including his habit of transplanting native plants that are scattered around the area. From here the track descended down onto Peats Crater Trail where we regrouped and discussed various moist muddy sections along the track. These were explained as ground water seeps from the hanging swamps that are a natural feature of the area.

Soon we came to a steeper section of the track where we learnt about the migration of soil on downslopes and the effect it had on the changing vegetation

Soil types relate to parent geological material and subsequent weathering. The soils derived from the sandstone are generally poor but the repeating ridge-slope-gully formations produce a number of types ranging from poorly structured sandy soils on the ridges and steep slopes to deep, strongly structured sandy clays in the gullies. The rolling terrain of the shale areas with slopes rarely exceeding 20% and the different parent material produces heavy textured red podsolic soils on upper and mid slopes and yellow podsolics on lower slopes and flat drainage depressions. On the alluvials the soil type depends on the age of the sediment. The

9. Hawkesbury River and bridges as seen from Deerubin Lookout.

10. Hawkesbury River is a drowned river valley. Tributary streams form hanging valleys on the ridges surrounding the river. Peat Island is in the foreground.

11. Cross bedding exposed in an eroded out overhang.

Tertiary related soils cover a wide range from sand deposits to gravel, silt soils and, at their most developed, duplex soils with distinct clay subsoils. The soils on the younger alluvials range from sandy loams to clays and often show little structure *(photo 5)*. (Sydney Vignerons Association).

We retraced our steps to an intersection where we turned north onto the Deerubin Track. We continued on only pausing for a quick lunch stop beside the track. At this point we were asked if we could explain a section of sandstone that had tube-like structures through it. As a group we all agreed that they were wormholes, yea! But no, it turns out the holes were the result of termite activity before lithification *(photo 6).*

Our next stop was an area where the sandstone had deeply eroded furrows. So, Peter with his professors hat on, asked us how this phenomenon had occurred. After much discussion he informed us that the sandstone had been subjected to jointing caused by unloading which subsequently eroded, the sandstone blocks then moving downslope leaving the wide gaps *(photo 7)*.

We continued our trek through the eroded sandstone only stopping to wait for some of the slower members. At one of these stops we could see how the vegetation has a huge effect on the sculpting and shaping of the countryside. A Red Bloodwood *(Corymbia gummifera)* had grown in a crevice in the sandstone. This is known as bedrock erosion by root fracture. There are many ways by which large rocks can be broken down into smaller rocks, but one of the more amazing is through the action of trees and plants. The slab of sandstone has been uplifted and separated from adjacent layers as the root grew in width *(photo 8)*.

Not far from here we came up over a rise and scrambled down to Deerubin Lookout. The view here is spectacular. At this point you are some 300 m above sea level looking directly down onto the Hawkesbury River road bridges, both old and new and to the railway bridge that carries the main lines from Sydney to Newcastle *(photo 9).*

Looking upstream with Peat Island in the foreground, the blue water of the mighty Hawkesbury River (within a drowned valley) with pleasure craft busily churning it up could be seen, as well as panoramic vistas of hanging valleys and ridges formed by the many tributary creeks of the Hawkesbury River Valley *(photo 10)*.

On the way back a large sandstone overhang caught our interest. The overhang displayed an unusual weathering pattern. Cross-bedded sandstone has been weathered out from beneath, rather than from what would normally be from the surface, displaying sheet like facies *(photo 11)*. Another feature Peter wished to discuss was the polygonal jointing that is common within the reserve. There were several theories bandied about, leaving us with no real consensus on what causes this phenomenon.

Back at the rotunda Peter gave a summary of the day and related his role in being a member of the City of Ryde Heritage Committee and his part in locating the gravesite of Bennelong, one of the most significant and important figures in Australian history. Peter was thanked and presented with a copy of Geo-Log 2018 along with a nice bottle of red wine for giving up his time and energy in leading a very rewarding day.

Post script: Peter has since offered to run a guided walk on Long Reef rock platform next year, and he has donated 40 books titled 'Field Guide to NSW Shore Platforms by himself and Phil Coleman.

Report by Chris Morton.
Photographs by Chris Morton.

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Aerial photo of Muogamarra Nature Reserve showing location of the diatremes, dyke and tracks walked during our visit.

Geological Tour - Tweed Volcano, Glass House Mountains, Main Range Volcano and Stanthorpe Granite Belt
Geological Safari 2019

Sunday 1st to Wednesday 18th September

Leaders: Brian and Barbara Dunn.

Attendance: Up to 23 members.

Introduction:

The annual safari to the Tweed Valley, the Sunshine Coast, the Main Range and Escarpment and the Granite Belt of SE Queensland was to explore the landscape and geology of these regions. This followed on from the 2009 safari which examined the northern side of the Mt Warning Caldera.

Hot Spot Plumes And Volcanic Eruptions.

The Miocene (5-24 Ma) shield volcanoes of eastern Australia occupy two parallel volcanic chains approximately 250 km apart *(figure 1)*. These formed from magmas generated in the lower mantle creating a heated plume or hot spot. This intruded the base of the Australian plate as it moved northwards under the influence of plate tectonics. This hot spot continued operating for tens of millions of years *(figure 2)*.

The Tweed Volcano.

This was active from 23 to 20 Ma ago. It was 2 km in height and 100 km in diameter. Since the end of eruptions it has eroded to form Wollumbin which means 'cloud catcher' (Mt. Warning) and the Tweed Erosion Caldera. This was the largest of the Miocene shield volcanoes and the estimated 4000 km^3 of volcanic material was approximately 75% of all magma held in the reservoir which had fed the hot spot plume to the

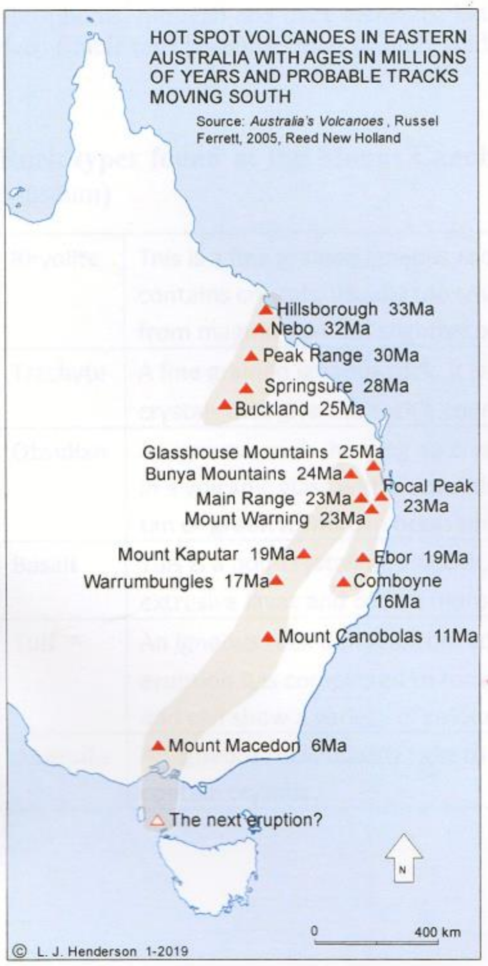


Figure 2. Hot-spot volcanoes in eastern Australia became younger as Australia drifted north over the fixed hot-spot.

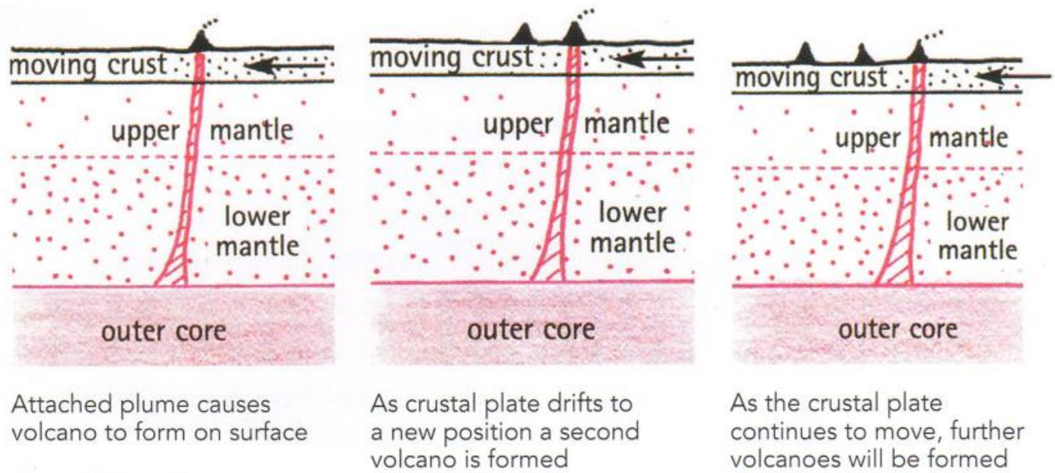


Figure 1. Formation of hot-spot volcanoes over time. As the crust moves over a fixed hot-spot plume, new volcanoes form at the surface each time an eruption occurs.

surface at the time. The erosion caldera, which is the present Tweed Valley, is unique in the world because of its size and the geological features it shows. These are due to the dissection of the volcano by erosion.

<u>Day 1</u>: Sunday 1st September. Murwillumbah.

The safari began at the Mt Warning Rainforest Resort, out of Murwillumbah, northern NSW with a meeting and get together at 5 pm around a picnic table in the Wild Camping section of the park. The leaders welcomed and briefed everyone on what to expect during the Tweed volcano section of the Safari. After the formalities the group settled in to renew acquaintances and share refreshments and travel tales.

<u>Day 2</u>: Monday 2nd September. Springbrook National Park to the Ocean.

We set off at 8:30 am in convoy towards our first destination for the day, the Natural Bridge in the Springbrook National Park, Queensland. This is a beautiful and unique location just over the border from NSW in Queensland.

From the carpark a 1 km sealed loop walking track took us through the subtropical rainforest across Cave Creek, a tributary to the Nerang River and into the arched cave to witness a waterfall plunging through a hole in the roof of the cave. At night thousands of glow worms illuminate the cave with tiny green lights. It is also the home of tiny bent wing bats. The Hoop Pines (*Araucaria cunninghamii)* found in the forest here are living relics of the Jurassic Age 180 mya. The pines are among the most primitive of the conifers.

