'Geo-Log' 2012

Journal of the Amateur Geological Society of the Hunter Valley

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Contents:

President's Introduction.

Hello members and friends,

Yet again we have enjoyed a very successful year. Although the Society has been running for over 30 years, our membership has remained stable and has even increased slightly in recent years, reflecting a continuing enthusiasm for and appreciation of the earth sciences and related activities. A background in geology is not a prerequisite to membership and every member is strongly encouraged to take part regardless of their level of knowledge.

Although the initial aim of the Society was the exploration and understanding of Hunter Valley geology, for several years now we have continued to widen our coverage well beyond the confines of the Valley. Even so, while the organizing committee tries to include new activities into the program each year, this is becoming more difficult. But new members bring new ideas and new experiences which everyone can benefit from. Occasionally old sites are revisited, either for the benefit of new members or where the availability of new information has allowed a greater understanding of earth history.

Our first extended excursion was organized (with some trepidation) into the Flinders Ranges in 1995, but this was so successful that similar trips have since taken place annually. This year's program included two such trips, the first to the Australian Alps in February and the second to Eyre Peninsula in South Australia in September/October. The latter gave us an insight into the incredible variety of South Australian geology as well as allowing participants to experience some of the frighteningly wild weather the Peninsula occasionally throws up.

Our program also benefits greatly from expertise from outside the Society. This year we were again very fortunate to have geologist Chris Herbert give up another day of his time in May to skillfully guide members through the geological history and stratigraphy of the sedimentary sequence at Redhead Bluff. We all hope Chris will continue to be involved with the Society.

Very special thanks go to the Social Committee for their rarely acknowledged input at events throughout the year, especially the 'soup and slides' night and the Christmas meeting. Thanks also to Sue and Ian Rogers who made their home available for both the AGM and the Christmas social. Grateful thanks also to our Treasurer Leonie Mills who keeps our finances in order and who also this year bore the brunt of preparations for our Flinders Island trip coming up in April. Our Secretary Ian Rogers continues to get our very informative newsletters out in a timely manner and oversees the Society website which provides a window on our activities and continues to attract enquiries which often result in new memberships.

Thanks to those members who took part in organizing and running our activities and who contributed to this journal and especially to Life Member Ron Evans for his determination and dedication (in sometimes difficult circumstances this year) for putting together another great addition of the Journal that we can all be proud of and which continues to draw accolades from both the scientific community and general public.

With very best regards,

Brian.

Australian Alps Safari

Saturday 19th to Friday 25th January 2012

Leader: Chris Morton.

Attendance: 20 members; 1 visitor.

There were many facets to our trip to the Snowy besides the magnificent scenery of the Kosciuszko region. Not least, the complex and diverse geology represented by four periods of time-based divisions, from the Ordovician through to the Holocene. There was also the Aboriginal and European history plus some 4X4 adventure driving and the comradeship of an enthusiastic and eclectic group of participants.

Geology of the Australian Alps – A Brief Summary

The Australian Alps are the highest section of Australia's Eastern Highlands, running from northern Queensland down into Victoria. The region contains a wide variety of rock types relating to its complex geological history going back some 520 million years (ma).

Southeastern Australia has only existed as land for 350 ma. Prior to that it was a region of volcanic islands scattered over a wide ocean similar to the present-day eastern Pacific. The oldest rocks in the Australian Alps are basalts erupted onto a deep ocean floor during the Cambrian period around 520 ma. In the following period, the Ordovician, vast areas of this ocean floor were covered in a several-kilometre thick blanket of sand and mud over the next 80Ma. The resulting sandstones, mudstones and shales now form much of the modern Alps. During the same period, a long chain of volcanic islands erupted basaltic and andesitic lavas and these rocks are now exposed around Kiandra.

Between the Silurian and Middle Devonian (440-360 ma) the sedimentary and volcanic rocks formed during the Cambrian and Ordovician were folded by mountain-building events brought on by collisions between several small tectonic plates. This folding took place in at least three separate events. The first stage (Benambran Folding Stage 1) occurred at the end of the Ordovician, after which sands and muds were deposited in the newly-formed Tantangara Trough resulting in the sandstones and shales of the Tantangara Formation now exposed east of Tantangara Reservoir. Following the third phase (Bowning Folding) in the early Devonian, ignimbrites of the Kelly's Plains Volcanics were erupted over the land surface in the region from just south of Tantangara Dam north to include the present–day Cooleman Mountains.

Spread over around 30 ma, these folding events lifted the rocks above sea level to form dry land and thicken the crust. Great blocks of this new continental crust were moved tens to hundreds of kilometres along major faults. Some of the rocks were forced deep into the crust where high temperature and pressures metamorphosed them into slate, schist and gneiss. Some were heated above 650°C, temperatures high enough to melt them. Ultrabasic rocks (perhaps Cambrian ocean floor basalts) were squeezed up along major sub-parallel faults and altered to form belts of serpentinite, such as the Tumut Ponds Serpentinite Belt. Slate is a common rock type throughout the high country, with schist and gneiss occurring to the south in the Victorian Alps.

Large bodies of granitic rocks were emplaced in the crust around the same time and large explosive volcanoes erupted ash (ignimbrite) and lava over the new land surface. The granitic rocks now form much of the high Kosciuszko Plateau.

During the Silurian and Devonian the geography of southeastern Australia was quite complex, comprising continuous land masses, islands and small seas. Some of these islands hosted coral reefs in the adjacent shallow seawater. These reefs developed into the limestones of Yarrangobilly and the Cooleman Karst.

Around 360 ma in the Late Devonian to Early Carboniferous, there was a final period of folding and mountain building during which southeastern Australia became a mountain range, but this was not the precursor to the Alps. Sand and mud was being deposited in rivers and lakes occupying broad valleys between the new mountain ridges, to later become sandstone and mudstone.

After this episode of folding, about 340 ma there was more or less a hiatus with very little happening during the Carboniferous, Permian, Triassic, Jurassic and Early Cretaceous. Australia was now part of Gondwana and lay in the interior of that huge land mass. The mountain ranges were being worn down to a low-lying plain.

Between 300 and 250 ma there was a global ice age and Australia lay very close to the South Pole. Ice sheets covered much of southeastern Australia but nothing has been preserved in the Alpine areas, having since been removed by erosion.

Just when the Australian Alps became an entity is still hotly debated. The majority of earth scientists believe the Alps rose between 100 and 60 ma. Around 130 ma Australia began to break free from Antarctica and Zealandia. Magma rose though the lithosphere in a line along what is now the east coast of Australia, causing a large domed plateau to rise to over 2000 metres in the region of the Australian Alps. By 100 ma the continent had begun top split along this zone of magma upwelling and a rift valley was formed along the centre of the plateau. A modern analogy of this process is the East Africa Rift Valley.

Zealandia moved to the east and by 90 ma seawater began filling the gap which by 60 ma had formed the Tasman Sea. The Australian Alps remained as a mere remnant of the original domed plateau, with a steep seaward side where Zealandia broke away and a gentle slope towards the inland. Since then erosion has carved deep valleys into the plateau to produce the extremely rugged topography we see today in the Kosciuszko region.

During the Cainozoic era, and specifically between 24 ma and 18 ma, valley-filling lava flows formed the Snowy Mountains Basalt Province, in some places burying auriferous gravels to form the famous deep leads of the Kiandra Goldfields.

Between 2.6 ma and 10,000 years (the Pleistocene) the earth was again affected by a global ice age. Cold dry conditions prevailed and a small ice cap formed around Kosciuszko, where several tarns and cirques remain as evidence of glacial erosion. Some small valleys near Mount Kosciuszko have the classic U-shape of a glacier-cut valley. Outside the ice cap area periglacial conditions resulted in block streams, such as those seen on the way into Lobbs Hole, and frost-shattered boulders.

In the Holocene (10,000 years till present-day) the Kosciuszko ice cap melted and the region became warmer and wetter. Erosion continued.

Monday 19th February

The group met up 9:30am at the Post Office in the main street of Adelong, Tumut Street, on a beautiful summer's morning *(Photo 1)*. After pleasantries a briefing was held on the proceedings over the coming week. Then from the Post Office we drove the short distance to the ruins of the Reefer Gold Battery at Adelong Falls, just out of town.

Hume and Hovel passed through this "rough and difficult country" on their way back to Sydney after their 1824-25 expedition, but gold was not reported in the district until 1841 by the Rev. W.B. Clarke. The first major alluvial gold was found in a gully off Adelong Creek in 1852, opposite the site of the Royal Hotel. Soon after 1858 there were 20,000 miners in the creeks and on the surrounding hills. Reef gold was in discovered in 1857 by William Williams, a wheelwright and blacksmith by trade, while he was burning timber on the hill for charcoal. He had already been successful in the gold diggings on the Turon River in 1851 and later at Kiandra. His habit of carrying gold wherever he went earned him the nickname of "old gold dust" (Ritchie, 1987).

In addition to the three main reefs – Old Hill, Gibraltar and Victoria – located on the ridge behind the Reefer Battery, seven others were discovered, all lying parallel to each other in a north-south direction. The reefs are fissure lodes associated with basic dykes and comprise quartz impregnated with auriferous pyrite and free gold in shear zones 0.5 to 3 metres thick within the Late Silurian Wondalga Granodiorite, a medium to coarse biotite granitic rock. The veins lie roughly parallel to the nearby Wondalga Shear Zone (NSW DPI Primefact 558, 2007). Workings extended to over 300 metres in depth. From both reef and alluvial deposits the field produced a total of 25 tonnes of gold between 1857 and 1941 according to NSW Department

1. Participants meeting in Adelong.

2. Remains of Reefer Battery on Adelong Creek.

3. All that's left of the big water wheel.

of Mineral Resources records, but the true amount mined may have been much greater.

The original Reefer Battery was built in 1860 on Adelong Creek above the falls, but later when William Ritchie became sole owner of the mill it was decided to build a more efficient plant downstream at the falls *(Photo 2).* This new battery first operated in 1871 (Ritchie, 1987).

The big water wheel (26ft diameter) was the largest of its kind in Australia and could generate 60 horsepower to crush 24 to 30 tons of quartz per day. It provided power for 15 stampers, Chilean mills and berdan pans, all sheltered under a big galvanized iron roof. The smaller wheel that drove the buddle just above the creek was 18 feet in diameter. Through all stages, mercury was used to recover the gold as amalgam. On the hillside above the stone-walled tailing pits was a furnace with an underground flue leading to the brick chimney still standing amongst the trees. This furnace was used to drive sulphur from the pyritic ore, making it easier to recover the gold, and to separate the gold from the amalgam. High stone walls around the plant were built in an attempt to protect the works from infrequent floods in Adelong Creek (Ritchie, 1987).

The area encompassing the mill ruins is covered by the Adelong Falls Reserve, established in 1971, and the car park now occupies the former site of William Williams' home "Campsie". A well-made concrete path winds its way around the rim of the gorge from the lookout and leads down to a low level footbridge over the creek and into the ruins. Granite boulders in the bed of Adelong Creek clearly show small sub-parallel shear zones up to several centimetres wide, some with associated veins of white quartz. A wander through the remnants of the stone buildings and the remains of the water wheels *(Photo 3)* makes for some interesting photography. After an hour and a half, the heat was becoming uncomfortable and, as the morning was racing by, everyone made their way back to the picnic area where some time was spent reading the series of excellent display boards on the area's history.

Some members decided to drive to Tumut for lunch and fuel, as there would be very few places to stock up around where we would be staying. The rest had a picnic lunch at the Reefer Battery site. The group reconvened at the Tumut Information Centre for maps and brochures of the area then headed off in convoy to Currango Homestead, which was to be our accommodation for the next week.

Along the way we stopped at Black Perry Lookout. Apart from spectacular views down the thickly wooded valley, the main feature here was Black Perry Mountain *(Photo 4)*. This is a prominent knob of skarn, formed by the metamorphism of an impure limestone by an adjacent igneous body. Fluids introduced from the igneous pluton as it was cooling reacted with the limestone to form new minerals, mainly silicates. The National Parks brochure on the region lists this skarn as being unique because of the presence of a mineral called babingtonite (first found beneath Rainbow Falls on the Sempill Creek near Ellerston, where it was formed by weathering of Paleogene basalt). However, since this is a hydrated carbonate mineral, it's reported presence in the Black Perry skarn, unless it was formed by weathering, is probably a misprint for the silicate mineral barringtonite.

Our arrival at Currango was a little later than planned, after Barry discovered he had a flat tyre along the Port Phillip Fire Trail *(Photo 5)*. A halt to the convoy had to be called while the offending wheel was changed, only to discover the spare had a potentially disastrous split in the sidewall! That done the

4. Black Perry Mountain, a skarn of Babingtonite.

6. Men's quarters, Currango Homestead.

party moved on, arriving at Currango at 3:30pm. We went straight to The Pines or Men's Hut; a rustic 1850's style slab timber dormitory surrounded by tall pine trees *(Photo 6)*. There were 6 rooms with a variety of bedding including three double beds and nine singles, a very cosy arrangement. The amenities comprised an outside shower cubicle with bucket shower, a tiny covered barbecue area beside the shower room, and a single one-seat long drop loo right down the back on the edge of the forest. Power was only 12V DC provided by solar panels, so torches were a basic requirement as were portable gas stoves for cooking. But the combined kitchen and dining room was more than adequate, with a large open wood fireplace complete with a 15 litre urn suspended over the fire to boil water for showers.

Two couples commandeered the Daffodil Cottage, a similar arrangement to the Men's Huts, but much smaller with only two bedrooms. Another couple stayed at the Caretaker's Cottage which is somewhat more civilized with flushing toilets plus hot and cold showers. Everyone was happy with their accommodation and settled in very quickly to a pleasant evening. Dawn and Stan had brought their caravan and stayed at Wares Yard camping area near Tantangara Dam to the south of Currango.

Monday 20th February

A fine but foggy morning and a rather brisk 9°C greeted us. The fog eventually cleared to a beautiful summer's day.

Departing Currango at 8:30am we headed off for out first stop at Tantangara Dam *(Photo 7)*, driving along Pocket Saddle Road which overlooks Tantangara Reservoir for much of the way. The entire valley was filled with fog, giving the impression that somehow it had been magically filled with cotton wool. At the dam we paused to look at the geological map of the region, which showed the dam wall sat on a nest of small sub-parallel splay faults just to the east of the major Tantangara Fault. This should have created construction problems for the dam, requiring a lot of grouting to prevent water escaping and possibly destroying the integrity of the wall. At least one of these faults plus several very tight anticlinal folds could be made out in the Silurian sandstone and shale in the road cutting adjacent to the dam wall. These rocks were deposited as proximal flysch sediments in the Tantangara Trough. A little further on Chris ques-

5. Plenty of helpers changing Barry's flat tyre.

7. Tantangara Dam.

tioned the origin of a patch of black rock in a small roadside quarry. With signs of several old fireplaces beneath the outcrop I'm sure Chris expected it to be smoke-blackened shale, but in fact it proved to be a small lens of black shale and had nothing to do with human activity, much to his surprise. A chance to confuse the geologists had been thwarted!

The next stop was the quarry from which aggregate and fill for construction of the dam wall had been obtained. This turned out to be a very unremarkable ignimbrite, part of the Devonian Kelly's Plains Volcanics. It gave us some insight into the vast time scale covered by the rocks of the Snowy Mountains and the incredible size of some of the volcanic events of the past. From here we drove to the Wares Yard camping area to join Dawn and Stan for a pleasant morning coffee *(Photo 8)*.

Continuing on south down Tantangara Road we joined the Snowy Mountains Highway and drove through to Kiandra, where we turned south towards Cabramurra. A large dot on most maps, Kiandra now lies deserted, with now only the old court house (restored) and a few scattered homes. Around 1860 miners from Adelong were being lured to the Kiandra deep leads but the continual snow and ice made prospecting too difficult and most men soon returned to the Adelong fields.

This was the first of the new goldfields that enticed Victorians over the border and in the autumn of 1860 the grasses that once pastured sheep were being uprooted by the picks and shovels of around 5000 diggers. Then came the deep snow and fierce winds of the following winter. The snow quickly buried the bright lustre of gold and at winter's end only 3000 white and Chinese diggers remained perched on the hills wresting gold from the gravels buried beneath the Paleogene basalt flow. Total recorded production was 4.6 tonnes.

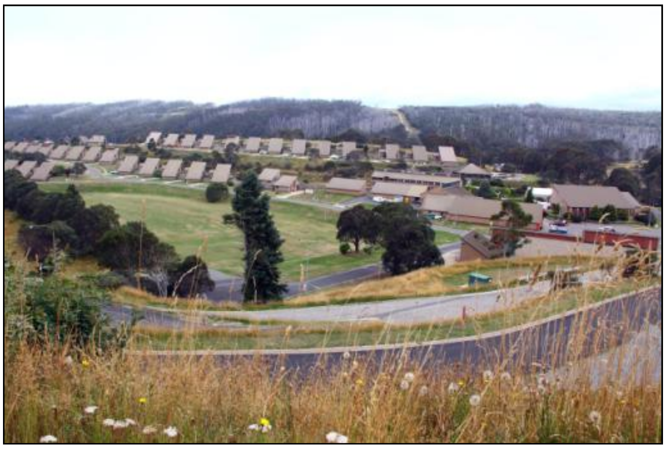
At New Chum Hill, on the western side of the road, there was evidence of extensive sluicing and mining of the Kiandra Deep Lead. A few mine relics, including a 5 head stamper, stood in a small park beside the road. A heritage walk tracks through the deep lead workings but we had no time to explore. There was more evidence of gold mining and water races on the ridge south of the road further up the valley.

9. Basalt columns.

Our next stop was Three Mile Dam on the link road towards Cabramurra. The dam is located a few kilometres along the Cabramurra Road and just past the turnoff to Mount Selwyn. The Chinese built it in 1882 to provide water for sluicing operations at New Chum Hill. There is also a walk here, a few hundred metres off the road past the dam, which includes the old races and clearly shows how the water flowed from the dam to the goldfields.

A few kilometres on towards Cabramurra we came to interesting columnar structures exposed in a cutting *(Photo 9)* in weathered basalt partly hidden by trees. This is part of the Snowy Mountains basalt province, for which Round Mountain may have acted as the source 18 to 24ma ago. These eastern basalts form elongate remnants aligned along two major valley infills each up to 30-35 kilometres long and 20 kilometres across. Eruptive sources were suggested as being 12 kilometres south of Cabramurra, 3 kilometres east-north-east of Cabramurra (dyke) and 11 kilome-

8. Morning tea at Stan and Dawn's camp.



10. Cabramurra village.

12. Dead trees.

tres south of Kiandra (plug). The flows reach 30-100 metres thick. Flow contacts are well-exposed at Kiandra, where basalt overlies lacustrine and fluviatile sediments of a deep lead (Sutherland, *et.al*., 2002).

While we were discussing the geology, Ross arrived late and promptly dropped both left side wheels of his 4WD into a deep muddy roadside ditch. Unfortunately low range 4WD did not remedy the situation, but a snatch-strap and Terry's 4X4 saved the day. Excitement over, a short walk down the hill brought us to another interesting rock outcrop in a road cutting. This occurs at the southern end of the Tumut Ponds Serpentinite Belt and appears to be a strongly slickensided dense fine-grained ultrabasic rock, with well-developed fibrous layers of bright green antigorite (a kaolinite-serpentine group mineral) on the slickenside's.

Cabramurra was our destination for lunch and some shopping *(Photo 10)*. Hot chips were enjoyed with lunch at the picnic shed overlooking Cabramurra, which also provided great views of the surrounding countryside. After lunch, a short drive to the northeast brought us to the abandoned Snow Ridge quarry, originally operated by the Snowy Mountains Authority. After closure it was used as a refuse tip, but has now been rehabilitated by National Parks. Here, a short stroll from where the cars could be parked on the Mount Selwyn Road, brought us in sight of more columnar basalt. But these columns were much larger than those seen earlier and freshly broken fragments proved the rock to be rich in grains of bright green olivine.

With the sky to the south where we were heading now looking quite threatening and thunder rumbling in the distance, we moved on. We arrived at Tumut Ponds Reservoir and Dam *(Photo 11)* under heavy skies and light rain. The views across the valley as we drove down the mountain were spectacular. The stark white skeletons of hectare after hectare of dead trees, killed in the disastrous fires of 2003, and the misty rain made the scenery quite eerie *(Photo 12).* It looked a little like the hillsides were dusted with snow. These had been the first fires in the Snowy Mountains since 1939.

A short time was spent taking photographs and looking around the dam wall before ascending the valley wall again on the other side. As we reached the summit on the southern side of the valley the heavens

11. Tumut Ponds Reservoir.

13. Waterfall over a columnar basalt flow.

opened up! We decided to drive to O'Brien's Hut and wait out the storm. On our arrival we found the ground covered in pea sized hail. After around 10 minutes the storm abated enough to enjoy a coffee and a chat with an overseas cyclist who had taken refuge in the hut.

We had one more site to find, out along the nearby Manjar Fire Trail. Its location and that of the refuse tip site had been kindly given to us by Regina Roach, a very enthusiastic and helpful interpretive guide at Yarrangobilly Caves, whom we would meet later on the trip. Unfortunately, the weather refused to play its part and as we arrived at the designated point along the track the rain became more persistent. Undaunted, our leader thought it better than a hot sunny day as we had at least a 600 metre walk through wet trackless scrub. So with umbrellas in hand we set off looking for a waterfall exposing some very unique columnar structures in basalt. Navigating by map and compass in very inhospitable conditions, the group did a great job sticking with their leader, who at times left us waiting and headed off into the mist to check things out. Eventually we heard him yelling from off in the distance and assumed he had found the waterfall. And indeed he had!

The basalt exposed at the falls is part of a flow that poured down an old valley *(Photo 13)*. The columns under the falls are much narrower than what would normally be expected and have formed a fan-like structure, giving great effect coupled with the tumbling water now being fed by heavy rain just upstream.

Before long thunder and lightning had returned so we started back to the cars. Some people became disoriented, expressing some concern as to our geographic location and the competency of our leader. We had often had the need to place unquestioned trust in Barry as leader, always with good outcomes, but this bloke was an unknown quantity! Colin came up with the suggestion that if Chris continues to lead us out "if we get lost you can explain the situation". However Chris was unconcerned and thought it might have provided a good opportunity to sell a few insurance policies! But everyone did make it back, a little wet but happy to have found the cars *(Photo 14).* The only thing left to do now was to drive back to Currango Station. Arriving back at 6:30pm it was a late arrival home but it had been a great day.

14. Soggy walk back to the vehicles.

Tuesday 21st February

It had rained most of the night, stopping at around 3am so .it was very wet underfoot and 11°C. in the morning. Although the clouds were breaking up, rain still threatened.

Ravine and the Lobbs Hole copper mine were to be our destinations for the day. There was some concern as to the condition of the 4X4 track down into Ravine and the Yarrangobilly River crossing, which proved to be unfounded. We had already arranged to meet a National Parks Discovery Ranger at 9:30am. However at 8:00am Chris received a call from our guide Shane Herrington, asking for details of the time and meeting place. National Parks had apparently not passed on our booking details. This did not bode well for the day! The meeting time and place sorted, we departed Currango and met up with Dawn and Stan at Kiandra. From there we drove to Wallace Creek Lookout on the Lobbs Hole Track. We arrived at 9:15am, time enough for morning coffee before Shane was to arrive at 9:30.

By 10:00am there was no sign of Shane and Chris decided to drive to where he could get phone reception and contact Tumut Information Centre for an explanation. The reply was that he (Shane) should have been there! Chris informed them that if Shane had not arrived by 10:30 the group would leave without him.

Shane arrived at 10:29 am! Poor Shane was informed of our displeasure for a poor and tardy performance. He was most apologetic and did his best to calm Chris and the group down. He then proceeded to play his didgeridoo and welcome us to country in the traditional Aboriginal fashion. Shane explained his connection with the land and that his people, the Walgalu and Wiradjuri, were the traditional custodians of the land, which supported many family groups. The mountains here provided a spiritual place for practising Aboriginal traditions, and the valleys and

15. Track down to Ravine.

17. Small brachiopods in shaley Devonian limestone.

plateaus provided many pathways to the coast. These pathways provided trading opportunities, as well as ways of leaving the high country as winter approached.

