FIELD GEOLOGY

OF THE SHOALHAVEN DISTRICT NSW AUSTRALIA

John G Paix

1970 (Reviewed 2013) ©

Australian Field Geology Club visit to the Cambewarra Range February 1965

A Word or Two of Explanation

This book was written in the years 1968-1970. At the close of my time as a Science teacher at Nowra High School in 1967, I undertook to write a report titled *The Geology of the Shoalhaven Shire* for the then Shoalhaven Shire Council, which was published by them early in 1968.

It soon became apparent that there was much additional information, especially relevant to the Geology excursions I had conducted during my 5 years in Nowra, which was not included in that book.

What you see in front of you today was prepared for publication over the next three years and I fully expected to see it published in 1970. For reasons that do not matter at this distance in time, this never happened. I was left with a typed, proof-read copy, all the maps, drawings, photographs and figures and a feeling that one day something should be done to make this material available to the public.

Well, here it is. Sadly, after 8 moves and a house fire, only the text and photographs remain. I have supplemented the text with additional photographs (some taken years later) and borrowed a few figures from "*Geology of the Shoalhaven Shire*" to make the text more meaningful.

Google Earth can provide detailed images of many of the places mentioned in this book. What a tremendous benefit this resource has become for teachers of Geology! Likewise there is no need for an index for this book as the Find and Search commands with your PDF reader will do this even better.

I am well aware that much has changed since I left Nowra in1967. There has been a lot of research into the Geology of the area since my time; we have been using the Metric System for ages and such things as access to property, the expansion of National Parks and urban development will affect your ability to visit many of the locations I have described. The only concession I have made to more recent events is my comment about the access to the summit of Pigeon House Mountain (see Excursion 15a, Stop 2). That place is simply too good to miss!

Things have changed, but the rocks themselves have not, so I hope this electronic publication brings pleasure to all those who make use of it.

 I am not planning to update the book. You should read it in conjunction with "*Geology of the Shoalhaven Shire",* which is downloadable from the Australian Lapidary Forum website and also from the NSW Geological Survey site DIGS.

John G Paix

Glen Innes 2013

TABLE OF CONTENTS

Junction Street Nowra December 1967

Chapter 1: Introduction.

"The land near the Sea coast still continues of a moderate height, forming alternately rocky points and Sandy beaches; but inland, between Mount Dromedary and the Pigeon House, are several pretty high Mountains, two only of which we saw but what were covered with Trees, and these lay inland behind the Pigeon House, and are remarkably flat a Top, with Steep rocky clifts all round then."

Lieutenant James Cook wrote this on Sunday 22nd April, 1770, as the "Endeavour" passed by the Shoalhaven district of New South Wales. Today, the scene has changed little. However we are now able to explain many of these geological features which were of such interest to Cook.

The Shoalhaven district, by which we mean the coastline from Bateman's Bay to Kiama and inland for up to 40 miles, is of great interest to geologists. There is a considerable variety of rock types and structures because the edge of the Sydney Basin runs across the area, allowing access to the older rocks beneath. Thus, in an area of 2,000 square miles there are sedimentary rocks of many varieties in age from Cambrian to Tertiary, igneous rocks ranging from coarse intrusives to fine grained volcanics and a wide variety of metamorphic rocks. There are examples of folds, faults, unconformities and similar features.

This book is designed to help your understanding of the Science of Geology by providing detailed descriptions of the rock types and structures found in the Shoalhaven district. It is not intended to be an exhaustive treatment of all aspects of the geology – this is available in the literature quoted at the end of this book. It is assumed that the reader has available to him the appropriate geological maps of the area.

Prior to the commencement of the Permian period, some 280 million years ago, the eastern part of Australia was involved in a number of mountain building episodes or orogenies. These involved the deposition of sediments, their subsequent uplift, folding and erosion. As part of the process, extrusion and intrusion of igneous rocks occurred with their associated metamorphic and mineralising effects. All of these rocks constitute what is known as the **basement** and by the beginning of the Permian period this had largely been levelled by the processes of erosion in the present coastal region.

However, high mountains still existed in the west and south west and from these glaciers may have moved towards the sea which began to cover the low-lying land. Subsidence led to the formation of the Sydney Basin, the extent of which is shown on the map. At first marine sedimentation prevailed, although small pockets of fresh water evidently existed temporarily, as the **Clyde Coal Measures** formed in restricted localities. Subsequently the marine **Shoalhaven Group** accumulated to a thickness of several thousand feet. Parts of these sediments are equivalent to the marine Dalwood and Maitland Groups in the Hunter Valley. Volcanic activity in the Kiama district led to the accumulation of the **Gerringong Volcanics**, and at the close of this episode marine sedimentation ceased.

Sediments younger than the Shoalhaven Group are only found north of the Shoalhaven River and it is thought that the area of the Sydney Basin had contracted by this time. These consist of the Permian **Illawarra Coal Measures** and the overlying **Narrabeen Group, Hawkesbury Sandstone** and **Wianamatta Group**, of Triassic age.

Tertiary volcanic rocks are widespread and are the remains of a more recent volcanic episode. Basaltic lavas are found in numerous places and basic and ultrabasic intrusions are common.

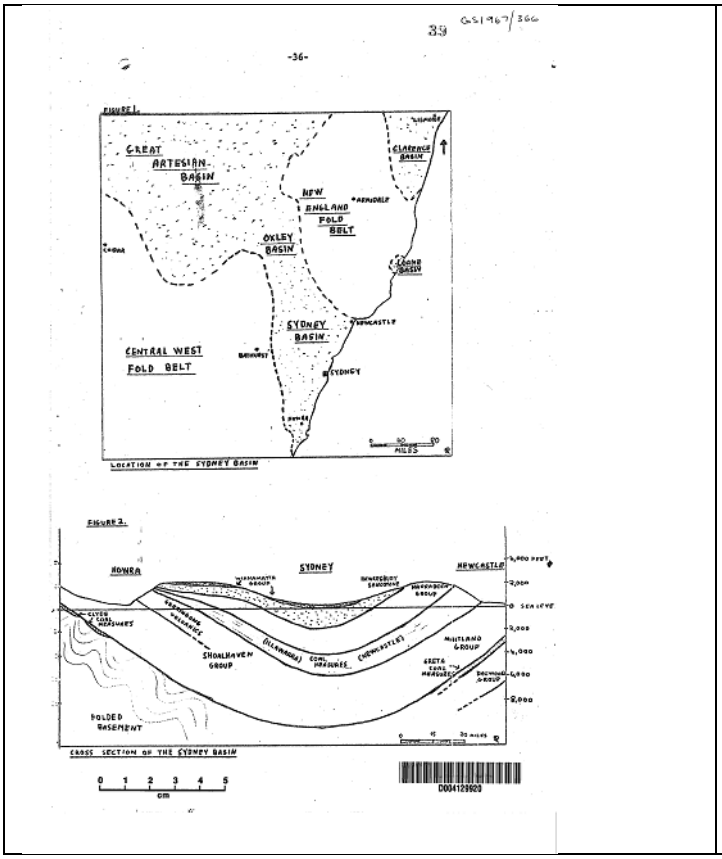
The landscape as we see it today is the result of the erosion of all these rocks. Uplift of as much as 3,000 feet has occurred since the Triassic period and this has created the present drainage system. The Sydney Basin sediments dip towards the north and the presence in the sequence of two resistant formations (the Nowra and Hawkesbury Sandstones) has created two gently inclined areas up to 3,000 feet above sea level intersected by deep valleys and gorges.

The last million years has seen the formation of vast ice caps, leading to a world-wide lowering of sea level. Their subsequent melting within the last 20,000 years caused the sea level to rise again, drowning many river valleys and forming the present coastline.

Fossils

For over a century the rocks of the Shoalhaven district have yielded excellent fossils to many collectors. The supply of good specimens is running out in all the better known collecting areas. Conservation of fossil and mineral specimens is in some ways more vital than that of wildlife, since there is no natural regeneration. You should only take such specimens as will be put to good use in representative collections, such as school collections, permanent public displays and similar places. Museum and University authorities are always pleased to identify or receive good specimens.

The sketches illustrate some of the more common forms you are likely to encounter. Reference to the literature should help in the identification of other forms.



GEOLOGICAL TIME SCALE

SUBDIVISIONS OF TIME	DURATION (MILLION YEARS)	TOTAL TIME	SIGNIFICANT EVENTS
A. CAINOZOIC ERA			
1. QUATERNARY PERIOD			
(a) RECENT OR HOLOCENE EPOCH	15,000 YEARS		SLIGHT DROP IN SEA LEVEL
(b) PLEISTOCENE EPOCH	1		GLACIAL PERIOD
2. TERTIARY PERIOD			
(a) PLIOCENE EPOCH	10		UPLIFT
(b) MIOCENE EPOCH	15		VULCANISM
(c) OLIGOCENE EPOCH	15		
(d) EOCENE EPOCH	20		
(e) PALAEOCENE EPOCH	10	71	
B. MESOZOIC ERA			
1. CRETACEOUS PERIOD	65		
2. JURASSIC PERIOD	45		POSSIBLE AGE OF MILTON GRANITE, INTRUSIONS AND DYKE
3. TRIASSIC PERIOD	45	226	NONMARINE SEDIMENTATION
C. PALAEOZOIC ERA			
1. PERMIAN PERIOD	45		GLACIATION. VULCANISM SUBSIDENCE.
2. CARBONIFEROUS PERIOD	80		ACIDIC INTRUSIONS. UPLIFT
3. DEVONIAN PERIOD	50		SUBSIDENCE
4. SILURIAN PERIOD	40		OROGENY
5. ORDOVICIAN PERIOD	60		OROGENY
6. CAMBRIAN PERIOD	100	600	OROGENY (?)
D. PROTEROZOIC ERA	1,400	2,000	
E. ARCHAEOZOIC ERA	1,500	3,500	OLDEST KNOWN ROCKS.

Chapter 2: The Kiama District

The country around Kiama has been visited by students for many years, for its volcanic rocks illustrate many important geological processes. Attention was first drawn to the area in 1797, when explorer George Bass discovered the now well-known Blow Hole. He also commented on the manner in which the rocks were jointed. At this time, most of the country was covered by thick rain forest and the presence of fine timber soon attracted cedar getters from Sydney. Settlers began arriving after 1820 and started clearing the jungle. From that point on the dairying industry has grown to its present importance.

The introduction of the railway and the subsequent demand for ballast led to extensive quarrying of the local volcanic rocks. Kiama became known as the "Blue Metal Metropolis" and there is abundant evidence around the town of this industry. In recent years quarrying has declined, but an increase in tourism and the expansion of industry around Wollongong has ensured the continued growth of the area.

The traveller approaching the Illawarra district from Sydney will observe three prominent topographical features, especially from a vantage point such as Mt Keira. The first of these is the distant hump of Saddleback Mountain at the tip of the Barren Grounds plateau. The other two (Red Point and Bass Point) project seawards from an otherwise smooth coastline. All three are made up of resistant volcanic rocks, not seen elsewhere on the south coast.

The cliffs of Hawkesbury Sandstone, which recede from the coast south of Stanwell Park, approach it again behind Kiama. Beneath the cliffs lie steep slopes formed from the Narrabeen Group and the Illawarra Coal Measures, and these slopes support remnants of the rain forest which formerly covered the district.

On the coast and lower slopes, the Berry Formation, part of the marine Shoalhaven Group, is dominant. The Gerringong Volcanics, whose stratigraphy was outlined in Chapter 1, is that part of the Berry Formation with which much of this chapter is concerned.

Excursion 2a

Shell Harbour Rail-Kiama-Gerringong (18 miles)

All the rocks seen on this excursion are of volcanic origin, being either flows, dykes, or tuffaceous sediments. Fine examples of volcanic features are seen and there are a number of places where marine fossils may be collected.

Route: Prince's Highway from Shell Harbour railway station to Omega, then Seven Mile Beach Road to Gerroa. Various side roads lead to places of interest along the coast.

Stop 1. The Dunmore Quarry is being worked west of Shell Harbour station. Request permission before entering.

The rock being quarried is the Bumbo Latite, a rock which will be seen again at numerous points south. The rock itself is greyish, with a tendency towards brown on weathered surfaces. It is characterised by phenocrysts of plagioclase felspar up to ½ inch long, showing excellent multiple twinning. The latite differs considerably from basalt, notably in the higher percentage of potassium felspar it contains. Olivine is comparatively rare.

Two flows may be observed in the quarry, the upper being less vesicular than the lower. In some places a small thickness of sediment lies between the two flows.

Columnar jointing is the most prominent feature visible, and this feature is due to the contraction of the flow on cooling. Cavities within the latite may contain zeolite minerals, calcite or quartz.

Return to the highway and proceed south to the Minnamurra River bridge.

Stop 2. The Bumbo Latite is well exposed in the road cutting. The river is typical of many small coastal streams. Tidal influence extends for miles upstream; in this case for half of the total length of the river.

Proceed ½ mile to the road leading left to Minnamurra. Take this road and subsequent roads to the right.

Stop 3. Old quarries expose the Bumbo Latite. Along the waterfront there are extensive shell and pebble beaches. Small pieces of petrified wood and agate may be collected here.

Stack Island Minnamurra January 1953

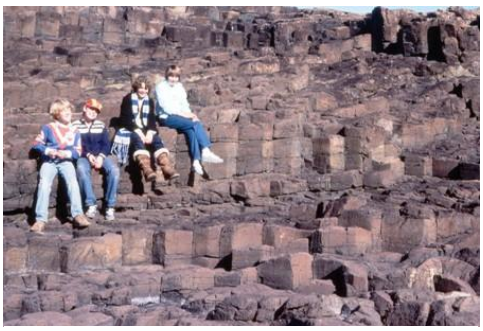
At Minnamurra Point there is a fine view of Stack Island, formerly an extension of this hill. A basalt dyke cuts right across the tip of the point. Similar dykes occur south along the coast and are associated with veins of calcite and chalcedony.

Return to the highway. Further outcrops of the Bumbo Flow are seen for the next 1 ½ miles. The road descends to Bombo and extensive operational quarries are seen on the right. Turn left just beyond the railway siding and proceed under the main railway line to Bombo Beach. The track may be followed for 200 yards to the old Bombo quarries.

The Bumbo Flow resting on the Kiama Sandstone at Bombo November 1965

Stop 4. At this point the junction between the Bumbo Flow and the underlying Kiama Sandstone may be studied. There is a zone of coarse agglomerate up to 6 feet thick between the two, containing blocks of sandstone and igneous rocks. Small springs issue from this zone.

Within the sandstone, which is a prominent pink colour due to oxidised iron minerals, are numerous pebbles of igneous rocks. Some may be blocks ejected from nearby volcanoes (volcanic bombs). Fossils are rare but vague organic marking are common.



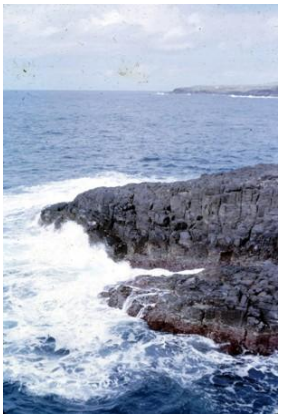
Latite columns at Bombo Quarry August 1982

Climb up into the main quarry area. Here, as at Dunmore, the typical features of the flow may be examined. Piles of agglomerate frequently contain masses of black, creamy, or clear calcite. Patches of red haematite are also common. At the northern end of the quarry there are several basalt dykes, which contain fragments of granite (xenoliths) brought up from deep within the earth's crust.

In fine weather at low tide the rock platform may be safely followed back to the beach. A weathered out dyke and large erratic blocks of igneous rock in the sandstone are seen en route.

Return to the highway and proceed into Kiama. Stop past the railway bridge where the road turns right.

Stop 5. Kiama Harbour was formerly a busy blue metal port. Walk north around the shore towards the baths. At first there are outcrops of the Blow Hole Flow, then volcanic agglomerate, similar to that at Bombo, and finally cliffs of Kiama Sandstone. The rock platform may be followed for some distance and a number of weathered out dykes seen.