The Natural Bridge *(photo 1)* has been formed from the Blue Knob Basalts from the eruption of the Tweed Volcano 23 million years ago. The bridge is the remains of harder, more resistant basalt and has been formed by Cave Creek, a swiftly flowing stream through the Numinbah Valley *(figure 3)*. Over time, a softer layer of broken volcanic rock at the base of the waterfall has been cut away by the force of the falling water to form a cavern. At the same time a deep pool formed at the top

1. Natural Bridge.

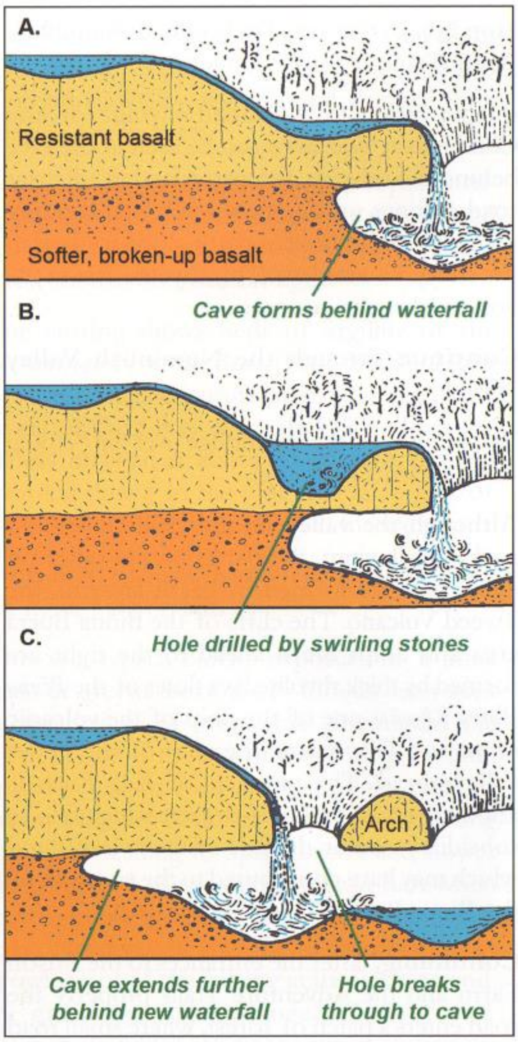


Figure 3. Evolution of the Natural Bridge at Springbrook National Park.

of the waterfall resulting in currents of circulating water and pebbles that in time eroded through the harder rock layer above forming a hole. The water now plunges through that hole into the cavern below before continuing its flow onward. The original waterfall lip now forms the natural arch or bridge.

Morning tea was enjoyed by all on the return from our walk.

Back on the road again, we returned to Numinbah Gap which is between the Springbrook and Lamington Plateaus on the northern rim of the Tweed Caldera. This also serves as the NSW/Queensland border as it is the watershed between the Nerang River (QLD) and the Tweed River (NSW). The features noted from this impressive lookout *(photo 2)* were the more rapidly eroding southern side of the caldera which has created the steep escarpment. This has highlighted the columnar jointing exposed in the prominent cliffs that had been formed by the rhyolites of the Binna Burra rhyolite (lower layer) and the Springbrook rhyolite (upper layer). There was significant soil creep on the lower slopes.

Returning to our vehicles we continued down the caldera rim into Murwillumbah noting as we approached the town, sugar cane harvesting taking place *(photo 3)*. The rich volcanic soils and high rainfall of the Tweed Valley make this a very successful crop in the region.

Fingal Head, our next destination, is one of the recognised Geo Sites of NSW. A short walk along a sandy track and up timber steps to the headland, took us to the Fingal Head Lighthouse. This lighthouse was completed in January 1879 and was designed, as was the lighthouse keeper's cottage, by Colonial Architect of NSW at the time, James Barnet. The lighthouse was originally fuelled by kerosene which meant the keeper was required to be on duty all night. The four bedroom cottage housing the first lighthouse keeper, his wife and eleven children had no laundry or bathroom. Some of the female members of the group commented on the hardships women faced at the time in caring for the needs of their families. In 1923 the lighthouse was automated and converted to acetylene and therefore the keeper was no longer required. The cottage was demolished when the lighthouse became automated.

2. View from Numimbah Gap.

3. Sugar cane harvesting.

4. Columnar jointing at Fingal Head.

5. View of Sand Collection Jetty.

Beyond the lighthouse were views north to the Gold Coast and offshore to Cook Island. A short walk, took us to the clifftop where we had an overview of an outcrop of columnar basalt jointing in a lava flow *(photo 4)*. This basalt is the Lismore Basalt which was the first of the flows from the Tweed Volcano 23 Ma. The flows continued 10 km further east from this point. The jointing has occurred by contraction as the lava cools from the outside towards the centre. Cook Island was also formed from this lava flow.

We explored this site for about an hour before retiring to the picnic area on the Tweed River for lunch.

The last activity of the day was to view the Tweed River Sand Bypass System from the lookout at Point Danger. This is also the border between NSW (Tweed Heads) and Queensland (Coolangatta). From this vantage point we could view the 450 m long Sand Collection Jetty *(photo 5)* at Letitia Spit on the southern side of the Tweed River. The sand slurry is pumped through a 400 mm steel pipeline under the Tweed River to the outlets on the northern side of the river at Snapper Rocks and Kirra. This maintains the longshore sand drift from south to north and allows a navigation channel at the Tweed River to be maintained. The continuing supply of sand to the Gold Coast Beaches is important for the surfing community and international and domestic tourism.

Members of the group were temporarily distracted by two whales breaching close to shore and the many water dragons sunning themselves on the rocks *(photo 6)* along the Centaur Memorial Walk. Some of the group walked down to the Snapper Rocks rock platform. These rocks are Lismore Basalts which are the same as Fingal Head. We saw where the sand outlets were, but they were not operating at this time. The difference they make to the build-up of sand on the beach was evident.

Others of the group viewed the war memorials and the Captain Cook Lighthouse and treated themselves to and ice cream or coffee before we all headed back to camp at the end of an active and interesting day.

<u>Day 3</u>*: Tuesday 3rd September. The Border Ranges National Park.*

There was a heavy dew during the night and we woke to mists rising as the morning sunshine became stronger. It appeared to be another fine and sunny day. Today we travelled along the Kyogle Road to Lillian Rock where we turned right to enter The Border Ranges National Park. This park is located on the rim of the western flank of the caldera and at the highest point is over 1000m in elevation. It is the furthest point from the Fingal Head Lismore Basalt columns and is mostly a World Heritage listed rainforest park. This wilderness is Gondwana Rainforest that extends from Mt Tamborine in the north to Barrington Tops in the south. The park contains four types of rainforest: cool temperate, warm temperate, dry and subtropical.

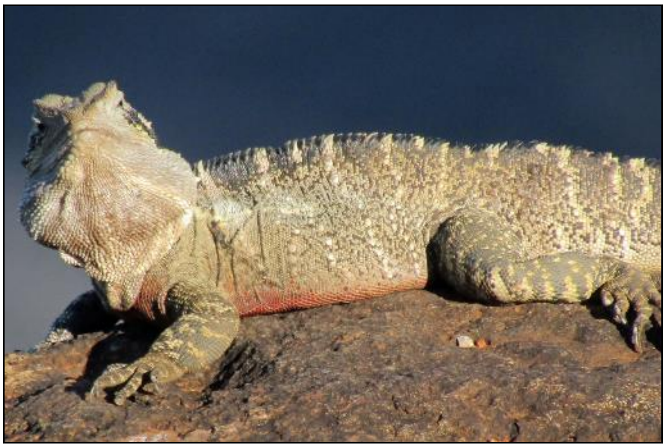
En-route to the national park we made a number of stops. The first of the day was at Clarrie Hall Dam *(photo 7)*. Here at the dam wall was rhyolite. The foundations of the dam are built on this layer. Clarrie Hall Dam is located on Doon Doon Creek - a tributary of the South Arm of the Tweed River, some 15 kilometres south west of Murwillumbah. The dam has a catchment area of 60 square kilometres.

The primary function of the dam it to store drinking water for the Tweed Area. When levels of freshwater in the Tweed River fall below 95%, which occurs mostly in winter and spring, water is released from the dam's intake tower and flows down the Tweed River. Otherwise the natural flows of the Tweed River provide 80% of the water needs of the Shire. At Bray Park, the water is drawn off and treated at a state-of-the-art treatment plant to ensure suitable drinking quality.

Clarrie Hall Dam construction commenced in 1979 and it was opened in 1983. Upgrades were carried out in 2013. The dam is a minor ungated concrete faced rock-fill embankment dam. The dam wall height is 43 m and it is 175 m long. The maximum water depth is 41 m and at 100% capacity the dam wall holds back 16,000 megalitres of water. The surface area of Lake Clarrie Hall is 220 hectares. The uncontrolled concrete chute spillway across Doon Doon Creek is capable of discharging 590 cubic metres per second. The estimated completion cost of the original dam work was $34 million.

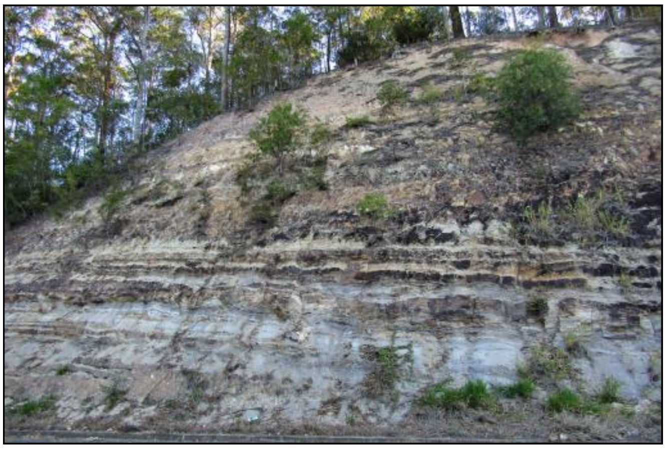
The next stop of the day was at a road cutting *(photo 8)* where parking was limited and where Hi-Vis vests had to be worn and a traffic lookout person appointed. The geologists in the group examined the rocks closely and concluded that there were siltstones, sandstones and metamorphosed sandstones present in the sedimentary bedding layers, dating from the Carboniferous to Devonian in age.

After passing through the village of Mt. Burrell another stop was made to view The Sphinx and Mt Burrell 933 m in the Nightcap National Park.



6. Water dragon sunning itself.

7. Clarrie Hall Dam.



8. Road cutting of sedimentary rocks.

9. Antarctic Beech Trees.

10. Beech Orchids.

11. Group at Pinnacles Lookout.

12. The view from Pinnacles Lookout.

13. White orchid.

14. Brushbox falls.

Continuing on our journey we reached the Border Ranges National Park and drove to the Bar Mountain Picnic Area. It is the highest point on the caldera rim in the park. It was time for morning tea. Being thus refreshed and enthused for a walk, we set off along the Falcorostrum Loop Walk to study the Antarctic Beech trees *(photo 9)*. Some may be 2000 years old in this section of cool temperate rainforest. We were delighted when we were able to locate the Beech Orchids *(photo 10)* which are only found in this location of the park. A lot of neck craning took place as they were perched very high along the trunks of the Antarctic Beech trees. Most were not fully open at this stage.