After a short drive *(Photo 15)* we stopped at a rock glacier or boulder field of angular basalt blocks streaming down the side of the canyon *(Photo 16)*. Water penetrating closely-spaced cracks in the rock expands as it freezes in the icy conditions, widening the fissures to allow more water to penetrate. This process continues until the basalt breaks up into blocks creating a boulder-strewn hillside. There were several more stops on the way down to discuss the use of plants and how a particular plant, although not directly producing food, attracted animals and/or insects which could be used to supplement the Aboriginal diet.

Further down we stopped on a steep section of the track where a lens of shaley Devonian (390ma) limestone had been exposed in cuttings. This proved to be of great interest and some time was spent picking up fossils including brachiopods *(Photo 17)*, crinoid stems and curious rounded elongate remains of algae colonies up to several centimetres in length. Shane mentioned that to him it was both fascinating and educational to be with a group of geologists who could explain what was going on. But time was moving on and we had to drag ourselves away, continuing down towards the valley floor past spectacular views of the surrounding countryside. Near our goal a distinct tilted bed of Yarrangobilly Limestone came into view across the end of one ridge.

At the bottom of the ravine lay the remnants of the deserted Lobbs Hole copper mine *(Photo 18)* which operated between 1874 and 1916, reaching its peak production between 1890 and 1902. Many old mine shafts are still evident and had been used for several years by campers to dump rubbish. Recently National Parks have cleaned most of the rubbish out and placed steel grids over the two larger shafts, allowing a good view down into them. Shane mentioned that the mines eventually became unprofitable due to mine gas, flooding, fluctuating copper prices and high transport costs to the rail head at Gundagai.

The mine worked relatively large vein-type deposits occupying fissures in the Late Silurian Ravine Beds which comprise greywacke, siltstone, sandstone, tuff and conglomerate. The veins consisted of quartz

16. Rock glacier.

18. Site of abandoned copper mines, Lobbs Hole.

with rich concentrations of chalcopyrite, the copper-iron sulphide. The veins strike northwest and dip vertically, with an average grade of 7-10% copper metal plus minor silver and gold. A total of 1600 tonnes of metallic copper was produced at the on-site smelter from ore obtained at depths of up to 60 metres. So at that time it was considered a major copper producer.

Little remains of the smelter apart from some slag and a few scattered bricks. Down beside the river lay the remnants of a water wheel foundation. A low cutting through the adjacent low ridge ended in what appeared to be an ore stockpile, composed of angular lumps of quartz vein material heavily stained pale to dark brown by secondary iron hydroxides formed by in-situ weathering of sulphides. Some minor chalcopyrite was found in the quartz and curiously several fragments of a heavy magnetite/andradite garnet skarn were also found. There is no record of skarn being found (or mined) locally so its source remains unknown. Small cavities in the skarn were lined by dodecahedral crystals of both component minerals.

During its peak, the Lobbs Hole area had an established village with a population of 500 people serviced by a school, butcher, blacksmith and Police Station. Produce was provided from surrounding farms. By 1919 all the mines had been abandoned and by 1920 it was reported that the only residents in the area were the relatives of the Yan family who owned a store at Kiandra.

Lunch was enjoyed beside the picturesque Yarrangobilly River amongst the remnants of the old copper smelter. After lunch we drove through what was once the village, the only recognizable structure being the eroded rammed earth walls of the Washington Hotel (also known as the Washington Arms or Ravine Hotel). This was built in 1874 and extended in 1905 *(Photo 19)*. It serviced both the locals and those travelling to the Kiandra Goldfields and also gave respite from the cold conditions at Kiandra in the winter months. Fruit trees and other plants from this time period can still be found scattered over the area.

The current road into Ravine was built in the 1960's during construction of the Snowy Mountains Hydro-Electric Scheme. The area is now part of Kosciuszko National Park and has become a popular spot for camping and fishing.

The fast-flowing Yarrangobilly River has to be crossed to exit the valley to the south; otherwise visitors must turn around and drive out the same way they came in. After some discussion it was decided to cross the river. First a safety briefing was given on correct procedures and then the crossing was completed without incident despite the deep swiftly-flowing water and loose rocky bottom.

We then continued on with Shane's commentary coming through clearly over the radios. The track out of the valley was steep and narrow, with sheer drops on the left side giving spectacular views along the valleys and over the Talbingo Reservoir. Several road cuttings appeared to reveal sections through cobble deposits associated with an ancient river bed. This demands further investigation.

Arriving at Jounama Homestead *(Photo 20)* later than expected, we explored the ruins and Shane delivered a history of Jounama, which was built in three stages between 1920 and 1950 during its occupation by three different families. The bricks used in the construction of the homestead were made in the kilns at the Lobbs Hole copper mine. An interesting aside was the thumb print in the corner of each brick, imprinted when the maker placed them in the kiln to be fired. The jasper flagstones used in the house steps also came from the Ravine area. A number of other smaller buildings are still extant, although in a very poor state. In its time the English-style garden would have

19. Remnants of the Washington Arms Hotel that was built with mud bricks.

20. Jounama Homestead.

21. Shane Hetherington demonstrating how to make twine from *Pimelea pauciflora*.

been a delight to walk in.

Time being against us, we drove to an Aboriginal stone artifact site where Shane explained the significance of the area to his people, and told us how they manufactured and used the stone tools. Shane took us into the scrub where he demonstrated the traditional way his people made and used twine *(Photo 21)* from the plant *Pimelea pauciflora* (poison rice flower). The twine was used as fishing line and had many other uses. Shane's final demonstration was to make a bracelet from the twine, replete with a few wildflowers, which he placed on Dawn's wrist. A nice touch as it was Dawn's birthday the previous day.

This brought our time with Shane to an end. Considering the rocky start to the day it had ended up being a splendid outing. Shane expertly recovered the situation quickly, leaving us with many fantastic memories. All that was left was to give him a warm thank you and then make our way back to Currango. We arrived back at 4:45pm, very satisfied.

Wednesday 22nd February

Greeting us this morning was fine weather with broken cloud and an outside temperature of 9°C. We left Currango at 8:40am bound for Landers Falls, which is in the Cumberland Range off the Snowy Mountains Highway. The track is marked on maps as 4WD, but most high clearance vehicles would have no problems in dry weather. Although the road was wet and slippery in the steeper parts all the vehicles, including the Foresters, arrived at the second car park without any problems, albeit spattered with sticky mud which back home proved next to impossible to remove! Of course morning coffee was mandatory before we set out on the 1.6 kilometre return walk to the lookouts. *(Photo 22)* The walk is well defined, if a little steep in places, and the latter part passes over spectacularly flow-banded rhyolite (probably the Cumberland Rhyolite) which contains scattered small hollow "thunder eggs" lined with colourless quartz crystals. A small copperhead snake was sighted beside the track, enjoying the early morning sun .

Half way along the track is a platform providing good views of the valley below and from here we could also see the next and final lookout well above us. This second lookout had been constructed to overlook Talbingo Reservoir and Landers Falls, *(Photos 23 and 24)* which had a reasonable amount of water tumbling over the drop into a deep slot canyon at its base. A special feature of this lookout platform is the presence of a rare gum tree *Eucalyptus glaucescens* (Tingini gum) found only in Kosciuszko National Park. This tree grows up through a gap in the lookout grating cut to allow it to continue growing unimpeded.

The Talbingo Dam was the last of the dams to be built as part of the Snowy Mountains Scheme. Three weeks after filling commenced in May 1971, the first of a long series of seismic events was recorded. This earthquake activity was not characterized by one major shock, but by several series of shocks each including an event up to 3.5 magnitude. Initial activity took place beneath the reservoir but migrated to a region about 5 kilometres downstream over a period of three years. Activity has continued sporadically to the present day. Normal dip-slip faulting occurs along the line of the reservoir and the activity may have been triggered by the weight of water in the reservoir or by an increase in pore water pressure in the rocks beneath the water (Muirhead, 1981).

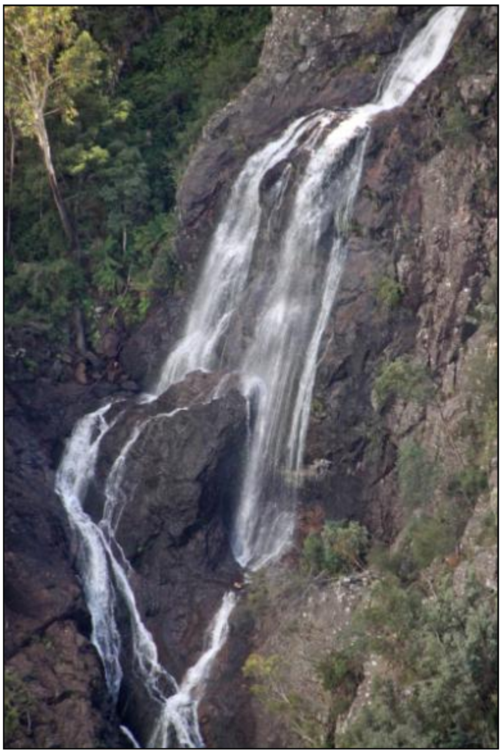
After arriving back at the car park, some decided to drive to Talbingo for fuel, while the remainder drove on to Yarrangobilly Caves for lunch. We had a tour of the Jersey Cave booked with Regina Roach for

22. Top viewing platform for Landers Falls.

24. Talbingo Reservoir below Landers Falls.

1:30pm, which left plenty of time to enjoy lunch and an ice cream. Regina seemed like a breath of fresh air! She was the contact who told Chris of the basalt waterfall off the Manjar Fire Trail and of several other columnar basalt outcrops in the Snowy region.

Once inside the cave, Regina explained how the 400ma old limestone had been laid down and, by using some of our tour group as models *(Photo 25)*, how the caves were formed. This provided a fascinating and unique beginning to the tour that was only surpassed by the many unique and spectacular speleothems (formations) along the cave passages. Several fossils were also pointed out in the exposed limestone of the cave walls. Highlights were the crystal gardens with cactus-like calcite crystal structures, a beautiful waist-deep pool with superb reflections and organ pipes, along with the bones and teeth of a fossilised



23. Landers Falls.

bat. In some sections there was a black coating over the formations, soot remaining from smoke which entered the caves long ago during bush fires. At least 4 major fire events are recorded in these soot layers.

A touch and feel section explained the formation of stalactites and stalagmites and how to tell the difference. Regina answered all our questions with an expertise gathered over years of association with caves and also had some of her own questions for the geologists on the tour. At the end of the tour Brian requested that the lights be turned out one final time before we left the cave. He had a surprise in store for everyone, including our guide Regina.

Once we were in complete darkness, Brian produced a hand-held long wave ultraviolet (UV) light torch which lit up the cave like no-one (even Brian) could have imagined. Many of the formations glowed a brilliant pure white, while others turned pink and a few turned bright red, all against a background of pure black! Put in simplistic terms, the effect is due to the UV energy causing electrons to be displaced from their normal orbits in the atoms making up the calcite formations and then on returning emitting excess energy in the form of visible light. Everyone, including

25. Tour guide Regina describing cave formation.

Regina, demanded to know where to get such a torch. Keep your eyes open at any of the local gem shows!

The caves were discovered by John Bowman circa 1834 while looking for stray cattle and sheltering from a thunderstorm. His discovery became known as the Glory Hole Arch. Regular excursions to the caves began in the early 1860's and coincided with the arrival of large numbers of people to the nearby Kiandra Goldfields.

Jersey Cave was found in the early 1890's and was named after New South Wales Governor Lord Jersey who officially opened the cave in 1892. Yarrangobilly Caves House was built in 1901, one of the earliest Government sponsored tourist destinations in New South Wales.

These caves developed in Late Silurian (440ma) limestone forming a belt 14 kilometres long and 1.5 kilometres wide, which is overlain by slates, shales, sandstone and conglomerate of the Ravine Beds. An outstanding collection of cave features *(Photo 26)* includes gorges, arches, blind valleys, springs, pinnacle fields and over 250 caves, six of which have been developed for tourism. Several of the caves contain rock falls and rock fills thought to be related to ice wedging associated with the ice ages. In Jersey Cave, thick flowstone sequences span 500,000 years and provide the longest single fire history record from a single locality in New South Wales.

The region is covered by open eucalypt forest, with stands of alpine ash, ribbon gum, snow gum and candle bark gum.

Exiting the cave around 4pm, it had taken far longer than we or our guide had expected and that put an end to thoughts of exploring the self-guided cave or a walk down to the geothermal pool beside the Yarrangobilly River. Here the underground water

26. Colourful shawl in the Jersey Cave.

27. Nearing Currango; a herd of browsing Brumbies.

reaches the surface at 27°C. A swimming pool using this naturally-heated water and adjacent picnic areas have been constructed for the public's enjoyment.

Before leaving the caves, a heartfelt thank you was expressed to Regina for her delightful and very informative presentation and for her assistance in locating other features of geological interest in the Snowy region. Brian had mentioned during the tour that he was working on a specific cave speleothem, moonmilk, with staff at the Australian Museum in Sydney and back at her office Regina offered to email two papers on the possible involvement of bacteria in the formation of this unusual cave mineral. These papers had arrived by the time we reached home.

The drive back to Currango *(Photo 27)* gave everyone the chance to reflect on the day's highlights. We could not waste much time though as showers were to be had and meals prepared before gathering for a presentation on the history of Currango by Caretaker Stewart Garner at 8:00pm. Stewart explained that the station's history dated back to either 1836 or 1839, depending on whose version you read. Even though we were all tired after what had been originally planned as an easy short day, most managed to stay awake during this very informative talk. Stewart also showed several specimens of sulphide ores (mainly the zinc sulphide mineral sphalerite) he had found in the area, particularly near the Blue Waterholes Reserve which we planned to visit on our last day.

Thursday 23rd February

The morning promised to provide the best weather yet on our trip, with clear skies and the temperature starting at 9°C. The day's trip to Geehi would be a late finish, so we began earlier than usual at 8:00am. First we drove to Kiandra to pick up Dawn and Stan, then a 2.5 hour drive to Khancoban to purchase day passes for this area of Kosciuszko National Park. A pit stop was required at Tumut Ponds Dam then on to Tooma Dam for morning coffee. We arrived at the Khancoban National Parks Office at 11:15am. With passes sorted, some shopping at the small shopping centre and purchase of fuel, we departed for Geehi at 11:50am.

The drive along the Alpine Way was narrow and very winding, with no centre lines. The bikers love it, but tend to use the whole road with total disregard for anyone else. Chris was fortunate at one bend on a particularly steep section as one of these pseudo-Kamikaze riders came around the bend on a distinct lean heading straight for him. Luckily he missed the biker, but is still wondering how!

We stopped at Scammell Spur Lookout for an overview of our destination. Surrounded by the high rugged mountains of the Kosciuszko region, this lookout provides spectacular views over the Geehi Gorge. The lookout is named after the Scammell family who lived in this area and ran cattle. There is an excellent interpretive board here detailing some of the area's history and another board fixed to the lookout railing identifies all the peaks stretching out on the distant horizon.

Having reached Geehi, we drove down to the stone hut at the far end of the camping area, which runs along where an airstrip and workers huts once existed during the construction of the Snowy Mountains Scheme. This hut, made from granite river stones *(Photo 28)*, was built in 1952 to support grazing and fishing in the immediate area. It was rebuilt in 2004 by KHuts and National Parks and since then has been well-maintained. After fording the Swampy Plains River *(Photo 29)* we drove on to Keeble's Hut. This hut is set overlooking the river with spectacular views up the Geehi Valley to the Snowy Mountains. Keeble's Hut *(Photo 30)*, also constructed of granite river stones

29. Ross crossing Swampy Plains River.

was built in 1942 by a number of individuals as a fishing lodge. It was resumed in 1970 by National Parks and is maintained by KHuts and National Parks, the last maintenance being carried out in 2002.

This was to be our lunch spot. However on arrival we found a venturer group had set up camp there, taking over virtually the entire site. Although that group was off somewhere exploring or whatever venturers do, we decided it prudent to move on to the Old Geehi Hut, which required another crossing of the Swampy Plains River further up the valley. This part of the river is almost half as wide again as the previous crossing, but there were no problems and some great images were captured during the exercise. Old Geehi Hut proved a wise choice for lunch as we had the place to ourselves. This hut is set in a beautiful bushland setting beside the river. It is also constructed from uniformly-sized river stones and was built in 1945 for the Water Irrigation Commission. It was used as a youth hostel in the 1960's and was resumed by National Parks in 1977. Like the other huts it is now maintained by KHuts and National Parks.

Some time was spent at this idyllic spot, with a few of the group having a swim while others enjoyed

28. Geehi Hut.

30. Keeble's Hut.

lunch in the shade of the enclosing forest, or simply wandered around the site checking out the hut and soaking up the atmosphere. An examination of freshly -broken river stones in one of the many campers' fireplaces showed there to be very nice examples of biotite granite.

But good things and places always come to an end eventually, so with a long trip back to Currango and lots more to see we reluctantly moved on. To get to our next destination, Major Clews Hut, we drove along the Geehi Walls Track, designated as 4WD only. However, most vehicles with reasonable clearance would have been able to handle this track. Major Clews was the principal surveyor for the Snowy Mountains Scheme, but prior to that he had had an extensive military career. After concluding his work for the Snowy Scheme, Clews built this hut as a retirement home. He added a substantial vegetable and flower garden as well as fruit trees to help him survive in this very remove location. But ill health eventually forced him to abandon his little Eden in the bush and return to civilization. The hut was rediscovered as a ruin in 1977 and in 2001 the hut and surrounding area were resumed by National Parks. The hut is of unique pisé or mud brick construction, with three rooms on a cement floor and a cement and stone fireplace. Restoration work has been carried out periodically since 2002. Outside there is an in-depth story board telling the hut's history.

We departed along the Major Clews Fire Trail, along the way admiring the views down into the Geehi Valley provided by the significant increase in altitude. Back on bitumen we drove on to Khancoban to pause briefly for ice-creams and very pleasant cappuccinos. Currango Station was reached at around 6:50pm with the travelers somewhat weary and looking forward to a shower and whatever could be cooked quickly and easily in a pot of boiling water.

Friday 24th February

The weather today was fine and clear with a temperature of 11°C. This, the last day of our adventure, saw us leaving camp at 8:30 am and heading out along Port Phillip Fire Trail. Long Plain Hut, constructed in 1916, was to be our first stop. Here 15 minutes were spent walking around the timber hut and reading its history on notice boards fixed to the inside walls. From there we drove to Coolamine Homestead, *(Photo 31)* where a considerable amount of restoration work has been carried out. Some time was spent here as there was a lot of history to read and digest. In the car park an extensive coverage of local history was presented on a number of interpretive boards

The first real house was built at Coolamine in 1883 and there were many buildings to wander through, all containing something to hold our interest for more than a few minutes. Of especial interest were the old newspapers lining the inner walls of the main cottage to seal the cracks between the wooden slabs to stop the ferocious winter winds and provide some sort of privacy. Perspex screens have been secured over these walls to protect and preserve them. Much time was spent reading these old newspapers and periodic bursts of laughter were heard coming from those rooms. Another hit was the two-seat dunny down the back. Just about everyone took photographs of it but no-one was game enough to use it, although that was probably a no-no in the eyes of National Parks!

It was tough dragging the group away from Coolamine, but we needed to move on if we were to do justice to the next stop on the program. Besides, everyone was beginning to show coffee withdrawal symptoms and some were getting desperate! Thankfully it was only a short drive down the side of the ridge along the Waterholes Trail and across the plains to Blue Waterholes, where we would spend the remainder of the day. At the Blue Waterholes camping area there were pit toilets and, at last, comfortable shelters where we could sit and enjoy our coffee.

The Cooleman Plains Karst occurs on a high altitude plain enclosed by extremely rugged terrain on the northeastern boundary of Kosciuszko National Park. It covers a roughly circular area of 1700-2000 hectares. The Cooleman Limestone was deposited in the Late Silurian 400 ma ago inside what was thought to have been a marine caldera formed by the explosive eruption and collapse of a huge volcano, as the outcropping limestone is completely enclosed by volcanic rocks. However later geological maps of the area show all the volcanic sequences to be later (more recent) than the limestone (Lishmund, et.al., 1986).

Caves and karst features first developed in the limestone after it was lifted above sea level after around 400 ma. Then it was once again submerged and covered by marine sediments, then again uplifted. By 65 ma most of the overlying marine sediment (the Blue Waterholes Formation) had been stripped off by erosion. Since then the present day karst and caves have formed by dissolution of the limestone, but some of the karst features formed during the first elevation

31. Cooleman Homestead.

33. Preparing to cross Caves Creek.

above sea level are still evident. Abundant brachiopod fossils, such as those located near the end of the Nicole Gorge walk suggest a Wenlockian to Ludlovian age in the mid Silurian (Lishmund, et.al., 1986).

The Cooleman Plains Karst is regarded as one of the most spectacular karst areas in New South Wales. The area comprises broad grassy plains pockmarked with sinkholes and surrounded by timbered hills covered mostly in snow gums. Its broad valleys drain cold air, creating frost hollows where winter temperatures drop so low that trees cannot survive. Of the caves present in the area, Murrays, Barber's *(Photo 32)* and the left and right Cooleman Caves are mainly horizontal and are easily explored by torch light. Unfortunately all were heavily souvenired in the 19th and 20th Centuries.

After coffee several of the group decided to explore Clarke Gorge along Cave Creek downstream from the camping area. This stunning gorge is named after the Rev. W.B. Clarke, a familiar name to geologists. Two creek crossings confronted us. The first presented only minor problems *(Photo 33)*, but the second was deeper and the stepping stones which might have once provided dry passage are now covered by water and very slippery green algae! The only alternative seemed to be to remove shoes and wade across the gravelly bottom through the freezing knee-deep water *(Photo 34)*. This stopped many. But Barry left his shoes on and ploughed on regardless.

A few stragglers came later, one being Ian. But poor Ian hadn't gone far when his collapsing walking stick which he was using for balance abruptly lived up to its name and collapsed under his weight, sending him face down into the freezing water *(Photo 35)*. Luckily he had wrapped his phone, wallet and other valuables in a spray jacket and placed them inside his backpack. He emerged from the creek saturated, his backpack and hat remaining the only dry items! Dianne was fortunate in being quick enough to capture the whole sequence of events on camera. This provided everyone else with a good laugh later in the day, but Ian was a real good sport and laughed along with everyone else. The last thing Dianne saw was this soaked bare-chested man walking back to the vehicles. Fortunately enough dry clothes were found so that Ian could change and dry his soaked jeans and shirt on a fence.

Those who continued on the few hundred metres

32. Lookout, Barber's Cave.

34. Crossing Goodradigbee River.

35. Ian’s method for crossing the river.

or so to the start of the gorge could not believe what confronted them when they arrived. Apart from Bungonia Canyon, which some of us had walked (and swam) through several years ago, this had to be the most spectacular limestone gorge in New South Wales, its vertical limestone walls soaring 50 metres or so into the dark blue sky *(Photo 36)*. From the very start the bed of the gorge was full of clear deep water so the only way to continue along it was to scale the low ridge of limestone on the right hand side and climb down to the narrow talus slope just above water level. Fortunately this limestone rubble along the base of the canyon wall provided relatively easy walking most of the way. But several times the wall had to be scaled again as the gorge meandered its way east for over a kilometre along Cave Creek. The limestone here was fine-grained and massive, although a few patches of pure white marble were present. No fossils were seen.

Eventually no continuation of the walking track could be found along the southern side of the gorge, although by now another track had appeared on the opposite side. But the water here was too deep to cross so we turned back. Anyway, a few hundred metres ahead we could see the walls of the gorge decreasing rapidly in height towards a region of steep forest-covered hillsides which typifies the edge of the Cooleman Karst, so proceeding further down the creek would have only taken us out of this spectacular scenery. Our exploration, punctuated by many photo stops, had taken just on two hours and it was time to return to the camping area for lunch. By now the weather was warming up and the day proved eventually to be our hottest so far.