The Blow Hole Flow at Blow Hole Point March 1963

Proceed to Blow Hole Point.

Stop 6. The Blow Hole Flow differs from the Bumbo Flow in that it is less porphyritic and more vesicular. Cavities within the rock frequently contain well crystallised minerals.

Dyke cutting through the Blow Hole Flow at Blow Hole Point March 1963

The genesis of the Blow Hole is well known, and will not be dealt with here. Climb over the rocks well to the right of the opening. A narrow dyke of dark basaltic composition may be followed down to the sea. The columnar nature of the flow is very clear at the mouth of the Blow Hole and the dyke which led to its formation may be seen if the seas are calm.

Return to the highway and proceed south for ¾ mile. Turn left instead of crossing the railway line. Keep straight ahead to the top of the hill beyond the beach. Turn right, then left and follow the road until it descends to a small bay where the Little Blow Hole is situated.

Stop 7. The sea has eroded along a joint and removed one of the columns to form the Little Blow Hole. This is a good place to examine these columns. They tend to be perpendicular to the cooling surface, in this case the base of the flow, which was itself irregular. Vesicles in the latite are elongated in the direction in which the lava was moving. Like the Bumbo Flow at Dunmore, the presence of agglomerate suggests that the Blow Hole Flow may be a composite of two or more flows one above the other.

Follow the coast to the north. A large tunnel has been formed by the marine erosion of a dyke. Climb the hill beside the tunnel and cross over to the other side. Vughs in this vicinity contain agate, calcite and amethyst.

Return to the highway and 1 mile beyond the railway bridge turn left (Attunga Avenue, then Anembo Crescent). Follow these roads until they descend towards the little bay in the south.

Stop 8. Westley Park has been visited by students for more than a century. Avoid damaging any of its unusual geological features so that it will remain of interest to future generations.

The accompanying map shows the main features and will help to locate them. At A the Blow Hole Flow contains large vughs lined with quartz and calcite crystals, many of which have been destroyed. The pebble beach nearby is composed mainly of latite pebbles with an occasional piece of agate or chalcedony. Other rock types originated as pebbles in the Westley Park Sandstone.

The rock platform is approached by way of a weathered out dyke (B). Along the track may be found boulders of ultrabasic rock, rich in olivine. These are xenoliths derived from the dyke, evidently brought up from below by the magma.

Dyke cutting through the Blow Hole Flow May 1959

The Westley Park Sandstone is distinctly tuffaceous and in places rich in marine fossils, especially brachiopods. There are also numerous erratic blocks of igneous rock, similar to those seen at Bombo. Some geologists regard these blocks as volcanic bombs while others consider that they were dropped by melting icebergs. The junction with the overlying flow is fairly regular; otherwise it resembles outcrops seen previously.

The Blow Hole Flow resting on Westley Park Sandstone May 1959

At C the dyke may be clearly seen. On either side there is a zone of hardened sandstone and joints are closer together here than away from the dyke. Likewise it shows joints parallel to the strike, and these are frequently filled by quartz, calcite, and chlorite. Another set of joints strikes across the dyke, at right angles to the cooling surface.

If the seas are high, it may be difficult to pass this point (D). Here the dyke has split in two and clearly shows those features seen at C. Beyond this point, the base of the flow continues to rise and marine fossils become more common. Notice how the rock platform continues to the south while northwards, where igneous rocks form the shore, there is no platform.

At E the Horizontal Blow Hole provides a spectacular example of marine erosion. Two dykes similar to those seen in other places have been eroded; one of them has formed a tunnel which the waves seal as they enter. When the water returns, the expansion of compressed air causes a violent expulsion of air and water.

Although walking becomes more difficult, the platform may be followed for 2 ½ miles to Werri Beach. Ten more dykes will be seen and there are opportunities to collect marine fossils.

Dykes north of Gerringong May 1965

Return to the highway and proceed south towards Gerringong. En route many exposures of the Kiama Sandstone and the Bumbo Flow will be seen. Just before the highest point on the road, two intersecting dykes may be seen on the rock platform below. The extensive view from above Gerringong shows how a small inlet of the sea has been cut off by Werri Beach. It has gradually been filled with sediment which now supports rich dairying country. Seven Mile Beach and Coolangatta Mountain may be seen beyond.

Werri Beach and Gerringong January 1953

Turn left at Omega railway station. Pass through Gerringong and turn left to Boat Harbour just beyond the town.

Stop 9. In addition to its geological features, Boat Harbour provides a rock pool and launching ramp. The cliff is wholly made of tuffaceous Westley Park Sandstone, which displays spheroidal weathering exceptionally well. The pool itself is built where a dyke has weathered out. The dyke may be seen in the cliff above as a zone of clay. The platform may be followed northwards to Werri Beach. There is a good view of a small stack at Bare Bluff to the north.

Return to Seven Mile Beach Road and go south towards Gerroa. At the crest of the last hill before the descent, the road cutting has yielded, from weathered latite, excellent specimens of amethyst, quartz crystal, and onyx. The descent to the Crooked River shows the Blow Hole Flow and Westley Park Sandstone, both extensively weathered. In the distance, Berry Mountain may be seen. It is a prominent outlier of the Hawkesbury Sandstone.

The Crooked River entrance Gerroa March 1963

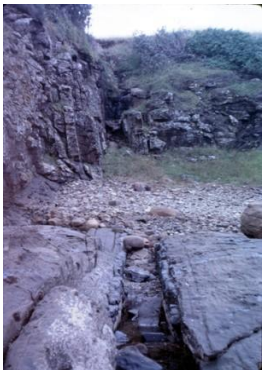
Stop 10. Gerroa is renowned as a collecting area for Permian marine fossils, some of which are found nowhere else. It must be remembered that all fossils are irreplaceable and should only be removed for legitimate purposes. Unusual or perfect specimens ought to be made available to universities and museums for study and preservation.

Most of the features to be seen here are similar to those described elsewhere. The map locates points of interest.

An old sea cliff may be seen at A and is a relic of the days before Seven Mile Beach cut off the bay behind it. The tuff displays spheroidal weathering on a grand scale. On the hillside numerous small nodules of agate and occasional quartz crystals are scattered, evidently weathered out of the rock above.

Spheroidal weathering in the Westley Park Sandstone at Gerroa August 1963

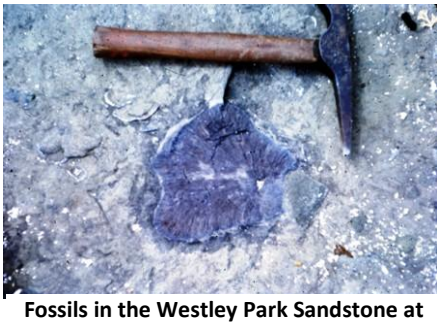
The dyke at B is particularly clear, although most of the igneous rock has been eroded. The close jointing in the surrounding tuff and the baked zone adjoining the dyke are obvious.



Dyke cutting through the Westley Park Sandstone at Gerroa March 1963

The rock platform at Gerroa March 1963

Fossils are abundant from this point on, both in the solid rock and in loose pieces. At C an aboriginal shell heap is seen. Another dyke, less obvious than the previous one, is seen at D. The same dyke is exposed at E, on the other side of Black Head. At this second exposure, masses of white calcite near the dyke probably represent fossiliferous material which has dissolved and recrystallised.



Fossils in the Westley Park Sandstone at Gerroa March 1963

Black Head (F) is an extensive area of tuff forming a prominent rock platform. There are examples here of fossil polyzoan colonies which are unique. They should not be disturbed. In places the rock is highly tuffaceous and crystals of augite up to ¼ inch in length are scattered through it.

Wave-cut rock platform at Gerroa March 1963

At G, a storm beach composed of large blocks or rock has yielded fine specimens of fossil brachiopods. Note also the notch at the base of the cliff formed by wave action at an earlier period of higher sea level.

Excursion 2b

Gerringong- Berry (17 miles)

This excursion deals mainly with the stratigraphy of the Berry Formation and the effects of differing lithology on landforms and soil fertility.

Route: Prince's Highway from Gerringong to Berry, with diversions to Toolijooa and Foxground.

Gerringong is close to the former centre of Permian volcanic activity. On this excursion, the flows are seen to become thinner and finally vanish while the tuffaceous sediments merge to become one unit, the Broughton Sandstone.

Stop 1. In the road cutting opposite Gerringong station, the Kiama Sandstone is well exposed. It is much the same as the outcrops seen at Kiama and Bombo, but with a higher proportion of pebbles.

Proceed towards Berry. Outcrops of Kiama Sandstone are seen for the next two miles, at which point turn left and go to Toolijooa station.

Stop 2. The Blow Hole Flow is exposed in the railway cutting. The rock is similar to that seen elsewhere and associated with it are masses of agglomerate. This contains black and white calcite, which displays a yellow fluorescence under the influence of ultraviolet rays.

Return to the highway and continue towards Berry. The road ascends Foxground Hill, where the Bumbo Flow is seen towards the top. Stop just beyond the hill, where the Foxground road branches to the right (1 ½ miles from the Toolijooa corner).

Stop 3. This small quarry exposes a coarse tuff, part of the Kiama Sandstone. On the slope above are many boulders of latite. The mountain rising beyond this is Curry's Hill, which is topped by an outlier of the Cambewarra Flow and the Coal Measures.

From here, the road into Foxground extends about 2 ½ miles. The scenery is very fine and the geology comparatively simple. The valley occupies a syncline in which the Kiama Sandstone is exposed at the southern end and the Bumbo Flow at the northern.

Broughton Creek, which drains the valley, carries a little alluvial gold in addition to the quartz minerals common in this area.

Proceed towards Berry. Broughton Creek carries a variety of rock types, similar to those seen at Foxground. Various road cuttings towards Berry expose weathered tuff and the Bumbo Flow, which becomes thin and patchy in this direction. The soil also deteriorates as the tuffaceous nature of the Broughton Sandstone becomes less dominant. A quarry on the left, 3 ½ miles from Broughton Creek, exposes siltstone of the Berry Formation.

Stop 4. The siltstone is quite weathered and contains little of interest other than a few poorly preserved fossils. It is fairly typical of much of the Berry Formation.

Continue towards Berry. Stop at a roadside rest area on the right ½ mile further on.

Stop 5. A normal fault cuts the siltstone in the road cutting. Its displacement seems to be about 20 feet, south side up. The view to the west shows the Cambewarra Range with Berry Mountain standing out.

Excursion 2c

Kiama-Robertson-Fitzroy Falls (52 miles)

The stratigraphy of the Permian and Triassic sequence is seen most completely on this excursion. Younger volcanic rocks of Tertiary age are also prominent and there are good examples of erosion by waterfalls.

Route: Kiama-Saddleback Mountain–Jamberoo–Minnamurra Falls–Jamberoo Pass–Barren Grounds-Carrington Falls-Robertson-Belmore Falls-Fitzroy Falls

From the harbour at Kiama, go south along the highway for ½ mile before turning right into Barney Street. Outcrops of pink Kiama Sandstone and a disused quarry in the Bumbo Flow are soon seen on the left and may be examined. Outcrops of the Bumbo Flow occur sporadically for the next 3 miles as the road ascends. After this the Jamberoo Sandstone becomes evident and the Saddleback Flow just before the final steep ascent.

Saddleback Mountain from Gerringong March 1963

The road then climbs steeply for 350 feet. Sediments of the Illawarra Coal Measures are seen at first, followed by the Bong Bong Basalt, which displays prominent columnar joints. This section is best examined by walking back from the summit.

Stop 1. Saddleback Mountain (elevation 1750 feet) is an intrusion of supposedly Tertiary age and probably represents the core of an extinct volcano. At the summit, volcanic agglomerate may be seen, surrounded by the basalt already seen in the road cutting.

The view from Saddleback Mountain August 1966

There are excellent views in all directions. In the west, Bong Bong Mountain forms the end of the Barren Grounds, capped by Hawkesbury Sandstone. The northern view is often marred by smoke from the Port Kembla industrial complex, but on a clear day the coast is visible from Kiama to Cronulla. Immediately below the mountain lies Werri Beach. The southern view is the most interesting in terms of the area covered by this book. The valley below is Foxground, through which Broughton Creek winds to the Shoalhaven River beyond. Along the coast may be seen in order: Seven Mile Beach, Coolangatta, Shoalhaven Heads, Crookhaven Heads, Lake Wollumboola, Culburra, Jervis Bay and the Beecroft Peninsula. Beyond this, landmarks are less distinct, but the prominent mountains on the horizon are, from the east, Durras, Boyne, Little Forest, Pigeon House, Talaterang and Tianjara. In the middle distance lies Nowra Hill and a vast expanse of bush beyond.

Return towards Kiama, turning left for Jamberoo at the bottom of the first steep hill. The road descends through the Cambewarra and Saddleback flows at first, then through the Jamberoo Sandstone and Bumbo Flow, as seen in the ascent on the Kiama side. Turn left at the Jamberoo road, pass through Jamberoo and proceed to Minnamurra Falls.

Stop 2. The rain forest here contains many unusual species not normally seen this far south and is worth visiting for this reason alone. Information concerning the flora and fauna may be obtained at the reserve.

From the Hawkesbury Sandstone cliffs down, the rock types here are the Narrabeen Group, Illawarra Coal Measures, Minumurra Flow, Cambewarra Flow and the Jamberoo Sandstone. The sandstone, which is fossiliferous, outcrops in the creek bed behind the kiosk. Upstream, the lower falls have formed by the weathering out of a dyke which intrudes the Cambewarra Flow. The upper falls have formed where a sill of nepheline syenite has intruded the Coal Measures, the sill being more resistant than the sediments.

Minnamurra Falls January 1953

An interesting variety of rock types may be found in the creek. Coal is fairly common, and the igneous rocks contain colourful zeolite minerals.

Return on the Jamberoo road and turn right towards Robertson (Jamberoo Pass). At the foot of the mountain, outcrops of the Kiama Sandstone may be seen. The ascent of 1,600 feet reveals few good outcrops, but weathered coal seams are visible towards the top and may be examined.

Turn left to the Barren Grounds Faunal Reserve just beyond a small creek 3 miles from the bottom of the mountain.

Stop 3. The Reserve, which has an area of 4,390 acres, was first gazetted in 1956 and is part of a vital system of reserves aiming to retain all types of habitats and the varied life found in them. It is largely composed of heath and swampy land, bounded by cliffs of sandstone with rain forest on the slopes below.

At the Visitor Centre, a map of the area indicates points of interest. No-one should miss the fine views of the coastal plain from Illawarra Lookout. The Griffith Trail leads to Wonga Falls, at the head of Broger's Creek, and from here a track leads to the Drawing Room (4 miles) and down to Woodhill Gap (see Excursion 4a).

From Wonga Falls the trail crosses the heart of the reserve, reaching its highest point at Barren Grounds trig. station (2,182 feet). The left branch leads back to the Visitor Centre while the right, following Surveyor Hoddle's 1830 route, leads to Bong Bong Mountain and eventually to Saddleback.

Return to the Robertson road. Red shales of the Narrabeen Group may be examined on the right about 300 yards further on. These sediments, of Triassic age, are widely distributed through the Sydney Basin and are thought to represent volcanic debris redeposited by running water. Some plant fossils may be found here. One mile further on the Hawkesbury Sandstone may be examined. A short climb to the cliff edge will be rewarded by a fine view of the coast. Knight's Hill, with its TV masts, is an outlier of the Wianamatta Group, mainly shale, overlain by Tertiary basalt.

The gorge at Carrington Falls March 1973

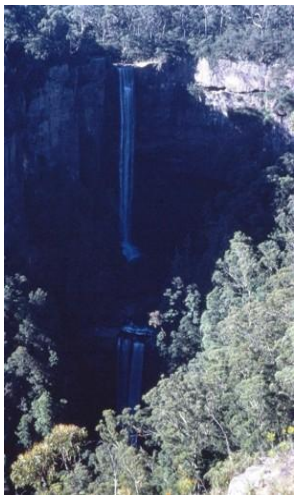
Turn left to Carrington Falls, 500 yards past the Kangaroo River.