There was a short drive to the car park for the Pinnacles Lookout *(photo 11)*. The journey along the Pinnacle walk to the lookout was one of the highlights of the day. From here we had uninterrupted views *(photo 12)* along the caldera rim to the coastline and to Wollumbin (the central core of the Tweed Valley Volcano). The steep sides of the caldera rim had been formed from Nimbin Rhyolites. These were extruded during the violent phase of the volcanic eruptions before the final phase of quiet eruptions which released the capping rock of Blue Knob Basalt. Barry's keen eyes found some beautiful pink orchids growing off the cliffs below the lookout while Jim found a white orchid growing on a tree trunk at eye level *(photo 13)*. The climate conditions at this exposed point were drier than at the other points along the rim so there were less rainforest species and more grass trees growing.

It was time for lunch and our designated lunch stop with the necessary facilities was Forest Tops. Upon reaching this point, however, we discovered it was crowded with tents of a school walking group and all the picnic tables were in use, so we travelled on to Sheepstation Campground and Picnic Area. This was a more spacious location and our afternoon walk was from here. A relaxing lunch was had at the various picnic tables scattered under the rainforest trees and open grassland. After lunch the majority of keen walkers completed the Palm Forest Walking Track to Brushbox Falls *(photo 14)*. This was an easy walk through the subtropical rainforest following some of the historic logging track of the cedar getters. Along the creek was a glade of bangalow and piccabeen palms. Here we viewed the moss covered carvings on a sandstone rockface on the north side of the creek, where cedar getters had carved their names. One date was 1888. Towering brush box, booyong and strangling figs were seen as we made our way to the picturesque falls below which was a shaded pool.

After this walk some members decided to return to camp, some went on to Kyogle for afternoon tea while six went down to Brindle Creek where *Helmholtsia* lilies grew. From here the Red Cedar Loop Track was undertaken. There were many varieties of fungi and mosses seen along the track; these decomposers recycle the nutrients to the trees. The focus of this walk was the 48m high giant red cedar. This tree is possibly 1000 years old. Epiphytes such as bird's nest fern, orchids and staghorns were perched in the flakey bark of the cedar. It looked like a vertical garden. The last stop for the day was Blackbutts Lookout where the viewing platform offered another view over the whole Tweed Valley and Mt Warning from the edge of the caldera escarpment.

15. Palm tree Glade.

16. Tweed Valley with Mt Warning on the left.

<u>Day 4</u>: Wednesday 4th September. Tweed Regional Art gallery, Tweed Museum & the Adrian Smith Mineral Collection.

It was a cool 10 degrees this morning with another heavy dew. Everyone could have had a sleep-in this morning with a later start of 9 am for the day's activities. Our first activity was to walk the Lyrebird Track in Wollumbin National Park. Three brave souls set off to do the five hour Mt Warning Summit Track which was about 9 km return. The rest of the group experienced the beautiful Gondwana Rainforest by taking a much shorter track, but with more steps than the leaders remembered. We crossed Breakfast Creek then climbed through a palm forest to a scenic viewing platform. There was no real Wow! factor to this walk but it was an excuse to stretch the legs and make room for morning tea.

The next stop of the day was along Baker's Road where we had views across the Tweed Valley to the caldera rim and over the farmlands either side of the meandering Tweed River. Out came the cameras to capture the view *(photo 16)*.

This road took us to the wonderful Tweed Regional Gallery. This is a modern building built in 2004 and extended in 2006 with magnificent views to Mt Warning and over the Tweed Valley. Once here everyone headed for the café where a luscious morning tea was consumed *(photo 17)*. Once nourished, the group dispersed throughout the gallery to pursue their particular interests. Most of us found our way to the outstanding Margaret Olley Gallery opened in 2014. Here the artist's home and studio have been recreated in its wonderfully chaotic state. Most of the contents were the actual possessions of Margaret *(photo 18)*.

From the gallery we moved across to the Tweed River Regional Museum where the special interest was the Adrian Smith Mineral Collection *(photo 19)*. The minerals and gems on display were some of the very best specimens of Adrian's 3000 specimen collection from Australia and the world. Next to the mineral display was the "Thunder Eggs, Tweed's Hidden Gems" exhibition. Fifty thunder eggs were on display. These are typical of the specimens found throughout the Tweed Valley.

Thunder eggs can look like unassuming spherical rocks from the outside, but once they are cut and polished they show a beautiful and wild array of colours. Thunder eggs form in silica-rich volcanic rocks, particularly rhyolite. They start life in the flowing volcanic lava. As the lava cools, trapped steam and other gases form expanding bubbles. Silica and feldspar minerals crystallise around the edge of the bubbles or grow outwards from the centre. These mineral filled bubbles with radiating structures are called spherulites, or more commonly thunder eggs *(photo 20)*. Internal gas pressure can force the spherulite apart to form a central cavity and this can fill with chalcedony, banded agate or various forms of quartz. Over time and with continued mineral infilling, unique patterns and shapes form *(photo 21)*. Thunder eggs can be different in appearance due to the different naturally occurring minerals in the area.

This completed the day's activities and the group had a free afternoon to prepare for the journey to Landsborough, the next destination of the safari. The evening Happy Hour was the chance to celebrate the 70th birthday of Brian Redmayne. He still had the energy to blow out the candles on the cake after successfully climbing to the top of Mt Warning with Sue during the day. Laurel also participated in the walk and made it to the chains.

17. Group at morning tea at the Gallery.

18. Margaret Olley Yellow room.

19. AGSHV members examining the Adrian Smith Mineral Collection.

A short time after sunset the group was treated to the awe inspiring sight of fireflies flickering with their ghostly light along the dry creek bed behind the campsite.

20. Large spherulite (thunder egg) on display.

21. Large spherulite that's been cut in half to expose the colourful quartz-rich minerals that grew in its cavity.

<u>Day 5</u>: *Thursday 5th September. Murwillumbah, NSW to Landsborough, Qld.*

Today the safari members travelled from Mt Warning Rainforest Resort to Landsborough Pines Caravan Park. Camps were set up and at 5 pm the group met in the BBQ shelter overlooking the lagoon to discuss the geology of this region.

The Glass House Mountains are a group of dome shaped hills and conical peaks protruding above the surrounding land surface. The Maleny Volcano erupted 31 Ma, producing basalt lava flows which flowed north and east. The thin flows continued to build up until 27 Ma. Remnants of these basalts are the capping of the Maleny-Mapleton and Buderim Plateaus and the hills in them between 27-26 Ma, dome like plugs of rhyolite or trachyte magma were pushed up into the older rocks filling volcanic vents and laccoliths. Since then the softer sandstone and basalt base has eroded away leaving the harder plugs exposed to form the shapes of the Glass House Mountains that we see today *(figure 4)*.

During the Landsborough section of the safari extreme weather conditions of high temperatures, strong winds, bushfires and the associated smoke led to the more strenuous planned outdoor activities being modified.

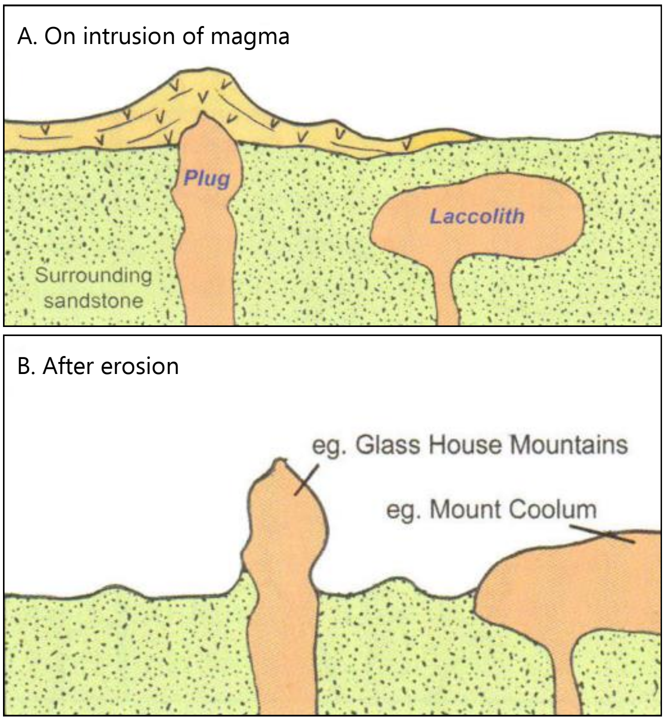


Figure 4. Process of un-roofing plugs and laccoliths.

<u>Day 6</u>: *Friday 6th September The Glass House Mountains.*

The convoy formed at 8.30 am at the caravan park entrance and we headed off along Old Gympie Road. We travelled along this to Mt Coochin (235 m) for the first photo stop of the day and Mt Ngungun (253 m) on route to the Glass House Mountains Visitors Information and Interpretative Centre. Here we listened to an explanation of the formation of the Glass House Mountains by Ivon Northage, the author of "The National Heritage Listed Glass House Mountains". Ivon was a very active member of the group that lobbied for the Glass House Mountains to be placed on the National Heritage List. 10 of the 14 mountains were so listed in 2006.

The group spent the rest of our time here devouring the information about the geology and history of the mountains given on the many outstanding panels displayed around the centre. Morning tea was taken in the parkland surrounding the Information Centre.

A tour of inspection of Hanson Quarry was next on our agenda. This tour, with the Manager Chris Wilson, proved to be a highlight of the day. Chris gave us a safety talk and we donned Hi-Vis vests *(photo 22)* before travelling in convoy behind his vehicle *(photo 23)*. He led us through the quarry workings to a site designated for us to inspect. The Glasshouse Quarry at Mount Beerwah Road has been operating for more than 15 years, although the quarry itself has been operating since 1976.