36. Start of the Clarke Gorge walk.

Following lunch in the shade of the trees in the camping area we decided to tackle Nicole Gorge, upstream of the Blue Waterholes. This was a much easier walk than the one up Clarke Gorge, significantly further but with relatively flat walking and insignificant dry creek crossings. The only problem any of the group experienced was that the track occasionally became indistinct and hard to follow.

Just inside the gorge we found Cooleman Cave and proceeded to explore as far in as we could. Only a few people had suitable torches, so that only Brian and Barry ventured into the depths of this mainly horizontal cave. The speleothems were nothing to write home about, certainly incomparable to the magnificent spectacle of Yarrangobilly Caves. The cave walls were blanketed by thick white deposits of finely crystalline calcite, with none of the shawls, stalactites or stalagmites one would expect. Brian’s UV torch produced no visible reactions anywhere in the cave.

The greatest point of interest was not the formations, but the curious dendritic (lace-like) patterns on the limestone walls where the calcite encrustations had been stripped or fallen away. These really intrigued Barry, who took numerous photographs. Very similar patterns had been observed by Brian many years ago on joint planes in Nobbys Tuff at Nobbys Headland in Newcastle and the origin of the patterns here in Cooleman Cave can probably be explained in a similar way. The gap between the calcite crust and the limestone wall appears to have once been filled with an extremely fine-grained soft gel-like material. As the calcite crust came away from the wall the parting of the two surfaces caused the soft gel between them to be stretched or drawn into a series of anastomosing ridges. Identical patterns can be produced artificially by squashing a gel-like substance between two layers of some hard material and then quickly pulling them apart directly, an experiment that can be easily reproduced at home.

Because of the rising temperature almost half the group decided to turn back to the camping area, while the remainder continued up the gorge past Murray Cave to the fossil beds. The track repeatedly crossed the mostly dry bed of Cave Creek as it passed along the grassy floor of the meandering gorge. The scenery was quite different from that of Clarke Gorge, not a continuous high-walled canyon, but more a series of tall limestone ramparts separated by short very steep tributary gullies.

The fossil beds were marked by an information board, but we didn't need the sign to know that superb examples lay everywhere in the limestone outcrops along the creek. It was easy to pick out crinoids, brachiopods (the species *Pentameris*) and pelecypods. According to the notice these life forms lived in shallow water 400 ma ago.

At this point the best of the gorge had been seen so everyone made their way back to the camping area at their own pace, most arriving by 4pm. Some paused here for coffee and bickies, but most went directly back to Currango to prepare for the end-of-tour barbecue being held at the Caretaker's cottage. It was a great evening and a fitting end to a fantastic trip.

A grateful thanks is extended to everyone who took part in the trip. Your eagerness, willingness and good humour, often in the face of uncertainty and hardship, made the leader's task a delight.

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

References

Environment, Climate Change and Water. National Parks and Wildlife Service. New South Wales Government. (2010). *Guide to New South Wales Caves and Karst.*

LISHMUND, S.R.; DAWOOD, A.D. and LANGLEY, W.V. (1986). The limestone deposits of New South Wales. *Geological Survey of New South Wales. Mineral Resources No.25, Department of Mineral Resources, 172-176*.

JOHNSON, D.P. (2009). The geology of Australia. *Cambridge University Press, Cambridge.*
Sunday 19th February.

MUIRHEAD, K.J. (1981). Seismicity induced by the filling of the Talbingo Reservoir. *Journal of the Geological Society of Australia, 28, 291-298.*

RITCHIE, W.R. (1987). Early Adelong and its gold. *Wilkie Watson Publications Pty. Ltd., Tumut.*
Geology of the Australian Alps. *Australian Alps National Parks Education Kit website.*

SCHEIBNER, E. (1999). The geological evolution of New South Wales – A brief review. *Geological Survey of New South Wales, Sydney.*

Websites:

IFHAA
http://www.historyaustralia.org.au/ifhaa/towns/adelong.htm
The Tumbarumba Basaltic Gem Field, New South Wales: In Relation to Sapphire-Ruby Depositsof Eastern Australia

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http://www.amonline.net.au/pdf/publications/1358_complete.pdf http://www.khuts.org/

New Hartley Excursion
Friday 30th March to Sunday 1st April 2012.

Leader: Brian England and Barry Collier.

Attendance: 10 members; 2 visitors.

Friday 30th March

Attendees met up between 10 and 10:30am at David and Lorraine Mahony's café at Sandy Hollow, a location which proved both convenient and refreshing with good coffee and copious servings of Lorraine's scones and/or cherry pie making a perfect start to the weekend. Some people had stayed overnight at the local caravan park and had spent the morning exploring a walking track to the summit of the ridge behind the town. This track lies on vacant Crown Land and is proposed in the distant future to be an addition to Manobalai Nature Reserve.

We left Sandy Hollow at 11am and proceeded west along the Bylong Valley Way, stopping for around an hour at a large road cutting on the western side of Cox's Gap to examine thinly bedded lacustrine shales of the Farmers Creek Formation within the Wallerawang Subgroup *(Photo 1)*. These shales are the same as those exposed in the nearby tunnel on the Sandy Hollow Railway at Kerrabee and lie at the top of the Permian sequence. They are uncomformably overlain by the basal conglomerate beds of the Triassic Narrabeen Group. Good examples of *Glossopteris* and *Vertebraria* were found in the shales and one particular horizon displayed spectacular intraformational slump structures, presumably formed when the lake bed was affected by an earthquake back in the late Permian. Near the top of Cox's Gap several normal

1. Lacustrine shales, Farmer's Creek Formation.

2. Rylstone Ignimbrite with lenticular glass 'bombs'.

faults with southern side up displacement are present in the Narrabeen conglomerates. These were examined on a previous excursion led by member Winston Pratt and were not revisited.

A lunch stop was made in the park opposite the Bylong Store. But we were a day too early for one of the region's biggest events being set up in the field adjacent to the park – the annual mice races!

Another interesting locality I had hoped to show the group wasn't where I had recorded it being! But there had been no major road works since my last visit, so how could a whole road cutting vanish! Thankfully it was eventually located a few kilometres south of Bylong. Here outcrops of a heavy black rock described as basalt by many geologists occur in a low cutting and small quarry adjacent to the Highway. But it isn't till the weathered surface of the rock is examined closely that something very odd is noticed. Small circular grey spots, not evident in the freshly broken rock, are evenly scattered over the exposed surfaces. These closely resemble aggregates of the mineral cordierite, a common component of contact metamorphosed shales and mudstones. So the rock here may be cordierite hornfels, not basalt. However, thin section microscopy and chemical microanalysis will be needed to verify this.

The last geological stop for the day was made at the road cutting on the northern side of Rylstone where there is an excellent exposure of the Carboniferous (?) Rylstone Tuff. This rock is actually an ignimbrite of rhyolitic to dacitic composition, comprising fragmented crystals of plagioclase, K-feldspar, quartz and biotite in a very fine groundmass. Preferentially aligned lenticular voids in the weathered outcrop give the rock a distinct lineation, probably indicating flow direction. These voids were formed by the weathering of flattened ellipsoidal enclaves of a soft altered glassy material containing coarse K-feldspar crystals. But it is not till the rock is freshly broken that the original enclaves are visible *(Photo 2)*. They are surrounded by irregular haloes of iron hydroxide (goethite), which is also present adjacent to joints in the rock.

None of the group could pass up another chance for coffee and before departing Rylstone a short stop was made at the Bizzy Birds Café.

By 5pm all had reached the Lithgow Tourist Park, our base for the next few days.

Some snippets from Lithgow's history.

Ever since the Blue Mountains were crossed from Sydney, the area of the City of Greater Lithgow has been a place of settlement as well as a staging post on the way to the western plains. The original town of Bowenfels on the Great Western Highway quickly declined in importance as the adjacent industrial town of Lithgow began to develop, but the old town still contains a wealth of architectural heritage.

Lithgow came into being because of its coal deposits and through its connection to the coast by rail with the opening of the Zig-Zag Railway in 1869. In the following 5 years it became a boom town. Coal production increased and in 1874 James Rutherford (the American owner of Cobb & Co) thought it a good idea to construct a blast furnace near the coal mines using iron ore contained in clay bands among the coal seams, supplemented by supplies from Clarence, Mount Wilson and Blayney. But Rutherford's furnace was unprofitable and in 1884 he brought in two drays of gunpowder and blew it up. His enterprise called the Eskbank Iron Works Company failed, but the associated foundry and rolling mill continued using railway scrap iron to make rails and remained in use till 1932.

3. Sandstone cliff on Mt. Airly.

There was almost a 25 year gap in large-scale iron smelting in Lithgow until the first steel produced in Australia was made at William Sandford's Eskbank plant on 25th April 1900 using iron ore from Carcoar. This was the precursor of Hoskins Iron and Steel, the ruins of which are now contained in Blast Furnace Park.

Because of the abundant coal in the valley, three separate companies smelted copper ores here, including the Lloyd Company which railed partly processed copper from its Burraga mine, and the Great Cobar Company which brought its blister copper all the way from Cobar. Only the Lloyd Company survived World War I.

Saturday 31st March

The main objective for this weekend excursion was to be the abandoned oil shale mining town of New Hartley on the northern slopes of Airly Mountain *(Photo 3)*. I had long ago heard of the oil shale retorts at Torbane and the long abandoned mining village of Airly on the eastern side of the mountain but only discovered the existence of New Hartley after purchasing a bushwalking map in Leura over Christmas. The text accompanying the map talked of a group of ruins so important and visually spectacular that they had been placed on the national heritage register. And they were easily accessed via a rough walking track! But as for locating the site I had only scant details and a few photographs, so was quite prepared for disappointment.

The old town and surrounds lie within the new Mugil Murum-ban State Conservation Area, gazetted only last year to ensure preservation of the natural and historic features while still allowing underground coal mining to proceed in such a way as to not cause surface deformation or cliff collapse. The SCA adjoins Centennial Coal's Airly mine lease.

After a brief introduction to the history of oil shale mining and processing in and around the Capertee Valley, it was only a short drive back up the Castlereagh Highway to Capertee, where we turned east along the Glen Davis Road. The early morning had been quite foggy in Lithgow. But up here it had cleared, leaving the thousands of dew-covered spider webs draping the long grass throughout the forest understorey, glinting in the low angle beams of sunlight like threaded strings of diamonds.

After a few kilometres a dirt road led off to the north which we presumed was the Airly Gap Road. This narrow but well-maintained gravel road wound up the steep eastern side of the heavily timbered canyon between Airly and Genowlan Mountains, arriving at the grassy saddle known as Airly Gap only 1.3 kilometres after leaving the Glen Davis Road. To our surprise we found a group already parked here – a bushwalking club from Lithgow, who were about to head off to Dingo Gallery and the summit of Genowlan. They had been to New Hartley last year and thankfully were able to put us on the right track, or we may have never found the old town.

In perfect weather with only occasional white fluffy clouds punctuating a bright blue sky we set off northwards down the road in eager anticipation of what might lay ahead. Half a kilometre beyond the well-maintained and still occasionally occupied Airly House, the last remaining building in the old shale mining town of Airly, we came to a new track closed off by a gate. The gate was open so we followed the track up the rise till it switched back sharply to the south. That was heading in the wrong direction so we diverged off it and headed off in a north-westerly direction following what appeared to be a faint vehicle track. But that terminated after only a few tens of metres, with no sign of any continuation. However down the steep slope to our right we could just make out a long-abandoned clearing which may just be the remnants of a road.

Just then we heard a vehicle coming down the new track and soon a tractor appeared. Flagging the driver down we learned that he was a contractor carting water for Centennial Coal to a drill site on the summit of Airly Mountain. This was one of a series of holes being sunk for bulk sampling of the underlying coal seams. That explained the well-maintained road up through Airly Gap! But this new road to the top was extremely steep, so steep in fact that the contractor had to attach weights alternately to the front and back of his tractor to stop it tumbling over! Like most others in the district he knew nothing of New Hartley, but expressed some interest in finding the old town on one of his days off.

4. Ruin of German Miner's hut.

Our only alternative now was to check out the cleared area below. Indeed it was an old road, now partly hidden by re-growth and debris, and it was heading in the right direction, following below the line of sandstone cliffs on the northeast side of Airly Mountain. But there was no sign of the continuation of Airly Gap Road through to Glen Alice as marked on my bushwalking map. At first the road seemed quite trafficable, apart from a few trees that a pruning saw would have dispatched quite easily. But then came a rocky creek crossing that would have severely taxed even the highest clearance 4WD. Then came another equally as bad, with a steep falloff into the wild and rocky gully below. Better to walk!

Within a few hundred metres we came to the first ruin, a small roofless two-roomed stone hut tucked between large sandstone boulders on a tiny area of flat ground enclosed by rampant vines. Then, one by one, other ruins appeared out of the thick scrub. Next was the German miner's hut, dominating a small clearing atop a sandy rise overlooking the densely wooded valley of Genowlan Creek. Now minus its roof, but with most of its concrete-rendered brick walls and even some of the timberwork around the windows still intact, it was obviously a significant building and in fact is one of the icons of the old village. It even had an outdoor oven up against one wall *(Photo 4)*!

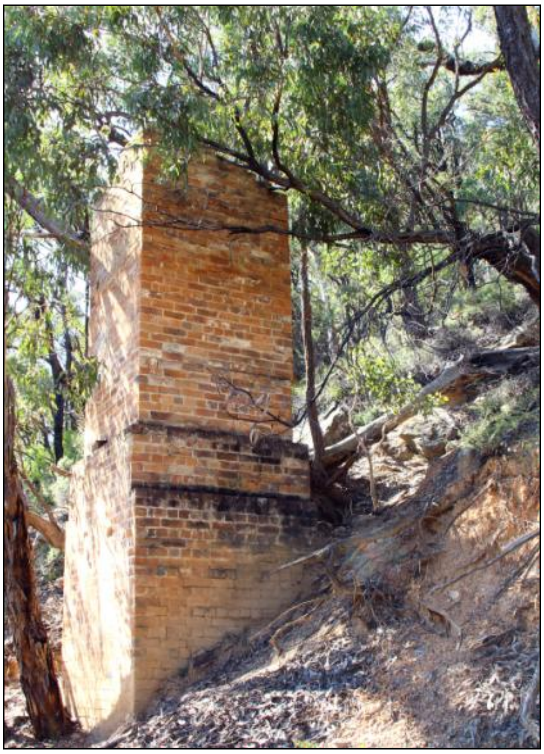
The old road continued more or less on the same level towards the northeast around Airly Mountain. But the shale band and associated sediments remained hidden by sandstone boulder scree and very dense vegetation. Only fleeting glimpses of the spectacular sandstone cliffs along the top of Airly Mountain could be seen through the trees. This contrasts sharply with old photographs of the area when the mines were active. Then the cliff line was clearly and constantly visible from the road and the village, dominating the scenery and providing a dramatic backdrop that the miners probably cursed rather than admired because of its occasional instability.

The next ruin was that of the Manager's house. Again nestled on a cleared grassy knob, this time looking back over the majestic sandstone cliffs of

Genowlan Mountain, all that remained was the massive stone fireplace and brick chimney. A shelf in the fireplace was adorned with ancient bottles, pots and pans. All lay broken, battered and corroded, having reached well beyond any form of useful life. But it all set the scene for some dramatic photographs, with the cliffs of Genowlan glowing yellow in the early morning sun and the sky above dotted with fluffy white clouds.

On the other side of the track and hidden from view in dense scrub lay a sandstone boulder hollowed out at the top to provide a drinking trough for horses, direct evidence of the early form of transport used along the old road. This was found only by accident when one of the group went off out of sight to answer a call of nature! What else lay undiscovered in the undergrowth?

No evidence of shale mining was seen until the first of the brick ventilation chimneys came into view, built into the scree slope on the south side of the track. These chimneys are found at most old oil shale mining centres and are connected directly into the mine workings at their base, often to a side portal off the main haulage way *(Photo 5)*. With the adjacent main portal closed off from the outside by wooden doors, the strong updraft from a wood fire lit inside the base of the chimney would draw air through the underground workings from distant openings, proving very effective ventilation throughout the mine. From here on fragments of tough dark grey torbanite began to appear in abundance embedded in and beside the track. Then, within a few hundred metres, the second ventilation chimney appeared.



5. Brick ventilation chimney.

6. Abandoned boiler and chimney.

With old photographs of the mine at hand, we tried to relate what we saw here to how it was back when the area was a hive of industry. But time changes things, in this case quite dramatically! The main mine portal on the eastern side of the second chimney had been blown down back in the 1950's and the large flat mine dump opposite had collapsed into the valley to be reclaimed by the forest. Gone also was the brick flue which connected the base of the chimney into the bricked ventilation portal, although that remained intact and still blocked by its original wooden doors, now almost buried in rubble. Of the flue, only a few of the wooden staves used to hold the structure together could be recognized. Even the chimney had lost some of its height, although what remained was well-preserved.

Continuing on around the mountain where tram tracks once ran, we came within a few hundred metres to a bench cut back into the scree slope. This was large enough to accommodate some significant structures but all that now remained was a large rusting boiler complete with chimney and a patch of concrete machine foundations *(Photo 6)*. This, we deduced later, was the site of the winding engine for the cable haulage skipway over Airly Mountain. But at the time we could see no other infrastructure in the dense scrub.

We continued to follow the old road around the side of Airly Mountain but now it became very uneven in elevation, rising and falling quite steeply in places. Obviously it could no longer have been a tramway and by now all signs of torbanite had vanished. As it turned to the south and headed in towards a blind ravine we decided to turn back. According to our meager maps, ahead lay a lookout point on the Airly Mountain summit, but time was running out.

Back near the foundations of the engine for the rope haulage skipway, Terry thought he could see a stone chimney down in the bush about 50 metres below the road. Eventually finding a way to scramble down the steep slope we did indeed come across a low chimney and fireplace, once part of a small hut. At first its presence in the tangle of half-dead vegetation seemed incongruous, with no apparent sign of any association with the mine and it was too small to be a miner's house. But then nearby we noticed a narrow clearing heading towards what was obviously a man-made cutting *(Photo 7)* through a ridge of sandstone and heading directly west. Tangles of rusted steel ropes nearby confirmed our thoughts that this was the part of the eastern section of the cable haulage skipway which carried the torbanite across Airly Mountain to the retorts at Torbane in the next valley. In fact, viewing the cutting from the western side we could match it with an old photograph which appears in the book 'Shale Railways of New South Wales'! Then everything else in the vicinity fitted into place, right down to the little hut with the chimney and the stone plinths that supported the raised initial section of the skipway as it crossed the gullies down from the winding engine.

Satisfied that we had seen the best of what the area had to offer we headed back down the track to the cars. But the old town still held a few surprises. Back past the Manager's house I noticed a narrow path heading off to the left into the scrub. What lay at the end of it after only a few metres left me spellbound. Here, sheltered in a hollow dug beneath a huge almost flat-lying sandstone slab, stood the epiphany of a miner's hut, its walls made of stacked sandstone blocks grouted with mud *(Photo 8)*. Exploring inside was discouraged by the presence of a large

7. Cutting through which the haulage skipway ran.

8. Remnants of a miners hut.

nest of defensive wasps at the entrance, but in the dim light it seemed quite roomy. An old rug lay spread across the dirt floor and an array of pots and pans were neatly arranged at one side near a fireplace. Outside the entrance there was even once a well-manicured lawn covering a small rectangle of level ground cleared from the bush. Another miner's hut, now largely in ruins, was found further down the track. How many more are hidden in the scrub no-one knows!

It seemed the large tilted sandstone slabs scattered over the steep slopes of the mountain had provided prime real estate opportunities for some of the miners! They only needed a little ingenuity (or desperation) to quite quickly turn them into a livable home. These rough shelters would have been cool and comfortable, if somewhat cramped, during the hot summer months. But they provided little protection during the cold winters when snow often covered the ground outside for days on end. It would have been a hard life!

Despite repeatedly bashing through dense undergrowth and forest debris the only snake we saw, a red belly black, was sunning itself on the grass near the walkers hut opposite where the cars were parked. It took one look at Elaine with her camera and quickly slithered off to hide in a patch of tall weeds! Wise snake!

We left the area amazed at what we had seen and were careful to disturb nothing, hoping that other visitors in the future would do the same. Back in Capertee the group recovered from their trek over cappuccinos at the only café in town at the garage. Then back to Lithgow Tourist Park to prepare for dinner and a night out at the Lithgow Workers Club.

What is oil shale, that strange rock that burns?

Typically over 80% of torbanite consists of volatile hydrocarbons. Because of this the rock can be lit easily with a match and its combustion leaves very little ash. It belongs to a group of organic-rich sedimentary rocks which also includes bitumen-impregnated rocks and coals. Oil shales can be of terrestrial, laccustrine or marine origin. Those of laccustrine origin can be subdivided into lamosite and torbanite, with torbanite forming in fresh water and brackish lakes due to the build up of algae of the *Botryococcus* family. Terrestrial oil shale or cannel coal, which is often confused with torbanite, is composed of resin spores, waxy leaf cuticles and the corky tissue of plant roots and stems. It characteristically forms in coal swamps and bogs so is often associated with coal seams. In contrast torbanite is seldom directly associated with coal, the only exception in this state being at Joadja where it occurs directly above the Lithgow Seam.

All the Torbanite seams in New South Wales occur at various levels within the Permian Upper Coal Measures, with the torbanite at New Hartley/Airly lying just above the Irondale Seam. Below the coal measures lies the Permian Upper Marine Series while above them are Triassic sediments of the Narrabeen Group (Pells & Hammon, 2009).

Historical Background to the Shale Oil Industry at New Hartley and Torbane.

The Wallerawang to Mudgee Railway, the first section of which opened to Capertee on 15th May 1882, encouraged a wave of settlers and prospectors. Large areas of the Capertee Valley were cleared for grazing. Then above the banks of Genowlan Creek below the eastern escarpment of Airly Mountain, a workable deposit of torbanite was found in 1883 by Bulkeley, Larkin, Massey, Melliday and Nicholson. They took up shale leases but lacked the finance to develop a mine and their leases were cancelled due to lack of work. The leases were taken up almost immediately by a German syndicate called the Genowlan Shale Company and adits were driven into the seam below Airly Mountain. Export shale was sent to Germany for gas enrichment as early as 1883, the product being taken from the mine in horse and bullock wagons to Capertee Station. Soon a small rambling village called Airly appeared – a group of primitive slab, bark, and corrugated iron huts clustered near the shale adits. Homes were placed wherever the land was flat enough to erect a building. Only one of these remains, a quite substantial house on the western bank of Genowlan Creek called Airly which once acted as Burnett's farmhouse and is now used as an occasional weekend retreat by the current owner.

The Genowlan Shale Company prospered for a few years but was devastated by the state-wide bank collapse of the early 1890's. In 1895 the company's assets were acquired by the Australian Shale Syndicate Limited which, in May 1897, leased the operations on tribute to the Australian Kerosene Oil and Mineral Company. Its first move was to arrange with the Railways Department for construction of a siding on the Wallerawang-Mudgee Railway. This opened on 10th June 1897 and in September the siding was named Torbane – a name that originated in Scotland where it was associated with the bog head coal called torbanite.

The operation was again taken over in 1908 by the Commonwealth Oil Corporation. But by 1914 the mines were idle, brought about by the political withdrawal of the Shale Oil Bounties Act which expired on 30th June 1913. The Commonwealth Oil Corporation went into liquidation in 1912 and its interests were purchased in 1916 by the Commonwealth Oil Federation. The shale they mined was sent to Newnes for retorting and to the railway gas works at Macdonaldtown near Sydney. Mining ceased in 1918.

Meanwhile the deposits along the northern escarpment of Airly Mountain had been worked in a small way from around 1883. In January 1893 the area was leased by F.W. King and in August 1896 that lease was taken over by the New South Wales Shale and Oil Company. It had been operating shale mines at Hartley Vale along with retorts and an oil refinery. But these deposits were nearing exhaustion and the company moved their operations to the Capertee Valley, calling their new lease New Hartley.