Stop 4. These falls mark the limit to which the Kangaroo River has removed the Hawkesbury Sandstone. The valley is very narrow at this point, a reminder that the width of a valley is often a measure of its age, rather than the erosive capacity of its major stream.

Potholes and pools in the sandstone bed of the river have yielded small sapphires, zircons and occasionally diamonds. Their origin is obscure, but is probably related to similar deposits near the head of the Nepean River, about 12 miles away, and the Wingecarribee River near Berrima. They are perhaps relics of a former river system which flowed to the sea across this country before it was uplifted.

Unconformity – Basalt on the Wianamatta Group near Robertson March 1973

Return to the main road. Pass through Robertson and turn left onto the Belmore Falls road. Most of the higher country is underlain by basalt and the rich soil derived from it is responsible for the high productivity of the area. The basalt has protected shales of the Wianamatta Group from erosion, as at Knight's Hill, but outcrops are usually poor. Good plant fossils have been found in some.



Belmore Falls February 1967

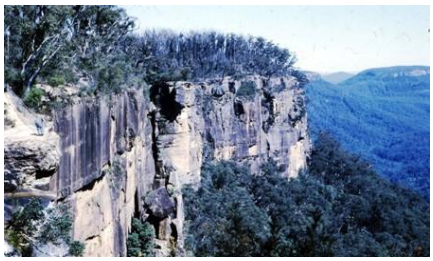
Turn left to Hindmarsh's Lookout, 5 miles from Robertson.

Stop 5. Belmore Falls represents the head of erosion of Barrengarry Creek. The valley below is deeper than that at Carrington falls, there being outcrops of the Narrabeen Group, Coal Measures and Berry Formation immediately below the falls.

Fitzroy Falls April 1960

Proceed to Fitzroy Falls.

Stop 6. In Fitzroy Falls, Yarrunga Creek has produced the highest fall in the district. The erosion, as at Belmore and Carrington, is headward. Paths lead to lookouts on both sides of the gorge and the descent to the bottom shows interesting outcrops of Coal Measure sediments. The view down the valley is partly blocked by an outlier of sandstone (Mt. Carrioloo).



The Hawkesbury Sandstone at Fitzroy Falls November 1967

Mt. Scanzi may be seen to the left of it in distance. See Excursion 4d, Stop 3.

Questions

1. Discuss the coastal topography formed from different members of the Berry Formation.
2. Why was Kiama developed on its particular site?
3. Give an account of the different types of igneous rocks to be seen in the Kiama district.
4. What part has the Hawkesbury Sandstone played in the development of the landscape?
5. What evidence suggests that the Blow Hole Flow was of submarine origin?
6. Discuss the influence of dykes on the development of particular landforms.

Chapter 3: The Nowra District

Nowra is strategically built on the first flood-free site upstream on the south bank of the Shoalhaven River. It was not an important settlement until about 1880, when Terara was extensively flooded. Soon after, the coming of the railway and the construction of the present road bridge assured its development as a rural centre. Today, it is a rapidly growing town, with developing industry, tourism, and defence establishments.

Several factors dominate the geology of the area. The Nowra Sandstone has provided a resistant surface, broken only by the Shoalhaven River and a few of its tributaries. Where this sandstone has dipped below sea level at Nowra, an extensive flood plain has developed, the origin of which is of considerable interest and will be explained later.

Coolangatta Mountain is the only unusual feature in the area. It is really an outlying part of the Cambewarra Range, which it resembles geologically. It is a local tradition to consider it to be an extinct volcano, perhaps because of its shape and the volcanic rocks found near its summit.

Excursion 3a

Nowra-Shoalhaven Heads (30 miles return)

Much of this excursion is through alluvial country; otherwise siltstones of the Berry Formation are dominant.

Route: Nowra-Bomaderry-Bolong-Coolangatta-Shoalhaven Heads-Berry-Nowra

Take the Prince's Highway north from Nowra. Turn right along Bolong Road towards Shoalhaven Heads. The Nowra Sandstone, seen at the river, gives way to recent sediments along Bolong Road. Several modern factories are passed and the road approaches Coolangatta Mountain over miles of river flats. Broughton Creek was formerly used by small ships moving upstream to Berry. Just past the bridge (right hand branch) extensive quarries are seen on the left.

Stop 1. The Berry Formation siltstone seen here is very fresh and unweathered. Fossils however, are rare. The siltstone has been used as road metal and as a filling to prevent river bank erosion.

Proceed to Coolangatta. Much of this land is easily flooded. Old buildings, part of the original Berry estate, are seen after the road leaves the river. 'Coolangatta' was first settled by Alexander Berry in 1820. For many years the Berry family managed the estate, draining waterlogged meadows and clearing the slopes. The original homestead was destroyed some years ago but many interesting relics remain and may be inspected by arrangement with the owner.

Stop opposite the turnoff to Shoalhaven Heads.

Stop 2. Coolangatta Mountain (992 feet) may be climbed quite easily from this point, but permission must first be sought from the landowner. Siltstone and tuff of the Berry Formation compose the bulk of the mountain, with a small remnant of the Bumbo Flow at the summit. The view is extensive, but partly obscured by thick vegetation.

The view from Coolangatta Mountain December 1961

Proceed to Shoalhaven Heads. Turn left at the river bank.

Stop 3. In recent years, the river mouth has silted so much that the bar has become a beach closing the Heads completely. The water now takes the longer route via The Canal, entering the

sea at Crookhaven Heads (see Excursion 3b). Floodwaters now take longer to drain and this is a problem which must be resolved before very serious flooding occurs.

Return to Coolangatta and turn right towards Berry. The few outcrops along this road are all of Berry Formation siltstone. The extensive swamps on the coastal side are due to the sand hills behind Seven Mile Beach preventing normal drainage. The hill behind Farmeadow is capped by an outlier of the Kiama Sandstone.

Turn left at the Prince's Highway. From here to Bomaderry, the underlying rocks are all Berry Formation siltstone. Six miles from Berry and 500 yards past Wiley's Creek, some river gravel is seen in a cutting on the right.

Stop 4. This represents the former course of a stream flowing from the Cambewarra Range. The gravel is typical of the present stream beds and may be the remnants of a former bed of Wiley's Creek. Boulders in nearby paddocks indicate more of its old course.

Return to Nowra. Stop at the park to the right of the bridge on the Bomaderry side.

Stop 5. These outcrops are typical of the Nowra Sandstone, which is most often a gritty, quartz sandstone with some cross bedding and layers of marine fossils. These may be found in the cliff face below the park and in the road cuttings towards Bomaderry Creek.

Excursion 3b

The Shoalhaven flood plain (30 miles)

Features of the flood plain and the development of the present system of distributaries are the main points to be studied on this excursion.

Route: Moss Street Nowra-Terara-Numbaa-Comerong Island-Numbaa-Brundee-Pyree-Greenwell Point-Nowra

Leave the Prince's Highway on the northern side of the shopping centre. Turn left and proceed towards Terara. Stop at the High School on the right. The school has a permanent display of local rock specimens and geological maps. Permission should be sought from the Principal if you wish to view these.

Stop 1. The school grounds, or the hill behind, allow good views of the flood plain and these will assist in explaining its origin.

Nowra High School during a flood June 1964

On the northern or river side, a small levee bank, on which building development is taking place, flanks the river. It appears to be above the present flood level. From the bridge at Nowra, the river leaves its meandering course and flows almost straight to the sea at Shoalhaven Heads. It would appear that, during the Quaternary Ice Age, the sea level fell on a world-wide scale by up to 400 feet. This allowed many streams to incise themselves into valleys that are now below sea level. The Shoalhaven was apparently confined in a sandstone gorge, the partly submerged remains of which are visible above the bridge. When the sea level rose towards its present level, the valley was drowned. Evidently the sea level, only 10,000 years ago, exceeded its present level by 10 feet or more and all of the plain east of Nowra was submerged. The former valley was gradually filled with sediment and when the sea dropped to its present level, the river took a

more direct route to the sea. The filled valley became the site of a series of lagoons, now mainly swamps.

Evidence for these hypotheses has come from wells and borings which have brought up shells and estuarine sediments from beneath the plain. At least 200 feet of sediment lies on the bed of the river at Nowra. Similar histories could be written for Port Jackson and Botany Bay.

Proceed towards Comerong Island. Note the flood drain from Worrigee Swamp. Terara and Numbaa are only small communities today, but were prosperous in the early days before severe flooding compelled their partial abandonment.

The Shoalhaven River near Numbaa August 1963

Stop 2. The Canal began as a trench dug in 1821 by Berry's convicts. Its purpose was to provide a safe entry into the Shoalhaven River by way of the Crookhaven River. Today, the river uses this route in preference to its former course and has greatly enlarged the Canal. This is causing serious problems in flood prevention and bank erosion.

Comerong Island, across the Canal, has a long ocean frontage which is really an extension of Seven Mile Beach. Much of the island is unsuitable for dairying because of the high salt content of the soil.

Return towards Nowra and turn left at Jindy Andy Lane (2 ½ miles from the Canal). Turn left again when the Greenwell Point road is reached. Flood drains in this vicinity have turned up thousands of estuarine shells; the whole area is barely above sea level.

Continue to Greenwell Point.

Stop 3. The Greenwell Point 'island' is one of a number of hills rising above the flood plain. A bore put down during an oil search penetrated 390 feet of silty sediments, perhaps the lower part of the Berry Formation as seen at Coolangatta. Occasional marine fossils are found here in surface exposures. From Greenwell Point, several other 'islands' of sedimentary rock may be seen nearby. Their presence here seems to be related to the fact that the Permian sediments have been uplifted by a broad anticline extending from Point Perpendicular.

Return towards Nowra, but turn left at Jindy Andy Lane. Stop at Crookhaven Creek, 400 yards further on.

Stop 4. Salt water extends 8 miles from Greenwell Point to these flood gates. Upstream an occasional mangrove struggling for survival shows that, in historic time, tidal water penetrated inland at least another 3 miles – possibly into Worrigee Swamp.

Worrigee Swamp during a flood June 1964

Continue towards Nowra. Three miles further on, at Worrigee, a group of houses and an old quarry are seen on the right.

Stop 5. A dolerite dyke is exposed here and was formerly quarried for use as road metal. It has a north-south strike in contrast to the east-west strike of most known South Coast dykes.

The road on the left just past the quarry leads to a council shale quarry, where occasional marine fossils may be found.

Excursion 3c

Crookhaven Heads, Culburra and Calalla (41 miles)

Isolated coastal outcrops of fossiliferous siltstone provide good localities to study representative Permian marine fossils.

Route: Nowra-Pyree-Crookhaven Heads-Culburra-Calalla Point-Forest Road-South Nowra-Nowra

Take the Greenwell Point road and turn right at Pyree. The road crosses Crookhaven Creek and then the flood gates at the Saltwater Swamp, an area still of little agricultural use because of its high salt content.

Go straight to Crookhaven Heads and stop to the right of the Pilot Station. Walk through to the beach.

Stop 1. The sediments exposed here are miles from the nearest rocks of known age, at Coolangatta or Currarong. They are considered by most geologists to belong to the Wandrawandian Siltstone. Although fossils are not abundant, there are a number of other points of interest.

An anticline, with its axis at right angles to the coast, buckles the strata just north of the beach. The siltstone here includes numerous erratic blocks of metamorphic rocks. Some of these have been found to be grooved on the underside in a similar fashion to pebbles found in present day glaciers where the grooving is caused by the pebbles being ground against the rock beneath the ice. This has been taken as good evidence in favour of the 'iceberg theory', which concludes that the Permian sea was cold and in the neighbourhood of glaciated mountains.

The beds also contain glendonites – peculiar crystalline structures up to 2 inches long. These are composed mainly of calcite, but were apparently formed from other minerals which crystallised in the icy bottom mud of the Permian sea. They have been replaced more recently by calcite, which was possibly derived from neighbouring fossils.

Weathered dyke at Crookhaven Heads June 1963

A weathered out dyke has produced a large channel a little further along the platform. The many pebbles found here are derived mainly from within the sandstone beds. The rock platform may be followed right around the headland and back to the road.

Return to Culburra. Park out on Wheeler's Point and descend onto the rock platform on the northern side.

Stop 2. The strata here strongly resemble those at Crookhaven Heads, being composed of a sandstone bed overlying siltstone, the whole being mapped as part of the Wandrawandian Siltstone. Fossils are quite common, and are frequently associated with large 'cannonball' concretions. These unusual structures seem to be the result of minerals in the sediment recrystallising

Nowra High School teachers at Wheeler's Point Culburra June 1963

around a nucleus, frequently a fossil. At the tip of the headland, the dip increases sharply, perhaps because of a fault just off the coast.

Lake Wollumboola, south of Culburra, is typical of many coastal lagoons, being the result of a rise in sea level followed by sand deposition across the inlet so formed. The lake shores show evidence that there has been, more recently, a slight fall in sea level.

Return on the Nowra road and turn left towards Currarong before the road descends to the flood plain. At the cross roads further on, go straight ahead to Calalla Bay. The traces of former roads in the bush are the remains of a grandiose subdivision called 'Jervis City' which failed many years ago.

Stop 3. At Calalla Point there are typical outcrops of Wandrawandian Siltstone. The rock is fine grained with a fair assortment of rounded pebbles and some large erratic blocks. Fossils tend to be grouped together, as at Culburra, but most are found as soft casts, as little calcite remains. At the southern end of the rock platform, where Calalla Creek enters Jervis bay, an aboriginal midden is found.

Return to the Currarong road and turn left towards the Prince's Highway. About 1 ½ miles further on, a small quarry may be seen on the right where the road passes through a low cutting.

Stop 4. Here the siltstone is intruded by a dyke of porphyritic dolerite. There are many such intrusions throughout the Currumbene State Forest. This particular dyke is quite weathered and cannot be traced for any great distance. A few fossils may be found in the siltstone, which has been altered to hornfels near the edge of the dyke.

Continue towards Nowra. This area has proved difficult to interpret geologically, for there are only scattered outcrops. It would appear that the Nowra Sandstone has lost its identity by gradually becoming more silty. Faulting also seems to have occurred, but its extent is uncertain.

There are several distinct vegetation changes along the road, from scrubby sandstone types to spotted gum forest. While this is due to a change in the underlying rock type, it is difficult to interpret precisely.

Turn right at the highway and return to Nowra (see Excursion 3e).

Excursion 3d

Bomaderry Creek and the Good Dog Intrusion (15 miles)

This excursion includes the Good Dog Lamprophyre intrusion and a number of interesting features within the catchment of Bomaderry Creek.

Route: Nowra-Moss Vale Road-Cambewarra-North Nowra-Nowra.

Proceed through Bomaderry and along the Moss Vale road. Stop at the bottom of the first hill, where Bomaderry Creek is seen on the left.

Stop 1. The creek gravel contains a lot of red jasper in addition to the normal rock types derived from the Cambewarra Range. Downstream, the creek enters a picturesque gorge cut into the Nowra Sandstone, emerging as a tidal stream ½ mile upstream of the bridge on the highway.

Examine the geological map of Bomaderry. It would appear that folding in the Pleistocene epoch deflected the stream southwards and the gradual uplift of the land entrenched the meandering stream into its gorge.

Continue towards Cambewarra and 400 yards further on turn right into Bell's Lane. Follow this to the most distant farm on the lower slopes of the mountains. Seek the landowner's permission before continuing on foot.

Stop 2. The Good Dog intrusion is the largest of at least 30 lamprophyre bodies intruding the Permian sediments on the Cambewarra Range. It has a roughly circular form and may be a volcanic neck of Triassic or Jurassic age. The rocks are all characterised by a high percentage of well crystallised ferromagnesian minerals – hornblende, biotite and augite, in that order – set in a greyish groundmass of intermediate composition.

The lower slopes of the mountain are strewn with boulders of these peculiar rock types, while the actual outcrop is obscured by the dense vegetation above. The best place to examine the rock is in the creek behind the farm, the bed of which is full of lamprophyre boulders.