Hanson is an Australian building and

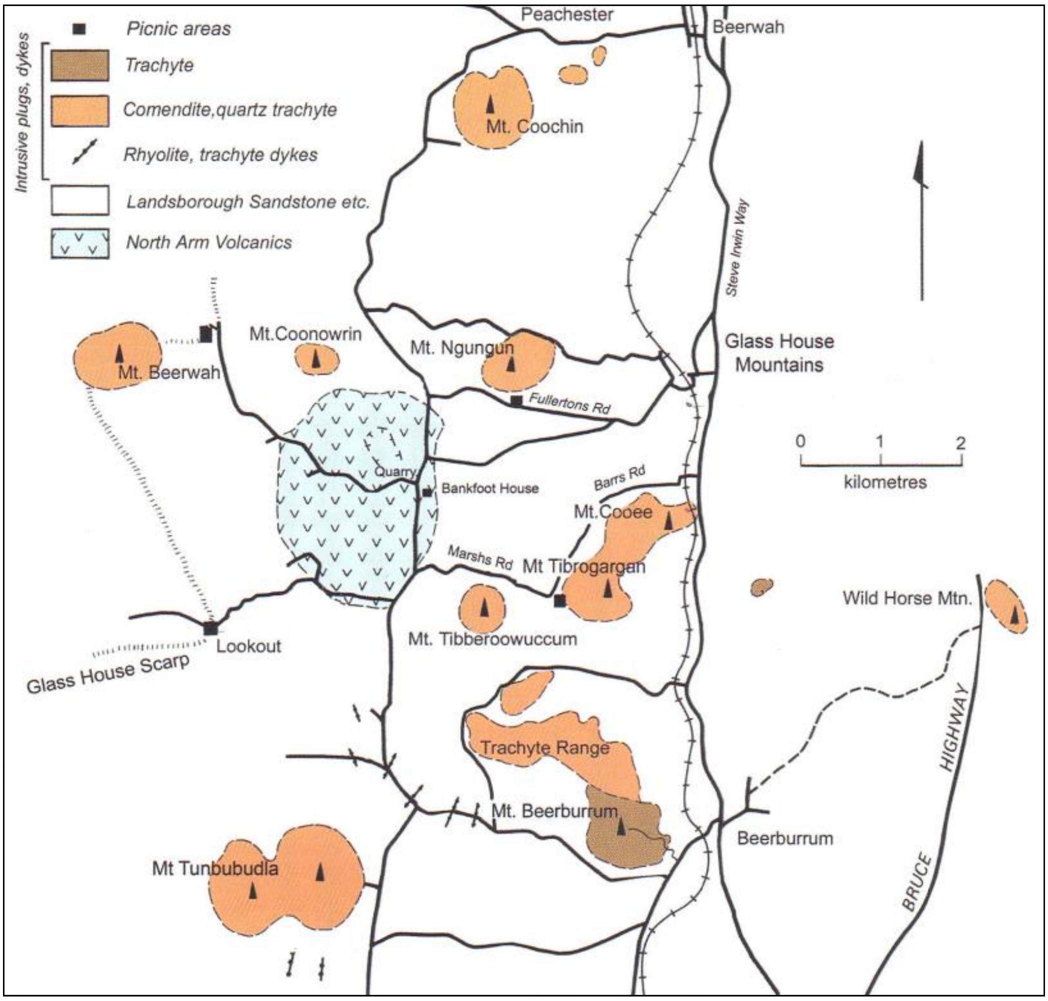


Figure 5. Glass House Mountains localities.

22. AGSHV members posing in the quarry.

23. Entering the quarry as a convoy. Mt Beerwah (L) and Mt Coonowrin (R) clearly visible from quarry.

construction materials company that is part of the Heidelberg Cement group. It is one of Australia's leading suppliers of quarry materials, crushed rock, sand, gravel, crusher dust and road base. It also supplies concrete, asphalt and recycled aggregates.

The Glass House Mountain quarry is located in an area where there is an outcrop of North Arm Volcanics due to overlying softer sandstone plain being eroded away. The igneous volcanic rocks formed when sub-surface volcanoes filled underground intrusions in the surrounding sandstone. The volcanic sequence appears to be a pyroclastic ignimbrite flow at depth, overlain by a cohesive tuff unit.

The two lithologies appear similar but there are differences in texture and mineralogy. The Latite Tuff unit is a consolidated volcanic ash. It has a high proportion of lithic fragments and rounded glass inclusions welded together by an aphanitic matrix. The ignimbrite unit was from a more viscous pyroclastic flow. It contains variations in colour, flow banding and

24. Organ pipes, Mt Beerwah.

25. Road cutting of Landsborough Sandstone. Note the folding and faulting in the exposure.

26. Aboriginal groove marks in sandstone.

elongated glass inclusions facing in the same direction as the flow banding.

The site is situated on an essentially flat coastal plain that is protruded by the sharp peaks and ridges of the Glass House Mountains. The current pit is on the upslope to the N-NW on a ridge that trends towards Mt Coonowrin (337 m).

The group were particularly impressed with the Quarry's engagement with the local community and their vision for the future. The revegetation of the quarrying terraces as each section was completed was also impressive. The 21 onsite staff are locals with their children in surrounding schools and sporting teams. Some of the employees have worked at the quarry for over 30 years. The quarry staff and contractors spend their dollars in the shops and other businesses in the district.

Open days, school visits, apprenticeship programs and truck driving licence schemes with the local high school are other ways the quarry is involved in promoting good relationships with the local community. Once the Quarry reaches the end of its useful life the plan for the site is that it will be redeveloped as recreational facilities such as water bodies, cultural precincts and fishing spots.

We then drove to The Glass House Mountains Lookout for a picnic lunch. Many photographs were taken from the many vantage points of the various Glass House Mountains and the surrounding pine plantations. Most of the group walked the 800 m Circuit Track from the lookout that led through an open eucalypt forest and then down into a wet sclerophyll forest gully where some rainforest species grew. The track was quite steep in places and returned back to the lookout. From here the group travelled to Mt Beerwah, where a short walk took us to a vantage point where a volcanic feature called the Organ Pipes *(photo 24)* could be viewed. These were basaltic columns formed by the cooling, shrinking and fracture of the lava. Mt Beerwah has special significance to the Jinibara women as a birthing place and place of refuge.

The Landsborough Sandstone outcrops in the road cuttings at the corner of Fullerton and Old Gympie Roads were examined next *(photo 25)*. These are the base rocks through which the volcanic intrusions have occurred. This sandstone was laid down around 200 mya.

This was the end of the day's official activities with the opportunity to walk one of the recommended walks in the Glass House Mountains; Mt Ngungun, Mt Beerburrum or White Horse Mountain.

With the temperatures being in the high 30's, most of the group decided to proceed to the Aboriginal Site on Little Rocky Creek, on Old Gympie Road.

This site has special significance to the Gubbi Gubbi peoples who for generations have used the sandstone beds in the creek to sharpen their axe and spear heads as well as cutting stones *(photo 26)*.

The sandstone beds were also a ford used by Cobb and Co mail coaches as they made their way from Brisbane to the Gympie Goldfields in the mid 1800's. The exposed rock contains the marks made by the wheels of these coaches. The group met up again in the afternoon for Happy Hour and discussion of the day's and future activities in the Landsborough region.

Day 7: Saturday 7th September. Free day.

Day 8: Sunday 8th September. Free morning with an afternoon eco cruise.

Fourteen of the group chose to do The Serenity Everglades eco cruise in the afternoon. This cruise left from Habitat Noosa located at Elanda Point (about 30 minutes north of Noosa) at 2.30 pm. The start of the cruise faltered when the 8 month old, $400,000 flat bottomed vessel had to be dragged across the sandy lake bottom to deeper water. The muscle power was provided by an obliging football team celebrating their end of the season trip *(photo 27)*. Once this was accomplished we travelled across Lake Cootharaba, the largest natural tidal lake in Queensland, to the Cooloola Conservation Reserve at the southern end of the Great Sandy National Park. The top end of Lake Cootharaba is extremely shallow and difficult to navigate. The lake has a depth of only 1.2 metres, a length of 10 km and width of 5 km. Kin Kin Creek and Kinaba Island create an illusion of a separate lake at the northern end, known locally as Fig Tree Lake. The Cooloola section of the Great Sandy National Park is a gateway to the area better known as the Noosa Everglades. The only other one in the world is the USA Florida Everglades. Only the presence of alligators would be needed to complete the fancied resemblance to these since the area has almost an exactly equivalent latitude and climate. The area is a tropical wetland which extends for 25 km. An everglade is a freshwater swamp that has fresh water flushing through it from the catchment area. It is one of Australia's most diverse ecosystems boasting over 40% of the country's bird species, 700 native animals and 1365 plant species. Today we saw only pelicans and a black cormorant.

The middle section of the Noosa River is little more than an elongated peat-bound lake. The water percolates from the huge spongelike sandmass of Cooloola which acts as an inverted reservoir. The water released eastwards trickles over the beaches in a constant stream, but the water flowing west is trapped in the peat swamps before filtering into the river which is still and has no perceptible flow except in floodtimes. The everglades are part of the traditional lands of the Gabi Gabi people whose territory stretched from Fraser Island to Caloundra. Europeans have exploited the area through logging, agriculture and sand mining in the past.

Once past the Kinaba Information Centre we entered the calmer waters of the Upper Noosa River. Sage, tea tree and swamp banksias lined the river course. Because of the organic staining it has received during its long, slow journey, the water bears the reddish organic colour of tea and, like tea, becomes inky black the deeper it gets. In the black peat-lined river, the water is so dark as to act as a brilliant mirror unless its surface is ruffled by the wind *(photo 28)*. It is the combination of mirror-like stillness, and the fringing vegetation plus the wealth of wildlife which frequent this area, which adds to the magic of the Noosa River.

Purple water lilies appeared where the river water becomes brackish. Only three species of fish are found in the river; Australian bass, silver perch and catfish. In contrast the saltwater lake supports seventeen species of fish.

During the cruise Captain Mark served tea, coffee and/or sparkling wine and Anzac cookies *(photo 29)* while we relaxed in the tranquil environment as it passed by.

27. Footballers pulling the boat off the shallow sandy bank near the shore.

28. Reflections in a stretch of the Upper Noosa River.

29. L to R - Brian, Ellen and Ron enjoying 'bickies' and 'bubbly' on the Everglades cruise.

The crown jewel of the Noosa Everglades is the Narrows, a narrow stretch of river with overhanging trees and perfect reflections. It is hear that the "River of Mirrors" takes on meaning. On the return journey the vessel pulled into Fig Tree Jetty to use the facilities and stretch the legs. This is an overnight camping spot for those who are canoeing and kayaking through the Everglades.

Returning across the lake to Habitat Noosa was less comfortable as the wind gusts made the lake waters choppy and many of us got wet with the sprays of water being whipped up. Back on dry land we returned to the Coothara Bar, Bistro and Brewery for an antipasto buffet which was very enjoyable. From here the group made their own way back to camp.

<u>Day 9</u>: Monday 9th September. Maleny Plateau.

The sunny conditions today were tempered by strong winds as we set off to travel the winding and steep ascent to the Maleny Plateau. The Mary Cairncross Reserve and Rainforest Discovery Centre was our destination. When we arrived the participants gravitated immediately to the view down over the Glass House Mountains *(photo 30)*. The view was hazy due to bushfire smoke lingering around the Sunshine Coast but the mountains were still visible. Entering the Discovery Centre with its magnificently carved doors in natural timbers *(photo 31),* we met our volunteer guides Felicity and Peter for our guided walk through the reserve.

This reserve was of particular interest because it is one of the few remnants of rainforest left still growing in the Blackall Range on the basalt lava flows from the Maleny Volcano (31-27 Ma). The reserve comprises 55 hectares of National Heritage subtropical rainforest. We followed an easy grade 1.7 km bush track that encompassed the sights and sounds of the forest. There were a number of distinct habitats including swamp mahogany wetlands, palm groves and an ecotonal forest -a reminder of drier times. Red cedar, Black bean, Black Apple, Sassafras, Yellow Carabeen, Blue Gums, Piccabeen Palms, Walking Stick palms, Giant Stinger and towering Strangler Figs *(photo 32)* were some of the 100 tree species in the park. Thick twisting Wonga vines *(photo 33)* wound their way from the forest floor to the canopy. The understorey consisted of a variety of shrubs, herbs, palm lilies, ferns and orchids. Fungi, mosses and lichens were struggling in the currently dry conditions. A number of red legged pademelons *(photo 34)* were glimpsed in the under storey. Whipbirds called and a cuckoo dove was seen. A carpet python *(photo 35)* was tightly coiled in the sun near the Centre.