A private township was established to the north-east of the retorts adjacent to the shale adits and the company also constructed a standard gauge railway to connect the retort area with the main Wallerawang-Mudgee line at Torbane Siding. This was opened in June 1898. The retorts at Torbane were designed to treat low grade shale that was too poor for export. The first tank wagon of crude oil was dispatched to Hartley Vale refinery in December 1900. The company had a contract to supply the Australian Gaslight Company with one million tons of crude oil annually for a period of 10 years. All this oil was sent to Hartley Vale for fractional distillation.

East of the Torbane retorts lay the northern spur of Airly Mountain and this had to be crossed by a narrow gauge skip haulage tramway to bring the shale from the New Hartley mines on the eastern side. No torbanite had been found or indeed occurs on the Torbane side of the mountain. The transported shale was offloaded at a picking table sheltered by a long galvanized steel shed, where "pickey boys" hand graded the lumps of shale. The skip tramway, once over the spur, followed along the horizontal outcrop of the shale where adits had been driven into it.

In May 1906 the New South Wales Shale and Oil Company's properties and works were purchased by the Commonwealth Oil Corporation, which now dominated the shale and oil industry. In April 1911 25,000 gallons of oil were dispatched to Darling Harbour for the Royal Australian Navy destroyers HMAS Parramatta and HMAS Yarra. This oil was retorted at Torbane and refined at Hartley Vale.

During 1911 industrial turmoil closed the Torbane works for over 7 months. Although work recommenced the following December, shale mining at New Hartley was winding down and the company began to concentrate on developing the industry at Newnes. However in 1912 the Commonwealth Oil Corporation went into liquidation and by July 1913 the retorts were being dismantled brick by brick for re-erection at Newnes. The shale mines were in operation again in February 1916, the shale being railed to Newnes. But by June 1918 shale mining at New Hartley had ceased. By April 1920 the company buildings at New Hartley were being dismantled and the materials sent to Newnes.

Further dismantling of the plant took place in 1925-6, the fire bricks recovered being sent by rail to the oil refinery near Duck River at Clyde. By 1973 little was left at Torbane apart from the Manager's house which is still being used as a farm house.

9. Walking track into Pagoda Country.

Sunday 1st April

This morning Barry led the group out along the Glow Worm Tunnel Road to visit an area of spectacular pagoda formations. We followed him north up the State Mine Gully Road along State Mine Creek to the southern rim of the Newnes Plateau. Here a short track led off to the left for a few hundred metres along a narrow ridge into spectacular pagoda country overlooking Lithgow *(Photo 9)*. The last section of road before we turned off into the pagodas passed up a narrow sandstone canyon where deep caves had been eroded back into the vertical rock faces by water seepage. This is apparently a haven for rock climbers and one group was already in action by the time we passed by.

An hour or so was spent exploring and photographing the pagodas *(Photo 10)* before returning to the cars for morning coffee. Then Barry, Elaine and a few others continued up the road to the Glow Worm Tunnel on the abandoned Wolgan Valley Railway.

The remainder of the group drove back down the mountain to Blast Furnace Park, conserved and landscaped as an important industrial heritage site by the Greater Lithgow City Council as a 1988 Bicentennial project.

The site was originally developed by William Sandford as an integrated ironworks in 1906. These works were taken over by Charles Hoskins in 1908 to become Hoskins Iron and Steel Company Limited. Hoskins expanded the works with the addition of a second blast furnace and operations continued through World War I., supplying significant amounts of steel to the small arms factory established in 1911 only three kilometres from the furnaces. However soon after the war ended, when it was realized that sea transport was the most economical way to move heavy materials, the Company decided to move iron and steel making from Lithgow to Port Kembla. While Port Kembla was still in the planning and building stage the Lithgow plant was kept going only to attain the maximum profit. Then in November 1928, the Lithgow blast furnaces ceased production. Lithgow was left without its greatest employer to face the Depression of the 1930's. The move had come almost without notice and signaled the failure of Lithgow as an industrial centre (Jack & Cremin, 1994).

10. Typical scenery amongst the pagodas.

The overwhelming bitterness of the community on the closure of the iron industry had a powerful and lasting affect on its attitude to industrial heritage. The site was quickly stripped of useable machinery and any remaining iron, including the blast furnaces and blowing engines, was cut up and taken away for scrap. Fortunately, attempts to demolish the buildings were only partly successful. For many years in the town's view the site was a "humiliating eyesore" which had to be destroyed. It had become a painful reminder of abandonment. The site's value as a memorial to two generations of ironworkers and the infant Australian iron and steel industry was ignored and went unrecognized until only recently when it was almost too late.

Stanford's massive engine house *(Photo 11)* remains as a poignant memorial, once a very fine industrial building which housed the magnificent 120 tonne Davy engine, imported from Britain and carried in sections from Sydney on specially-built railway trucks to be assembled on site over a period of 6 weeks. It was a major industrial showpiece!

A network of pathways connect the various points of interest and the site is ringed by excellent recently-erected display boards showing the history of the works in the form of annotated copies of historical photographs. Ironically, probably the most dramatic sight in Lithgow today is the view of the ruins of the Davy Engine House through the iron skull of the number 1 blast furnace!

11. Stanford's Engine House ruin.

After some confusion finding our way through the City of Lithgow, which saw cars separated and heading off in different directions, all eventually met up at Hassan's Walls Lookout for lunch and some truly spectacular views before returning home.

The Nature and Formation of Pagodas.

It has been reported that in the northern Sydney Basin these spectacular features only form in the Banks Wall and Burra-Moko Sandstone (Washington, 2001) within the Triassic Narrabeen Group. They are common where these characteristically thinly bedded sandstones are intersected by gully erosion cutting back into the rocks from the edge of plateaus or ridges. They are seldom found in thick-bedded homogeneous sandstones, where slot canyons and high vertical walls predominate, as in the Grose Valley near Katoomba.

Like the more massive sandstone beds, these thinly bedded sandstones are split by intersecting sets of vertical joints spaced from a few metres to tens of metres apart to form huge roughly rectangular to square joint blocks. Weathering and erosion along these joints by running water gradually widens them, initiating miniature V-shaped valleys between the joint blocks. These small valleys are slowly deepened and widened and the once continuous sandstone beds are gradually carved into a series of separate monoliths.

The different layers in the thinly bedded sandstones show different susceptibility to weathering and erosion, due to differences in texture and/or composition. More weakly cemented layers are easily weathered and removed by erosion. These alternate at irregular intervals with more resistant layers, which are slowly undercut by removal of the softer layers beneath them, then periodically collapse to collect as rubble in the beds of the streamlets. This is the cause of the stepped sides.

Why the convex sides? The upper sandstone layers exposed along the sides of the pagodas have retreated further from the joints than the successive layers below. This is because the upper layers were the first to be exposed to weathering and erosion as the streamlets cut down along the joints. So as we go down the sides of the pagodas, the upper layers of sandstone have had more time to weather and erode (and so retreat) from the adjacent joint than each successive layer below.

Why are the corners rounded? As well as the process outlined above, flat surfaces such as joints are attacked from only one direction during weathering and erosion, whereas edges are bound by two planes and corners by three. So corners weather, erode and retreat more rapidly than edges, and edges erode faster than flat faces (Twidale and Campbell, 2005). As a result the originally angular joint blocks are transformed into roughly conical "core towers"

The stepped structure is often accentuated by the presence of thin erosion-resistant dark brown ironstone bands which lead to wider steps and a riot of shapes including pipes, plates, pulpits, skeletons and weird sculptures. These often protrude more than a metre from the sandstone surface. The origin of these ironstone bands is uncertain but they may be due to seasonal precipitation of iron hydroxide from stream waters during sedimentation or as a result of precipitation of iron minerals along bedding planes and/or cracks, the iron having leached from overlying Paleogene (Tertiary) basalts which characteristically form waterlogged swampy areas (Washington, 2001). In fact both processes may play a part.

In thick bedded sandstone like the Hawkesbury Sandstone, the rock is more or less uniform in nature and the cliff face retreats uniformly, albeit slowly, only breaking off along vertical joints where erosion of underlying shale bands undermines it and gravity takes over.

As a result of these processes, the Capertee Valley is surrounded by vertical cliffs of Hawkesbury Sandstone *(Photo 12)*.

Report by Brian England.
Photographs by Ron Evans.

References:

EARDLEY, G.H. and STEPHENS, E.M. (2000). The shale railways of New South Wales. *Australian Railways Historical Society, New South Wales Division.*

JACK, I. and CREMIN, A (1994). Australia's age of iron. History and archaeology. *Oxford University Press.*

PELLS, P.J. and HAMMON, P.J. (2009). The burning mists of time. *Writelight Pty. Ltd.*

TWIDALE, C.R. and CAMPBELL, E.M. (2005). Australian landforms. *Rosenberg Publishing Pty. Ltd.*

WASHINGTON, H. (2001). Focus on Geodiversity. Sites, values and management for the Hawkesbury-Nepean. *Department of Land and Water Conservation.*

12. Patoney's Crown, a mesa in the Capertee Valley as seen from Paterson's Lookout.

Redhead Bluff; Stratigraphy and Paleoenvironment.

Saturday 12th May 2012.

Leaders: Chris and Liz Herbert.

Attendance: 12 members; 2 visitors.

This excursion examined in detail the lithology and stratigraphy of the rock section lying between the lower split of the Fern Valley Seam and the Nobbys Tuff member of the Lambton Sub-group near the base of the Newcastle Coal Measures. As well as containing a number of extraordinary features, this section provided a fascinating insight into past depositional environments and how they were influenced by plate tectonics, climate change, sea level rise and fall, and spectacular proximal volcanic eruptions.

We were fortunate to have a magnificent autumn day, perfect weather for the event, and even more fortunate to have Chris and Liz Herbert who had generously given up their time to lead the group and explain the geology. Chris is no stranger to the Society, having volunteered his time on two previous occasions to accompany members on field trips to Spoon Bay / Putty Beach in 2011 and more recently to join a few (fool)hardy souls who braved exceptionally foul weather and gale force winds to re-explore Winney Bay.

Before starting down to the rock platform, Chris produced a series of stratigraphic columns and charts to introduce the group to the geological section we were to examine and how the rocks and geological environments that produced them are inter-related. One important lesson that quickly became apparent was that the column representing the complete stratigraphy of a region or sequence such as the Newcastle Coal Measures is a *composite* section so that not every formation that appears in it is present in every area. Prime examples are the various conglomerate beds such as the Redhead and Merewether Conglomerates which have only limited lateral extend.

Access to the rock platform was provided via a well-defined track leading off Ocean Street at its junction with Cowlishaw Street at the top of the Bluff. At first the track descended slowly through dense heath land, and then continued as a steep deeply eroded gutter across which wooden planks had been anchored at intervals to provide crude steps.

1. Track down to rock platform.

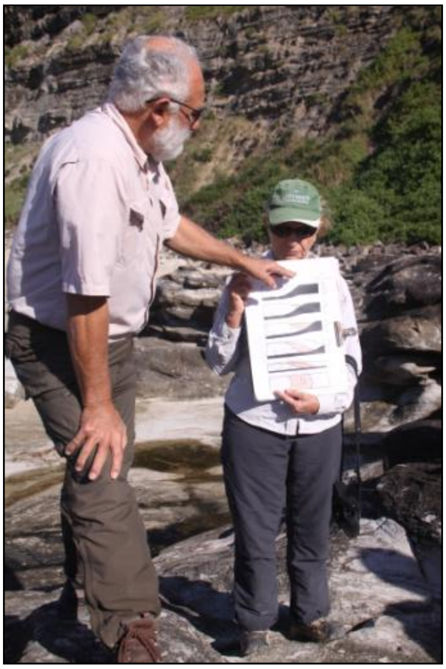
The first outcrop to become visible below the regolith (weathered surface) layer was the lower split of the Fern Valley Seam, conveniently exposed by a recent slump just as the track began to descend the near-vertical cliff. Here a small fault has displaced the rock layers, causing a small synclinal drag fold in the coal beds adjacent to it, as well as a fine example of kink folding a metre or so away from it.

The path continued almost vertically over a 20m drop, forcing us to climb down a series of hard sandstone shelves separated by friable shale bands *(Photo 1)*, both rocks forming the upper part of the Kotara Formation. It looked scary, and a few were deterred, but a fall here would at worst result in a few abrasions before landing in the relatively soft stand of bitu bush covering the base of the scree slope. At the start of the climb down we noticed the first of many siderite-replaced tree stumps standing in its growth position. These shales contain few plant fossils, only a few scattered *Glossopteris* leaves, and the presence of in-situ stumps indicates that the original sediments were exposed sub-aerially and that trees were growing on them. The absence of any body fossils in these rocks is a result of the very cold (Antarctic) conditions prevailing in Gondwana during the Permian.

Near the base of the scree at the foot of the cliff and largely covered by bitu bush is the Victoria Tunnel Seam, which overlies shales of the Shepherds Hill Formation. Both these rocks were examined later further to the north where they became more accessible. At the base of the scree just below the line of bitu bush the path crossed an Aboriginal midden crowded with bleached marine mollusc fragments.

The rock platform here comprises the upper part of the Nobbys Tuff member, its contorted and convoluted layers evidence of its origin as a base surge (nuee ardente) of volcanic debris from a major volcanic rise to the southeast around 30 kilometres off our present shoreline. This volcanic province resulted in the intermittent deposition of tuff beds throughout the coastal plain sediments of the Newcastle Coal Measures during the Late Permian. These tuffs decrease in grain size and thin significantly inland from the source area.

At this time the region was rapidly sinking adjacent to the Hunter-Mooki Thrust, developing as a result of overthrusting by the New England Fold Belt to the north which eventually developed into a huge rapidly eroding mountain range. This rapid sinking adjacent to the Thrust resulted in a prograding (advancing) shoreline along the margin of a rapidly deepening foredeep basin. This explains the huge quantity of non-marine sediment compared to marine sediment. The proportion of marine sediment increases away from the thrust zone, with the region subsiding more along the eastern side to form a half-graben (rift valley) with the Newcastle Coal Basin formed largely due to the development of the Macquarie Syncline. Because the region lay adjacent to the thrust huge amounts of conglomerate were being introduced from the north as well as the tuffs coming from the volcanic uplift to the southeast. The finer sediments coming from the north were washed further south where basin depth was much shallower and the sediments became spread over a much wider area within a lower energy environment to form the sandstones of the southern Sydney Basin.



2. Chris (with the assistance of Liz) describing depositional process.

The formation of peat bogs, the precursor of today's coal seams, requires an environment in which rainfall far exceeds evaporation. It also requires prolific vegetation growth. These are high latitude coals since, when the coal measure sediments were being laid down, Gondwana lay very close to the South Pole. Cold dark winters contrasted with warm summers where three months of 24 hour daylight would have promoted rapid and prolific growth of deciduous forests, providing the vegetable matter to form the peat bogs.

The formation of significant coal seams required the peat bogs to form in regions where sediment input by rivers was not possible over long periods. Recent ideas suggest that the bogs which formed the Newcastle Basin coal seams were not low-lying fringing swamps along lake shores, but were more likely to have been raised bogs extending over huge areas of rolling tundra and flat valley floors. Any rivers were deeply incised so there was no opportunity for them to overtop and spread sediment over a wide area. The environment would have been constantly non-oxidising due to the water table keeping pace with the upper surface of the bogs. Wherever their surface became raised above the groundwater level the peat bogs became inactive and the vegetable matter contained in them underwent oxidation to eventually form dull coal.

Peat bog development is thought to have been directly related to sea level. In times of relatively low sea level the bogs became inactive as they dried out. Then during a sea level rise, as fluvial environments were pushed back inland, the water table rose and the bogs become saturated again and so were reactivated. But eventually the rise in sea level overtook the bogs and fluvial deltas formed over them in a marginal marine estuarine environment from sediments washed in from the north and from the volcanic rise to the southeast. An example at Redhead Bluff is the Kotara Formation. Then sea level fell again and the process repeated.

Strolling down to the southern end of the beach, where further access along the coast was blocked by rock falls, we paused to look up at the prominent outcrop of Redhead Conglomerate forming the upper 20 metres or so of the sea cliff *(Photo 3)*. Comprising interbedded conglomerate and cross-bedded sandstone this conglomerate, like others in the Newcastle Coal Measures including the Merewether Conglomerate which outcrops within the Kotara Formation nearby to the north, shows very steep dips of up to 45°. These dips were previously thought to represent huge foreset beds comprising a large river delta, but more recent studies have suggested an alternative and very plausible explanation.

It was explained by Chris *(Photo 2)* that these conglomerates were laid down within south to north oriented river channels cutting across the newly submerged peat bogs following a rise in sea level. As each layer of conglomerate prograded across the bog, the soft spongy peat immediately beneath it was compacted, causing each successive conglomerate bed to become steeply tilted towards the delta front. We must remember here that waterlogged peat is extremely compressible with compression ratios of up to 10:1 between peat and coal.

Factors favouring this scenario include the very steep dips which are much greater than those normally observed in delta foreset beds; the lack of gradation in sediment size which characterises foreset beds; and the absence of typical delta shapes within the conglomerate units. In fact the conglomerates map as long sinuous belts up to 5 kilometres wide and are lensoidal in transverse section. These clearly represent major river valleys characterised by a single braided stream channel. In addition, the coal beds and underlying sediments beneath the conglomerates remain almost horizontal, so the observed high dips are not due to later deformation.

The Redhead conglomerate contains red jasper pebbles from the Woolomin Beds to the north as well as green and black jaspers from the New England Fold Belt, providing direct evidence for the provenance of the sediments.

3. Cliff formed from Redhead Conglomerate.

4. Fossil tree stump (siderite replacement).

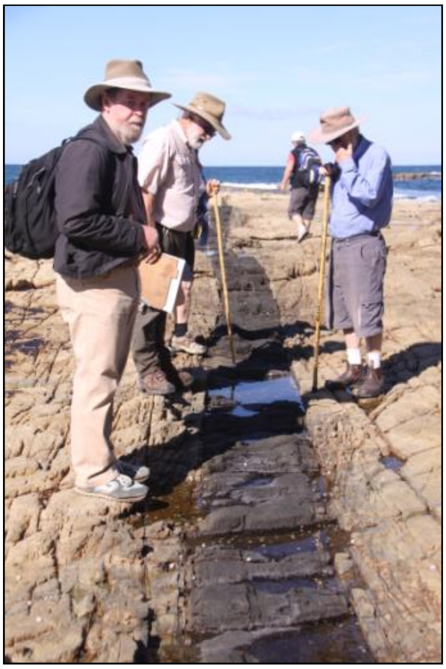
Walking back north along the rock platform we noticed an unusual concentration of siderite-replaced fossil logs and stumps *(Photo 4)* confined to a relatively thin layer of sediment where overlying areas of Nobbys Tuff had been stripped away. Many of the logs were rimmed by bright coal representing the original bark and sediments adjacent to some of the stumps contained scattered *Glossopteris* leaves. Some time was spent in discussion on the demise of this once dense forest. Since there appeared to be no preferred orientation of the logs and the trees had apparently been snapped off at their base, the eventual conclusion was that the trees had been knocked over by a volcanic base surge associated with the Nobbys Tuff. So the trees would have been growing on the land surface between ash flows. The trees were probably deciduous, given the Antarctic climate, but any leaves that might have been present would have been blown away as the stumps and logs were buried by the ash.

On the rock platform further north we came upon a prominent vertical basalt dyke *(Photo 5)* intruded along joints during the Paleogene (Tertiary) as the Tasman Sea (“the ditch”) was opening. This dyke is unusual in that it gradually pinches out seaward, but back towards the cliffs abruptly jumps along a thin crack to an adjacent parallel joint some distance to the north.

Further to the north again and exposed on a bench below the normal coastal access route, we found possibly the best example of tessellated pavement to be seen anywhere along the Australian east coast *(Photo 6)*. Many Society members had seen this on previous walks but seeing it again still provoked exclamations of astonishment. This particular tuff bed had probably acted as an aquifer between more impervious layers and over time seasonal variations in water flow had altered the composition of the rock matrix adjacent to an intersecting pattern of joints, resulting in concentric layers of differing resistance to erosion. The result – a patch of crazy paving almost too perfect to be natural! The initial close-spaced rectangular joint pattern may have resulted from cracking of a more competent (undeformable) bed during flexing of the rocks as they were lightly folded. Lateral outward movement of the tuff bed as the adjacent confining rocks were removed by erosion probably also played a significant part. Similar lateral movement (towards the roadway) was observed in the fluvial sandstone beds exposed in deep cuttings on the F3 Freeway and this had to be allowed for in the construction of overpasses.

Just north of the tessellated pavement, a short scramble along a thin uneven path precariously perched beside a 4 metre drop into the crashing surf brought us to the base of a high sea cliff where we could clearly observe the Victoria Tunnel Seam lying above the Nobbys Tuff. Here there are a number of in-situ fossil tree stumps, some up to 6 metres in length, which once grew in the peat bog. The strata in the overlying Kotara Formation here are more sandy, having been deposited back from delta fronts in brackish lagoons behind sandy barrier islands which separated the lagoons from the sea.

The last exercise for the day was the challenging climb back up the cliff face to the car park. Here Chris completed the excursion with a discussion on present-day analogues to the tectonic/depositional situation in the Sydney/Gunnedah/Bowen Basin complex. The



5. Dolerite dyke.

6. Tesselated pavement.

Arafura Sea, a present-day foredeep basin being formed as Australia pushes northwards against New Guinea was presented as a direct tectonic analogue to this area of Gondwana in the Late Permian, albeit in a different orientation.

Chris Morton then thanked Chris and Liz Herbert for so freely giving up their time in presenting such an absolutely fascinating account of the stratigraphy and associated geological history of the cliff section here. The meeting closed with the presentation of a copy of Geo-Log 2011 to Chris and Liz in appreciation. A small group stayed on to accompany Chris and Liz for lunch and more lively discussions.

Report by Chris Morton and Brian England (Geology).
Photographs by Chris Morton.

Further Reading.

HERBERT, C.; HELBY, R. (1980) A guide to the Sydney Basin. Geological Survey of New South Wales. Bulletin 26. *Department of Mineral Resources.*

HERBERT C. (1997) Relative sea level control of deposition in the Late Permian Newcastle Coal Measures in the Sydney Basin. *Sedimentary Geology 107, 167-187.*

LINDSAY G.; HERBERT C. (2002) Coal and conglomerate in the Newcastle Coal Measures - coeval facies or temporally unrelated? *International Journal of Coal Geology 51, 169-184.*

Those who attended previous excursions to Redhead Bluff or have read the reports in Geo-Log will have noticed that some of the above information is at variance with that given previously. This is due to access to more recent information plus the far greater expertise of our guides on this excursion.

Glacial Rocks in the Seaham and Raymond Terrace Area

Saturday 21st July 2012

Leader: Ron Evans.

Attendance: 21 members; 4 visitors.

The excursion was to examine glacially derived rocks in the Seaham Beds, the topmost formation within the Carboniferous Kuttung 'Series'. Mostly these rocks consist of glacial deposits with much volcanic material. *(See Figure 1.)*

Era	Period	Rock Units		Maximim thickness	Lithology
		Group	Formation		
PHANEROZOIC	CARBONIFEROUS	KUTTUNG 'SERIES'	Seaham Beds	580m	Tillite,varved shale, fluvo-glacial conglomerate, tuff, sandstone, mudstone, lava
			Paterson Volcanics	122m	Acid lava flows, tuffs, interbedded conglomerates
			Mt. Johnston Formation	670m	Conglomerate, tuffs, tuffaceous sandstone, shale
			Gilmore Volcanics including Martin's Creek Andesite Member	792m	Intermediate to acid lavas and tuffs, conglomerate, lithic sandstone
			Wallaringa Formation	792m	Conglomerate, tuff, tuffaceous sandstone

Fig 1. **Stratigraphic Column of the Kuttung 'Series'**

The main rock types to be observed during the day include:

Varved Shale. Sediments that formed these were deposited from melted ice in a lake. Varved shale is well banded or layered. The layers appear in pairs, the coarser layer representing the summer deposit when ice melts and a thin layer of finer material representing a winter deposit when most of the sediment is 'locked up' in ice. Thus, each pair of 'varve' represents a seasonal deposit.