Return to the Moss Vale road and continue towards the Cambewarra Range. Turn left (Barfield Road) just beyond the first road cutting on the mountain. Turn right after ½ mile into Tannery Road and follow it until the road descends to Good Dog Creek near the reservoir.

Stop 3. By following Good Dog Creek downstream for 200 yards, two small dykes and a sill can be seen intruding dark Berry Formation siltstone. Upstream, there are extensive gravel banks, in which blocks of shale and tuff containing marine fossils are quite common.

Return to Cambewarra by following Tannery Road back to the bitumen. Follow Hockey's Lane, directly opposite, until the ford on Tapitallee Creek is reached.

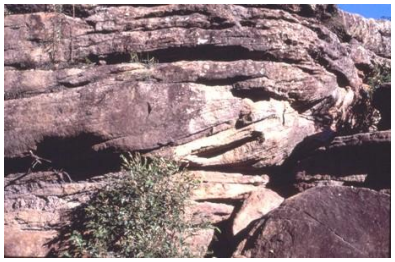
Stop 4. This creek, the main tributary of Bomaderry Creek, carries the same type of gravel as the latter. The bed of the stream has frequently changed over the years and there are terraces, swamps, and stranded gravel deposits to illustrate this.

Continue to Illaroo Road (bitumen), turn left and proceed towards Nowra for 1 mile. Turn right near the water tower and continue along this road until a cross road (McMahon's Road) is reached (¾ mile). Turn right, then left after ½ mile. This road leads down to the river at Humbug Reach, where permission to enter must be sought from the landowner.

Stop 5. The river takes a sharp bend, turning back on itself and leaving only a narrow neck of land across the meander. In flood, the river uses this as an alternative route, but because of the tidal nature of the stream at this point, it is not likely to adopt this course permanently.

Return along McMahon's Road to Nowra, turning right at Illaroo Road. A fine view of the river may be seen from near the power line. Turn right to the golf links, a short distance from the Prince's Highway.

Stop 6. A good section of the Nowra Sandstone is seen here and may be studied in detail. It is practically complete; the Wandrawandian Siltstone, although not visible, would outcrop behind the golf links. Note the cross bedding and the steeply dipping joints.



The Nowra Sandstone at the Golf Links April 1969

Excursion 3e

Nowra Hill and Falls Creek (17 miles return)

This short excursion covers a wide range of stratigraphic and erosional features, and is probably the most profitable of all the excursions based on Nowra.

Route: Nowra Showground-South Nowra-Falls Creek-Nowra Hill-Nowra

Stop 1. The Showground is situated at the top end of Junction Street, beyond the shops and the Council Chambers. At the Hanging Rock (now fenced in to avoid accidents) a fine view of the drowned river valley may be had. Other points of interest include the Nowra Sandstone (similar to the golf links outcrop), the levee on the left bank of the river, and the dip slope of the sandstone on the opposite bank towards the bridge.

Nowra Creek, which enters the Shoalhaven on the left below the showground, is tidal for 1 mile upstream. Within this tidal part is an isolated group of mangrove trees, miles from their nearest neighbours. They may be relics of the days when the river was more saline than at present.

Proceed to the Prince's Highway and go south as far as the brickworks, on the right through South Nowra. Obtain permission before entering.

Stop 2. The brick pit is in black siltstone of the Berry Formation, and the deep soil formed from this rock type is clearly visible. Solid unweathered siltstone is found only in the deepest part of the pit, at the water table. Above this level, the rock is considerably altered, at most to reddish clay.

Numerous crinoid stems and other rare fossils may be found here, but are mostly very weathered. The best place to look is in the quarry floor, where they are least altered.

There are several reverse faults in the face behind the pool and these may be traced to the opposite side. A small, very weathered dyke of vesicular basalt runs parallel to these faults, its course no doubt being influenced by their's.

Dyke cutting through the Berry Formation at South Nowra brick pit August 1967

Continue south to Falls Creek. At the Currumbene Creek bridge, Berry siltstone outcrops in road cuttings and in the creek bed, where there are numerous marine fossils. Stop on the left side of the highway between the school and the Parma Creek bridge. It is a short walk through the bush to the falls.

Stop 3. The falls owe their origin to a bed of siltstone within the Nowra Sandstone, which allows the rock above to be undercut permitting gradual retreat of the lip. The lower part of the Sandstone outcrops downstream, and 500 yards below the falls tidal water is reached.

The Falls at Falls Creek June 1963

The easiest descent is on the left side of the smaller fall, from the bottom of which the undercutting siltstone may be followed beneath both falls, and the rock ascended on the opposite side of the pool.

Behind the Falls at Falls Creek June 1963

There are numerous pot holes in the sandstone, both in the present bed and above it. If the water level is low, most of it will be seen to vanish into a prominent open joint, emerging a short distance away.

Potholes at Falls Creek February 1965

The sandstone here is typical of most outcrops. Few, if any, fossils occur and the most prominent feature is the number of small erratics of metamorphic rocks.

Currumbene Creek below the Falls February 1965

Return towards Nowra. About 2 miles from Falls Creek take the road on the left leading to Nowra Hill and HMAS 'Albatross'. After 1 mile across level country the road ascends Nowra Hill. Outcrops of siltstone are seen from this point on. Park just beyond the highest point on the road, from where a track leads to the summit.

Stop 4. The view, especially if seen from the summit, is very extensive. Nowra Hill seems to be merely a residual of the Berry Formation, with no particular structural origin.

The view from Nowra Hill June 1963

Blocks of grey siltstone along the track past the gate are richly fossiliferous. Do not destroy these, since this only a small outcrop and of considerable interest. More fossils may be found in the nearby road cutting.

Continue through the Naval Air Station, and then turn right towards Nowra. The road descends after a short distance and few outcrops are seen from this point on.

Questions

1. Discuss the probable origin of the main features of the Shoalhaven River flood plain.
2. Describe the principle sedimentary structures observed in the Nowra Sandstone.
3. List geological reasons for the growth of Nowra at the expense of towns on the flood plain.
4. Give an account of the various structures observed in the brick pit at South Nowra.

Fifth Form Nowra High School Geology Excursion July 1966

Chapter 4: The Cambewarra Range

Cambewarra Lookout is renowned for its superb views of the rich dairying country below. The aboriginal word 'Cambewarra' is believed to mean 'smoke coming from mountain'. Many people have therefore assumed that the mountain on which the lookout is situated is an extinct volcano, and its shape seems to support this belief. In fact, this shape is due to a small capping of sandstone, this having preserved the mountain's flat top. The word probably refers to the fact that mist frequently pours over gaps in the range from Kangaroo Valley, giving the impression of smoke. Also contrary to common belief, the lookout is actually situated on Good Dog Mountain; Cambewarra Mountain is south of the Moss Vale road.

When viewed from below, these mountains give an appearance of solidity and permanence, but from their summits they appear in their true light – a remnant of the Robertson Plateau cut off from it by the broad sweep of Kangaroo Valley. In places the crest of the range is more than two miles across, narrowing to only a few yards in others. The geology of the range is very similar to that seen further north at Kiama and the Barren Grounds. The backbone of the whole mass is its capping of Hawkesbury Sandstone, the top of which lies at an altitude of about 2,000 feet throughout. The highest points lie on Cambewarra Mountain (2,050 feet).

Erosion has removed much of this capping, and sizable residuals of it are found only at Broughton Head (Berry Mountain), Kangaroo Mountain, Cambewarra Mountain and Mt Scanzi, with several smaller ones. The gaps between these residuals provide access into Kangaroo Valley, and roads enter the valley through four of them. It is impossible to consider the geology of the Cambewarra Range without reference to Kangaroo Valley, and much of the information outlined below should be referred to when considering that district.

Beneath the Hawkesbury Sandstone lie the Illawarra Coal Measures. The Shoalhaven region lay near the southern end of the Sydney Basin when the Coal Measures were deposited and they thicken from south to north – from 40 feet at Cambewarra Mountain to 500 feet at Woodhill. Minable coal is not present, but inferior coal and outcrops of lithic sandstone and reddish shale are common.

Most of the range is carved out of the Berry Formation. This includes a considerable thickness of volcanic rocks, which are considered in detail in Chapter 2.

From top to bottom, the Berry Formation is subdivided in this area as follows:

Cambewarra Flow	500 feet}	Gerringong
Broughton Sandstone	500 feet}	Volcanics
Berry Siltstone	800 feet	

This comparatively simple arrangement is complicated by the fact that the volcanic nature of the Formation increases from south to north, towards the Kiama district. Thus, at Woodhill, at least two other flows occur, while south of Good Dog Mountain the name Budgong Sandstone replaces the Broughton Sandstone as its volcanic fraction ceases to be dominant.

Beneath the Berry Formation lie older sediments of the Shoalhaven Group. These are only seen in lower Kangaroo Valley and Budgong Creek.

Excursion 4a

Berry-Woodhill (17 miles return)

This excursion shows the following features:

The stratigraphy of the Berry Formation and Illawarra Coal Measures

Permian marine and nonmarine fossils

Coastal landforms and a young deep V-shaped valley.

Route: Berry-Broughton Vale Road-Broughton Vale and return-Woodhill Gap-upper Broger's Creek-Berry

The Broughton Vale road leaves the Prince's Highway at Broughton Mill Creek. For the first mile, the road crosses recent alluvial deposits. Both Broughton Creek and Broughton Mill Creek are subject to extensive flooding. Tidal influence extends up the creeks almost as far as the highway, below which are broad flats criss-crossed by flood drains.

Turn right for Broughton Vale 1 ½ miles from the highway and proceed to Broughton Mill Creek.

Stop 1. The creek carries gravel which gives a fair indication of the rock types found upstream. Such types as vesicular and porphyritic latite, coal, tuff and sandstone are common. Careful search will also turn up pieces of agate, jasper, and petrified wood. The rock outcrops on the hill nearby are of the Broughton Sandstone. The view to the north shows clearly sandstone cliffs of Triassic and Permian age.

Return to the Woodhill road and turn right towards the range.

Stop 2. Weathered siltstone of the Berry Formation is seen in cuttings on the left of the road one mile further on. Bedding planes and vertical joints are prominent.

Stop 3. Outcrops of Broughton Sandstone are frequent in road cuttings on the right. Spheroidal weathering is very obvious, while fossils to be found include small molluscs, brachiopods and fragments of polyzoa.

The view to the south is excellent. Immediately behind Nowra looms Nowra Hill, while Coolangatta is clearly seen against the sea to the east. In the far south, the characteristic flat top of Tianjara and the top of the Pigeon House are visible.

Stop 4. A roadside quarry on the right is cut into pink tuff, here equivalent to the Jamberoo Sandstone. It is somewhat weathered and contains numerous pebbles of igneous rocks. Few marine fossils are to be seen, but traces of plant fossils are found high in the quarry. Evidently the transition from marine to non marine conditions was very gradual and did not coincide with the close of volcanic activity. The fact that occasional marine fossils are found even above the Cambewarra Flow suggests that the sea periodically returned before retreating finally when Coal Measures sedimentation began. For this reason, the top of the Cambewarra Flow is taken to be the top of the Shoalhaven Group, since it marks a precise instant in time.

Boulders of igneous rock found in this quarry are derived from the overlying flow.

The line of boulders which can be seen on the southern side of the road, at a slightly lower level, represents the diminished outcrop of the Bumbo Flow. This is not readily seen where it crosses the road.

The steep climb which follows is best examined on the return trip. Cuttings on the right show good exposures of the Cambewarra Flow, the top of which is seen just below the concrete supports.

Stop 5. About 400 yards from the crest of the hill, tuffaceous Coal Measures sediments are exposed on the left. Some fine pieces of chalcedony and greenish chert may be found here and in the creeks below.

Stop 6. Woodhill Gap, with an altitude of 1,170 feet, is the lowest part of the Cambewarra Range and the lowest point on the coastal ranges between Stanwell Park and Nowra. It has provided access to Kangaroo Valley since 1820, but has never been well used because of the steep and difficult descent on the western side.

Note the steeply dipping strata at the road junction – this is due to slumping of the rock down the slope rather than any tectonic process. Climb the steep slope on the southwest (high) side of the road. The eroded slope is strewn with boulders of petrified wood, some weighing more than 50 pounds. They owe their origin to the replacement by silica of the cells in wood buried in the tuffaceous sediments. Fragments of coal and fossiliferous shale may also be found. The extensive view includes the broad sweep of Seven Mile Beach, the deep valley of Broger's Creek, and the TV masts on Knight's Hill. If the track is followed up for ½ mile, the foot of Broughton Head will be reached. This is a very prominent outlier of Hawkesbury Sandstone, which can be scaled with difficulty. The igneous rock found here is the Kangaroo Mountain Basanite, part of a sill of basaltic rock squeezed in between the Coal Measures and the sandstone. Occasional masses of brown chalcedony weighing 2 or 3 pounds are found here.

Return to the road junction. The bitumen road leads down into Kangaroo Valley, and is described in Excursion 5c.

Diversion.

The gravel road ahead leads into upper Broger's Creek. The old building on the left formerly served as a school and church.

Just before the descent begins, a track on the right leads up to the Barren Ground. The sandstone at the top has eroded into weird shapes resembling tables and chairs and this locality is known as the Drawing Room (3 miles return). Basalt outcrops along this track are of the Bong Bong Sill.

Proceed up the road as far as conditions allow. Broger's Creek is incised 1,400 feet below the adjoining plateau. Tuff is the common rock outcropping, while coal fragments are often found in the creek. About 2 miles beyond the first ford, good outcrops of coal can be seen in the bed of the creek.

Broughton Head (Berry Mountain) from Broger's Creek May 1964

Return to Woodhill Gap.

Stop 7. The top of the Cambewarra Flow, seen just beyond the concrete roadside supports, is rather vesicular and includes glassy phenocrysts in a dark groundmass. The flow is often called a trachyte, rather than a latite, and is noticeably paler then the Bumbo and Blow Hole Flows.

If this section is walked as far as the quarry at Stop 4, it will be seen that the flow becomes darker and coarser towards the base. This due to the settling out of the denser ferromagnesian minerals during crystallisation.

The Cambewarra Flow is about 500 feet thick on Cambewarra Mountain; it extends from Budgong Valley to Jamberoo. It appears to have been a submarine flow and in some areas is represented only by a bed of boulders, attesting to the fact that it was subjected to immediate erosion. Marine fossils are sometimes found associated with this boulder horizon, which marks the close of marine sedimentation on the South Coast.

Excursion 4b

Nowra – Berry via Cambewarra Lookout (17 miles)

The rocks seen are similar to those seen on the previous excursion. In addition, a number of interesting small igneous intrusions are encountered.

Route: Nowra-Cambewarra Range-Bellawongarah-Berry.

Proceed to the Cambewarra Range via the Moss Vale road. Through Bomaderry, Permian marine sediments are seen and the road continues over undulating country to the foot of the range. See Excursion 3b.

Stop 1. In the first road cutting after the sign 'Cambewarra Mountain', two very weathered dykes may be seen intruding weathered Berry siltstone. Weathered mica is their main characteristic and this identifies them as related to the Good Dog intrusion. At least 14 similar dykes occur along this road and the next ½ mile should be walked to see them properly.

Stop 2. Cars can be parked on the left 400 yards past the previous stop. Several lamprophyre dykes occur in cuttings across the road (watch for traffic!).The less weathered ones contain fine crystals of hornblende. Boulders of similar rocks occur in adjacent paddocks. Marine fossils abound in some of the siltstones.

The view to the south is rewarding. One of the most remarkable features is the extent to which the lower boundary of the Berry Formation marks the edge of the cleared country. Soil derived from the Nowra Sandstone is much less fertile.

Stop 3. Just beyond a group of farm buildings on the left, comparatively unweathered tuff outcrops on the right. From here upwards, the soil is mainly derived from volcanic rocks and supports luxuriant rain forest.

Stop 4. The road reaches the crest of the range at an altitude of 1,600 feet, where outcrops of the Cambewarra Flow occur and may be examined. The views of Kangaroo Valley and the coastal plain are very fine. In the valley, the upper cliff is of Hawkesbury Sandstone and the lower of Budgong Sandstone.