Returning to the Centre everyone enjoyed a morning tea at the Mt View Cafe and then spent more time looking at the static displays of Rainforest Birds

30. View of the Glasshouse Mountains from Mary Caincross reserve.

31. Carved entry doors to the Rainforest Discovery Centre.

32. Mature Strangler fig with radiating buttress roots.

33. Large Wonga vine.

34. Red legged pademelon.

35. Carpet python sunning itself next to the Visitors Centre.

36. Baroon pocket Dam.

(the current exhibition).

Returning to the vehicles, we drove next to two lookouts, Mc Carthy's and Gerrard's. The first was further along Mt View Road from Mary Cairncross Reserve and gave another view of the Glass House Mountains to the coast. This lookout is on the southern escarpment of the plateau. It showed the exposure of the harder intrusive peaks as a result of the erosion of the softer basalt and Landsborough Sandstone beneath it.

The second, Gerrard's Lookout, was on the Maleny to Montville Road. It faced to the coast and was on the eastern edge of the escarpment. It showed the lower slopes of the plateau and the towns of Coolum, Maroochydore and Caloundra spreading along the coastal plain. The residence built into the side of the escarpment, with a grass meadow roof, attracted much comment from the group.

To get to the next destination we travelled down Western Avenue and then turned into Narrow Road where a steep descent of 16% grade led us to drive over the dam wall and spillway of the Baroon Pocket Dam.

Upstream from the dam wall is the broad valley of Baroon Pocket. This is because Obi Obi Creek has eroded through the basalt lavas and the upper reaches of the softer sediments of the Landsborough Sandstone. Downstream from the dam wall is a steep sided gorge, consisting of rhyolites of the North Arm Volcanics. A picnic lunch was had in the gazebo on the shores of Baroon Pocket Dam *(photo 36)* with the gusting wind, making this a rather unpleasant experience.

In the afternoon we travelled to Kondalilla Falls National Park *(photo 37)*. Kondalilla, an Aboriginal word meaning 'rushing waters', describes this park's waterfall during the summer wet season. From the carpark there was a steep 100 m descent to a grassed picnic area. The Picnic Creek Circuit, a 1.7 km moderate grade walk, began from here. It led across Picnic Creek through tall eucalypt forest which mingles with rainforest species in the wetter areas. A drier forest grows on the western escarpment, featuring casuarinas with a grass tree understorey.

Weathered basalt of the plateau was seen in the

37. Kondilla Falls, Kondilla National Park.

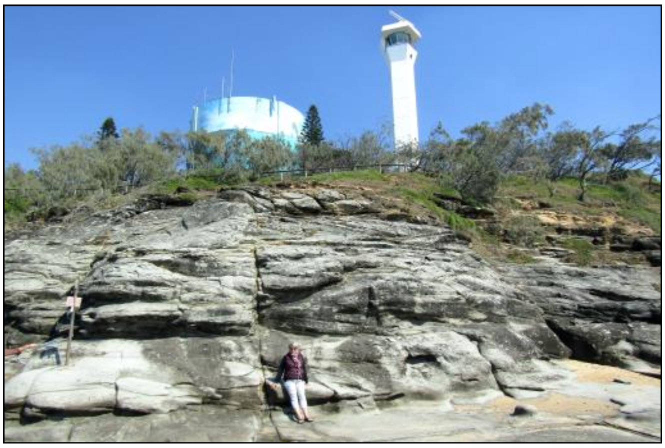
parking area and below the picnic area there were large boulders of rhyolitic tuff with the beds dipping at a low angle. The tuff was from an explosive eruption. The group walked as far as the lookout over the valley and then to a cool rock pool above the falls.

At the falls there are large slabs of rhyolite lava, over which Skene Creek, a tributary to Obi Obi Creek flows. The falls drop 90 m to the valley below. Subtropical rainforest grows below the escarpment, where soil and aspect is suitable, and riparian rainforest lines the creek. We were unable to give this walk the time it deserved because the wind became gale strength and branches were crashing down from the trees overhead. It became unsafe to proceed further.

Returning to camp the tour leader had a branch spear into the windscreen of his vehicle. Luckily no-one was injured but the windscreen broke with concoidal fractures. Happy hour was held as usual with a run - down of the next day's planned activities.

Day 10*: Tuesday 10th September. The Sandstone Headlands.*

The group met this morning at Point Cartwright after the team leader left earlier to drop his vehicle for windscreen replacement in Maroochydore. Thanks to the cooperation of other members who lent assistance the morning went ahead as planned. Descending a steep set of wooden stairs the group walked on the eastern side of the headland where thick beds of grey course quartz-rich Landsborough Sandstone formed the rock platform and cliff *(photo 38)*. This unit was formed in early Jurassic times (190-180 Ma) in the Nambour Basin. The more interesting side of the headland was the west side where the cliff displayed a fresher profile of concretions, honeycomb weathering, mineral bands and seasonal variations in the bedding *(photo 39)*. A



38. Colleen leaning on the Landsborough sandstone cliff at Point Cartwright .

39. Large grey concretion weathering out beside other light-coloured weathered concretions.

40. Walking up to Lighthouse Park towards the lighthouse and decorated reservoir.

gravel filled scour channel lay at the base of the cliffs. On the wave cut platform thin bands of shale lie beneath thick beds of sandstone. The beds slope gently to the east and have a regular fracture pattern. The quicker erosion of the shale has led to the retreat of the cliff.

The group continued to walk towards the mouth of the Mooloola River and then climbed up the hill to Lighthouse Park where a lighthouse and reservoir are located *(photo 40)*. The lighthouse was built in 1979 and is a 32 m high concrete tower. Next to the lighthouse is the reservoir also built in 1979 and standing 17 m tall and 20.5 m in diameter. It holds 6 Ml of water. The artwork over the reservoir exterior was created in 2016. The design of a turtle, a whale, a butterfly, a fish and a sea bird aims to capture the tranquillity felt when gazing out to sea. Many colourful butterflies were seen in the coastal rosemary growing on the headland. Views from the headland to the west were of the coastal towns of Mooloolaba and Alexandra Head.

Morning tea was had on the foreshore of the Mooloola River in La Balsa Park. The out of control fire front at Peregian Beach and the evacuation centre being at Coolum Surf Lifesaving Club led to the afternoon activity of exploring the cliffs, rock platform and embayments from Point Arkwright to Coolum Beach to be attempted by four of the group only *(photo 41)*. The rest of the group had free time to follow their own interests. The Maroochy Bushland Botanical gardens proved popular with many.

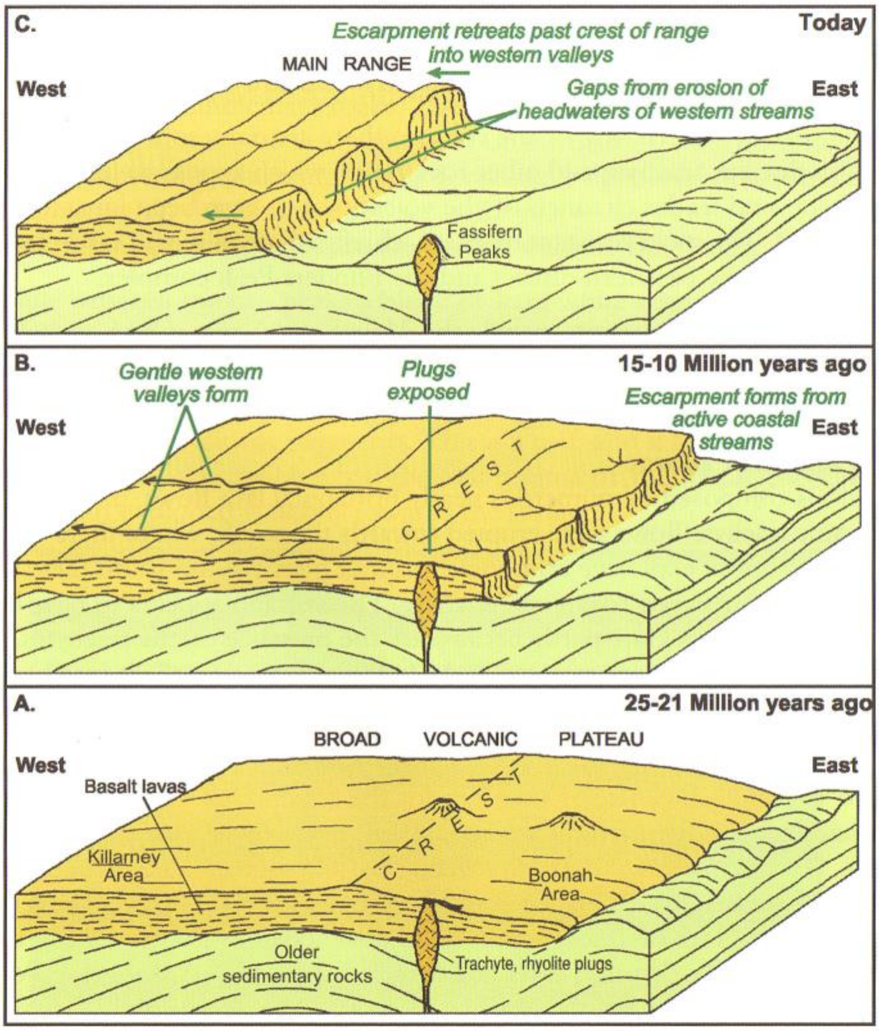


Figure 6. Progressive erosion of the Main Range Volcano.

At Happy Hour later in the day people seemed to be pleased with their afternoon explorations and happy to share their experiences.


41. Exploring the cliff-line from Point Arkwright to Coolum.

Day 11: Wednesday 11th September. Landsborough to Killarney.

Today the group moved camp from Landsborough to Killarney View Cabin and Caravan Park. A number of routes were suggested and the group were made aware of the bushfires on the outskirts of the town of Esk. Glenda and Ross found oil leaks under their vehicle in the morning and had to tend to this before being able to travel. They arrived safely at the Killarney camp late that night. We welcomed Shayne and Roz to the safari group at Killarney.

Killarney is near the remnants of the Main Range Volcano. This shield volcano erupted between 25-22 Ma producing numerous nearly horizontal lava flows. Most of the lavas were basalt but some trachyte and local rhyolite erupted towards the south. There is no well-marked centre of eruption for the basalt lavas but it is thought the southern ones came from dyke swarms. For the trachytes there are several possible sources. Since then erosion has removed the eastern side of the volcano which contained the vents to produce an escarpment. This has exposed the underlying soft shale and sandstone layers *(figure 6)*.

Day 12: Thursday 12th September. The Settlers Route, Cambanoora Gorge and Yangan Quarry.