Tillite. These are coarse conglomeritic rocks formed from masses of unweathered blocks (large, angular sediments) and **glacial till** (unsorted and unstratified rock material deposited by melting glacial ice) in a **rock flour** (matrix of fine unweathered rock).

Aqueo-Glacial Conglomerate. Generally dark greyish, bluish perhaps green tints. Usually not bedded. It consists of an unsorted mass of fine and coarse material, is compact and contains grains partly rounded and partly angular. May contain fresh feldspar.

Tuffaceous Sandstone. Sand-sized grains containing a matrix of volcanic ash.

Breccia. Angular fragments cemented together by a fine matrix.

Those attending the excursion met at Riverside Park in Raymond Terrace. While we were having morning tea, I presented an overview of the geological history of the area, showed examples of the rocks to be found (thanks to Brian for supplying some samples) and answered questions.

Abercrombie Quarry:

This was our first stop. The quarry is located on the southern side of Six Mile Road, a few kilometers north of Raymond Terrace *(See Figure 2)*. The now disused quarry was overgrown and contained litter dumped by local residents. I gave a quick overview of the rocks and sedimentary structures to be found and suggested that interesting specimens collected be brought back to a central point where they could be shown to all, discussed and explanation given as to their significance *(Photo 1).*

Because of the overgrown nature of the quarry, difficulty was had in finding and observing a fault and dyke in the south eastern wall of the quarry. However, the top of another eroding dolerite dyke was found *(Photo 2)*, as well as varved shales, some showing graded bedding, others containing dropstones and intra-formational folding *(Photo 3)*. Excellent examples of the weathering process called 'fretting' was seen in fine-grained varves *(Photo 4)*.

We returned to our vehicles and drove north to Seaham. The first stop was for toilets before parking near St. Andrews Church. From there, we walked to the historic Seaham Quarry.

Seaham Quarry:

This is a small, disused varved shale quarry at Seaham. In 1925, a signboard erected by Edgeworth David proclaimed that the area was to be 'preserved in perpetuity'. Perhaps the most spectacular features exposed in the quarry are localised contorted beds interstratified between apparently undisturbed layers of strata. The height of the contorted layers ranges from a few centimetres to a metre or more.

In the Seaham area the formation consists of some 600m of tillite, varved shale, aqueo-glacial conglomerate, tuffaceous sandstone, and mudstone. Osborne (1925) recognised three tillite and three varved shale horizons. The one exposed in the quarry is the lower most and thickest.

Some varved shale horizons contain trace fossils (trails and resting places) of an arthropod named *Isopodichnus osborni.* Such trace fossils point to an environment of shallow periglacial lakes, which received sediment influxes via turbidity currents.

A **periglacial lake** is one formed where the natural drainage of the topography is obstructed by an ice sheet, ice cap or glacier.

On our walk to the quarry, we passed an excellent exposure of varved shales in a road cutting. Starved Ripples were observed in one section of the cutting. Of interest, were the many drill holes where samples of the rock had been removed for research. Unfortunately, we could find no examples of trace fossils in the shale samples lying at the base of the cutting.

Although very wet in the centre, we were able to walk around the edge of the Seaham Quarry and observe the contorted beds sandwiched between apparently undisturbed beds *(Photo 5)*.

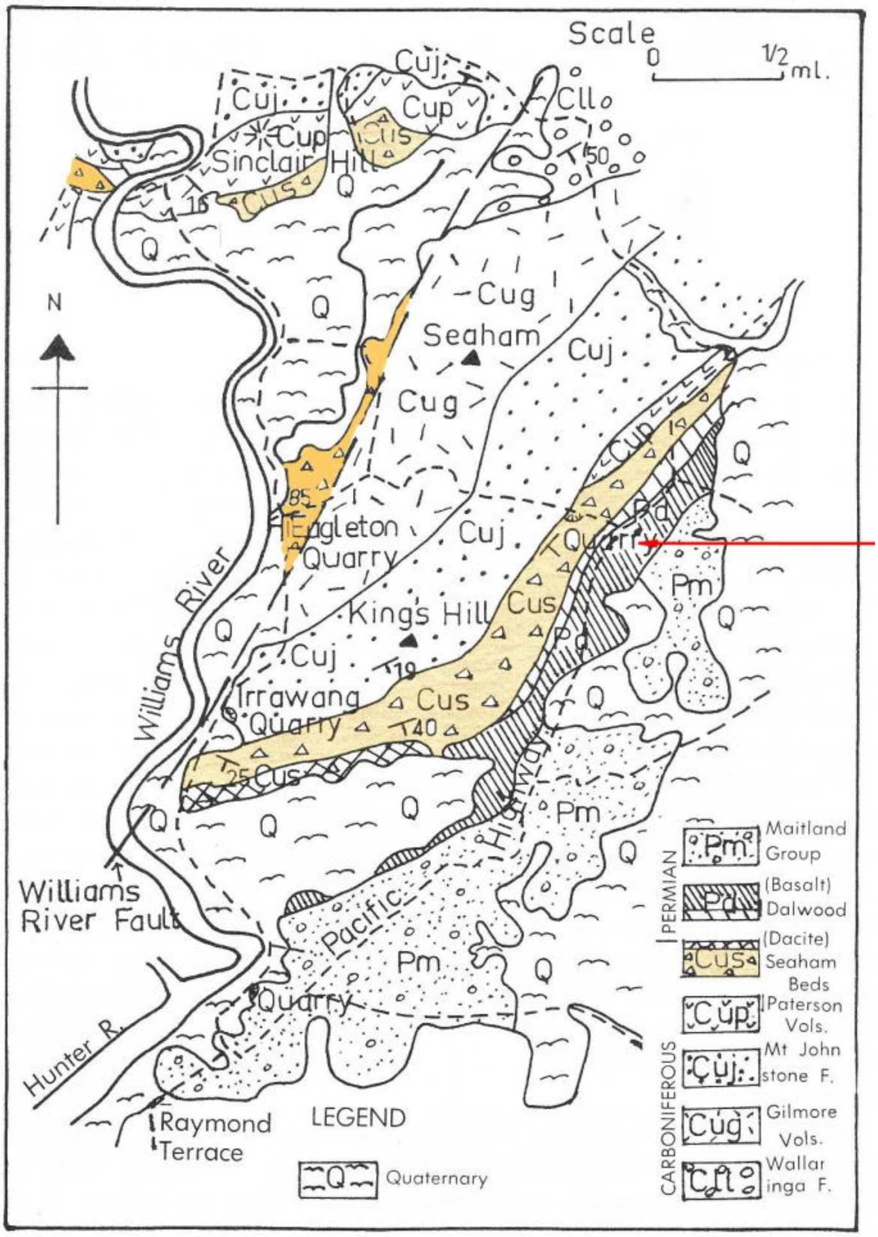
2. Eroding dolerite dyke.

3. Graded bedding and intra-formational slumping.

4. Varved shale weathering by 'Fretting'.

1. Exploring Abercrombie Quarry.

5. Intra-formational folding, Seaham Quarry.



Abercrombie Quarry.

Fig 2. **Geological Map of the Raymond Terrace-Seaham Area**.

Returning to the cars, we drove back to Raymond Terrace for a very welcome lunch at the Junction Inn Hotel.

Report by Ron Evans.
Photographs by Ron Evans.

Reference.

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

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Coolah Tops NP Weekend

Friday 9th to Monday 12th November 2012

Leader: Chris Morton

Attendance: 14 Members

Geology of the Liverpool Ranges ~ A brief summary

The Liverpool Range Volcanic Province is the largest volcanic province in NSW, covering an area of 6000 km^2 to a depth of 300 - 400 m. Johnson assumed the original mass of volcanic material was 4000 – 6000 km^3. The Liverpool range overlies the Permian-Triassic Sydney-Gunnedah Basin, forming a surface feature separating the Sydney Basin on the south from the Gunnedah Basin on the north. The Liverpool Range also overlies sediment of the Oxley basin, the most southerly part of the Surat Basin.

The dominant rock is basalt. Surprisingly there is a small diversity of rock types associated with this volcanism. Extensive K-Ar dating has a range of 40-38 ma (Eocene) in the east and 35-32 ma (Oligocene) in the west. Geochemical differences point to two distinct volcanic sources and Shon (1989) recognised three extrusive events.

Underlying the Liverpool Range is the upper Jurassic Pilliga Sandstone, which in turn unconformably overlies the Triassic Narrabeen Group. Basalts near the contact are mostly weathered and tend to be amygdaloidal, containing alkali rich zeolites, which have thought to been produced by contact with meteoric fluids immediately after eruption. Individual flows cannot be distinguished and material now consists of compact clay and zeolite (thomsonite, natrolite) mixture.

The erosion patterns differ from the western end to the eastern end of the ranges. The western end comprises a plateau, dissected by a number of creeks while the older eastern end has been eroded to a residual spine. The plateau generally has an altitude of 800^{+}m above sea level; the peaks along the spine range from 950–1000 m. The maximum height reached by the peaks that rise above the plateau is 1197 m.

Many sequences of massive lava flows can be distinguished by colour, degree of erosion and amygdaloidal flows. Numerous examples of columnar structure, up to a metre in diameter, are inter-bedded with some massive flows. Slab jointing and possible pahoehoe flows have been identified. The rocks of the Liverpool Range are predominantly sodic basanite and alkali basalt porphyritic in olivine

There are a few examples of lava caves to be found, but National Parks and Wildlife Services has removed any signs to where these caves may be found due to the dangers in accessing the caves. The formation of these caves is open to debate.

Ludwig Leichhardt wrote in his journal, of his 1843 trip to the Liverpool Range, 'On ascending Norfolk Island Creek and approaching the foot of the Liverpool Range, I found in a rocky bank of a waterhole the amygdaloidal rock of 'Dalkieith' with radiated zeolites and hair like crystals cropping out and very dense".

Friday 9th

Although some of our members arrived the day before most arrived from between lunch and 4:15 pm. A meeting scheduled for 3pm had to be delayed until 4pm to accommodate some late arrivals.

An introduction and general information was delivered by our leader, explaining the age and some of the features regarding the geology, the local history and the exploration of the area, from Oxley, Morisset, Lawson and Leichhardt.

Winston Pratt then gave a very comprehensive and well-researched dissertation on the Governor Bros, who had evaded police in this area in 1900 (Thank you Winston). After a short break some of the group ventured into the Xanthorrhoea Forest where many photos were captured of these impressive ancient plants *(Photo 1)*. The remainder finished setting up tents, had a showers while others organised their evening meal. After dinner and cleaning up, a fire was lit and most sat around the communal fire relating past stories and plans for future planned trips. This would have to be one of the more enjoyable pursuits in life.

2. Ron examining and describing the volcanic breccia.

Saturday 10th

A cool overcast morning greeted us. With everyone ready by 9 am, we drove towards Coolah along the Coolah Tops Road, stopping a number of times to examine geological features. First was a site where an ancient lava flow had occurred *(Photo 2).* Winston pointed out how the lava surface had solidified while the fluid lava beneath continued to flow, cracking the crust into fragments, which then sank into the flowing lava to form a breccia. As the lava flows out into the countryside, dissolved gases within the lava expand with decreasing pressure to form bubbles that form circular cavities called vesicles as the lava solidifies. Continued flow of plastic lave may stretch the vesicles into almond shaped cavities which may fill with sec-

1. Ancient Xanthorrhoea beside walking track.

3. Winston walking up slope to point out the difference between the ancient lava flows.

4. Chris next to a high angle reverse fault and fold.

6. Glossopteris leaf fossils .

ondary minerals including calcite, zeolites, chalcedony or quartz to form amygdales (amygdules).

Our next stop was where a lava flow had flowed over a soil horizon baking the weathered surface of the underlying flow *(Photo 3)*. Time was spent explaining the processes involved and examining the result.

From there we moved down the hill to examine a very interesting structure. A compressional regime had generated a high angle reverse fault, which appeared to have dragged horizontal beds on the footwall up, warping then into an arc or drag fold *(Photo 4)*. On the opposite side of the graben a lower angle reverse or thrust fault had developed to accommodate the compression induced shortening. Some time and discussion was devoted to this striking and prominent feature *(Photo 5)*.

It was also noted that a number of boreholes had been drilled into the basalt up and down Coolah Tops Road. It was discovered later that Nathan M. Padilla conducted a project on the *Paleomagnetism and Investigation of 40 ma Lavas, Liverpool Range, New South Wales, Australia in 2011. Senior Project For The Physics Department Cal Poly State University, San Luis Obispo.*

(Abstract: The main focus of this project is the continued study of a reversal of the earth's magnetic field recorded from lavas in the Liverpool Range of New South Wales, Australia. This reverse-to-normal transition, recently dated at ~40 ma, was first reported in Nature in 1986. [2] In March 2011 some 200+ cores were drilled from several sections about the volcanic range—Jemmy's Creek, Bald Hill, Rock Creek, Yarraman, and Coolah Tops Road. Here we focus on paleomagnetic findings from samples drilled from the most extensive section, that being along the trail near Jemmy's Creek. Results from alternating field demagnetization show the earth's magnetic field was in the reverse direction for all 24 distinct lava outcrops sampled as well as some interesting behavior. The project also involved the rewriting and development of our software in FORTRAN 77 code in order for our output data to be compatible with an existing modern freeware program capable of graphing paleomagnetic analyses and plotting the results.)

Thirst and hunger was becoming an issue, so it was decided that the coffee shop in Coolah would be a welcome stop. After refuelling the body we drove to a leaf fossil site near Coolah where a number of Permian Glossopteris leaves and other plant debris were found *(Photos 6 and 7)* in a matrix of tuffaceous material and fine sediments. Although time did not permit a

5. Explanations being given as to causes of deformation.

7. Glossopteris leaves - note venation.

8. Site of Cunninghams Camp.

10. Large amygdale, probably Natrolite.

detailed examination, it appeared that Jurassic Pilliga Sandstone directly overlay the Permian Beds, implying that both the Triassic sequence and the Jurassic Purlewaugh Formations were not developed or have been eroded in this area. Lunch was at the park in Coolah, where a sandstone monument to the WW1 fallen displayed some interesting ripple marks.

After lunch a pleasant drive along Coolah Valley to Cunningham's monument that details his campsite in this area was undertaken *(Photo 8).* A short history on the explorers, who were sent in search of an easy path into the rich fertile Liverpool Plains was given by our leader. We then went up to Pandora Pass which Cunningham discovered in 1823 and stopped to capture the obligatory photo or two and take in the scenery. A short distance back down the hill, a poor quality coal seam overlain by mudstone was developed between lava flows *(Photo 9).* Although coal seams inter-bedded with lava flows are rare, a similar occurrence is exposed in a railway cutting west of Murrurundi. For coal to form in this way there must have been a reasonable amount of time for a swamp or peat to form in a large enough depression.

On our way to the Pinnacles we stopped again on Coolah Tops Road to view some very large amygdales (amygdules) that Ron had seen along the way in the morning *(Photo 10)*. This was another rewarding spot as we also found what was possibly a feeder dyke and another lava flow on top of a soil horizon and also some columnar structures *(Photo 11).* From here we drove to the Bundella Lookout that has expansive views over the Liverpool Plains followed by a walk around to the Pinnacle's with fantastic vistas to the Warrumbungle and the Mt. Kaputar volcanic centres.

We arrived back at the Barracks camp ground at 4:45 pm where showers and meal preparation was the order of the day. After evening meals we gathered around the fire, where a very pleasant evening was spent with all but a couple heading off to bed around 9 pm feeling very tired.

Sunday 11th

A cool change overnight brought a cold 8°C morning with a brisk southerly to chill us even further. A clear sky and the promise of a fine day to make our bush walking easy had no one complaining.

9. Outcrop of poor quality coal between lava flows.

11. Amygdaloidal basalt flow below a massive flow.

13. Remains of boiler and chimney at Mill Creek.

14. Looking over lava Rock towards the Breeza Plains.

Meeting at 8:30 am, we set off with a short drive to the nearby old saw mill burnt down in 1959. All that remains are the foundations and the steam boiler that powered the mill. Near a deep pit, a large Red Belly Black snake was sun bathing *(Photo 12)* putting an end to some walking around the steam boiler *(Photo 13)* that lay in the scrub to get photographs.

We had a quick look at Cox's Creek camp area before heading east along Forest Rd. to the eastern end of the Range. Next stop was some 15 km along the road for a 500 m walk through trackless scrub to the edge of the escarpment to observe an old lava flow named Lava Rock on the map *(Photo 14).* The views from here to the north across the lowlands are quite spectacular. Returning to our vehicles we drove to Breeza Lookout at the far end of the range for some well-earned refreshments. Being Remembrance Day, a minute's silence was held at 11 am.

A 3 km walk to Shepherds Peak was our next task with two of our members remaining at the vehicles. The pleasant walk seemed to fly by and we were at Shepherds Peak in no time. The scramble up the peak is not for the faint hearted because the climb out onto Shepherds Peak is very narrow with a sheer drop off on both sides (*Photo 15*). The rough track makes it easy to loose ones balance, so only 4 or 5 of us made it to the lookout. Ron pointed out that the rock at the top of the lookout was visibly different from the nearby basalt and was probably trachyte with distinct flow bands *(Photo 16).*

By the time we returned to the cars at Breeza Lookout, it was lunchtime and a better spot could not have been asked for. Lunch eaten, we drove west to the Cattle Creek Huts where the early timber getters had built some very rudimentary huts *(Photo 17).* The huts were built out of rough sawn timber, corrugated iron and hessian bagging. A few peach trees still grew behind the hut. Although one of the sheds had been pulled down by National Parks, the remaining shed showed how spartanly these men had lived. These men were self taught and performed a variety of tasks from road building to machine and track maintenance.

A short distance up the track brought us to the tallest Snow Gums in Australia. Elsewhere the *Eucalyptus pauciflora* is a straggly twisted small tree. But in Coolah Tops these trees grow to 40 m and are the tallest snow gums in the world. The bark is mostly smooth and is conspicuously marked by scribbles caused by burrowing insect lava.

The trip back to Brackens Hut near our camp area is a delightful drive through a montane environment. Brackens Shepherds Hut *(Photo 18)* was our last stop for the day. The hut was built in 1937, with local timber and sheets of corrugated iron. The iron that clad

12. Black snake sunning itself.

15. Climb to the summit of Shepherds Peak.

16. Flow banding in Trachyte, Shepherds Peak.

17. Restored Cattle Creek Hut.

this rustic hut was carried in on horseback; the sheets could be no longer than 6ft as they had to be transported up the steep and scrubby hillside along Cox's Creek. The hut was for the shepherds who grazed

18. Brackens Hut.

sheep from October through to the end of March when it was time to take them back down into the valley to be shorn. There are many fruit trees in a paddock nearby for the shepherds had to be totally self-sufficient and all their supplies had to last for 6 months.

Time being our enemy, and the tempting suggestion of a Happy Hour, showers and a meal saw us arrive back at camp at 3:45 pm somewhat weary, although a few decided to go to Norfolk Falls arriving back much later. After showers, a cup of tea and a few minor chores, we gathered around with a drink or two and discussed the weekend and other trips we could plan. After dinner the communal fire was again lit and a pleasant warm evening was enjoyed under the starry skies.

Monday 12th

As I was staying an extra day it was a pleasant change to watch others pack up and start their long trek home. All our members had left by 9:30 am leaving Dianne and myself to enjoy the tranquility of this beautiful place.

Report by Chris Morton and Winston Pratt.
Photos 1, 2, 3, 4, 5, 8 by Chris Morton.
Photos 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 by Ron Evans.

References:

ROY CAMERON. (1993). A local History of the Bundella and Werong State forests. *National Parks and Wildlife Service, literature.*

R.W. JOHNSON. Intraplate Volcanism in eastern Australia and New Zealand.

WINSTON PRATT. Gunnedah Coalfields.

Some Regional Geology of the Eyre Peninsula, South Australia
Geological Safari 2012

Monday 3rd September to Wednesday 17th September 2012

Safari Leaders: Ron Evans & Barry Collier.

Attendance: 17 members.

The aims of the 2012 Safari were to examine:

The geology and geological features of the southern Eyre Peninsula around Port Lincoln.
The weathering processes of Aeolianites and subsequent landforms these processes produce.
Granite Inselbergs and their features in the Wudinna district, and
Volcanic structures and features of the Gawler Ranges.

The Port Lincoln region, Wudinna district and Gawler Ranges lie within the Gawler Craton which occupies occupies about 440,000 km^2 of central South Australia. Prior to about 1550 million years ago it was composed of a number of active Proterozoic orogenic belts that had existed back to at least 2450 ma. It is one of the largest blocks of Achaean-Proterozoic crystalline basement in Australia. *(See Figure 1.)*

Background Geology, Port Lincoln Area.

1. *Regional Geology.*

The crystalline basement of southern Eyre Peninsula and surrounding islands forms part of the Archean to Mesoproterozoic southern Gawler Craton. It is a terrain that underwent extension and sedimentation (2000 to 1850 ma) before magma that formed the Lincoln Batholith was intruded (1853 to 1848 ma). The basement geology of the eastern Eyre Peninsula is an amalgamation of three deformed rock packages, ranging from late Archean to Palaeoproterozoic in age, forming the Kimban mobile belt *(See Figure 2)*.

The **Sleaford Complex** contains the oldest rocks that are a series of layered crystalline Archean gneisses of sedimentary and igneous parentage.

At **Cape Donington**, Palaeoproterozoic Lincoln Complex metasediments with meta-dolerite intrusives occur. Dating of some of the granite gneiss in this area gave 1845 (±10) million years old (ma).

Here, the only known occurrence in South Australia of quartz gabbronorite gneiss, which is part of the Donington Granitoid Suite of the Palaeoproterozoic metasedimentary Lincoln Complex, is found. It contains numerous xenoliths. This is a rare rock-type. The gabbronorite gneiss is believed to be the earliest intrusive of the Donington Suite, having an age of 1,843 (±2) million years.

Proterozoic metasediments of the **Hutchison Group**, including quartzite, pelite, dolomite, banded iron formation and metavolcanics, have a maximum age constraint of 2000 ma and a minimum, provided by intrusion of the Proterozoic Donington Granitoid Suite, of 1850 ma.

The **Kimban Orogeny** multiply deformed the Sleaford Complex gneisses and Hutchison Group metasediments between 1850 and 1710 ma, with intrusion of the Donington Granitoid Suite and associated Tournefort Dyke Swarm.

Granite and monzonite of the **Moody Suite** were intruded synchronous with development of the Kalinjala Mylonite Zone on eastern Eyre Peninsula.

At 1530 ma, the **Spilsby Suite** (the youngest known magmatism in the Gawler Craton) intruded the Donington Granitoid Suite in the Spencer Gulf region.

Lateritic weathering during the Tertiary resulted in extensive development of ferricrete and lesser silcrete followed by deposition of calcarenite of the Bridgewater Formation (an ancient sand dune complex) during the Pleistocene. (See appendix – Port Lincoln Regional Geology, Streaky Bay and Gawler Volcanics and Reference).