Diversion. Take the rough road which ascends to the left of the lookout. This climbs steadily for 1 ½ miles until the top of Cambewarra Mountain is reached at an altitude of 2,000 feet. Near the top the change of soil as the Hawkesbury Sandstone is reached is very clear.

The highest point (1 mile further on, altitude 2,050 feet) is ablaze with wildflowers in spring. The valley on the left is upper Budgong Creek. Good specimens of agate may be found by walking down the valley for 1 mile, where the limit of Excursion 4c is reached.

If the road is followed further, outcrops of the Coal Measures will be seen after 3 miles and the road deteriorates after 5 miles when a damaged bridge makes a return to the Moss Vale road necessary.

Stop 5. Cambewarra Lookout is well known for its coastal panorama. Good Dog Mountain, on which the lookout is situated, is a small outlier of Hawkesbury Sandstone, outcrops of which are seen on the ascent. The lush vegetation around the mountain includes stinging trees and numerous ferns. See Excursion 5a for more information.

Sunrise at Cambewarra Lookout
November 1965

Take the road to Berry where the lookout road begins to ascend. At the junction, two very weathered dykes and weathered Coal Measures sediments are seen.

Stop 6. A disused quarry on the left 400 yards further on supplied road material. Outcrops of coal and weathered lithic sandstone are found in it. Perfect clay pseudomorphs after augite may be found on the surface to the left of the track leading into the quarry. Some of these form star shaped twin groups and they have evidently weathered out of a lamprophyre dyke.

About 100 yards after the quarry, two weathered dykes intersect the Coal Measures on the right.

Stop 7. As Kangaroo Mountain is approached 1 ½ miles further on, a track is seen leading off on the left. By way of this track, the mountain may be ascended. It is a narrow residual of sandstone, whose flat swampy top abounds in Christmas Bells in summer.

Beneath the mountain is the Kangaroo Mountain Sill. This is about 100 feet thick and is composed of basanite, a rock resembling basalt in hand specimens. Where the track leaves the Berry road, weathered basanite has formed red soil exposures, from which agate may be collected.

From this point on, the road skirts the edge of Kangaroo Mountain, with views of the coast below. Creeks draining from this area have yielded fine specimens of moss agate weighing up to 50 pounds. Associated with the agate are veins of pyrolusite and it is thought that both formed at the time when the Kangaroo Mountain Sill invaded the Coal Measures.

The descent to Berry repeats the stratigraphy observed previously. Good outcrops of the Cambewarra Flow are seen on the right and the view of Broughton Head is excellent.

Excursion 4c

Nowra – Brown's Mountain (14 miles return)

Good outcrops of the Budgong Sandstone are seen and jasper from the base of the Cambewarra Flow is common.

The Shoalhaven River from Illaroo Road April 1969

Route: Proceed along Illaroo Road after turning left on the northern side of the Shoalhaven River bridge. After 4 miles, take the branch leading to Brown's Mountain.

Stop 1. Tapitallee Creek carries down large quantities of jasper and some agate from the range above. The gravel is deficient in volcanic rocks, since the Cambewarra Flow

barely reached this far south.

Proceed towards Brown's Mountain. The entire climb may not be possible by vehicle due to landslides carrying away the road. Good marine fossils may be collected from freshly fallen blocks by the roadside. At higher levels, the Budgong Sandstone (equivalent to the Broughton Sandstone further north) is seen.

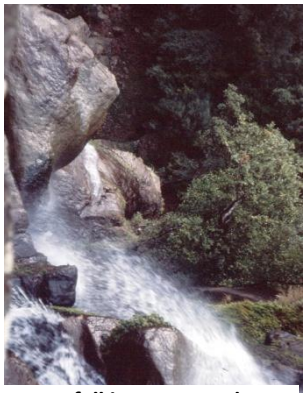
Nowra from Brown's Mountain June 1964

Stop 2. At a height of 1,250 feet, the road branches. The right branch, if followed for 2 ½ miles, leads to the Moss Vale road. Excellent golden jasper occurs along this track, apparently at the base of the Cambewarra Flow.

Proceed along the left branch. After 500 yards, an interesting waterfall on the left plunges into the valley over cliffs of Budgong Sandstone. About 500 yards further on, cleared country is entered. Jasper of all colours may be found along the track, which runs below the summit of Brown's Mountain on the right. The track to the left leads to the Budgong road.

The valley of Upper Budgong Creek June 1964

The ruined farm house is one of many in the hills around Nowra. Proceed through the bush behind the ruin, heading towards the valley visible through the trees. A tributary of Budgong Creek drops over a fine waterfall at a point where the Budgong Sandstone may be studied to advantage. Jasper and agate are found in the gravel of this and all other branches of Budgong Creek in this vicinity.



Waterfall in Upper Budgong Creek June 1964

The track may be followed for at least another mile and a climb of 700 feet from the next valley leads to the summit of the Cambewarra Range (Excursion 4b).

Return to Nowra by the same route.

Excursion 4d

Nowra – Budgong – Kangaroo Valley (20 miles)

Budgong Creek drains the south-west part of the Cambewarra Range, of which Mt Scanzi is the westernmost peak. The sediments seen on this excursion range from the Conjola Formation to the Hawkesbury Sandstone. Typical quartz minerals are common in Budgong Creek.

Route: Nowra-Illaroo Road-Tapitallee-Budgong-Mt Scanzi-Kangaroo Valley

Some parts of the road are in poor condition. In addition to the direct route, there are several diversions to places of interest.

Proceed as in Excursion 4c. After 4 miles, take the left branch towards Budgong. The road crosses Bengalee Creek, descending through the base of the Berry Formation at a level of 250 feet. Between this point and Kangaroo Valley, the road frequently runs close to this boundary, with uncleared Nowra Sandstone country on the left and cleared Berry Formation on the right.

At the first major fork (2 ½ miles from Illaroo Road), keep straight ahead. The left branch leads down to farms on the Shoalhaven River near Burrier. At the top of the hill immediately after the fork, a road to the right leads, after a very steep climb, to Brown's Mountain. About 1 ½ miles further on, a road to the left gives access to lower Budgong Creek.

Diversion 1. (7 miles return) At the road junction, the Nowra Sandstone is at a level of 650 feet and outcrops well in a creek. Some 300 yards downstream a fine view of the Shoalhaven River opens out. Turn left along this road just past the creek crossing. After 1 mile, the road descends sharply through the Nowra Sandstone, Wandrawandian Siltstone and Conjola Formation, which may be examined at convenient points. At Budgong Creek, good agate may be found. The track to the left near the creek leads down to the Shoalhaven River. A fine alluvial terrace skirts the river just above its junction with Budgong Creek. The river gravel consists principally of quartzite, rhyolite and granite. Devonian rocks outcrop on the opposite bank; the river (elevation 30 feet) is at the base of the Permian and therefore of the Sydney Basin sedimentary pile, but no clear unconformity is seen here.

Return to the Budgong road. About ¾ mile further on, a similar road on the left also leads down to Budgong Creek. Keep straight ahead for Mt Scanzi and Kangaroo Valley.

Stop 1. Budgong Creek is crossed after a rough descent through the Nowra Sandstone. The gravel should be examined for red and green jasper, agate, and petrified wood.

Continue for 1 mile. Fine views of the cliffs high above are seen. At a point near several old buildings on the left, the road to Kangaroo Valley turns to the right.

Diversion 2. The road ahead leads out through the Morton National Park to a point high above the junction of the Shoalhaven and Kangaroo Rivers (14 miles return). With care, the descent to the junction can be made on foot from the end of the road. The last 400 feet is very steep and shows fine exposures of Upper Devonian quartzite. The river is 100 feet above sea level at this point. The peculiar angle at which the Kangaroo River meets the main stream suggests that this is an example of river capture (see Chapter 1).

Return to the Budgong road and proceed towards Kangaroo Valley. After a steep climb of 600 feet, a gap in the range is reached.

Budgong Creek Valley from Mt Scanzi August 1966

Stop 2. Mt Scanzi is quite isolated from the rest of the Cambewarra Range. At the gap, fossiliferous Berry Formation siltstone outcrops, while, just above, the Budgong Sandstone outcrops prominently.

Diversion 3. Take the road to the left leading up the mountain. Mt Scanzi has an elevation of 2050 feet and is 2 miles west of the gap. If the road is impassable, the walk is very worthwhile.

Examine the sandstone in the cliffs alongside the road. It is a greenish tuffaceous sandstone, with occasional marine fossils. The volcanic fraction within this rock decreases westerly from the Gerringong Volcanic centre. The Cambewarra Flow is not found here; apparently it never reached this far.

Veer to the right at any forks in the road as the vegetation is much denser on the southern slopes, and the ascent more difficult. From here take the best route to the summit.

Stop 1. Scarcely an acre of Hawkesbury Sandstone survives as a tiny outlier. The name of the mountain commemorates a Polish immigrant whose epitaph is carved into the sandstone. From Budgong Trig. Station, the unsurpassed view takes in Kangaroo Valley, Mt Gibraltar, Fitzroy Falls, Currockbilly, Pigeon House, and Cambewarra Mountain.

Kangaroo Valley from near Mt Scanzi August 1966

Beneath the sandstone, fragments of carbonaceous shale indicate the presence of a small outlier of the Coal Measures.

Return to the Kangaroo Valley road. From the gap, the road improves and the descent reveals outcrops of the Berry Formation and Nowra Sandstone as expected.

Questions

1. In what way has the distribution of the Hawkesbury Sandstone affected access into Kangaroo Valley?
2. Show how the volcanic nature of the upper Berry Formation increases from Mt Scanzi to Woodhill.
3. Present evidence for at least two periods of igneous activity in the Cambewarra district.
4. Explain how the summit level of the Cambewarra Range is consistently around 2,000 feet while the Coal Measures increase in thickness in a northerly direction.
5. What is the probable source of the quartz minerals found in this area?
6. Which fossils are characteristic of (a) the Coal Measures, and (b) the Berry Formation?
7. Comment on the cliff forming ability of the various members of the Berry Formation.
8. Did the close of Permian volcanic activity correspond with the last deposition of marine sediments? Present evidence for and against.

The author at Budgong Trig Mt Scanzi October 1966

Chapter 5: Kangaroo Valley

The Cambewarra Range effectively seals in one of Australia's scenic gems – Kangaroo Valley. Like any other impressive piece of nature's handiwork, people have ascribed its origin to anything but the simplest of causes. Since 1818, when white men first entered the "Kangaroo Ground", as it was then known, there have been numerous suggestions to explain its existence. It has been described as a 'picturesque sunken valley', the implication being that its present form is the result of subsidence. Others have thought that it represents a former lake, or that volcanoes led to its formation. The truth is that the Kangaroo River and its tributaries have carried away the products of erosion over a period of many thousands of years, leaving the framework of the rock structure exposed as we see it today.

Volcanic rocks belonging to the upper Berry Formation are mainly confined to the eastern half of the valley and by their weathering have released the quartz minerals which are well know to most visitors. Being more resistant than other local rocks and minerals, these have accumulated in the river and streams, where they are eagerly sought today.

The story of the rocks themselves is the same as that outlined in the previous chapters. Their exposure in the valley is the result of uplift and erosion on a large scale. The Kangaroo River, like its neighbour the Wingecarribee to the north, flows to the west, away from the coast. In earlier times, before the present Shoalhaven gorge was carved, drainage probably continued to the west and into the upper Wollondilly River. However, streams draining to the east captured this part of the Wollondilly system incorporating it into the present Shoalhaven drainage basin.

Excursion 5a

Kangaroo River and Barrengarry (75 miles)

Most of the valley is included in this excursion. The rock types range from the Devonian basement up to the Hawkesbury Sandstone and special attention is paid to the occurrence of semi-precious stones.

Route: Cambewarra Lookout-Fitzroy Falls via Kangaroo Valley (with diversions to Yarrunga Creek and Upper Kangaroo River)

Stop 1. The view from Cambewarra Lookout shows the dependence of scenery on the underlying geology. Immediately below the lookout lie steep sandstone slopes and the forest clad outcrops of the Gerringong Volcanics. The cleared land is underlain either by Berry siltstones or alluvial deposits. Outcrops of sandstone near Bomaderry and Nowra show up by virtue of the bushland remaining uncleared in their vicinity. Most prominent of all are the swamps and watercourses of the lower Shoalhaven River, described in Chapter 3. Other features easily recognisable include Coolangatta Mountain, Nowra Hill, and Jervis Bay. It is worth the trouble trying to locate geological boundaries from a vantage point such as this. It is the next best thing to an aerial view.

Stop 2. (See Stop 4, Excursion 4b) In Kangaroo Valley, clearing has been largely confined to the Berry Formation below the Budgong Sandstone, which forms the lower line of cliffs. Across the valley in the distance lies the fertile Robertson district, where better soils derived from Wianamatta shales and Tertiary volcanics contrast with the poor sandstone soils seen on Cambewarra Mountain (to the left of this point).

Take the road into the Valley. Outcrops of the Cambewarra Flow are soon succeeded by red tuffs and dark siltstone. Good exposures are rare. Fragments of coal and pieces of petrified wood and

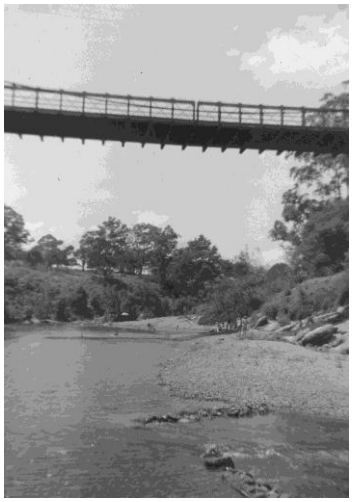
jasper may be found in any of the creeks draining from Cambewarra Mountain above the road. Excursion 5b begins at the Berry road, 3.7 miles from Stop 2. Nugent's Creek (4.7 miles) has yielded fine specimens of agate and jasper. Excursion 4b terminates at the Mt Scanzi road, just past Kangaroo Valley township. Stop at the Hampden Bridge over the Kangaroo River.

Stop 3. This bridge, opened in 1898, is the landmark of the Valley. It replaces an earlier wooden structure, rather like the one across Yarrunga Creek at Fitzroy Falls.

Hampden Bridge Kangaroo Valley January 1960

Just above this spot, the river enters a narrow sandstone gorge, which is spanned picturesquely by the suspension bridge. It must not be thought that the presence of such a gorge in the valley floor is the result of uplift and rejuvenation of the stream. It is merely the expression of the Nowra Sandstone at this point, whose cliff forming tendencies have prevented the widening of the valley. Similar gorges occur where the river intersects the other resistant strata in the sequence, notably the Hawkesbury and Budgong Sandstones, and the Conjola Formation.

The sandstone, while being similar to the Nowra Sandstone elsewhere, is not noticeably fossiliferous here, but a careful search may reveal some fossils. Most visitors are interested in finding specimens of petrified wood, jasper, and agate in the river gravel.



The Kangaroo River beneath Hampden Bridge January 1960

At such a popular picnic ground as this, the chance of finding good specimens is small, except after a flood when a fresh surface of gravel has been exposed. Other rock types found here include coal and the Cambewarra latite, brought down from further up the valley. Quartz minerals may be found all along the river, but permission should always be sought before entering private property. This area has been a hunting ground for such specimens for many years and good material is becoming scarce.

Continue towards Moss Vale. Diversions up and down the valley may be made to Bendeela and Upper Kangaroo River within half a mile of the bridge.

Diversion 1. Bendeela, Yarrunga Creek and Meryla Pass.

Turn left a short distance beyond Hampden Bridge. For 2 miles the road passes over sandstone and occasionally siltstone. Some 1.7 miles from the main road, a branch to the right continues along the level of the base of the Berry Formation for several miles. Fine views of the valley walls are to be had from this junction, Berry Mountain, Cambewarra and Mt Scanzi being prominent. Shortly after, the road passes down through the Nowra Sandstone into the Wandrawandian Siltstone. The Kangaroo River emerges from its gorge nearby and the road follows its meandering course for a further 4 miles before branching.