It was a cool 6 degrees this morning in Killarney, a great contrast to conditions on the Sunshine Coast. The out of control fires around Drake, Tenterfield and at Legume gave a smoke haze to the morning. We had a slower start to give members a chance to catch up with washing and groceries. The convoy then got underway to drive via the Settlers Route to Tannymorel.

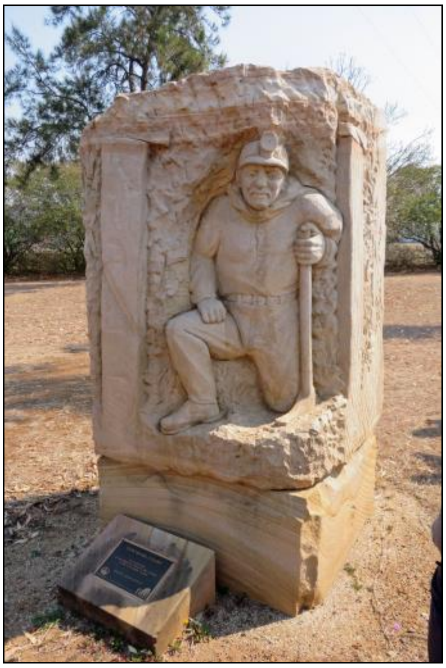
This village was originally a service centre for the Canning Downs district and Mt Colliery. Coal was mined in the Upper reaches of Farm Creek from 1883 which is 6 km from Tannymorel. The coal mined was from the Walloon Coal Measures in the McPherson Ranges, the western flank of the Main Volcano. The coal formed 165 Ma during the Middle Jurassic period and is overlain by the volcanic rocks of the Main Range Volcano. The formation is 400-700 m thick and is comprised of thin bedded claystone, shale, siltstone, lithic and sublithic to feldspathic arenites, coal seams and minor limestones. Demand for coal increased when the railway line was opened from Warwick to Killarney in 1885 because it was needed for the steam locomotives. Coal from Mt Colliery mine also supplied several dairy factories, the Warwick hospital and the gas works. The mine closed in 1967 and little remains from this coal mine which was the first in Queensland.

A sculpture in sandstone of the Tannymorel Collier *(photo 42)* by Dr Rhyl Hinwood is one of the few reminders from this part of the region's history.

From Tannymorel, we followed Farm Creek to Mt Colliery and then turned into Gambubul Road. This road followed the course of Farm Creek towards its source near Mt Superbus in The Main Range National Park. The crests of the ridge showed the approximate position of the western flank of the Main Range Volcano, while the gravel road services the grazing properties and pine plantations found in the upper reaches of Farm Creek. The grazing lands were no longer lush green but were dry and brown as drought conditions persist. At the furthest point out at a height of 1050 m above sea level we stopped for morning tea. On the way back down from the peaks we stopped many times to take in the view of Cambanoora Gorge which has been formed by the Condamine River *(photo 43)*. The layer of trachyte lava is more resistant to erosion than basalt and this has formed the steep sides of the gorge. Several road cuttings gave us the opportunity to study the various basalt lava flows that also came from the volcano. The vesicular basalts were the most common in this area and some gas vesicles contained zeolites. Two thick trachyte flows were crossed along the way which had vertical fractures (a factor in the erosion of these trachyte flows).

In pockets of remnant rainforest which would have covered the ridges in the past there were many butterflies, assassin beetles and other unidentified small red bugs. We found rock lilies and orange blossom orchids *(photo 44)* along the tree trunks. We then returned to Farm Creek Park in Tannymorel for lunch.

After lunch, we drove to Yangan to have a look at the Rosehill Quarry where the quarrying of sandstone is undertaken. As no formal arrangement had been possible with the quarry management prior to the safari we drove past the cemetery and stopped at the fence line at the perimeter of the quarry. This proved to be detrimental to the quarrying processes as all the machinery suddenly ceased to operate. Unbeknown to us "Greenie protesters" (which is what the quarry workers call them) had been harassing the quarry owner over the past 18 months over dust and noise pollution and he suspected we were another group of these protestors. Fortunately the owner/manager John Doherty followed our convoy into Yangan and Terry, using all his diplomacy skills, was able to get the group a tour of the quarry workings *(photo 45)*.



42. Sandstone sculpture of the Tannymorel Collier.

43. View of Cambanoora Gorge from Gambubul Road.

This was not the only mishap of the day. While we were in Yangan looking at the heritage buildings namely the School of Arts (1897) and the Masonic Hall (1898) the local policeman wanted to issue fines to the six car drivers for parking in a no parking zone which we hadn't seen. Brian used his charm to dissuade him from his purpose and eventually he told Brian to move us along elsewhere. In convoy, we followed John back to the quarry and drove into the entrance, parking at a

44. Orange blossom orchid .

45. Some of the 13 tungsten-tipped saws cutting out sandstone blocks in Rosehill Quarry, Yangan.

46. Quarry face. Note the saw cuts in the sandstone where blocks have been removed.

47. AGSHV members posing for a photograph in Rosehill Quarry, Yangan.

spot which gave us an overview of the quarry face currently being worked *(photo 46)*. We saw the stone cutting saws in operation and the stone being raised and lifted into dump trucks for transport.

The sandstone is a premium grade sandstone consistent in grade and features flawless beauty and strength. Its wonderful characteristics and uniqueness makes the stone one of rich appeal. It is used in building construction. St Mary's Catholic Church in Warwick is one of the last buildings built with this stone. The sandstone is graded A and B^+ and sold by weight as sawn prisms of various sizes. Lesser quality sandstone is sold for paving, retaining walls and for landscaping projects.

Yangan sandstone is 150-200 Ma from the early to mid- Jurassic period and is a quartz sandstone. The fresh sandstone is grey in colour and the yellow and pink types come at different depths. A purple sandstone is also found in one section of the quarry.

The quarrying operations at Yangan have been going since 2011 and the current site is 18 months old and is located 500 m from the town. 20 locals work at the quarry, 6 days per week from 6.30 am to 5 pm.

There are 13 stone saws in operation and the operators control the cutting rate. The saw blades and teeth are of tungsten and are replaced every 10 days in the newer section of the quarry and every 3 days in the older section. In the new section of the quarry the overburden is just 200 mm. John said the life of the quarry was about 80-100 years. The sandstone is sold throughout Queensland and NSW with some of the largest blocks being sold to China where they are processed and sold back to Australia.

The quarry has taken a number of steps to reduce the dust and noise. A wall around the working areas of the quarry has been created to a height of 4 m in the direction of the town and a barrier of vegetation forms a natural buffer against noise and dust; the dust settling within 15 m of the quarry. The Department of Natural Resources and Mines conducts regular inspections and the quarry follows the guidelines to the letter.

A newspaper article in the Warwick newspaper dated 13th June, 2016 claimed the quarry contributed $40,000 to $50,000 to the local region's economy each week.

We had a group photo *(photo 47)* taken with John at the quarry as a finale to the tour and then returned back to Killarney. Happy Hour was held to outline the next day's activities and to review the day's adventures.

Day 13: Friday 13th September. The Main Range and Escarpment.

The convoy for the Scenic Rim Drive formed at 8:30 am and a very big day of discovery lay ahead. Dagg's Falls *(photo 48)* was reached via Spring Creek Rd where the lookout gave great views of the 10-15 m drop over two thick, less fractured, resistant basalt flows. The columnar jointing in the basalt cliff was also very clear.

We drove to Queen Mary Falls which is further upstream. Here the westerly flowing creek, while eroding down through the pile of basalt lavas has encountered a thick resistant trachyte flow between softer basalts. The walk to view the features was done clockwise along the Queen Mary Falls Circuit to give the best view of the falls *(photo 49)*. After returning from the falls we crossed the road to The Falls Café where the group had morning tea. Feeding the colourful parrots and consuming treats such as carrot cake and baked lemon cheesecake was a real hit.

Carr's Lookout was the next place where we stopped. At 1060 m it gave us a clear view of Mt Superbus and the Main Range ridge crests sloping gradually to the west *(photo 50)*. These approximate the western flank of the volcano.

The next section of the road was steep, narrow and winding in sections with deep gutters on the sides. The stop at the Moss Gardens gave the tour leader some trepidation because of these factors. Hi-Vis jackets were worn to warn passing motorists but luckily few cars drove past. All went well and when searching the dark grey basalt 50 m below the car park with the geology hammer we found excellent examples of basalt containing vesicles filled with zeolite chabazite *(photo 51)*.

Further up the road 100 m from the car park gave us a chance to study massive light purple grey trachyte sill *(photo 52)* that had feldspar crystals and flow banding. The trees with flowering rock lilies and mosses draped on them, the ferns, lichen, orchids and moss kept the photographers very busy when following the track beside the rabbit fence which is the Qld/NSW border.

While travelling toward Teviot Falls we followed the ridge line which was a continuation of the border

48. Dagg's falls.

49. Queen Mary Falls. Note the tiny figures of people on the track at the base of the falls.

50. View east from Carr's Lookout towards the peak of Mt Superbus.

51. Sample of vesicular basalt with zeolite crystals (chabazite) in some of the gas bubble cavities.

and passed a region called the Head. This grazing property is the start of the Condamine River and is the headwaters of the Murray-Darling basin. At Teviot Falls the parking space was quite limited at this point, the crest of the range. The 38 m falls did not have any water coming over them but as Roz pointed out a dark stain of Cyanobacteria showed where the water would be when it was flowing *(photo 53)*. There was evidence of the Eastern escarpment still retreating when we studied the landslide and talus slope at the base of the cliff. Great care was taken because the track to the viewing point was built on the top of this retreating cliff line. The road built on this eastern escarpment was very steep to the base of the range.

A small cutting of sandstone was found near the base of the range. The foothills are formed on shale and sandstone of the Walloon Coal Measures. These measures are weathered and poorly exposed. We had been following Teviot Brook from the Falls and it was crossed many times. Further along the road a trachyte sill was exposed which showed some flow banding in the samples that were retrieved. Wildflowers and red dragon flies distracted some of the photographers in the group.

Grazing land was passed when we drove out of the foothills and on our way to lunch at Boonah. After lunch we drove around town to view the public artwork of the Clydebuilt Horse, Blumbergville Clock and With An Eye On The Sky. After leaving town we viewed Frog Buttress on Mt French, a popular rock climbing site, on our way to Lake Moogerah.

We arrived in time to have clear views across the lake but shortly after arrival the wind started blowing strongly from the west which brought heat and smoke from fires. Moogerah Dam was only 43% full due to the drought but the walk across the dam wall was a real highlight. It is a mass concrete double curvature wall 38 m in height *(photo 54)*. At each end of the 219 m wall the abutments were studied going into the rock walls. The middle of the wall gave a feeling of vertigo because it curved underneath the viewing point and it felt like there was nothing underneath to hold the structure up. The rocky outcrops that could be seen were the Walloon Coal Measures again.