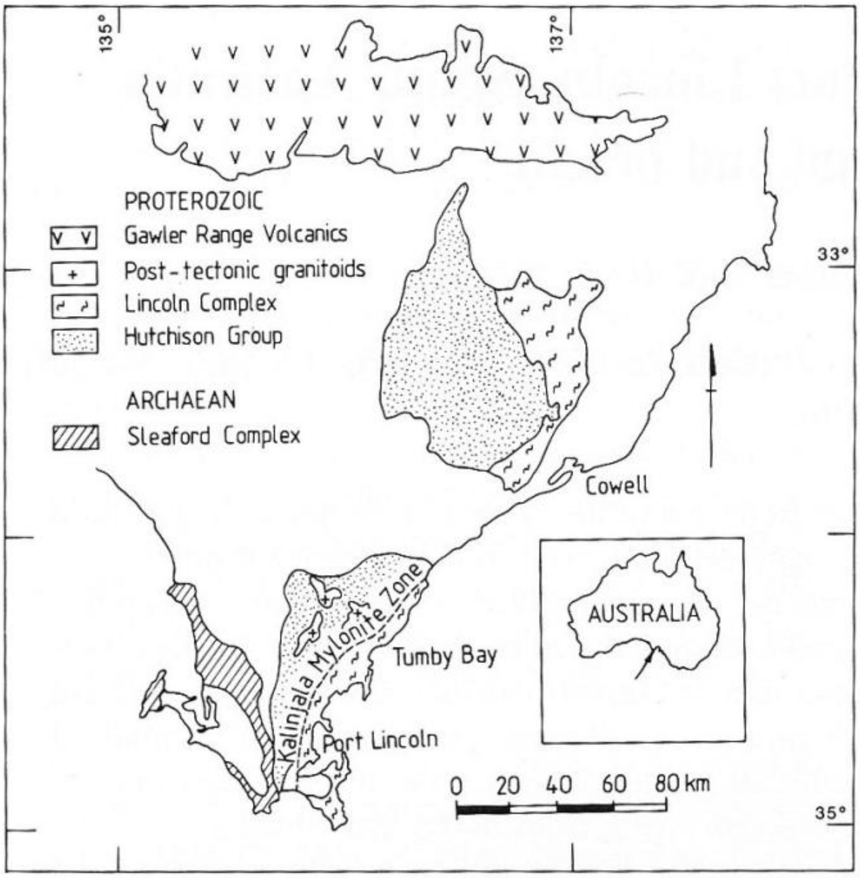


Fig 1.
Simplified Map showing the location of the Port Lincoln region and Gawler Range Volcanics.

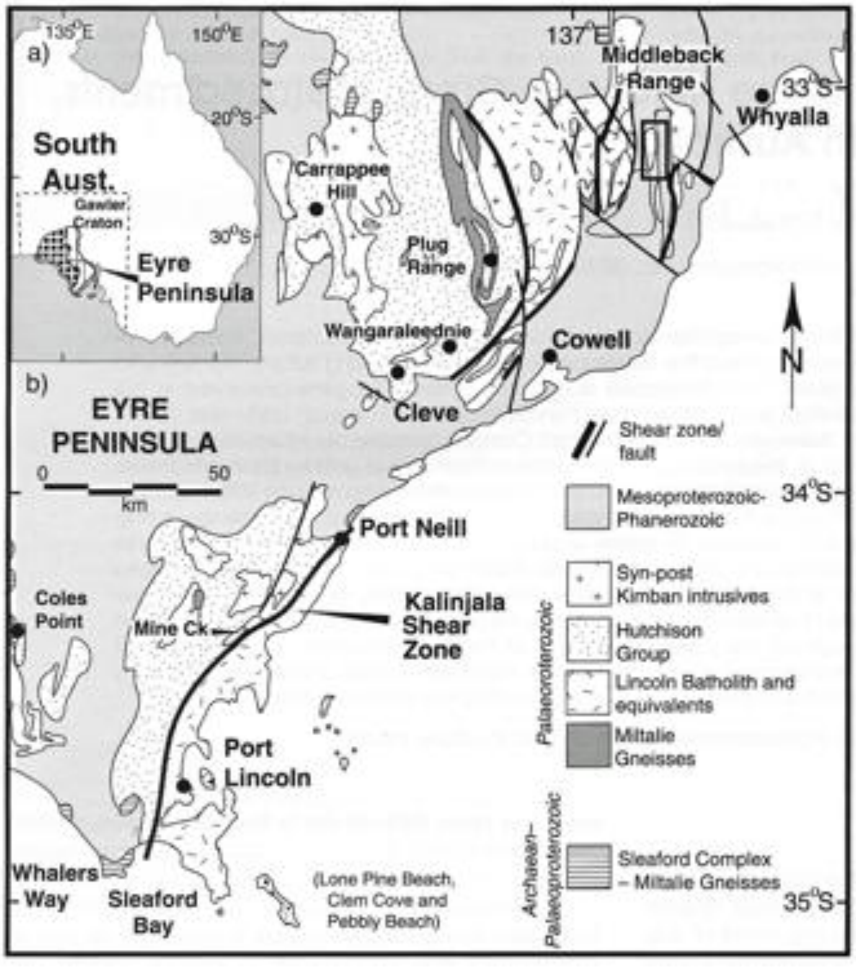


Fig 2.
(a) Eyre Peninsula and the Gawler Craton, South Australia. Eyre Peninsula consists of Archaen-Palaeoproterozoic basement in the west (stippled) and younger Palaeoproterozoic sequences in the east (hatching).
(b) Outline of the main structural elements of the Eyre Peninsula (after Parker 1993).

2. *Port Lincoln Mafic Dykes.*

Igneous-textured and recrystallized amphibolite or pyroxene granulite dykes cut granitoid gneisses in the Port Lincoln area of South Australia. They trend in a N-S direction.

The following groups of dykes are recognised in the Port Lincoln area:

1. Coarse-grained norites, gabbronorites and rare pyroxenites.
2. Fine grained plagioclase-phyric, pyroxene-phyric and olivine-phyric dolerites.
3. Very fine-grained aphyric rocks.
4. Granuloblastic pyroxene granulites and hornblende granulites.
5. Foliated amphibolites.

3. *Aeolianites.*

Aeolianite units are lithified dunes composed of quartz and shell fragments separated by paleosols (a soil horizon from the geologic past, usually buried beneath layers of rock or younger soil horizons).

This alternation between dune activity and stability reflects a cycle of intermittent aridity.

Variation in cross-bed orientation, carbonate content and grain size of aeolianites follows trends indicative of longer-term paleoenvironment (an environment of a past geologic age) change.

Evidence suggests that deposition occurred during the earliest part of the last glacial cycle (last 2 my during the Pleistocene).

When arid, dunes become mobile migrating over large areas (sparse vegetation, larger temperature variation, higher wind speeds and lower precipitation due to lower temperatures).

When wetter, vegetation dominates stabilizing dunes and facilitates **pedogenesis** (soil formation from unconsolidated rock).

The **Bridgewater Formation** (Quaternary) covers large areas along the coast. They consist of relic calcareous dunes formed during the last interglacial period. These are exposed in the coastal cliffs of the Eyre Peninsula.

Safari Activities.

Sunday 2/9/12.

We met David and Jan in Port Augusta departing for Port Lincoln at 9:00 am. Our first stop was in a park on the outskirts of Whyalla for morning tea.

As it was Fathers Day, we decided to call into Cowell and have fish and chips for lunch. Near the jetty, we found a takeaway that served fish and chips. Because it was windy, we sat inside the eatery and waited for lunch. The cook presented us with a large platter containing freshly cooked King George Whiting and chips - very nice!

Arriving in Port Lincoln, we set up our caravans in the Foreshore Caravan Park at 3:30. pm We had been given new concrete slabs looking out over Boston Bay to set our vans up on *(Photo 1)*. Stan and Dawn were already set up next to us.

Monday 3/9/12.

The morning was overcast. After a leisurely breakfast, Ellen and I went downtown to gather information from the visitors centre and National Parks.

Brian, Ian and Jan arrived about 2:00 pm followed by Barry and Elaine, and Jan and Kathy at 3:00 pm. Jim and Helena had booked into a motel downtown.

All participants gathered at our caravan at 5:00 for an 'information session' and 'happy hour.'

I outlined the purpose of the Safari and general geology of the area after handing out Safari notes. The need for each vehicle to purchase a Holiday Pass that enabled entry into National Parks in South Australia was discussed and car pooling organized for next days trip.

1. Ellen relaxing in front of our caravan, Port Lincoln.

2. An outcrop of Donnington Suite orthogneiss.

4. Contact zone between recent limestone and basement rock. Note how shells have been incorporated into the limestone.

Tuesday 4/9/12.

After a morning free of organized activities (time for Monday arrivals to shop, wash, obtain holiday passes etc, we left the caravan park and drove to Cape Donnington lighthouse in Lincoln NP.

Orthogneisses of the Donnington Suite outcrop (type section) below the lighthouse *(Photo 2)*. Tournefort Metadolerite dykes (fine to coarse-grained massive black gabbroic and dolerite dykes) are also found in the area.

We examined a large exposure of coarse augen gneiss *(Photo 3)* bordered on both sides by finer-grained gneiss. A small magic injection dyke was found bordering one side of the augen gneiss.

Next stop was Stamford Hill picnic area for afternoon tea. New facilities (shelter, tables, toilets) were present. It was our intention to walk to the top of the hill, but with very strong winds and increasing cloud cover the walk was abandoned. Instead, we walked west along the beach to a small headland composed of fine grained quartz rich gneiss. A small mafic dyke had intruded the gneiss. An excellent contact zone between the overlying limestone and the gneissic basement rock was discovered *(Photo 4)*. Shells, pebbles and cobbles were cemented together by limestone along the contact zone.

The next stop was Taylor's Landing on the eastern side of the park. We walked along a nice beach to a limestone headland on the northern end of the beach. Low coastal heath with lots of wild flowers covered the hind dune and headland. Smooth vertical solution tubes were exposed in a low limestone cliff where waves undercutting the limestone had caused cliff collapse *(Photo 5)*.

Many of the group wandered up to the top of the headland taking lots of photos of wildflowers and a large Pacific Gull sitting on the edge of the cliff. It seemed unconcerned with us and the photos being taken.

3. Coarse-grained augen gneiss.

5. Solution tubes exposed in the collapsing limestone cliff.

6. Windswept limestone headlands covering Donnington Suite gneisses.

8. Mafic dykes intruding Donnington Suite gneiss.

Wednesday 5/9/12.

Memory Cove Wilderness Area in Lincoln NP was the programmed activity for the day.

Although the morning was showery with strong winds, the weather map indicated that the rain would clear during the day, so we decided to go. When the Visitors Centre opened at 9:00 am, drivers registered and collected an entry key for access to Memory Cove. The road through the Wilderness area was good. *(see map next page for route)*

Our first stop (6) was on an exposed headland; very, very windy weather with horizontal scuds of rain resulted in a short stop *(Photo 6)*.

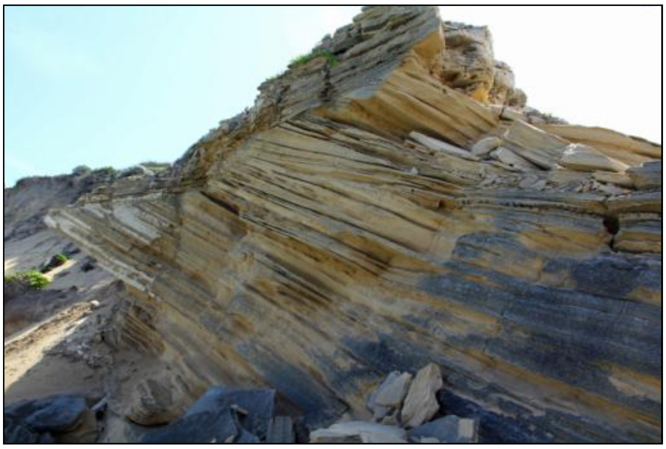
A short drive took us to stop 7 reached along a narrow 4x4 track which ended at a sheltered beach situated at the base of limestone cliffs. Brian got half-way down the track before a rock ledge stopped him. He parked his car and walked down the remainder of the track while his passengers squeezed into the other cars. Morning tea was followed by a walk down to the beach after Barry found an easy way down *(Photo 7)*. Fantastic limestone cliffs showing several paleosols were observed. Donnington Suite basement rocks intruded by mafic dykes were an obvious feature at the base of one cliff *(Photo 8)*.

An outcrop of partly consolidated calcareous sandstone exhibiting wonderful cross-bedding, evidence of its origin as a wind deposited dune, was discovered *(Photo 9)*.

It was then onto Memory Cove camping area for lunch. There was some shelter from the wind amongst the Mallee trees. Beautiful Spider Orchids were found in the bush - much photographing.

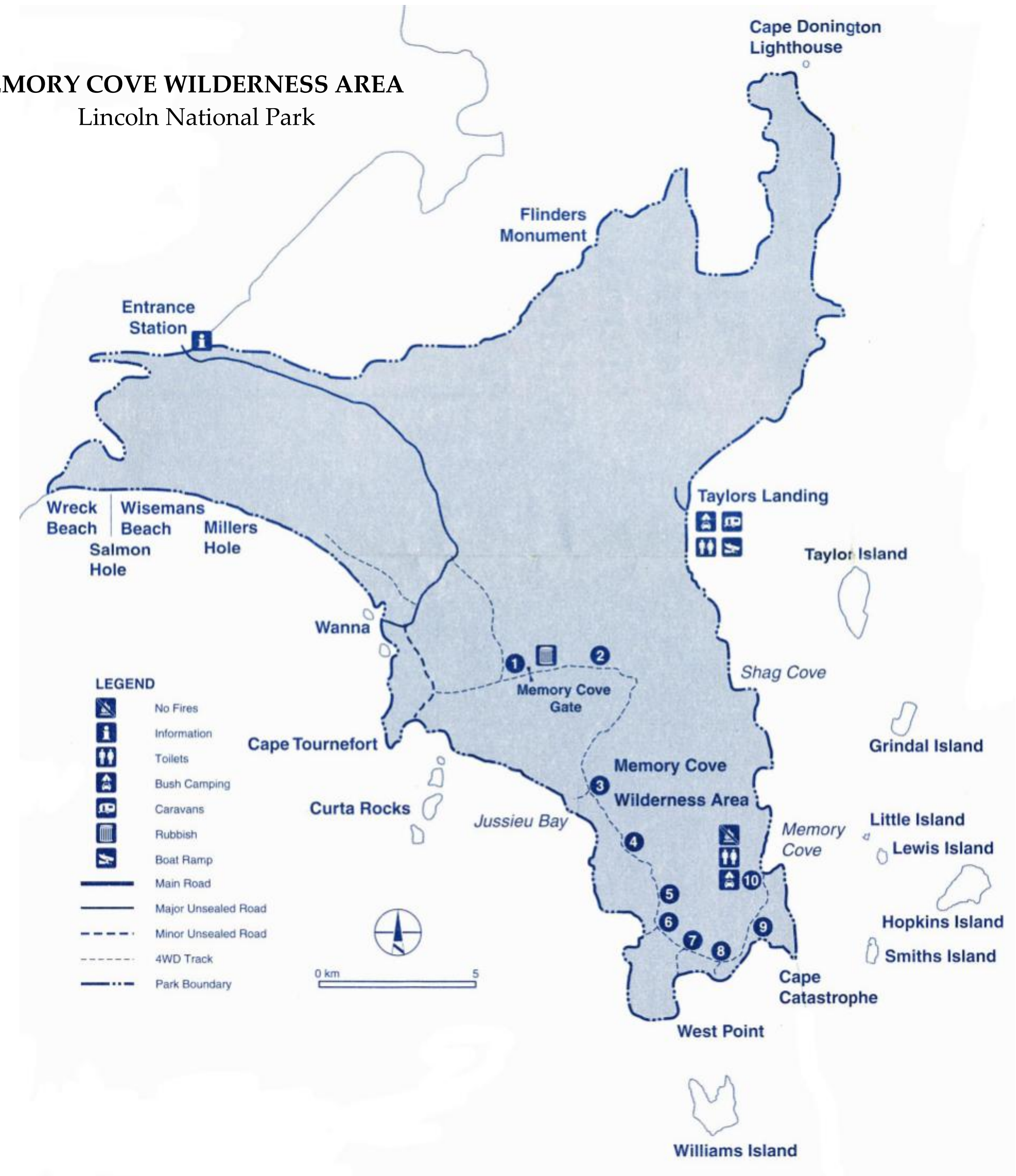
On our drive out, we first stopped at site 9 which provided a wonderful view of Cape Catastrophe *(Photo 10)* from a lookout named 'Ivy's Leap' after a local tour operator who forgot to put on the hand-brake of the tour bus which subsequently rolled over the cliff into the bay below. An eroding cliff east from the lookout showed wonderful examples of paleosols *(Photo 11)*.

7. Climbing down to the beach.



9. Cross-bedded dune deposits.

MEMORY COVE WILDERNESS AREA
Lincoln National Park



10. Cape Catastrophe from 'Ivy's Leap.'

11. Paleosol horizons in limestone cliffs.

12. Jessieu Metadolerite (a member of the Donnington Suite) intruded by many dykes.

15. Barry walking onto a large pegmatite intrusion of feldspar and quartz.

13. Spherically weathered Jessieu Metadolerite cobbles indurated by overlying limestone of the Bridgewater Formation.

14. Fossilised traces of plant roots exposed on a slab of Bridgewater Formation limestone.

Site 8 was our last stop. It was very windy on top of the headland. However the wind lessened considerably as the cliff (limestone) edge was reached.

A fascinating outcrop of dark basement rocks (Jessieu Metadolerite) intruded by a large number of dykes were observed *(Photo 12)*. Barry and I went down to the rocks - extraordinary geology!

The fine grained dark Metadolerite was well jointed and was weathered spherically. Several large blocks of limestone were in situ on top of the weathered basement rock *(Photo 13)*. One large block of limestone was covered in an amazing array of fossilized plant roots *(Photo 14).*

The numerous dykes intruding the basement rock varied from ultra-mafic dilation dykes to felsic injection dykes, some pyric *(Photo 15).*

Before reaching the gate out of Memory Cove Wilderness Area, we drove into and out of stop 3 which was too exposed and windy to leave our vehicles.

Of particular interest on our drive through Memory Cove Wilderness Area were the number of large emus observed, many sitting in puddles both on and beside the road.

Returning to Port Lincoln, we handed in our keys and had a nice coffee before returning to camp damp, wind blown and covered in sand. Hot showers were our immediate priority.

Thursday 6/9/12.

After consulting weather forecasts, we decided to visit Coffin Bay NP today, have a free day Friday and do Whalers Way on Saturday. A fine, somewhat hazy morning greeted us for our trip to Coffin Bay NP. The forecast was for a passing front with showers around lunchtime.

As we drove into the NP, the forecast rain front hit early. It poured down causing us to park while the storm front passed. After about 15 minutes, the weather improved (little rain, but strong winds) so we drove to Golden Island lookout on top of high limestone cliffs (Bridgewater Formation) *(Photos 16, 17)*. Very scenic, but windy and cold (around 12°C). Photos were taken and some of us walked down to Gunyah Beach *(Photo 18)* which was somewhat sheltered.

We called into the nearby Point Avoid lookout on the way to Yangie Bay. Similar scenery and wind, so onto Yangie Bay. There were no shelters, but toilets and one wet picnic table. After a 'cuppa', we investigated the 4x4 track north deciding not to proceed after reading about track conditions.

Because the weather had continued to improve, some of the group went back to Point Avoid while Ellen, Barry , Elaine and I explored the vegetation covering the sand dune complex forming the first part of the NP *(Photo 19)*. We had lunch in Coffin Bay and decided to go back to camp as it was still windy and cold.

Friday 7/9/12.

At 9:00 am, I took the group down to the shore of Boston Bay where Donnington Suite Gneisses outcrop. They varied in composition from those with a leuco micro-granitic fabric to coarser foliated and lineated gneiss.

Intruding the gneisses in a N-S direction were a number of large Tournefort Metadolerite dykes *(Photos 20, 21)* with vertical foliation. Stoped edges occurred on some dykes *(Photo 22)* while folded feldspar veins in others indicated plastic flow movement after emplacement. One boundary between two gneiss bands showed evidence of a low pressure zone (layers moving apart) as folded gneiss and late-stage feldspar pegmatite was present.

16. A very windy Golden Island Lookout.

18. View SE along Gunyah Beach to Coffin Bay Dunes.

17. Small stack and limestone cliffs, Golden Is. Lookout.

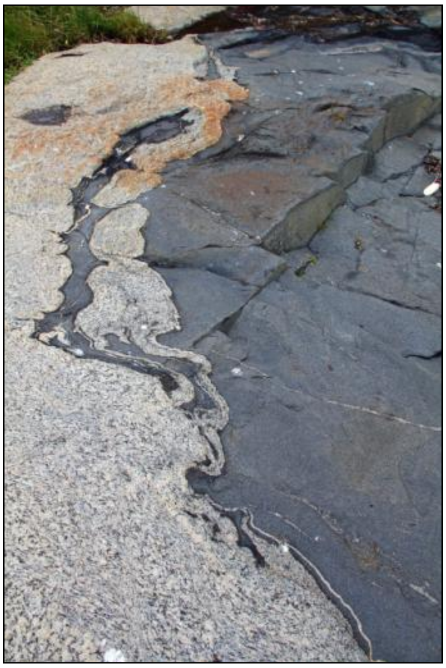
19. Cockies Tongue *(Templetonia retusa).*

Further along the foreshore there were many more dykes, one some 50 m wide. In one section, more dykes were present than gneiss.

The remainder of the day was free time. Ellen and I and the Cheethams went to a local vineyard for a wine tasting followed by a very pleasant lunch.

20. Two large Metadolerite dykes intruding gneiss.

21. Folded feldspar veins within a Metadolerite dyke.



22.
Gneiss that has stoped off as the Metadolerite dyke was being intruded.

Saturday 8/9/12.

We had been waiting for good weather before undertaking the scenic Whalers Way, a drive to the very rugged Cape Wiles and Cape Carnot *(See map next page)*. The drive is on private property meaning that we had to pick up a key (after paying $30) from the Visitors Centre.

The area is composed of Archean age gneiss covered with Aeolinitic limestone of the Bridgewater Formation. This forms tall vertical cliffs due to undercutting by the ocean followed by collapse of the limestone. Gneiss is exposed at the base of cliffs and headlands.

On the drive to Whalers Way, we stopped at the end of Sleaford Road. Here, limestone cliffs were only a few metres high, but the formations were amazing: undercut cliffs and solution tubes through the cliffs to the beach underneath *(Photo 23)*. Sleaford Complex gneisses outcropped on a nearby headland.

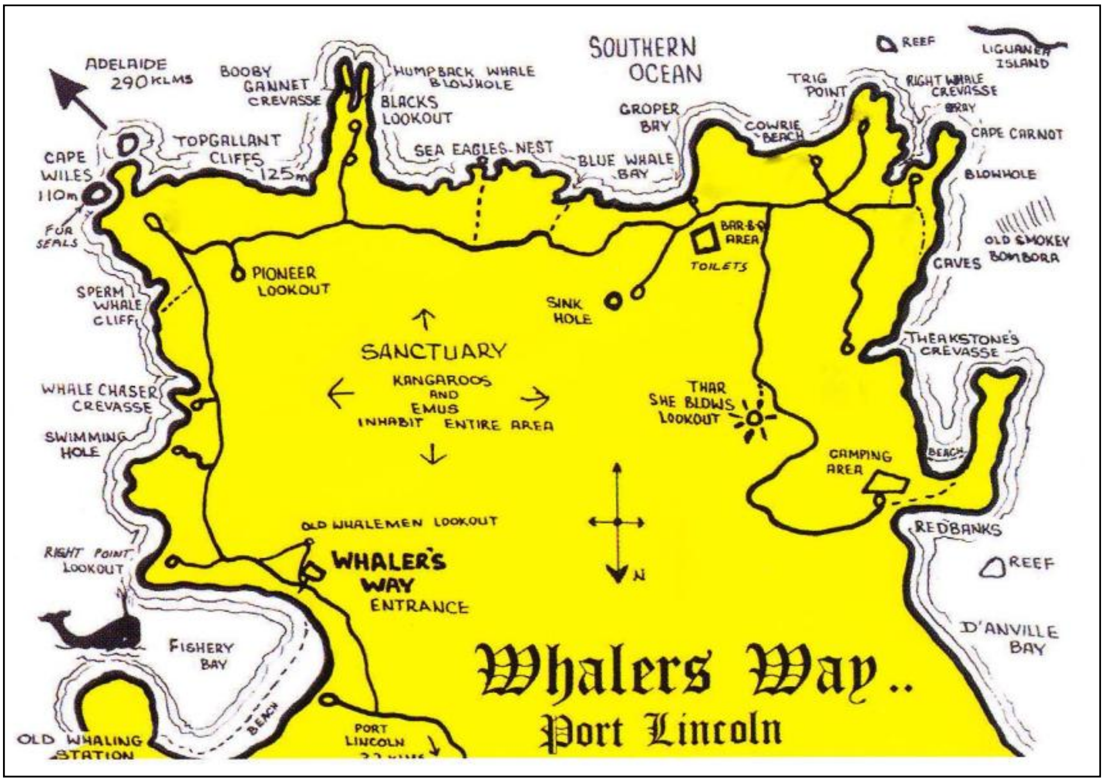
Once through the gate into Whalers Way, our first stop was Whale Chaser Crevasse.