The right hand branch first ascends the side of the valley then descends to Yarrunga Creek, 12 miles from Hampden Bridge. Sandstone of the Conjola Formation outcrops here, but Devonian quartzite and conglomerate outcrop in the river bed 1 mile below the ford.

The Yarrunga Dam, part of the MWS&DB's Shoalhaven Scheme, will be built across the Kangaroo River downstream of its junction with Yarrunga Creek. It will be a 125 feet high

concrete gravity dam, with an associated underground pumping station designed to lift 600 million gallons of water a day through a height of 2,200 feet, for storage near Fitzroy Falls.

Beyond Yarrunga Creek, the road deteriorates and is probably untrafficable for most vehicles coming from this direction. It is approximately 7 miles to the top of Meryla Pass and the road passes through a fine section of strata right up to the Hawkesbury Sandstone. From the top, a road may be followed to Moss Vale; otherwise the route from Kangaroo Valley must be retraced.

View from the top of Meryla Pass towards Mt Scanzi June 1972

Diversion 2. Upper Kangaroo River.

Turn right ½ mile beyond Hampden Bridge. This road leads to farms scattered along the upper part of Kangaroo Valley and may be followed for 7 or more miles before a return journey must be made along the same route. The rocks exposed along the road are all siltstones of the Berry Formation while high above the road may be seen the continuous cliffs so typical of Kangaroo Valley. Most visitors are interested in collecting stones from the river gravel and this may be done with caution at many places.

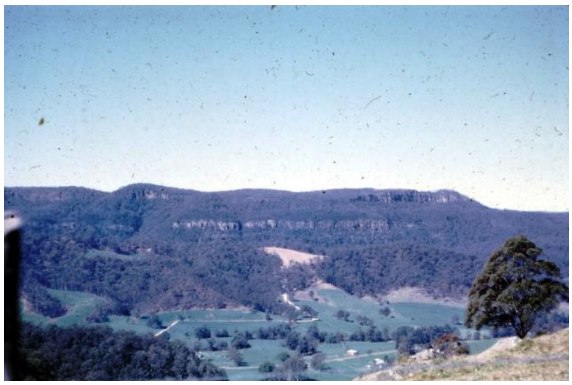
Kangaroo Valley April 1969

Barrengarry Creek is crossed soon after leaving the Moss Vale road. The gravel is deficient in volcanic rocks, since the flows of the Gerringong Volcanics barely reached into the area within its catchment. Otherwise, the fragments of coal, sandstone etc reveal that the geology is similar to that seen elsewhere in the valley.

Roadside quarries may be examined at points 1.4 and 4.4 miles past Barrengarry Creek. The rock is a typical siltstone, containing occasional marine fossils and displaying spheroidal weathering.

A road branching to the right 1.5 miles further on fords the river and then follows the valley of Geringong Creek for about 1 mile. The river and the creek here yield occasional specimens of agate, green and red jasper, and boulders of fossiliferous Budgong Sandstone, brought down from higher up.

The little community of Upper Kangaroo Valley is marked by its church, school, and hall. Beyond this point, the valley begins to narrow and farming land becomes more precipitous, although there are farms for more than 3 miles above Geringong Creek. Timber roads provide access to the higher slopes and some of these have been connected with roads leading south from Robertson, only a few miles away.



The Hawkesbury and Budgong Sandstones near Barrengarry November 1967

Return to the Moss Vale road and turn right towards Barrengarry Mountain. The ascent begins 2.6 miles further on. The first bend to the left reveals a typical exposure of Berry siltstone. About 1 mile further on, it is possible to park on the roadside at a sharp bend backed by a sandstone cliff.

Stop 4. This is the Budgong Sandstone and it is noticeably different from the Hawkesbury Sandstone

seen higher up. It will be recalled that it is the equivalent of the Broughton Sandstone, which is highly tuffaceous, in the eastern part of the valley. There is still a small tuffaceous element in this sandstone, but it has lessened considerably because of the distance from the Gerringong Volcanic centre.

There are few good outcrops higher up the mountain. Steeply dipping sandstone is seen at a sharp bend on the left 1.4 miles beyond Stop 4. This may be due to folding or faulting of the strata, or merely to the overturning of a large block of sandstone during erosion. The cause is not immediately apparent.

Turn right to Manning's Lookout, 8 miles from Hampden Bridge.

Barrengarry Creek from Manning's Lookout
June 1972

Stop 5. A clear view of the valley with its many geological features is seen from this lookout. The two sandstone cliff lines are clear enough. Notice how there has been less clearing on this side of the valley. The Berry Formation contains a much higher volcanic fraction on the eastern side, so the soils derived from it are more fertile.

The Hawkesbury Sandstone here is at the same level as at Good Dog Mountain. What a vast amount of rock has been carried away by erosion in between! Cross bedding, pebble beds, and prominent open joints may be examined here, just as they may in any similar outcrop.

Return to the Moss Vale road. A short distance towards Fitzroy Falls, a track on the left leads to the cliff top overlooking Yarrunga Creek.

Stop 6. The creek lies 1,400 feet below this point and the slope beneath is composed of all the rock types seen earlier on this excursion. It is a good place to stop and consider the impermanence of our scenery. How long will it take before this valley enlarges to the size of the one we have just left, and how long will it be before all of this is reduced to a plain? When we consider these questions it becomes clear that nature's own land-shaping forces are on a much grander scale than man's.

The Moss Vale road joins the Robertson road 1 mile further on, where Excursion 2c continues the narrative at Fitzroy Falls.

Excursion 5b

Broger's Creek (9 miles)

This is a delightful little valley similar to Kangaroo Valley, but on a smaller scale. Except in its lowest part, near the Kangaroo River junction, the rocks seen along the creek are tuffs of the Gerringong Volcanics. There is little of unusual geological interest, but the scenery is sufficient to make this excursion a must.

Route: Moss Vale road-Broger's Creek-Wattamolla-Woodhill, thence via Excursion 4a to Berry.

Turn right from the Moss Vale road at the 'Berry' signpost, 3.7 miles from the crest of the Cambewarra Range. Stop at Sawyer Creek, a short distance towards Berry.

Stop 1. The gravel of this creek contains the typical rock types derived from the Cambewarra Range. Quartz minerals are not common in this creek or any other tributary of Broger's Creek. It

seems as if their major source area lies between Kangaroo Mountain and Brown's Mountain, since beyond these limits even jasper is scarcely to be found.

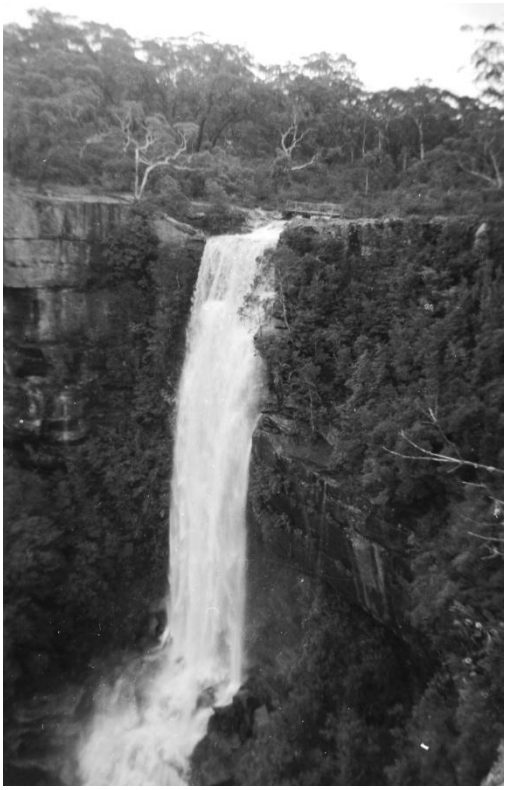
Just beyond the bridge, a road branches to the left, leading to Kangaroo River (2 miles).

One mile further on towards Berry, the road forks. The right branch climbs up the range and over to Berry via Bellawongarah, passing up through the Broughton Sandstone and the Cambewarra Flow before reaching the Coal Measures along the crest of the range. See Excursion 4b.

The left branch closely follows Broger's Creek for several miles, passing through tuffaceous units of the Berry Formation as far as Wattamolla. This little village, with its old church, cemetery, school and post office no longer in use, is typical of the small community centres of the nineteenth century and it is sad to see history being lost as these centres decay.

Beyond Wattamolla, the road ascends to Woodhill, skirting the back of Broughton Head (Berry Mountain) before joining Excursion 4a at Woodhill Gap.

Questions



Fitzroy Falls April 1960

1. Give evidence to support the statement that Kangaroo Valley was carved by the normal agents of erosion.
2. Discuss the probable nature of the rocks exposed by drilling at Hampden Bridge to a depth of 1,000 feet.
3. Compare specimens of the Budgong Sandstone (or its equivalent) as seen at various points in Kangaroo Valley.
4. Suppose that Kangaroo Valley is to be turned into a storage reservoir for the Sydney water supply. List arguments against this proposal from the point of view of scenery preservation.

Chapter 6: The Yalwal and Burrier Districts

Scattered throughout Australia are numerous ghost towns. Yalwal is such a place, but time has removed all but a trace of the town itself and left only the mines which once brought prosperity.

That famous cleric-cum-geologist, the Rev. WB Clarke, noted the existence of gold here as early as 1852. He reported that fine gold was to be found in Danjera and Yalwal Creeks, recommending further prospecting to the local settlers. The 'golden era' began in 1872 and lasted into the present century, with minor revivals ever since.

The Permian strata rise gradually to the west, exposing the basement rocks in all valleys west of Grassy Gully. The oldest strata are comparable to those known to be of Ordovician age and consist of altered clastic sediments. They are exposed only in parts of Danjera and Yarramunmun Creeks. They are overlain by sandstones and conglomerate, containing Upper Devonian marine fossils, and by nonmarine shales, rhyolite, and basalt flows. The whole has been intruded by a body of granite and a number of basic sills.

Excursion 6a

Nowra environs (25 miles return)

The Nowra Sandstone gives rise to steep cliffs, waterfalls, and pleasant little valleys. This kind of scenery is best seen within 5 miles of Nowra, where the Shoalhaven River and its tributaries have cut through to the underlying siltstones. A number of Permian fossil localities and unusual erosional features are included in this excursion.

Route: Nowra-Flat Rock Dam-Cabbage Tree Creek-Saltwater Creek-Bamarang-Wogamia-Nowra

Stop 1. Nowra Showground is the starting point of Excursion 3e, and could well be visited first on this excursion. The structural map shows that this point is on the eastern flank of a north-south trending anticline, the uplift of which has caused the high ground immediately opposite.

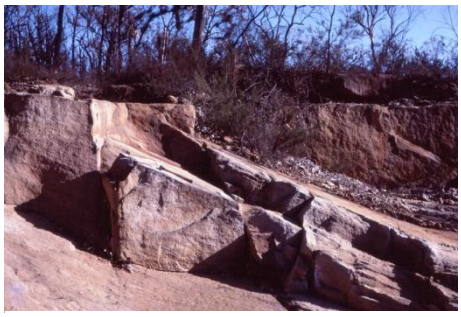
Proceed down Junction Street and turn right into Berry Street at the Methodist Church. Turn right at the end of Berry Street onto the Braidwood road, and shortly after right again towards Yalwal. Another 0.7 miles further on, turn right and then left to reach the wall of Flat Rock Dam.

Stop 2. This acts as a temporary storage for water pumped from the Shoalhaven River above Burrier and intended for local consumption. The dam has been thrown across Flat Rock Creek at a point where it has cut through the entire thickness of the Nowra Sandstone. A road to the right just before the dam descends to the creek and along the valley floor as far as the river, opposite the Showground. The pipeline seen on the descent supplies the Wiggins Teape paper mill at Bomaderry. Numerous Permian marine fossils have been found on the hillside where the pipeline is buried. Between the pipeline and the dam there are a number of small waterfalls marking the base of the Nowra Sandstone. Many brachiopod fossils crowd the underlying siltstone. Blocks of this rock are to be found in the creek bed.

Dip slope of the Nowra Sandstone as seen from near Flat Rock Creek July 1964

Return to the Yalwal road. Stop just across Flat Rock Creek.

Stop 3. The Nowra Sandstone displays cross bedding which may be seen unusually well here. On the left of the road, the strike lines of the cross beds are very obvious and this may be seen again in the quarries on the opposite side of the road, where the face exposes the cross beds better than in a natural outcrop.



Nowra Sandstone quarry near Flat Rock Creek June 1965

(A diversion may be made to Cabbage Tree Flat by turning right at the top of the hill beyond the dam. There has been extensive stripping of the laterised surface along this road, for use as road surfacing metal. Fine views of the river and its associated sandstone cliffs may be had at Cabbage Tree Flat.)

Laterite Cabbage Tree Creek Road August 1963

Shoalhaven River and the Cambewarra Range from above Cabbage Tree Flat October 1964

Beyond this hill, the road descends the western flank of the Bhewherre Anticline and the reappearance of the Berry Formation is marked by a prominent change in vegetation. Stop just beyond Cabbage Tree Creek, where siltstone is exposed below the bridge.

Stop 4. This small exposure, due to the pipeline which will be seen often on this and subsequent excursions, has yielded many small marine fossils, especially corals. Before long, all evidence of this rock will vanish as it is weathering very rapidly.

Nowra Hill may be seen on the left as the next hill is ascended. A diversion to the river may be made at the top, otherwise take the left hand branch.

Diversion. (3 miles return) A rough track leads out to the Shoalhaven River at the western edge of Cabbage Tree Flat. Just before the descent, walk through the bush to the creek on the right. The stream drops by way of a fine waterfall directly into a deep tidal pool, accessible by boat from the river a short distance away.

Return to the Yalwal road. Some 2 ½ miles further on, the road descends through the Nowra Sandstone, which may be examined on foot if desired. Outcrops of the underlying Wandrawandian Siltstone are poor. Stop near a small bridge a short distance further on.

Stop 5. From this point a rough foot track leads to The Pulpit, a prominent residual of sandstone overlooking the river. Walk through the bush on the right of the road, keeping up hill until the ground begins to drop away to the river ahead. Then keep to the ridge on the left, which leads to The Pulpit. The entire walk is less than half a mile and well worth the exertion since the view of the river is unique.

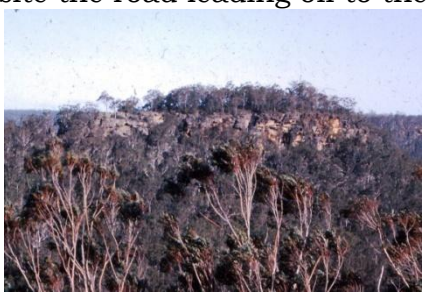
The Pulpit at Bamarang November 1967

En route notice the prominent cross bedded sandstone outcrops, covered with ferns, orchids, and moss. The highest point overlooks the little valley of Saltwater Creek and the view extends to the Cambewarra

The View from The Pulpit August 1963

Range beyond.

Return to the road and proceed to the bottom of the hill. Stop opposite the road leading off to the right.



Calymea Mesa July 1964

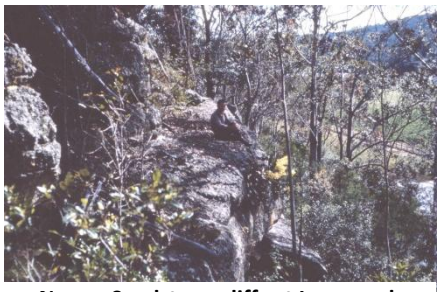
Stop 6. Pebbly Wandrawandian Siltstone is exposed beside the road. The pebbles are well rounded, being composed largely of quartzite. A small mesa of sandstone, on which is situated Calymea Trig. Station, may be climbed from here. Head into the bush on the left beside the road until the sandstone cliff is reached a short distance away. Access to the summit is possible by way of a large joint in the cliff, or by climbing over fallen rocks at the western end, where the trig. cairn is situated. There is a clear view of Nowra Hill from here.