The group dispersed to find their own way back to camp. Most travelled via Cunninghams Gap which gave the energetic the chance to walk the track to the viewpoint over Fassifern Valley. The views of the cliffs of The Ramparts on the right showed the numerous layers of Basalt flows. We turned off the highway to divert through Maryvale to view basalt columns that were curved at the base. It was thought that the surface over which the lava flowed was undulating to cause this phenomenon.

A cold drink was enjoyed at the end of this long hot day while watching the blood red sun set and a variety of colours sweep across the darkening sky.

52. Ron examining a sample of trachyte from the outcrop beside the road.

53. Looking at the trachyte cliffs over which Teviot falls flows after rain.

54. Double concrete curvature wall of Moogerah Dam.

Day 14: Saturday 14th September. Cambanoora Gorge and fossilised wood in Gatton Sandstone.

It was another cold morning and during the day there was a mild temperature of 18 degrees. Today we needed 4WD high clearance vehicles to tackle the 20 km gravel road through Cambanoora Gorge. The trip wasn't as challenging as we had thought as the drought conditions meant many of the 14 river crossings on the Condamine River were dry. Stops were made at Rocky Crossing to view the creek bed and swimming hole where platypus are sometimes sighted and at Flaggie Creek where a weekender with an outside bath caused much amusement *(photo 55)*. More importantly because the causeway was dry we were able to see a worn pavement in the hexagonal columnar jointing of the basalt located here *(photo 56)*. Mt Stump was a rounded pillar of volcanic origin and the vertical walls of trachyte were seen in other locations along the gorge *(photo 57)*. We were fortunate to see many wallabies, long horned cattle, alpacas protecting highland cattle, Angus mothers suckling their calves and horses you could feed for $5.

The elevation of the gorge was 650 m and the road followed the original bullockys' track to Killarney which was used for mail, timber and other supplies for the railway there. Finally we reached The Head *(photo 58)* which is the headwaters of the Condamine River and turned right to return along Spring Creek Road to Brown's Falls picnic area for morning tea.

Afterwards we walked along an ill-defined trail following Spring Creek to Brown's waterfall *(photo 59)*. The route involved rock hopping over the creek, clambering up banks, scrambling over and under tree roots and fallen logs. The effort was worth it to see the 15 m falls, with water flowing over the truncated basalt columnar jointing. The columns were sheared off at the same height probably indicating a fracture point. The walk took about an hour and our timing was excellent because when we returned to our vehicles a four wheel drive club had arrived at the picnic spot and this tranquil area had become a carpark. Our group travelled back to the campground at Killarney to have lunch before the afternoon's activity.

55. Flaggie Creek weekender with an outside bath and wash basin.

56. Outline of hexagonal basalt columns on the eroded basalt creek bed.

57. Trachyte cliffs bordering the Condamine Valley form the Cambanoora Gorge walls.

58. View south down the Condamine River valley towards Cambanoora Gorge from The Head.

Brian Redmayne led the group to Vinegar Hill Road, near Legume in NSW to view an outcrop of Gatton Sandstone in a road cutting. Gatton Sandstone was formed in the Early Jurassic period and it is a basal unit of the Marburg Subgroup found in the Clarence-Moreton basin. It commonly contains abundant wood and conglomerate in discrete intervals, the beds occurring at different levels throughout the sandstone

59. Browns Falls - note the hanging basalt columns being undercut by the plunge pool.

60. Fossil wood found in the Gatton Sandstone.

and their position is probably controlled by the preservation of the fluvial sedimentation cycle. Sometimes logs of fossil wood up to 18 m long and 0.6 m in diameter have been found in this unit with the wood mostly being replaced by hematite and limonite but rarely silica. Our group had success in finding large pieces of fossilised wood thought to be oak in this sedimentary outcrop *(photo 60)*. The first pieces were found embedded in the roadway and when this layer was followed into the embankment and down the hill good quality examples were observed. The group collected specimens to be used as garden features when they returned home.

We drove through pastoral properties to Flagstone Creek and a site where Brian had panned for gold as a child. We then headed back to camp.

Fourteen of the group went to the historic Killarney Hotel (1920's) to have a celebratory dinner for Barry and Elaine's 51st wedding anniversary in the evening. It was a very happy occasion enjoyed by all of us.

Day 15: Sunday 15th September. Killarney to Stanthorpe.

A special treat of a pancake breakfast in the camp kitchen provided by Kevin and Bronwyn our hosts at Killarney View was enjoyed. It was a fund raiser for the local aged care facility. We are proud to say our contribution raised $90. Afterwards our intrepid group set off for Stanthorpe and the Top of the Town Tourist Park to enjoy the last few days of this year's safari.

We met again as a group at 5 pm at the Stanthorpe Heritage Museum where Lorene and her staff of dedicated volunteers provided a stew and damper dinner *(photo 61)*. We ate under the cover of the blacksmiths forge as a result of the total fire ban which meant we had to forgo the campfire outdoors. We were free to visit the exhibits in the museum before and after dinner and to return again during our stay in town. The museum patron Don Lightfoot shared his reminisces of days past in the pastoral industry and his knowledge of the Chinese involvement in tin mining in the early days.

Subduction zones and granitic intrusions are to be seen near Stanthorpe. The Stanthorpe and Ruby Creek Granites intruded meta-sediments in the Triassic Period about 240 Ma. This was probably the last expression of the subduction zone which began in the late Devonian 370 Ma. Since the Triassic Period, erosion has removed a tremendous thickness of rock to reveal the granites which originally solidified at considerable depths in the crust. Erosion has reduced the downward pressure on the granite allowing it to expand upwards. This creates large horizontal fractures that separate large slabs and also cracks to make vertical fractures. This process generates valleys, domes of rock and rounded boulders at the surface *(figure 7)*.

61. Lining up for stew and damper at Stanthorpe Heritage Museum.

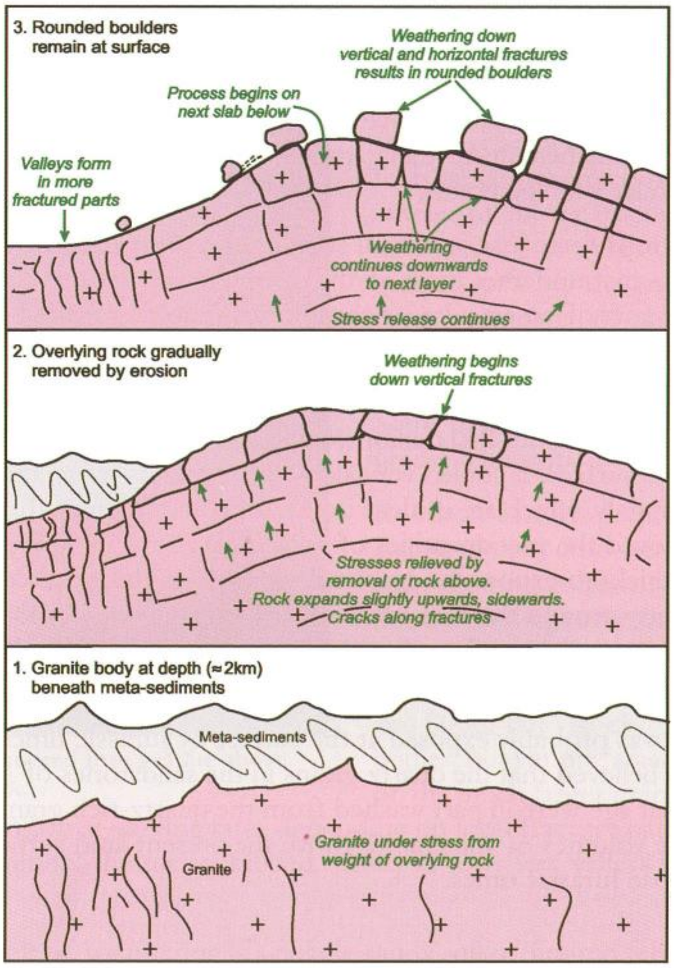


Figure 7. Formation of rounded boulders in granite terrain.

62. Terry and Laurel near a granite tor during the Sentimental Rocks walk, Stanthorpe.

63. Pink Stanthorpe Granite.

64. Members enjoying morning tea at Heavenly Chocolates.

Day 16: Monday 16th September. Sentimental Rocks, Girraween and Wallangarra.

The planned activities at Stanthorpe had to be reorganised due to the bushfires ravaging the landscape and causing an extreme fire danger. After contact with National Parks it was confirmed that three of the four National Parks we had planned to visit were closed with only two walks accessible in Boonoo Boonoo National Park, the last left open. With adjustments here and there we still managed to make the best of our time. With this in mind the convoy formed at the caravan park entrance at 8:30 am and we drove up the steep and winding ascent to Mount Marlay Lookout for a panoramic view over Stanthorpe and surrounds. More of the granite landscape was exposed as the fires had removed the cover of vegetation.

Next we drove to an outcrop of granitic boulders called Sentimental Rocks, in Jardine St, right in Stanthorpe itself. This is described as a mini Girraween and the short walking track gave us the chance to view and climb the granite tors *(photo 62)* and titans (some as big as a house) and noticed the exfoliation due to the weathering processes. The Stanthorpe Granite (*photo 63)* seen here contains large crystals of potassium feldspar (50%), plagioclase feldspar (10%), quartz (30%), biotite mica (7%) and hornblende (3%).

Driving from Stanthorpe to Girraween National Park via Eukey and Pyramid Roads we were able to enter the eastern boundary of Girraween National Park and drive through the park itself by the public access road. The fire damage was evident and barriers had been placed across all tracks and walks leading into the park. We stopped for photographs of huge granite boulders, The Pyramid (a natural icon of the park) and the burnt out forest.

To lighten the mood after witnessing the fire devastation, we stopped for morning tea at Heavenly Chocolates *(photo 64)*. Excellent coffees and hot chocolates were consumed on the shaded garden terrace where the owners' chooks kept us entertained with their antics. We sampled fudge and rocky road served to us while we relaxed in this tranquil setting at Wisteria Cottage. The daughter of the owner had made the chocolates and was also a rural fire brigade member and member of the SES. She was able to give us an update of what had been happening in the area. The family were very friendly and welcoming and were very appreciative to have our business. The chocolate tasting was enjoyed and purchases made.

Travelling further south along Old Wallangarra Road we stopped at an outcrop of rocks dark grey/ black in appearance with fine grains and many well-formed biotite crystals and a small amount of quartz and feldspar. Warwick Willmott states that these are welded tuffs *(photo 65)* in The Wallangarra Volcanics series consolidated from the hot debris from violent volcanic eruptions during the late Permian. When Ron checked his Geology app he thought it was Dundee Rhyodacite. Geological hammers appeared and a number of rock samples were collected before we carried on to the twin border towns of Wallangarra (Qld) and Jennings(NSW).