Stop 1. Whale Chaser Crevasse.

Basement rock consisting of undifferentiated, interlayered para-and orthogneisses outcrops at sea level. These have eroded along a shear/fault zone to form a crevasse running into the surrounding cliffs *(Photo 24)*. Black mafic granulites were observed intruding gneisses *(Photo 25)* near a small natural arch formed from gneiss.

Stunning views of limestone cliffs to the south were obtained from the headland. On the southern side of the headland, limestone cliffs capped by hard calcrete were undercut by solution weathering.

23. Solution tubes down through the undercut cliff.



Stop 2. Cape Wiles.

At Cape Wiles on the eastern edge of Whalers Way Peninsula, wonderful views of pyramidal limestone stacks *(Photos 26, 27)* were obtained. Refraction of waves around the headland caused erosion on both sides eventually separating the stacks.

The stacks are composed of mid-late Pleistocene Aeolian calcarenite (limestone). Their origin as a coastal dune facies is evidenced by tilted foreset beds capped by thick indurated calcrete *(Photo 28)*. Fossils of the weevil *Leptopius duponti* and land snail *Bothriembryon barretti* are common (not observed).

The coast around Cape Wiles consists of high limestone cliffs above numerous small bays *(Photo 29).*

24. Whale Chaser Crevasse.

25. Black granulites intruding gneiss.

26. Limestone sea stacks, Cape Wiles.

27. Limestone sea stacks, Cape Wiles.

28. Tilted foreset beds (cross-bedding) capped by indurated calcrete (harder) obvious in the face of the stacks.

29. Small by west from Cape Wiles.
Note how two small tongues of limestone are in the process of being separated from the cliff to eventually form stacks.
The light-coloured bands in the cliff are calcrete layers.

Stop 3. Moonlight Bay.

This is situated near the BBQ area and toilets, our lunch stop. From the car park, a short walk over limestone took us to the edge of a low cliff where the easterly view showed us a coastline of rugged limestone cliffs *(Photo 30)*. To the west, actuate waves flowed into the coast in the bay *(Photo 31).*

After many photos, we drove into the BBQ area, which was surrounded by many wildflowers, *(Photo 32)* for our lunch stop.

30. East from Moonlight Bay towards Cape Wiles.

31. Moonlight Bay.

32. Coast Velvet Bush (*Lasiopetalum discolour*).

Stop 4. Trig Point.

On the drive to Trig Point, we stopped briefly at Cowrie Beach which turned out to be a cliff line and not very spectacular. At Trig Point, a good view of Liguana Island and Wreck Reef were obtained from the start of a walking track leading down to the headland *(Photo 33).*

After a walk down the narrow track over limestone, we came to the edge of a low cliff. What geology greeted us! Brian and I were almost dumbstruck as neither of us had seen gneiss intruded in such a manner or scale *(Photo 34).*

The rocks exposed were undifferentiated interlayered para- and orthogneisses intruded by mafic granulites. They were Carnot Gneisses, part of the Archean Sleaford Complex.

Orthogneisses form by metamorphism of igneous rocks, while the paragneisses form from metamorphism of sedimentary rocks. They have an estimated age of 2640 ma.

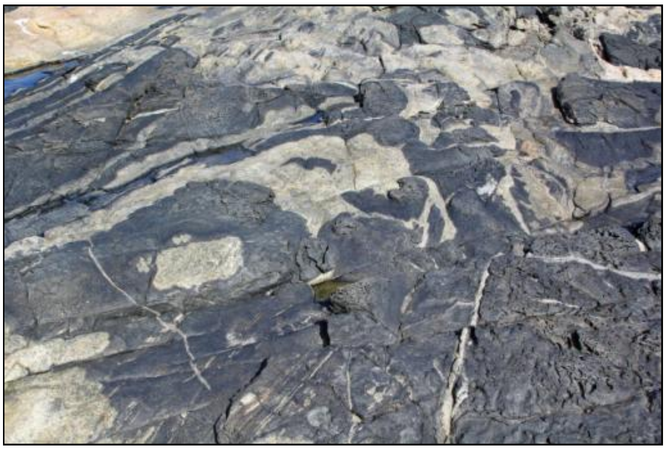
Brian and I found a way down the cliff to the exposed gneisses and had a wonderful time discovering all types of rock and intrusive structures including garnet-rich pods within a banded paragneiss *(Photos 35, 36, 37).*

Barry had discovered a large crevasse (Flinders Crevasses) weathered out along fault zone in the gneiss. At the head of the crevasse, the overlying limestone formed a cave. Barry and I managed to get into the cave and look out along the crevasse - spectacular! *(Photo 38)*

All to soon, we had to return to the cars as we had two more stops before heading home.

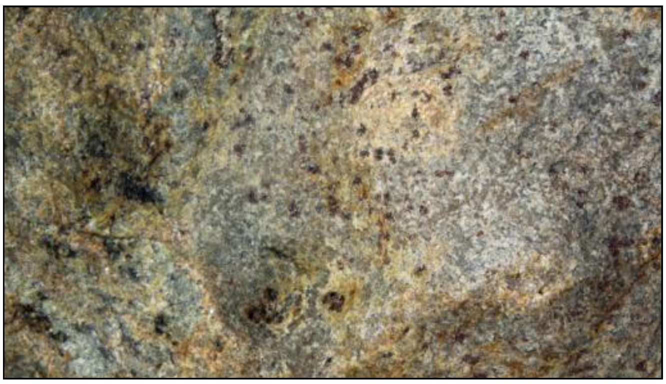
33. Start of track down to Trig Point.

34. Intruded Carnot gneisses exposed below limestone.



35. Dark mafic granulites intruding Carnot gneiss.

36. Banded gneiss flowing around a mafic intrusive.



37. Garnet rich pod within a paragneiss.

Stop 5. Cape Carnot.

This is situated a few hundred metres north west of Trig Point. It is in the process of being separated from the headland as a fault zone is being eroded away on both sides of the cape *(Photo 38)*. The presence of blowholes in the eroding gutter indicates undercutting of overlying rock *(Photo 39)*.

Cape Carnot, like Trig Point, is composed of Carnot Gneisses intruded by mafic granulites, although the exposure at Trig Point is more extensive.

A narrow saddle can be crossed enabling you to access Cape Carnot. However, because of blowhole activity and huge waves breaking onto the shore, *(Photo 40)* it was a dangerous undertaking, so we stayed on the headland and took lots of photos.

38. Cape Carnot on right with Trig Point in the distance. The gutter (foreground) eroding out follows a fault zone, a zone of weakness in the rocks enabling Flinders Crevasse at Trig Point to have been formed by erosion.

39. Blowholes above the erosion gutter that is slowly separating Cape Carnot from the headland.

40. Breaking waves, Cape Carnot.

Stop 6. Threakstone's Crevasse.

This was about a kilometer south of Cape Carnot. It turned out to be a narrow (2 m), vertical crevasse eroded west through gneiss and overlying limestone *(Photo 41)*.

There was no indication of a dyke, so we assumed it also to be erosion along a shear zone where fractured rock is easily weathered.

Leaving Threakstone's Crevasse, we drove directly back to the Tourist Information Centre to hand our keys in. We arrived two minutes after scheduled closing time. Luckily, they were still open so we were able to hand our keys in before adjourning to Del Giorno's Restaurant for coffee and cake.

Another wonderful day!

41. Threakstone's Crevasse.

Sunday 9/9/12.

Port Lincoln to Streaky Bay with a stop at Talia Caves on the way was the days agenda on a sunny warm day with little wind.

We had agreed to meet in Elliston at 12:30 for lunch before traveling in convoy to Talia Caves.

On the drive north, I (together with Brian and Ian) decided to call into Coles Point where a 520 ma old unconformity between Wangary Gneiss (Archean - Sleaford Complex) and Warrow Quartzite (early Palaeoproterozoic - Hutchison Group) was situated. None of us had been to Coles Point before, so it was a 'seek and ye shall find' exercise.

The road to Coles Point took us to the northern lookout. Wonderful views up and down the coast were obtained including Mt. Greenly to the north-east (composed of Warrow Quartzite). Limestone covered the basement rock which turned out to be quartzite.

We then drove to the southern lookout where a vertical limestone cliff prevented us from climbing down to the rocks below which were Warrow Quartzite *(Photo 42).*

After consulting our geological map, we decided that a small outcrop of rock visible on the beach south may be the gneiss *(Photo 43 - red arrow)*. Brian found a vehicle track to a low headland above the outcrop which was suitable for my caravan, so I followed.

Looking down onto the outcrop, it was obvious that it was gneiss, so we clambered down to the beach and walked onto the outcrop of Wangary Gneiss.

The gneiss was very different to what we had seen at Port Lincoln. Very foliated with large pegmatite veins of quartz and feldspar parallel to the rocks lineation *(Photo 44)*. Large augens of quartz and feldspar were present. In places, veins of strained quartz cut across the lineation. Our map reference (Lincoln Sheet S513-11) stated that Wangary Gneiss is a "massive to compositionally layered quartz-feldspar-biotite-muscovite gneiss." Our observations certainly supported this.

43. Wangary Gneiss outcrop. The hill on the right is 'Frenchman' composed of Warrow Quartzite. Marble Range is in the distance.

Because of our lunch deadline, we dragged ourselves away and drove to Elliston where we had lunch in the park with the others.

After lunch and a quick drive around town, our group undertook the 'Great Ocean Tourist Drive' providing views of the spectacular Elliston limestone cliffs and several sculptures left in place *(Photo 45)* from the bi-annual 'Sculpture of the Cliffs.'

Talia Caves are located 50 km north of Elliston, 6 km off Flinders Highway. The caves and grottos have been cut by wave action at the base of sea cliffs composed of Pleistocene Bridgewater Formation aeolianite overlying well jointed Mesoproterozoic Tarcoola Formation red sandstones. The sandstone is coarse and shows structures such as graded bedding, cross bed-

42. Tilted Warrow Quartzite below the limestone cliff.

44. Wangary Gneiss and 'Frenchman.'

45. Sculptures on top of spectacular limestone cliffs.

47. Looking out of Woolshed Cave.

ding and trough cross-bedding indicative of a fluvial depositional environment. A spectacular mobile Holocene dunefield was seen to the south.

The largest cave, Woolshed Cave, is better described as a grotto, cavity or eroded cliff. From the car park, the cave was accessed by an easy walking track with wooden steps *(Photo 46)*. The erosion of a joint in the sandstone has left a wide gutter to form Woolshed Cave. A limestone layer on top of the sandstone creates a roof (or upper part) of the cave *(Photo 47).*

The nearby 'Tub' is a depression that formed when the roof of its cave (limestone) collapsed to expose the underlying sandstone. The exit to the ocean from the cave can still be seen from the western side of the Tub.

After a quick 'cuppa,' is was non-stop to Streaky Bay Caravan Park (very full) to set up for three nights. We all had beach-side sites which were 'smallish' resulting in us waiting patiently as each caravan was backed into position.

Monday 10/9/12.

Monday turned out to be beautiful clear, warm and sunny. Streaky Bay looked beautiful in the morning light *(Photo 49)*. After a free morning and an early lunch, we car-pooled and departed for Point Labatt Conservation Park where the only permanent breeding sea-lion colony on Australia's mainland is found. Point Labatt Conservation Park is located 50 km south of Streaky Bay on the Calca Peninsula. *(See Streaky Bay District Map page 59)*

Found in no other country in the world, the Australian Sea-lion is one of Australia's most endangered marine mammals and rarest seals. Point Labatt is the only place on the mainland where Australian seal pups can be seen learning to swim, play and rest on the beach which is protected from land predators *(Photo 48).*

A viewing platform about 50 m above the colony enabled us to spend time observing the Sea-lions and taking many photos *(Photo 50).*

A decision was made to visit Murphy's Haystacks on the way home. To reach them we drove through

46. Steps leading to Woolshed Cave.

48. Sea-lion habitat, Point Labatt..

49. Streaky Bay and Streaky Bay Caravan Park.

50. Australian sea-lions basking on the beach.

52. Walking track through Murphy's Haystacks.

the historic village of Calca where 15 minutes was spent looking at the hall and an old house.

The granite boulders and pillars of Murphy's Haystacks are located on private property 39 km from Streaky Bay. We knew that the afternoon sunlight would highlight the colours of the granite boulders and lichen growing on them. After parking and paying a $2 entry fee, we spent an enjoyable hour following the walking track through the boulders and pillars. Boards, explaining how the structures formed, were present in several places.

Murphy's Haystacks are composed of 1600 ma granite belonging to the Hiltaba Suite, part of the Lincoln Batholith. They were formed 100 thousand years ago by sub-surface chemical weathering. About 30,000 years ago, they were covered by sand dunes. Subsequent erosion by rain and wind gradually uncovered the structures we see today *(Photo 51).* The bright red colour seen on the granite is caused by lichen growing on their surface *(Photo 52).*

51. First view of Murphy's Haystack; boulders, pillars and tafoni.

Tuesday 11/09/12.

Another beautiful day to explore the Westall Way Loop and Cape Bauer Loop.

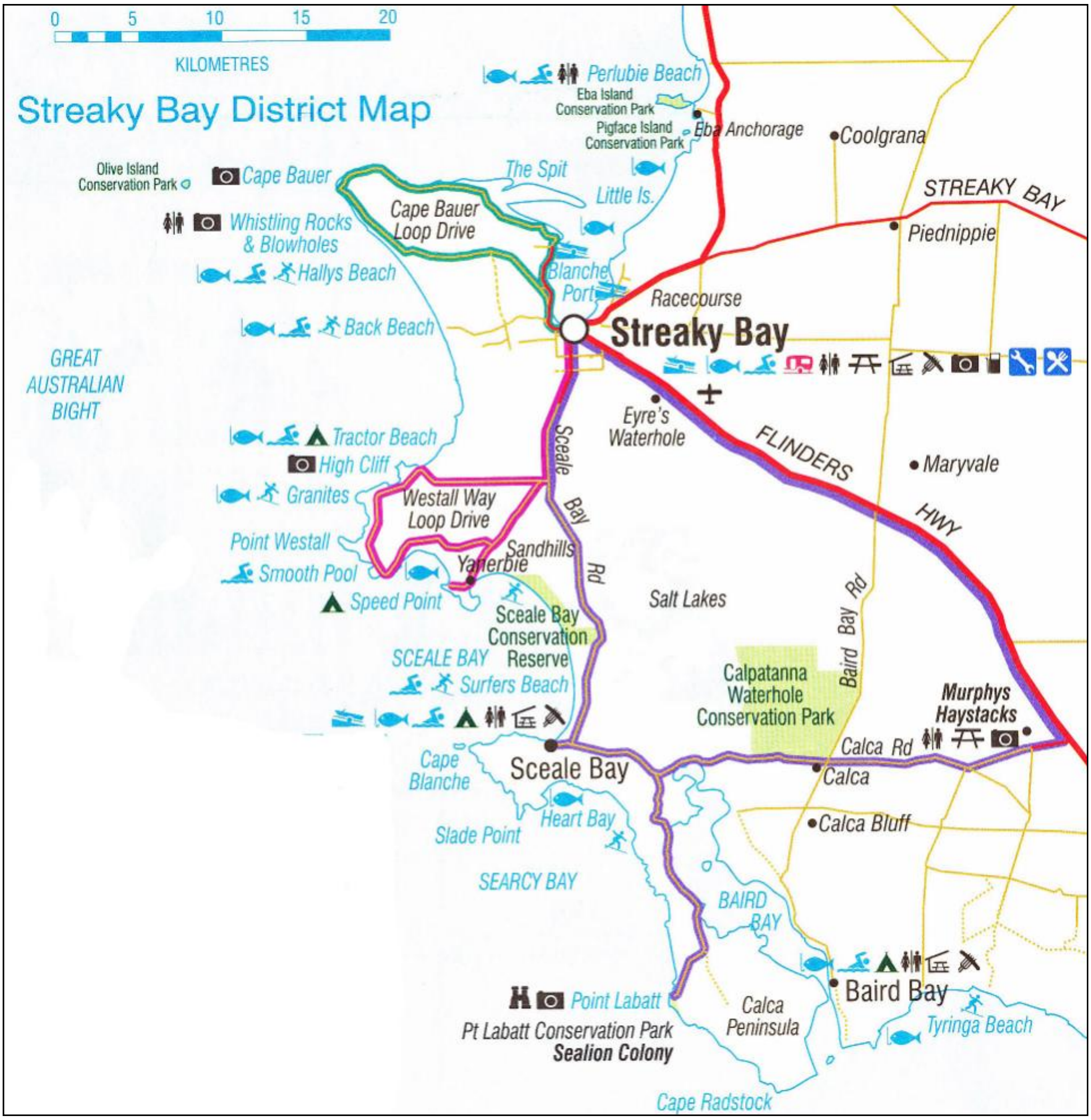
The first activity was a walk to the top of High Cliff *(Photo 53)*. From a previous visit I knew that the views were spectacular and that plentiful 'clog' fossils were to be found *(Photo 54)*.

A series of sea stacks called the Dreadnoughts jut into the ocean from the point of High Cliff *(Photo 55)*. After reaching the top, many 'clogs' (fossilized pupal cases of the Weevil *Leptopius dupo*nti) were found as well as a wonderful example of an eroding, partly consolidated calcareous sand dune *(Photo 56)*. Several small bays enclosed by vertical cliffs with small rocky beaches were also discovered from the top of High Cliff *(Photo 57)*.

Because there was lots to see during the day, I had to 'drag' people away for the drive to our next stop, The Granites.

The Granites have been formed by an exposure of early Proterozoic foliated and non-foliated augen gneisses, adamellites, migmatites and leucogranites. The rocks outcrop below limestone cliffs and are reached by a walkway leading from the car park to the beach *(Photos 58, 59)*.

The next scheduled stop was Smooth Pool for lunch. However, a sign to a lookout on the way looked promising, so in we drove. Lucky us! A great view of Point Westall *(Photo 60)* to the south was obtained as well as a rocky beach to the north where many rips were observed.



At smooth Pool, intruded gneisses and granites of the Lincoln complex are also exposed, as well as a wonderful example of Pisolitic Limestone *(Photo 61).* We also discovered late phase intrusions of quartz and feldspar pegmatite dykes *(Photo 62)* within gneisses.

At 1:15 pm, we departed for Whistling Rocks along the Cape Bauer Loop drive through the Gibson Peninsula. The Gibson Peninsula coast features colorful cliffs with unique shapes and large number of bays and coves.

Small sea caves have formed under some cliffs due to undercutting. Vertical 'pipes' have been eroded through the limestone reaching some of the sea caves below. As a wave enters such a cave, air is forced up through small blowholes causing them to whistle or 'breathe' *(Photo 63).*

Blowholes occur when waves enter larger sea caves and water as well as air is forced up the 'pipes' to form the blowhole.

The area is reached by a recently constructed walkway with viewing platforms for the Whistling Rocks and Blowhole sections. Much fun was had listening to the 'whistles' of some pipes, as well as watching the ascending air lifting Barry's hat up *(Photo 64)*. No blowholes were observed in action as the swell was too small.

We called into Cape Bauer lookout on the drive back to Streaky Bay. Familiar scenery greeted us; limestone cliffs, small bays, sea stacks and rocky points.

54. Clog fossils exposed by wind erosion.

55. The Dreadnoughts from the top of High Cliff.

56. Eroding calcareous sand dune.

53. Start of the walk to High Cliff.

57. Small bays formed as the limestone cliffs erode.

58. The Granites.

62. Late phase pegmatite intrusion.

59. Intruded and faulted gneiss.

63. Whistling Rocks area with undercut cliff.

60. Cape Westall in distance. Paleozoic gneisses exposed.

61. Pisolitic Limestone at Smooth Pool.

64. Barry's hat supported by air ascending up the vent.

66. Multiple flares near the base of Uncontitchie Hill.

67. Large sheet fracture with tafoni developing at its base.

Wednesday 12/09/12.

Leaving Streaky Bay, we all made our own way to Wudinna, 140 km inland from Streaky Bay. Some of us met in Poochera and had lunch in their Pioneer Park. We booked into Gawler Ranges Caravan Park in Wudinna at mid-day, had lunch and went down the to the main street for shopping and coffee in the local bakery.

There was some nuisance rain in the afternoon but not enough to prevent us having 'happy hour' under the awning of Jan's onsite van. The program for the next few days was outlined and I handed leadership over to Barry.

Thursday 13/09/12.

The day was spent visiting some of the granite inselbergs found in the Wudinna district. These structures are composed of middle Proterozoic Hiltaba Suite granite, part of the Lincoln Batholith. They have been exposed by erosion of overlying sediments.

A number of weathering structures are to be found on the inselbergs, although some are more common on the different inselbergs visited. Structures observed include Gnammas, Rillen, A-tents, Tafoni, Wave or Flared slopes and Sheet Fracture. *See Appendix for a description of how these different structures form.*

Uncontitchie Hill.

Located on private property, this 37 m high dome is situated 35 km south west of Wudinna *(Photo 65)*. The obvious structure around the base of the granite dome are flared slopes; up to 4 *(Photo 66)*. Further up the dome, large scale sheet fractures become obvious *(Photo 67)*. Tafoni have developed along the edge of some of the fractures. On top of the hill, many isolated boulders (many developing tafoni) are found *(Photo 68)*. Because the surface on top is uneven and covered with boulders *(Photo 69)*, few gnammas have developed. Many rillen had formed down the smooth slopes of the dome *(Photo 68).*

After our walk around and over the top of Uncontitchie Hill, we sat at the base of a large flare and enjoyed morning tea. We then departed for Polda Rock 7 km east of Wudinna.

65. Arriving at Uncontitchie Hill, a granite Inselberg or dome formed from middle Proterozoic Hiltaba Suite granite.

68. Boulders, tafoni and rillen near top of the hill.

70. Twin flares and water collecting wall, Polda Rock.

69. Boulder and pillar strewn top of Uncontitchie Hill.

71. Water filled gnammas covering the top of Polda Rock.

Polda Rock.

Polda Rock has heritage significance due to its use as a water supply for the township of Wudinna in the early settlement days. In 2002 the local Council restored Polda's water supply infrastructure and laid new pipes from Polda into Wudinna. This water is collected by a low rock wall surrounding Polda Rock *(Photo 70)* and is used on parklands, ovals and sporting facilities in the Wudinna township. Little Mount Wudinna is also contained within the reserve and is connected to the Polda Water Scheme.

Polda Rock is a low dome with a relatively flat top. This has facilitated the development of large gnammas, many interconnected by rillen *(Photo 71).* Tadpoles were plentiful in many of the water filled gnammas. Mt. Wudinna was an obvious dome to the north.

Polda Rock Recreation Reserve with its shelter, tables and toilet was our lunch venue after our walk over and around the rock.

Mt. Wudinna.

Located 10 km north east of Wudinna, Mt. Wudinna at 260 m above is claimed to be the second largest granite dome in Australia *(Photo 72).* At the parking area, picnic sites, BBQ's, shelters and toilets are present, as well as a well marked 1.5 km Mt. Wudinna Trail with explanatory plaques along the way.

We spent an hour following the interpretative trail over and around Mt. Wudinna. We noted that two distinct phases of granite intrusion had apparently taken place, one of homogeneous granite and the other with distinct lineated feldspar phenocrysts.

The crest of Mt. Wudinna may be more that 70 million years old (roughly the same age as Ayres Rock). This age has been determined by correlating the three flared slopes present with other land surfaces in the Eyre Peninsula.

Sheet fracture and boulders *(Photo 73)*, A-tents *(Photo 74)*, rillen *(Photo 75)*, tafoni *(Photo 76)* are common on Mt. Wudinna, but not so gnammas

72. Mt. Wudinna from the summit of Little Wudinna.

73.Vertically jointed sheet fracture weathering into boulders

75. Smooth rillen, Mt. Wudinna..

74. 'A' tent.