Nowra High School Science Club members on Calymea mesa July 1964

Turn right from the Yalwal road towards the river. The road passes around the base of The Pulpit, where the Wandrawandian Siltstone is exposed, and follows the river for two miles before ascending the Nowra Sandstone scarp again. Levee banks and swamps may be seen on the river flats. Turn right at the top and proceed for a further mile. Stop where the road descends to the river on the left.

Stop 7. This section of the Nowra Sandstone shows features not seen elsewhere. At the top are several silty members, which may mark the base of the overlying Berry Formation. Fossils similar to those seen at Cabbage Tree Creek (Stop 4) are found here and in spoil dumped on the opposite side of the road. Massive sandstone follows, with a large block detached along a joint plain lying against the cliff. In the bush at the base of the cliff may be seen a prominent conglomerate bed and some cross bedded sandstone of the type more common at the top of the formation.

The road continues to a large river flat at Wogamia, one of the earliest parts of this district to be settled.



Nowra Sandstone cliffs at Longreach September 1964

The right hand branch at the top of the descent leads to Longreach, where a narrow flat borders the river for several miles. A weir was planned to block the salt water in this vicinity, but it could not be constructed because of the thickness of silt on the river bed.

Return to Nowra by the same route as far as the pipeline, then turning left.

Excursion 6b

Burrier and Grassy Gully (45 miles return)

The Shoalhaven River has cut through successively older rocks upstream from Saltwater Creek and the Devonian basement is exposed near Grassy Gully.

Gold was mined here some time ago and the old mines add to the interest of this place.

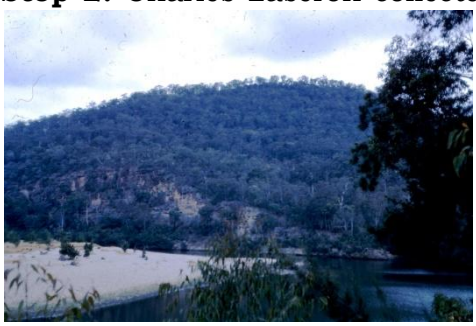
Proceed as in Excursion 6a. The road continues past The Pulpit and crosses Saltwater Creek. Keep straight ahead at the Yalwal turnoff, 0.3 miles further on. One mile beyond this, the road

ascends and the pipeline is seen close by the road. Comparatively fresh siltstone (Wandrawandian) is exposed here. Stop where the road reaches it highest point.

Stop 1. A flying fox maintains contact with farms across the river, which are otherwise approached by the Budgong road. Immediately below is a cliff composed of Conjola Formation which first outcrops at river level upstream from The Pulpit on the opposite bank.

The road descends rather sharply, crosses a small stream and skirts the river with prominent Conjola sediments on the left. Stop at the far end of this section, where the road cuttings cease.

Stop 2. Charles Laseron collected fossils here sixty years ago, when access was easier by boat and the cuttings had not yet been blasted. Fossils can still be found along the water's edge in loose rocks thrown here by the road makers.



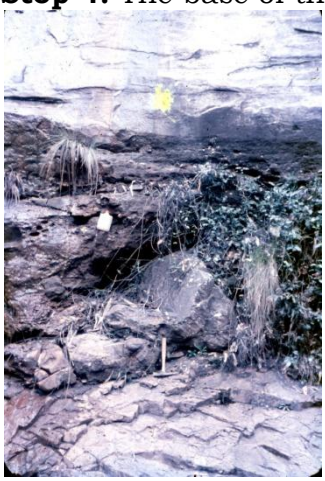
The Shoalhaven River near Burrier February 1966

Continue towards Burrier. One mile further on, instead of turning left, go straight ahead to the gravel dumps.

Stop 3. These pebbles are representative of the geology upstream – porphyry, rhyolite, quartzite, and hornfels are all found here. Tidal water penetrates as far as this point, where the first rapids are found.

Return to the main road, and turn right towards Grassy Gully. The road to the right just beyond a group of farm buildings leads to the pumping station. The Grassy Gully road leads up a steep hill, crosses the pipeline and winds around the hillside for several miles. Stop 2.6 miles past the pumping station road, where the road crosses a small creek.

Stop 4. The base of the Conjola Formation is exposed in a small creek bed downstream from the road. The lowermost sandstone has created a waterfall immediately below which are outcrops of basalt of Devonian age. A boulder horizon marks the actual unconformity. Thin papery shale is wrapped around some of the boulders and may contain nonmarine fossils. Brachiopods have been found in the sandstone immediately above the unconformity.



Unconformity near Grassy Gully September 1963

The entire outcrop is duplicated in a tributary coming in on the left a short distance downstream. Fissures in the old basalt surface are still filled with pebbles washed in as the marine subsidence took place. This exposure is 400 feet above sea level and considerably higher than the basement rocks along Yalwal Creek, Grassy Gully, and the Shoalhaven River. High ground evidently persisted here as an island while much of the surrounding country was being submerged in early Permian times.

Continue towards Grassy Gully. 2 miles further on, the road passes between mullock heaps right on the level of the unconformity.

Stop 5. The basement rock exposed here is a silicified, flow banded rhyolite, in which the gold mineralisation occurs. The mines of Yalwal and Grassy Gully extracted oxidised, near-surface deposits only, since at deeper levels the gold yield was too small. For this reason, most workings are shallow and above the water table. The primary, unoxidised ore usually contains pyrite and arsenopyrite but rarely visible gold.

Further shafts and tunnels occur towards the creek, where alluvial gold was mined. Most of the Devonian outcrops seen are of rhyolite, but a sheet of basaltic rock, possibly a contemporaneous flow, occupies much of the lower part of the valley. Tuffaceous sediments are associated with it.

Beyond Grassy Gully, the road climbs steeply again and heads towards Yalwal Creek. There are many other tracks here, some leading down to the Shoalhaven River while others are merely timber tracks. The most obvious route leads to private property, but a fire road to the left a short distance before the gate leads down steeply to Yalwal Creek.

Stop 6. The creek crossing, being entirely of gravel, may be hazardous, but beyond the creek the road ascends steeply, leading towards Tolwong. Many interesting features may be seen on foot, however.

At this point, the base of the Permian is only a short distance above creek level. The gravel includes granite, rhyolite, basalt and quartzite.

The Ettrema Creek junction is on the right about 1 mile upstream and should be visited. Ettrema Creek evidently supplies a tremendous quantity of gravel, most of it composed of quartzite with an occasional piece of granite and basalt. Cavities in the basalt may contain sulphide minerals. An outcrop of sandstone on the southern bank right at the junction with Yalwal Creek contains numerous poorly preserved brachiopods, probably of Upper Devonian age. Ettrema Creek may be followed upstream for several miles. The vast gravel banks continue, and folded Devonian strata outcrop prominently beneath the Permian sandstones.

Yalwal Creek also exhibits folded strata, especially at a point 1 mile further upstream. A little beyond this, rhyolite outcrops on the eastern bank and is intruded by granite on the west.

Downstream from the creek crossing, nonmarine Permian strata outcrop between the unconformity and the Conjola Formation. Glossopteris has been found here. The Shoalhaven junction is just around the corner. The proposed Shoalhaven Dam, to be built towards the end of the century, could well be built less than a mile upstream from its junction with Yalwal Creek. Devonian quartzite outcrops in the river bed and has been extensively drilled in the search for a suitable site. At this point, a low point in the cliffs on the southern side would permit a spillway to be built, diverting excess water into Yalwal Creek.

The return journey to Nowra must be made by the same route.

Excursion 6c

Yalwal (40 miles return)

This excursion covers the most interesting area of basement rocks in the Shoalhaven district. It has the added interest of being mineralised and of having been the source of $500,000 worth of gold. The new dam on Danjera Creek is included in this excursion.

Proceed as in Excursions 6a and 6b. Take the Yalwal road 0.3 miles past Saltwater Creek. The road climbs steadily, reaching the base of the Nowra Sandstone 400 feet above sea level, or approximately the same height as The Pulpit. This illustrates the gradual dip of the strata to the east. Stop where gravel has been obtained on the right, 1.7 miles from the Burrier road.

Stop 1. The Nowra Sandstone cliff is a short distance away to the right, from where there is a sharp drop of 600 feet to Barringella Creek, a small tributary of the Shoalhaven.

The road gradually rises and in places small outliers of the lower Berry Formation cap the ridge. Excursion 6d turns off to the left 4.3 miles from the Burrier road. Cliffs of sandstone mark the edge of the narrow ridge along most of the road up to this point. Turn right along the Old Burrier fire road 1.7 miles further on. A further view is obtained on the left 1.3 miles along this road.

Stop 2. The view below takes in the granite country around the junction of Yalwal and Bundundah Creeks. It is a three mile walk from here down to Yalwal Creek and upstream to meet the road again. The fire road deteriorates beyond this point, but may be followed down to Burrier. Return to the Yalwal road and proceed to Yalwal Gap 1.5 miles further on.

View at Yalwal Gap October 1964

Stop 3. The Nowra Sandstone displays all its usual features at this point and in the road cuttings towards Yalwal. There has been considerable fretting of the rock to form minor caves, and enlarged joints have added to the ruggedness of the scarp.

Immediately below lies Yarramunmun Creek, the eastern branch of Yalwal Creek. It is a walk of 2 ½ miles to the road by way of the creek. The threefold subdivision of the Permian strata and the underlying Devonian sediments can be noted en route.

Across Yarramunmun Creek, the cleared paddocks of Devonian basalt are obvious, beyond which is the mining area of Yalwal itself, on Danjera Creek, the western branch. Upstream from Yalwal, but still within the valley, are prominent cliffs of granite and rhyolite. Above all this lies the characteristic Nowra Sandstone surface, with outliers of the Berry Formation forming the Ettrema Tops, 8 miles beyond Yalwal.

During the descent from Yalwal Gap, the following boundaries may be observed: base of the Nowra Sandstone, 0.2 miles; base of the Wandrawandian Siltstone, 0.7 miles; and the base of the Conjola Formation, 1.0 miles. Fossiliferous outcrops of the latter occur in an old quarry on the right just before the unconformity with the Devonian. Stop 1.0 miles from Yalwal Gap, where basement rocks first occur. It may prove difficult to locate the exact boundary except on foot.

Stop 4. The Devonian strata are steeply dipping in contrast to the nearby horizontal Permian sediments. At this point, they consist of slaty siltstones and quartzite, apparently devoid of fossils. Permian marine fossils occur within inches of the unconformity. Below the base of the Permian, there is a marked change of the land surface and the vegetation.

Continue to the bottom of the hill and stop at the creek crossing.

Stop 5. Outcrops of weathered basalt occur on the Yalwal side of the creek. The rock is considerably altered, largely due to the hydration of the ferromagnesian minerals. This feature is common to all the Yalwal basalt exposures. The basalt is thought to be younger than the sediments observed earlier, and is preserved here in the core of a syncline whose axis runs northerly near the Danjera Creek Dam.

The gravel of Yarramunmun Creek should be examined. It will be found to include quartzite, slate, and basalt, but no other volcanic rocks. A short distance below the bridge, Danjera Creek comes in from the left and the united stream forms Yalwal Creek. Its gravel includes flow banded rhyolite, spotted slate, and granite, brought down mainly from miles upstream.

If the track on the bank is followed downstream for half a mile, the edge of the Carboniferous granite will be reached. It consists of quartz felspar porphyry at this point but the texture

becomes more granitic further downstream. Nearby, the Conjola Formation descends to a lower level than elsewhere, suggesting that a small valley was filled in here in Permian time.

Continue on to the dam. The reddish soil in the road cutting is the product of weathering of the underlying basalt.

Stop 6. Danjera Creek Dam has a height of 108 feet 6 inches and a width of 1,322 feet. The underlying strata include siltstone as well as basalt and an old fault line was located during investigation work. It now lies beneath the dam but is not expected to cause any problems.

The basalt exposed during construction was shown to contain a considerable amount of pyrite. Some cavities contained other sulphides as well. Fine alluvial gold may be washed in the creek below the dam but never occurred here in payable quantities.

Much of the old town of Yalwal has been lost because of the building of this dam. Its waters are essential to maintain the flow of the Shoalhaven River down to the Burrier pumping station. It was built by the Shoalhaven Shire Council in view of current schemes to divert Shoalhaven River water to supply Sydney.

The waters of the dam have not removed all traces of the gold mines, but access may be limited in view of possible contamination of the water supply.

From the dam a strenuous climb of 1,000 feet leads up to the base of the Nowra Sandstone cliff. This is part of an outlier of these rocks and the edge of the cliff resembles a saw in the way it has been intersected by innumerable joint planes. To the right of the cliff, a saddle 700 feet above Yalwal gives access to Bundundah Creek. Here the valley floor is largely granite, but basalt and Devonian sediments outcrop upstream. Silver was mined from fissures in the granite at one time. From the dam across to Bundundah Creek is a little more than 3 miles.

Take the highest road above the dam, which leads to the old Yalwal cemetery.

Stop 7. Reference should be made to the map of the Yalwal mines area to locate the main features of interest.

View from the Yalwal cemetery November 1967

The cemetery is situated on the south west side of a syncline which has folded the Devonian strata. At this point, the basalt gives way to sandstone and siltstone, in which Upper Devonian plant fossils occur. These may be collected beside the track 200 yards down the hill towards Danjera Creek. Beneath these sediments lie conglomerates, which outcrop prominently where the creek emerges from its narrow gorge upstream from the dam. Older sediments, including quartzite and slate, occupy most of the area where the mines are situated. These are faulted against all the younger strata and it is thought that they may represent part of the Ordovician basement. The whole of these strata are folded along a roughly north-south axis.

The gold mineralisation appears to be associated with the faults mentioned above. The gold is found with pyrite and arsenopyrite and the minerals have been introduced along zones of weakness in the sediments, being deposited as impregnations in the altered rock. They appear to have had their origin in the underlying granite, outcrops of which occur a short distance north of Danjera Creek. The nature of the mineralisation is such that large scale quarrying rather than normal mining has been necessary to make operations payable. In view of the limited testing that has been carried out in some areas and the fact that the productive zone is concealed

beneath the overlying Permian sediments in the south, it seems certain that large quantities of gold remain undiscovered. It should also be noted that gold could only be mined profitably from the oxidised zone, down to a depth of 100 feet. The primary sulphide ore beneath that is comparatively low in gold values.

The main mining claims and some of their important features are listed below.

The Poor Man. Situated to the north of most of the larger mines, its main feature is a large open cut in quartzite and slate.

The Eclipse and Pinnacle mines were worked together after 1901 and are the site of recent prospecting work. The workings include several tunnels and an open cut. At least 8,000 ounces of gold were extracted.

The Golden Crown. Conglomerate outcrops prominently near this mine, which has sizeable underground workings in addition to an open cut.

Sawpit Gully was the only real alluvial area on the field, although some fine gold was washed in the main creek near the present dam site. Coarse gold, but in limited quantities, was found here.

The Albion and Hidden Treasure workings each consist essentially of a single tunnel cut through quartzite.

The Fountainhead property consists of a few shallow excavations.

The Pioneer has been one of the leading producers and at least 12,000 ounces of gold have been produced. Several large open cuts were operated and ore was removed by way of the long Pioneer tunnel underneath.

Ruins at the Homeward Bound Mine January 1966

The Homeward Bound adjoins the Pioneer claim and the two were worked together from around 1927. Something like 30,000 ounces has been produced and the large excavation indicates the enormous tonnage of rock that has been quarried. Recent attempts towards further production have been unsuccessful.

The Star workings adjoin the Permian capping and have not proved to very economical.

The Caledonian, although it produced 20,000 of gold before 1900, has not been worked much since. Little is known about the underground workings. The gold occurred in rich quartz veins, unlike most of the other mines. This seems to be another form of secondary enrichment as the values did not persist at depth.

Geology Excursion Danjera Creek April 1966

The Golden Quarry workings consist of a number of small cuttings adjoining the Caledonian, in an area which is worthy of further prospecting.