At Wallangarra we visited the heritage railway station *(photo 66)* that had been built in 1887. The station was built on the Qld/NSW border and it allowed train travellers to change from the NSW standard gauge of 4 ft 8½ inches to Queensland's narrow gauge of 3 ft 6 inches. We noted the distinctive architectural differences between the western and eastern platforms which emphasised the tensions between the colonies before Federation. The museum located in the Station Master's Office was of special interest housing many press cuttings, memorabilia and a simulator booth with actual rail carriage seats to sit in. The Station Master's House faced the eastern platform and is constructed of brick, in an "L" shape with posted verandah and prominent chimneys. It was sold in 1995. The Custom's House officially gazetted in October 24, 1885 is now a private residence and is located to the west of the station. All goods coming into Queensland had to pay customs duty prior to 1901. A quick stop at the 1865 border survey marker (carved into a tree trunk) was made before lunch at the Lion's Park.

Travelling north along the highway we stopped at a road cutting of dark welded tuff of the Wallangarra Volcanics for a closer look. This was a very short stop because of the danger of traffic travelling at speed on the highway.

At Ballandean we stopped to view the Ballandean Pyramid *(photo 67)* built from 7,500 tonnes of Stanthorpe Granite boulders removed from land prepared for tillage on the Henty Estate, formerly owned by Stewart Morland. The pyramid took 8 months to build by contractor Ken Stubberfield in 2006. It has a square base of 30 m each side and is 15 m in

65. Sample of Dundee rhyodacite, a rock found in the Permian Wallangarra Volcanics.

66. Wallangarra heritage railway station. The Brisbane line is on the left and NSW on the right.

67. Ballandean Pyramid composed of 7.5 tonnes of Stanthorpe granite boulders.

height and has become a local icon.

The last stop of the day was at Storm King Dam the major water supply for Stanthorpe residents and irrigators. It is owned by Council and it was built in 1954. It has just one inflow source, Quart Pot Creek. Its catchment area is 91 km². At full capacity it holds 2065 Ml of fresh water. At present it is 17.5% of its capacity. An infrastructure update was commenced in March, 2019 costing $6.5 million to renew the pipeline from the dam to the Mount Marlay Treatment Plant. This should be completed by December this year. We noted the very low dam levels and the construction work taking place at the dam. The name Storm King comes from a sailing ship on which two mine owners John Yaldwyn and James Ross came to Australia in 1872. These men established Storm King Mining Co and built an earlier dam for mining purposes. From here we made our way back to camp and met again at Happy Hour to confirm bookings for the next day's activities.

<u>Day 17</u>: *Tuesday 17th September. Boonoo National Park, Stannum House and Australian Vinegar Company.*

The departure time this morning was 8.15 am and we travelled from Stanthorpe along Mount Lindesay Road towards Tenterfield. The groups' first stop was at the comical bike sculpture where bicycles of various sizes and colours were attached either right side up or upside down along a burnt out tree trunk *(photo 68)*.

Boonoo Boonoo National Park was open but only two walks were available; the Falls Walk and the Rock Pools Walk. We stopped at various locations along the route to photograph the fire devastation and noted the trees were in survival mode sprouting leaves directly from their trunks. After parking at the Falls Picnic area we walked along a sealed pathway on the southern side of the gorge through dry sclerophyll forest and grassy woodland to a scenic lookout There was a 210 m drop of the falls over granite rock into the gorge below. Unfortunately due to the drought conditions there was no water flowing *(photo 69)*. Legend has it that Banjo Patterson proposed to his sweetheart Alice Walker at this very spot.

In the cliff face opposite the lookout, numerous flowering rock lilies were seen. Returning the way we had come we deviated to a path leading down to the rock pools *(photo 70)* above the falls. In wet conditions cascades of water would have flowed from one pool to another towards the fall but not today. Here outcrops of the pink Stanthorpe Granite were seen and examined.

Returning to the picnic area for morning tea we celebrated Ellen's birthday a few days early by consuming very tasty lamingtons Sue and Ian had organised *(photo 71)*. A boisterous Happy Birthday was sung before we headed off again towards Tenterfield. By chance we located a climbing orchid on a tree trunk as we were leaving the carpark.

Back on Mount Lindesay Road travelling towards Tenterfield we made two stops. The first was at the Tank Traps from World War II. These were part of the "Brisbane Line" first discussed in 1942-3 by the Prime Minister of the time Robert Menzies. If there was to be a Japanese invasion the Government was prepared to sacrifice the northern parts of Australia and defend only from the line joining Brisbane to Melbourne.

Thunderbolts Gully was chosen as a narrow steep sided place to set exploding mines in the then gravel road and the concrete retaining wall and the huge granite boulders on the eastern side of the gully would be obstacles for the light Japanese tanks. Three rows of wooden posts were set in the ground *(photo 72)* were to force the tanks to rise up exposing their soft underbelly. Well dug in forces could hold the Japanese back for some time. The London bridge army camp was 1 km to the south.

The second stop was at Thunderbolt's Hideout. A short climb of about 150 m took us to a network of

68. Bike sculpture beside the Mount Lindesay road.

69. Location of Boonoo Boonoo Falls and the gorge below.

70. Exploring the scenic rock pools above the Boonoo Boonoo Falls.


71. Ellen waiting to 'pile into' the stack of lamingtons.


72. Remnants of Japanese Tank Traps built during WWII.


73. Members admiring Stannum House in Tenterfield before entering for lunch and a tour.

caves where the bushranger Fredrick Ward hid out from the troopers. He used the area between the rocks to stable his horses and the small shelter under the large rock as a place to camp. The top of the rock made an ideal lookout.

Reaching Tenterfield at lunch time the majority of the group enjoyed the Sri Lankan cuisine served in the buffet luncheon at the restaurant in Stannum House *(photo 73)*. After lunch we were able to do a tour of this Victorian Italianate mansion with Kirk Jensen a former owner of the house and an expert in Victorian era restoration.

The house was built by John Holmes Reid, a tin mining magnate and politician who had aspirations to be Prime Minister and Stannum House was to be Government House. The foundations of the house are on a bedrock of granite. The house was built in 1888 and was a family home for his wife and 12 children cared for by 14 domestic staff. It is a three storey brick and stucco building with front bay windows and cast iron veranda and balcony decoration. The vestibule has an archway supported by Corinthian columns. Off this are three beautifully restored rooms which present magnificent antiques and curios, some of which belonged to the Reid family who lived in the house for 50 years. A grand staircase of red cedar leads to the first floor rooms. The master bedroom has a Juliet balcony.

A unique cedar spiral staircase leads to the third floor. There are ten Italian marble fireplaces in the house. A small narrow ladder led to the roof garden where we had views over a very smoky Tenterfield. Helicopters carrying water buckets flew overhead. It was hard to leave this tour as Kirk had so much to tell us but we had commitments in Stanthorpe and had to leave after an hour.

The last activity for the day was a visit to the Australian Vinegar Factory in Rowley Court, Stanthorpe. We met the owner/expert vinegar maker, Ian Henderson who from humble beginnings in 2003 has built his business based on state of the art vinegar making technology. The factory was built in 2017 at a cost of $1.5 million. It is stage 1 of his proposed development on the site. Ian has a background in Science and Mathematics, is a qualified wine maker and in 2006 won a prestigious Churchill fellowship to study vinegar making in Italy, Spain and Austria. Jim and Lorraine had first met Ian at an Olive Symposium at the Gold Coast in 2005 and had arranged this tour for our group.

We dressed in Hi-Vis vests and wore hairnets for this tour as the factory has to meet the stringent requirements of the food industry. Seventeen highly qualified employees all with backgrounds in science, bio-chemistry, chemistry, clinical pathology and engineering work at the factory. Some of the traditional vinegars are made in oak barrels and the bulk vinegars are made in stainless steel tanks. Ian said "At a basic level vinegar is the substance produced when wine goes bad. But making it deliberately and doing it well, is a surprisingly complicated and scientific process."

Making vinegar is a two stage process which starts with sugar. For wine vinegar the sugar comes from grapes and for apple cider vinegar the sugar is from apple juice. Yeast ferments the sugar to make alcohol and for the first stage. In the second stage a bacteria is introduced which then ferments the alcohol to turn it into acetic acid, so grape juice becomes wine, wine becomes wine vinegar. Bulk vinegar is sold under the brand Australian Vinegar; retail vinegar and foodservice vinegar is sold under the Lirah Australian Vinegar brand. Healthy drinking vinegar is sold under the brand name Your ACV. Ian exports to USA, Canada, UK, Taiwan, Singapore, Malaysia, Hong Kong and New Zealand and sells domestically and to leading Australian chefs.

At the end of the tour we tasted several vinegar products from Ian's range on ceramic spoons. Many purchases were made with strawberry, garlic and ginger infused vinegar being popular purchases. A group photo was taken here *(photo 74)*.

There was a short burst of rain as we left the factory and then a number of dry lightning strikes were seen towards the south. Very soon afterwards plumes of smoke started to rise. We learned later on the news that 7 bushfires had started in the Tenterfield area as a result of these lightning strikes. At the Happy Hour meeting, the tour leaders suggested a Gourmet Trail activity for the last day of the safari. Rather than this being an organised affair people decided they would appreciate free time to follow their own interests. We would all meet at 6 pm at the RSL at the end of the next day.

74. Group at the Australian Vinegar Factory.

Day 18: 18th September. Last day of the Safari - Free Day and Farewell Dinner.

As is the tradition, the group met at the Stanthorpe RSL for a final get-together and meal to celebrate the safari. Thank 'yous', goodbyes and safe travels were shared as the group dispersed at the end of the evening. It was a very enjoyable night. The group leaders Brian and Barbara were very appreciative of the kind words and generosity shared by everyone involved in the 2019 AGSHV Safari.

75. AGSHV group enjoying an 'end-of-Safari' dinner in the Stanthorpe RSL.

Report by Brian and Barbara Dunn.
Photographs by Barbara Dunn and Ron Evans (4, 7, 10, 13, 14, 24, 25, 27, 32, 33, 37, 38, 41, 42, 45, 46, 55, 56, 58, 59, 61, 68, 69 & 70).

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Geo-Log 2019, as usual, is a collaborative publication with input from trip leaders who organise and conduct activities and submit reports of the activity they organised for inclusion in Geo-Log 2019. Various members also provided photographs for inclusion.

Geo-Log 2019 includes reports from several geologically complex areas requiring considerable research from leaders who organised and ran the outings, as well as preparing long and rigorous reports, hence the large size of Geo-Log 2019. A big thank you to those members as well as other members who provided geological and social input during the activities.

Congratulations goes to Brian and Barbara Dunn who, for the first time, organised and ran the Annual Safari, *'Geological Tour - Tweed Volcano, Glass House Mountains, Main Range Volcano and Stanthorpe Granite Belt'*.

Although not geologists, the many hours of research and preparation they carried out resulted in a wonderful and educational Safari. They had to contend with drought, bushfires and National Park closures during the trip resulting in program changes 'on the run'.

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As usual, Life Member Ron Evans compiled Geo-Log 2019 and organised its publication by Lakemac Print, Speers Point.

Ron Evans.