76. Brian looking out from a tafoni.

although a large shallow soil filled one had healthy examples of the endangered needle leaf honey myrtle (*Melaleuca armillaris)* growing within it.

Wonderful views of the surrounding farmland *(Photo 77)* and Mt. Wudinna were obtained from the summit. After an hours exploration we headed home, calling into Little Wudinna on the way. This was similar to the other granite dome explored; sheet fracture, rillen, gnammas (many with water and tadpoles) and flared slopes.

77. View north from Mt. Wudinna over rich farmlands.

Friday 10/09/12.

The Gawler Ranges.

Background Information:

The Gawler Range Volcanics covers 25,000 km^2 of the central part of the Gawler Craton and forms one of the world's largest felsic volcanic provinces. *(See Map next page)*

Isotope dating (U-Pb zircon) suggests that volcanism occurred between 1592-1591(± 3) ma at the end of the Gawler Craton formation.

The volcanics are thought to be ignimbrites laid down during explosive nuée ardente-type eruptions ('glowing clouds') of silicic magma and are unmetamorphosed, but have been affected by oxidation to produce their characteristic red colour.

They display a prominent regional joint pattern. Major joint sets strike NW and NE with a third set EW.

Erosion along the joints has produced domical hills or bornhardts, some isolated, but most standing in ordered rows above interconnecting sediment-filled valleys.

Gawler Ranges National Park.

The 163,500 ha NP is located 40 km north of the Eyre Highway with road access from Wudinna, Minnipa, Kimba and Iron Knob. There are no services within the park and water is scarce.

Historic sites in the park include Old Paney Homestead, Policeman's Point precinct, Stone Dam and Pondanna Outstation. **Landmarks** of note include Paney Bluff, Mt. Allalone, Mt. Sturt, Conical Hill and Scrubby Peak, Kolay Mirica Falls, The Organ Pipes and Yandinga Gorge.

Wudinna District Council Map showing the relationship between the granite inselbergs around Wudinna and Minnipa and the Gawler Ranges NP.

78. Laterised granite/gneiss in the Corrobinnie Depression.

80. Morning tea at Kolay Hut.

Fridays outing was a drive from Wudinna into the Gawler Ranges NP with a scheduled stop at Paney Homestead before following the LP Track to Kolay Hut and Kolay Mirica Falls. The return drive would be along Turkey Flat Track and Old Paney Scenic Route to Paney Homestead before returning to Wudinna along the road taken in the morning.

Leaving Wudinna, we drove north along a well formed dirt road (Battery Road) through farmland. Turning onto the Paney Homestead-Pygery Road, the country became undulating as the road passed over a series of longitudinal sand dunes well covered in wildflowers. Suddenly, the road dropped down into a flat, saltbush covered area called the Corrobinnie Depression that developed some 130-140 ma along the Corrobinnie Fault.

We had an unscheduled stop near a salt pan to examine a lateritic outcrop near the park entrance. Reddish Goethite covered weathered granite/gneiss, much of which was kaolinised *(Photo 78)*. The laterised breakaway was observed to continue around the edge of the salt pan. It was a very interesting area and apparently common around salt pans in the Corrobinnie Depression.

Continuing on, we drove past Paney Homestead calling into the Shearing Shed for a 'pit' stop. Then onto the LP Track which was rough in places, but nothing to worry about. Rounded domes of Gawler Range Volcanics were passed in places along the track, the remainder being surrounded by salt bush plains. Large flocks of 'skittish' emus and herds of eastern grey kangaroos were also abundant *(Photo 79).*

After 14 km of slow going, we reached Kolay Hut for morning tea *(Photo 80)*. The hut has been renovated and a new toilet block built. Hot showers are obtained by lighting a fire in the 'Donkey' to heat water.

It was a short drive from the hut to Kolay Mirica Falls. These have been formed from the weathering of columnar jointed rhyolite flows separated by sheet fracture sitting on a massive domed sheet of rhyolite *(Photos 81, 82).*

We walked very quietly up to the falls in the hope of seeing yellow footed rock wallabies which live around the falls. Not to be! Instead, we surprised some emus drinking from pools of water. Stokes Skinks *(Photo 83)* and Peninsula Rock Dragons were common in the area.

79. LP Track descending into a saltbush covered valley.

81. First view of Kolay Mirica Falls.

82. Columns of rhyolite, Kolay Mirica Falls.

84. Collapsing columns of rhyolite.

Near the top on the right side of the falls, columns had fallen over possibly due to undercutting *(Photo 84)*. One series of columns showed an excellent example of horizontal fractures *(Photo 85)*.

Plenty of photos were taken and questions answered before we departed driving a further 6 km along the LP Track to the junction of Turkey Creek Track.

This track followed a valley running south which drained to the Corrobinnie Depression. At one place, we passed a rock outcrop with a large crevasse at its base. It looked interesting, so of course we stopped for a look and decided to have lunch while we were stopped.

There was a brief stop to photograph Mt. Allalone, a 348 m high conical hill composed of conglomerate some 1600 million years old.

When we left the park it was still early, so we decided to drive up the sandy Sturts Track which, according to our map, would take us past a large salt lake. After 6 km of sandy track, we drove up a bank and found a dry salt pan in front of us. Rows of animal tracks led across the salt pan to the opposite bank of red laterite *(Photo 86)*. So, of course, most of us also walked across to the other side for a look.

Because our map gave no detail we went no further and returned to the main road. Once back crossing the longitudinal sand dunes, Barry called for a stop on the top of one where a stand of colourful Sandhill Hakea were growing *(Photo 87)*. These small trees have wonderful red flowers. Pink Boronia bushes were also found and photographed.

Back in camp, we showered and tidied up as we were all having dinner in the restaurant to celebrate Barry and Elaine's 44th wedding anniversary, a great way to end an interesting and varied day.

That evening, Barry looked in Google Maps for information on the salt lake we had visited beside Sturts Track and discovered that by driving a further half kilometer from where we parked, the main water filled salt lake would be reached. We resolved to go back for another look the following Monday afternoon .

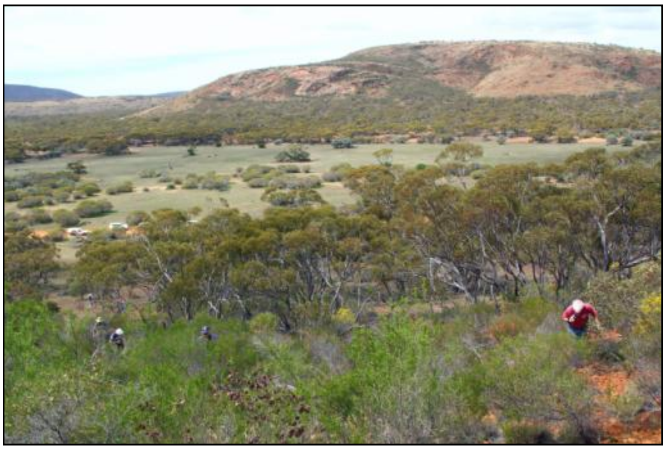
83. Stokes Skink *(Egernia stokesii).*

85. Horizontal fractures in rhyolite columns.

86. Animal tracks preserved in damp mud in a salt pan.

88. Collapsing rhyolite columns on top of ridge.

87. Sandhill Hakea flower.



89. Typical Gawler Ranges scenery.

Saturday 15/09/12.

Another day spent in the Gawler Ranges NP. This time we entered the park along the Yardea Road accessed from Minnipa, west of Wudinna. As we drove towards the northern park boundary, we came across streaky marks on the road, a bit like the trail snakes leave. None of us could figure out how the marks were made until we came across a young Asian guy riding, very unsteadily, a well loaded mountain bike.

After reaching the park boundary, we turned around aiming to call into points of interest on the return drive. Our first stop was Kododo Hill Campground, a flat area with unmarked tracks leading in all directions. Not terribly scenic, but a good morning tea stop.

Next, we drove into Scrubby Creek Campground also not very inviting causing us to turn around and drive out without stopping.

Before reaching the Yandinga Falls turnoff, we passed a layer of spectacular columnar jointing on a hillside above the road. What looked to be about a 15 minute walk to the formations turned out to be an hour for those of us who climbed up. It was a rough climb to what turned out to be spectacular formations *(Photo 88)* and views of typical Gawler range features; bare rounded rocky hills, mallee scrub and saltbush in the valleys *(Photo 89).*

Returning to the cars, we drove into Yandinga Falls which we knew was special. Beautiful columnar jointing in the rhyolite was present along the sides of the valley leading to the falls. One spectacular set of long columns jutted out from the valley side *(Photo 90)*. In fact, it was the column whose photograph appeared in tourist brochures outlining features of the Gawler Ranges NP. We took turns in standing on or beside the column while our photographs were taken.

Yandinga Falls are really a series of cascades flowing over massive sheets of rhyolite. Many lizards were seen as we made our way up and down the cascades including a very large Western Bluetongue lizard.

Lunch completed, the next stop was the Organ Pipes, a valley and falls surrounded by massive rock columns. The 10 km track into the Organ Pipes was in good condition and presented no problems *(Photo 91).*

From the car park, a 500 m track took us to the falls. A real thrill was to spot a rare Yellow Footed Rock Wallaby feeding on grass at the base of the falls *(Photo 92).* It soon spotted us and disappeared into the bushes.

Some of us climbed to the top of the falls and were rewarded with a wonderful view down the valley *(Photo 93)*. On the way back to camp, some of us stopped to examine and photograph saltbush that grew abundantly near the edge of the park.

90. Columns of rhyolite, Yandinga Falls.

91. Track into the Organ Pipes and Falls.

92 Yellow Footed Rock Wallaby.

93. Organ Pipes and cascades below the falls.

Sunday 16/09/12.

Following the two big days in the Gawler Ranges, the morning activity (free afternoon) was a drive to Peela Rocks and Corrobinnie Hill, two granite inselbergs some 50 km north east of Kyancutta.

Peela Rocks turned out to be a series of low granite domes just outside the Pinkawillinie Conservation Park. Rillen and a few gnammas were the main structures present. In the distance, the higher and much more interesting looking Corrobinnie Hill could be seen.

Upon entering the Pinkawillinie Conservation Park through a gate, we made our way along a sandy access track which became rocky as it climbed up into Corrobinnie Hill Conservation Park.

Corrobinnie Hill consists of outcrops of eroded granite about 1585 ma old. It consists of two NNS-SSE trending granite domes with a corridor between. The hills themselves are strewn with large boulders, many of them hollow or tafoni *(Photo 94).*

At the crest of the larger hill, polygonal cracking has developed in the granite *(Photo 95)* and the NE slopes of both hills are flared. Many of the boulders and rock domes were actively weathering by exfoliation with spalling at the base of boulders common *(Photo 96).*

We spent a wonderful time exploring the hill and of course, taking lots of photos before returning to the cars for morning tea *(Photo 97).* Many species of wildflowers were growing in the sandy soil below the hill and on the longitudinal sand dunes crossed by the access road which meant more stops and photographs on the way back *(Photo 98).*

94. Large tafoni on the dome of Corrobinnie Hill.

95. Polygonal cracking in a granite dome.

96. Exfoliation and spalling at the base of a sheet fracture.

97. Morning tea. Pinkawillinie Conservation Park to East.

98. Spider Orchids, Corrobinnie Hill.

Monday 17/09/12.

After breakfast, we headed for Pildappa Rock, 16 km north of Minnipa. Its most spectacular feature is a tall 80 m long wave that faces NE *(Photo 99)*. By the time we arrived, it was well lit by sunlight.

In fact, Pildappa Rock is surrounded by waves which have been walled to catch run-off water for use by local farmers.

All the features seen on domes before were present; rillen, gnammas, tafoni, sheet fracture, pot-holes, small boulders, sheet fracture. Some of the large rillen had been dammed with a series of low stone walls, an obvious attempt to catch and store as much water as possible when it rained *(Photo 100).*

A wonderful view over farmland to the Gawler Ranges was obtained from the top of the rock *(Photo 101).* A new toilet and picnic shelter was present on the southern side, a welcome addition to the older facilities on the northern side.

When morning tea was finished, we departed for a short drive to Tcharkuldu Rock, the last dome on our list to be visited. It turned out to be a low dome covered with large boulders, many weathered into tafoni. The surface of many boulders were covered in polygonal cracks. Much sheet fracture was present, the probable cause of boulder formation *(Photo 102).*

Several shingle-back lizards were discovered around the rock and actively photographed.

After lunch, some of us decided to drive across country to visit the large salina (salt lake) visited previously along Sturts Track. On the way, we passed by Lake Agars, a small salina. Of course, we had to have a look. Good choice as Lake Agars was spectacular

99. The main flared wall (wave) Pildappa Rock.

101. Water collecting wall below waves; Gawler Ranges.

100. Small stone dam walls across rillen.

102. Sheet fracture, boulders, polygonal cracking, tafoni.

being half filled with greenish water *(Photo 103).* Around the edge was a band of salt crystals about 5 m wide displaying wonderful patterns. In the red laterite bank surrounding the lake, we discovered gypsum crystals which resulted in much digging.

After half an hour we reluctantly continued our drive to the salina along Stuarts Track this time parking further along on top of the surrounding lunette (sand dune).

What scenery greeted us! A large salina partly filled with water with a very wide band of salt crystals along its edges. To the north of the lake, two rounded hills called 'The Sturts' added to the scenery *(Photo 104)*. The banks above the lake were covered in a profusion of reddish Samphire and pink flowering Pig Face. A small sandy-looking island was seen in the centre of the lake.

An interpretative sign explained that sixty five million years ago, a river system drained the Gawler Ranges travelling NW along the Corrobinnie Depression before turning south entering the ocean at what is now Smoky Bay. With the onset of desert conditions, the river system became choked with sand. Wind has

103. Lake Agars.

since blown the sand into U-shaped and irregular dunes, now fixed by vegetation.

Salt-laden water still enters the depression forming ephemeral salt or playa lakes (salinas). When they dry up, salt (halite) and gypsum crystallizes out causing the irregular pressure ridges observed to form. The lake edges consist of red lateritic soils *(Photo 105).* All too soon we had to drive back to Wudinna after another fascinating day.

Tuesday 18/09/12.

A final visit into the Gawler Ranges NP was our agenda for the day. Travelling via Minnipa we entered the park along Yardea Road and turned right along the Old Paney Scenic Route.

Stop 1. Stone Dam.

Early settlers had built a rock dam wall over a smooth stony base of rhyolite (probably due to sheet fracture) in a small creek to trap water *(Photo 106).* Long since abandoned, the dam wall is in remarkably good condition. Half a kilometer upstream, a small waterfall could be seen as the creek flowed over another massive layer of rhyolite. Colourful wild flowers were present along the banks of the creek.

An excellent view over the Corrobinnie Depression was obtained from the track leaving Stone Dam.

106. Stone Dam wall.

Stop 2. Old Paney Homestead.

The front verandah of the homestead provided a shady area for morning tea *(Photo 107).* Nearby, a family of emus was grazing while keeping a wary eye on us. The homestead is still in very good condition both inside and out. A new toilet block for visitors has been built. Somewhat out of character, an extension built out of concrete blocks had been added in the past to the front of the homestead *(Photo 108).*

104. "The Sturts" behind the partly filled salt lake.

107. Front view of Old Paney Homestead.

105. Pressure ridges in salt with red laterite bank behind.

108. Additions to the original homestead.

109. Corrobinnie Depression adjoining the rounded hills of the Gawler Ranges.

Stop 3. Small Hill 3 km East of Old Paney Homestead.

It was a short walk to the top of the hill where we obtained the best view so far of the Gawler Ranges with their low rounded hills and the adjoining Corrobinnie depression covered with grasses and saltbush *(Photo 109)*. Looking back west along the Old Paney Scenic Route, Old Paney Homestead could be clearly seen. Large pot-holes had been eroded into the rock down the side of the hill where water drains during rain.

Stop 4. Mattera Track to Pondanna Outstation.

This was a very scenic drive through a valley draining the Gawler Ranges south into the Corrobinnie Depression. Hills on the eastern side of the track had many layers of volcanic rock that had cooled into columns. A herd of healthy feral goats was disturbed on the drive.

As we reached the LP Track, the valley opened up into a broad undulating plain. After following the LP Track NW for 10 km, we reached Pondanna Outstation *(Photo 110)*.

111. Pondanna Outstation.

Pondanna Outstation has been restored by Friends of Gawler Ranges NP who spent over 5,500 volunteer hours (and travelled over 50,000 km) in the process. In August 2009, Pondanna Outstation was made available for hire to the public *(Photo 111)*.

The home is well equipped; floor coverings, solar power, telephone, well equipped kitchen, hot water, shower, 4 bedrooms and country style lounge room with open fire. A display of historic farm machinery is available behind the house.

110. Approaching Pondanna Outstation.

112. AGSHV members, Pondanna Outstation.

After eating lunch on the front verandah *(Photo 112),* we continued west along the one-way Conical Hill Track, the start of our drive home.

Stop 5. Paney-Yardea Gate.

This was situated on top of a stony ridge where the track descended into a valley below to meet with the Minnipa-Yardea road that would take us back to Wudinna via Minnipa.

The ridge provided a lookout into the valley which contained a number of E-W trending sand dunes. The sand dunes originated about 4,000 years ago, blown by westerly winds and now stabilized by vegetation.

The dunes are composed of quartz sand deposited by old rivers to the west in the Corrobinnie Depression. The sand, picked up by wind has shaped the east travelling sand dunes. The dunes migrate across the hills and valleys. They are known as climbing dunes when they travel up slopes and falling dunes when they descend into valleys *(Photo 113).*

Of interest was a small fenced off area with colourful flowering bushes growing inside. Initially, we thought that they were an Eremophila species, but Barry informed us that it was a small Mint Bush *(Photo 114).*

Dawn found a spider orchid *(Caladenia Sp.)* that has been broken off probably by previous visitors. As she held it up for us to look at, it was besieged by a wasp trying to mate with it *(Photo 115)*, a method of pollination used by some orchids. A frenzy of photographing the goings-on followed. It was then back in Wudinna for coffee.

114. Colourful Mint Bush.

115. Wasp mating with a spider orchid.

113. View of EW trending sand dunes from Paney-Yardea Gate.

Appendix.

A. A-tents.

An A-tent consists of a pair of slabs, roughly rectangular in plan form, each touching the adjacent rock surface at it's outer edge, but standing a few cm above the general surface level where the two are in contact in the centre of the structure. The slabs thus form a cavity that is triangular in shape like a tent. Large A-tents can be seen on the western mid-slope of Mt. Wudinna.

B. Tafoni.

Hollows or caverns on the underside of rock outcrops are known as tafoni and are formed by the flaking or granular disintegration due to crystallisation of salts in the granite. Tafoni are initiated by soil moisture attacking the granite beneath the land surface - the same process responsible for the formation of flares or waves. Spectacular tafoni can be seen at Murphys Haystacks.

C. Rillen.

Gutters or channels cut into fresh granite by water flowing down the side of outcrops are known as rillen. Most rillen are flat-floored and steep sided (U-shaped) but some formed by water flowing along a crack or joint are V-shaped. These can be seen on both the upper surfaces and steeper sidewalls of Mt. Wudinna.

D. Gnammas.

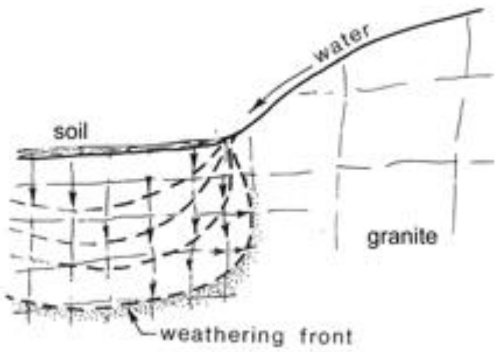
These are shallow pan-shaped pits (an aboriginal word meaning rock hole). They are formed from small depressions and crevices that are enlarged by water collecting in them, causing the granite to weather and crumble. Large gnammas can be seen on Pildappa Rock.

Wave or Flared Slopes.

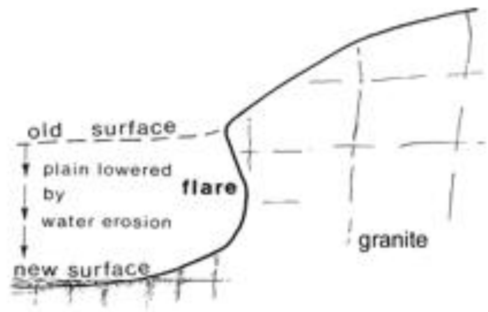
A smooth concavity cut in rock commonly developed at the base of a hill, but also found on higher slopes and on boulders and in armchair-shaped hollows.

Flared slopes are thought to form in two stages:

Water running off a hill infiltrates the subsurface where it alters the bedrock by solution, hydration and hydrolysis. A 'moat' filled with altered rock ends up surrounding the hill. In time, the exposed hill slope becomes undermined and a flare develops.



With time, the weathered rock is stripped away exposing the smooth, concave weathering front as a flared slope.



Several phases of flare development may be seen on some flared slopes.

F. Sheet Structures.

Sheet structures and sheet fractures are essential features of inselbergs. Fractures parallel to the surface rock results in convex sheets of rock separating from the core rock below it. Sheets may creep down slopes resulting in A-tents forming.

Several theories are used to explain sheet formation. The release of compressive stress from above the inselberg due to erosion and removal of overlaying rock is one such theory.

G. Inselbergs.

These are isolated steep sided hills or mountains rising above a surrounding plain.

The inselbergs around Wudinna are composed of granites, part of the Middle Proterozoic Hiltaba Suite of rocks.

References

ALLEN, S.R.; SIMPSON, C.J.; MCPHIE, J.; DALY, S.J. (2002) Stratigraphy, distribution and geochemistry of widespread felsic volcanic units in the Mesoproterozoic Gawler Range Volcanics, South Australia. *Australian Journal of Earth Sciences, 50, 97-99.*

BALDWIN, S.L.; MCDOUGALL, I.; WILLIAMS, G.E. (1991) K/Ar and $^{40}Ar/^{39}Ar$ analysis of meltrock from the Acraman impact structure, Gawler Ranges, South Australia. *Australian Journal of Earth Sciences, 38, 291-298.*

MORTIMER, G.E.; COOPER, J.A.; OLIVER, R.L. (1988) Proterozoic mafic dykes near Port Lincoln, South Australia: Composition, age and origin. *Australian Journal of Earth Sciences, 35, 93-97.*

TWIDALE, C.R.; SIMPSON, E.M. (2005) Australian Landforms. *Rosenberg Publishing Pty. Ltd.*

VASSALLO, J.J.; WILSON, C.J.L.; Structural repetition of the Hutcheson Group metasediments, Eyre Peninsula, South Australia. *Australian Journal of Earth Sciences, 48, 331-334.*

WEB, A.W.; THOMPSON, B.P.; BLISSETT, A.H.; DALY, S.J.; FLINT, R.B.; PARKER, A.J. (1986) Geochronology of the Gawler Craton, South Australia. *Australian Journal of Earth Sciences, 33, 119-123. Appendix, Geological Map.*

Department of Environment and Natural Resources – Home; http://www.environment.sa.gov.au/parks/Home

http://digital.library.adelaide.edu.au/theses/09PH/09phs2938.pdf

http://keckgeology.org/files/pdf/symvol/16th/australia/davis.pdf

Murphy's Haystacks, Eyre Peninsula :: Places - Yegor Korzh :: Travel Photography
http://www.yktravelphoto.com/places/murphys-haystacks-eyre-peninsula/513/en/

http://www.pir.sa.gov.au/minerals/geological_survey_of_sa/commodities/nephrite_jade

Report by Ron Evans.
Photograph 113 by Barry Collier.
Remainder of photographs by Ron Evans.

Note:

National Park Brochures in pdf format for Lincoln NP, Lincoln NP Memory Cove Wilderness Area, Coffin Bay NP and Gawler Ranges NP can be downloaded from
http://www.environment.sa.gov.au/parks/Home
by accessing the Parks Explore Section.

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