Basement rocks outcrop in Danjera Creek for 10 miles upstream from Yalwal. The rock types are the same as those seen around the mine. Great cliffs of rhyolite and

granite are very prominent and their level above the creek suggests that high land existed here in Permian time. Some sulphide mineralisation has been discovered around the margins of the granite where it intrudes dolerite, 3 miles upstream.

Excursion 6d

Yarramunmun and Calymea Creeks (30 miles)

These creeks flow northwards from the ridge along which the Braidwood road runs. The first plunges over the Tianjara Falls and joins Danjera Creek at Yalwal. The second flows through the Yerriyong Valley to become Saltwater Creek before joining the Shoalhaven. As remote places they are of interest to bushwalkers, but less so to geologists. The remarks below explain the places of greatest interest, accessible in these valleys.

The Dean's Gap fire road leaves the Yalwal road on the left at a point 4.3 miles from the Burrier road. See Excursion 6c, Stop 1. Dean's Gap is reached 3 ½ miles south along this road.

Stop 1. At this point the ridge reaches its narrowest point and it is possible to descend into the valleys on either side. The road to the right leads into the valley of Yarramunmun Creek. There are many fire and logging roads in this valley. Take the branch on the left after 400 yards. This leads down to the valley floor, a total drop of 800 feet, descending to a point at the junction of Yarramunmun and Boolijong Creeks. The typical subdivision of the Permian strata may be noted on the way down. Although all published geological maps of the area show basement rocks at creek level, outcrops of Permian sandstone certainly occur for ½ mile downstream from the junction. It is quite possible that basement rocks do outcrop upstream and that there was a valley here in Permian time, now filled with sandstone. From the Boolijong Creek junction, it is a 7 mile walk downstream to the Yalwal road at Danjera Creek.

Continue south towards the Braidwood road. About 2 ½ miles further on, turn right along Hyland's Lookout fire road.

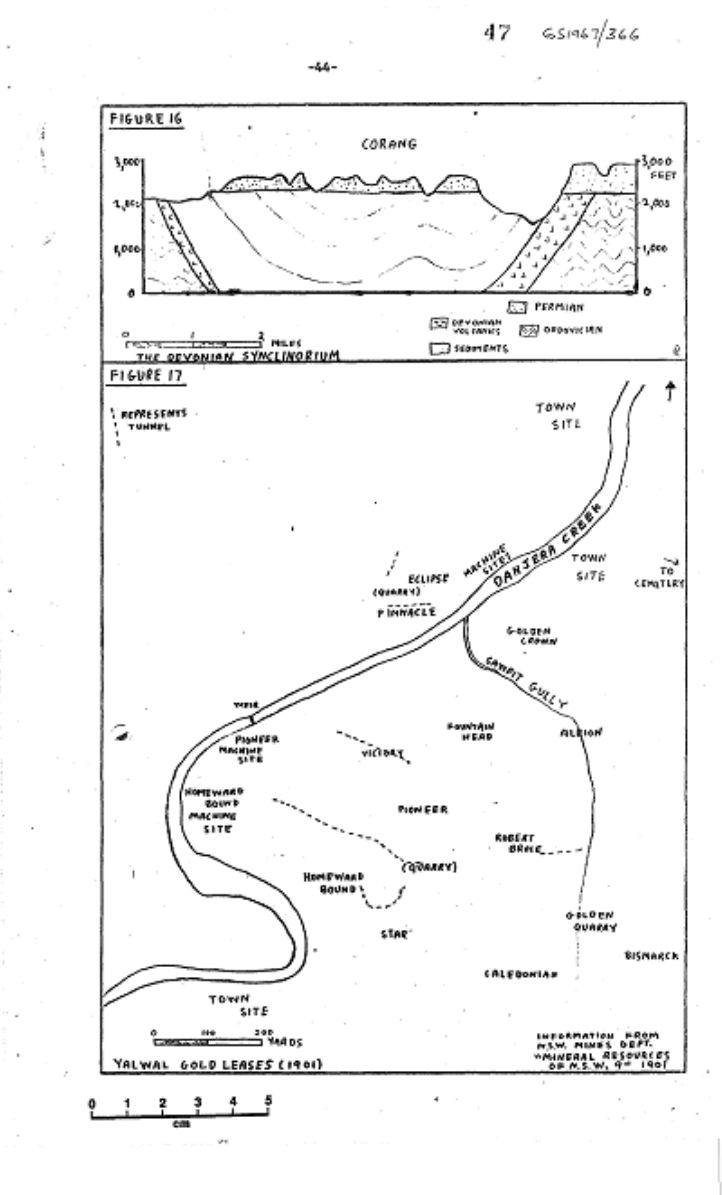
Stop 2. This provides a fine view of the valley of Boolijong Creek 750 feet below. In the distance, from right to left, are the Ettrema Tops (outliers of the Berry Formation), the basalt hills of Sassafras, and the Tianjara mesas.

Some 2 ½ miles further on, the Dean's Gap road joins the Braidwood road at Turpentine. The last few miles are over the Berry Formation and at Turpentine the vegetation is much richer than that seen along the Yalwal road. Turn left, and keep left towards Nowra. After a short distance, the Nowra Sandstone is met again and the change in vegetation is remarkable. Shortly afterwards, gravel pits are to be seen on the right. These are numerous between Turpentine and the aerodrome. About 3 ½ miles from Turpentine, a fire road to the right leads to the Parma Creek fire road (see Excursion 8a). One mile further on, a view of Calymea Creek may be had on the left a short distance from the road. At 6.5 miles from Turpentine Corner, a road branches off on the left to Yerriyong, on Calymea Creek. There is little of geological interest in the valley. Shortly afterwards, a view of Nowra Hill opens up and the road crosses the Berry Formation all the way to Nowra.

Questions

1. Discuss the scenic effects of the Nowra Sandstone.
2. In what way has the distribution of Permian rocks hindered mining in the Yalwal-Grassy Gully region?

3. Discuss the merits of the sites for the Danjera Creek and proposed Shoalhaven River dams.
4. Give a brief account of the Devonian and Carboniferous history of the Yalwal gold field.
5. What unusual features are noticeable about the earliest Permian sediments west of Grassy Gully? Suggest possible causes for these.
6. Discuss the evidence which supports the existence of folds in the Cabbage Tree Creek-Flat Rock Creek area.
7. The high country west of Nowra presents a uniformly smooth surface from a distance. Suggest reasons why this is so.
8. Give an account, based on field observations, of the nature and origins of the igneous rocks of the Yalwal district.



Detail of the Devonian unconformity at Grassy Gully – is this perhaps Permian conglomerate filling cracks in the basalt or is it a conglomerate bed within the Devonian basalt?

Photo taken September 1963

Chapter 7: The Beecroft Peninsula

The heads of Jervis Bay are unique features. Both of them project seawards contrary to the south westerly trend of the coast and both are flanked by great sea cliffs unequalled in NSW. The northern headland is much more accessible than the southern. The southern headland lies in Commonwealth Territory and will be considered in chapter 8.

The geological map indicates that the Conjola Formation is the dominant underlying rock, but there is far more to the understanding of its origin than this fact alone. It would appear that a combination of folding and a major offshore fault may have elevated this area in comparatively recent times. If we remember that the sea has been at its present level for only the last 10,000 years, then we cannot explain the cliffs or the great opening of Jervis Bay by marine erosion only. Suggested explanations for these features include the idea that the cliffs are remnants of a former valley now submerged, or that, in the days when the sea was far removed, a major river once meandered northwards through the heads and out by way of the gap north of Currarong. While there may be some truth in these notions, it is more likely that the bay follows the course of a syncline and the heads an anticline, both being much eroded and drowned by the sea. The entrance to the bay is, on this explanation, the drowned course of Currumbene Creek and its tributaries, much the same as the heads of Sydney Harbour or Broken Bay represent drowned river valleys.

Because this is a compact area, it will not be treated as a series of excursions but rather place by place. These will be taken from the north (Kinghorne) then in an anticlockwise direction via Point Perpendicular to Currarong.

Much of the peninsula is a naval practice range and access is often restricted. Such times are well advertised in the local newspapers and by prominent signs. Spring is probably the best time to visit the area, when the wildflowers are an added attraction.

Kinghorne (A) is approached by a rough road leaving the bitumen where it swings south to follow the beach. There is an extensive outcrop of the Wandrawandian Siltstone exposed here in a low rock platform. The strata, which are dominantly grey siltstones, dip to the east and their strike is made very obvious as the edge of each bed appears as a line on the surface of the platform.

Wandrawandian Siltstone at Kinghorne November 1965

The siltstone contains many small fossils and numerous spherical concretions. There are thousands of crinoid stems in all states of preservation. They tend to point in a north easterly direction, this evidently being the direction in which they were carried when they died. This evidence concerning the current direction in the Permian sea has been backed up by measurements of similarly oriented long pebbles.

Intruding the strata is a complex igneous mass, evidently a series of basalt sills about 3 feet thick which have caused minor alteration of the sediments.

The **roadside quarry** at B exposes weathered pebbly siltstone, resembling that seen at Kinghorne. Its presence suggests that the Wandrawandian Siltstone overlies much of the northern part of the peninsula.

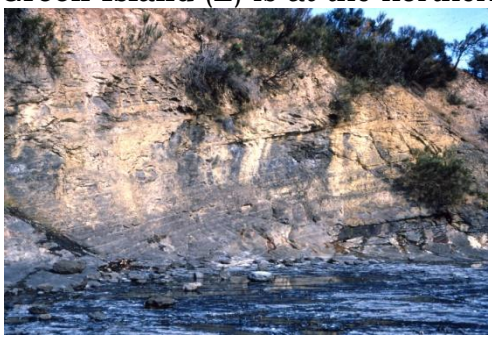
There has been speculation concerning the **isthmus** at C. Only 200 yards of recent sand separates the sea from Cabbage Tree Creek, part of Jervis Bay. Was the peninsula an island in

recent times, and if so what caused its separation from the mainland? Many see in this isthmus evidence for the ancient river valley mentioned at the beginning of this chapter.

Quartz crystals by the thousand have been found at D. While so many have been taken from here that it is hard to find a good specimen today, it is worth noting that similar crystals have been found over at least two square miles west of Currarong. There seems to be no good reason for their presence in such an unlikely place. One clue may be their association with limonite casts of fossils which are also common here. Perhaps some obscure weathering process has produced them. Similar crystals have been reported from Cave Beach, Pyree, and Culburra, although not is such quantities. In all cases they are found in clay or ironstone at a depth of a foot or more. Their discovery here is the result of their exposure in drains and shell craters.

The best crystals are glass clear, doubly terminated, and up to 1 inch long. Most are inferior, although nearly all show both terminations.

Green Island (E) is at the northern limit of a rock platform of siltstone. This has a northerly dip, somewhat irregular in places, and contains some good fossils and many large erratics, like those seen at Crookhaven Heads.



Wandrawandian Siltstone at Green Island
November 1965

Montagu Point (F) has features of exceptional interest. It lies at the end of Long Beach and is the first exposure of siltstone north of Point Perpendicular. The sediments, whose dip and strike are variable, are richly fossiliferous and a walk from the beach north for a mile will give many opportunities to collect a representative range of Permian marine fossils.

Schist erratic block
at Montagu Point January 1966

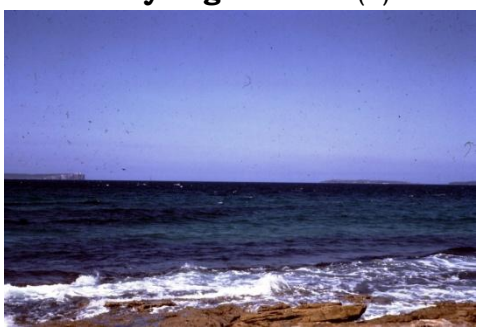
Edge of dyke intruding siltstone
at Montagu Point January 1966

Just north of the beach, the rock platform is interrupted by a large porphyritic dolerite dyke, 85 feet wide. This is unusually wide when compared with the dykes near Kiama, but typical of those south of Nowra. There is an indurated zone up to 12 inches wide in the adjoining siltstone and abundant evidence of alteration of the dyke on both margins, perhaps by water in the siltstone at the time of intrusion. The phenocrysts, like those in the Bumbo Flow, are of plagioclase felspar.

Honeymoon Bay (G) is a popular swimming and skindiving area. It may be formed from a weathered out dyke, but its origin is unknown. The sandstone and conglomerates of the Conjola Formation has a westerly dip along this part of the coast.

Target Beach (H) may also be due to a dyke since it is in a direct line with the one at Montagu Point. East of the beach the cliffs rise prominently. There is a distinct shale bed within the sandstone which may be traced beneath Point Perpendicular to where it is seen again at K.

Jervis Bay Lighthouse (J) has stood on Point Perpendicular since the late nineteenth century, when it replaced an earlier light near Cape St George on the south head. Solidly built, the lighthouse has survived seventy years of stormy weather in this isolated place. The cliffs of sandstone drop 270 feet directly into the sea. There is always a breeze here and more often a gale due to the configuration of the land. Joints have split the rock into enormous blocks by the collapse of which the cliffs recede. These blocks are softer in their centres, since solutions migrating through the rock tend to crystallise along the cracks, hardening their sides. The tops of these blocks have been scoured out by the wind and are often full of water.



The heads of Jervis Bay from Vincentia February 1965

The entrance to Jervis Bay from Point Perpendicular April 1987

Jervis Bay Lighthouse April 1987

A **large crack** splits the cliff at K and provides a fine vantage point to view the cliffs. A rough track descends through this gap and leads out onto the same broad ledge seen from Target Beach. The sandstone is very coarse, and contains many erratics of slate and quartzite. The shale which has formed the ledge has weathered into a shelter as much as 15 feet deep and may be followed for as far as one's steadiness will allow. Marine fossils are fairly common here, having weathered out intact from the sandstone.

The **Devil's Gorge** (L) is the most spectacular result of marine erosion on the peninsula. It lies just north of Crocodile Head, where the cliffs exceed 200 feet in height. The observation post nearby stands on sand hills whose elevation (323 feet) is the highest in the neighbourhood.

A rough track leads out to the coast just south of the Gorge. If the cliff top is followed northwards a great crack of apparently unfathomable depth is met. When this is followed inland for 200 yards, it is seen to be less than 20 feet wide. Even though the bottom cannot be seen, the sea can be heard roaring below.

A descent can be made into the amphitheatre at the inner end of the Gorge, where sand spills down into it. The towering cliffs above and the surge of waves make this a frightening place, even in calm weather. Its origin is as yet unexplained, but it is probably the result of marine enlargement of a prominent joint. At least 15 other gorges, all less spectacular, occur between Point Perpendicular and Currarong.

The **Drum and Drumsticks** (M) are a group of sandstone stacks formed by the erosion of a former headland. The Drum rises sheerly about 50 feet from the sea and has an area of several acres. The Drumsticks are all smaller relics. A minor fault cuts across the Drum and its neighbouring Drumstick, to reappear on the mainland nearby.

From the hill above, the view extends up the coast to Beecroft Head. Most of the beds are persistent and can be clearly traced as they dip northwards. A series of shoals continues the trend beyond the Head, making this a dangerous place for navigation.

Currarong (N) is a popular holiday resort, which, like many others on the south coast, has developed from practically nothing in the last few years. The remains of the "Merimbula" wreck may still be seen on the rocks north of Abraham's Bosom.

The Devil's Gorge Beecroft Peninsula October 1964

Questions

1. Discuss the possible origin of Jervis Bay and the cliffs near Point Perpendicular.
2. Compare typical outcrops of the Wandrawandian Siltstone (eg Montagu Point) and the Conjola Formation (eg Honeymoon Bay).
3. List features of the dyke at Montagu Point which could be observed by walking across it.
4. Suggest a possible origin for the 'Bombing Range' quartz crystals.
5. Make sketches of notable examples of marine erosion observed on the Beecroft Peninsula.

Chapter 8: The Tomerong District

In earlier days, when there were few casual visitors to the South Coast, Tomerong was much more a rural centre than it is today. The growth of holiday areas around Jervis Bay and St George's Basin has rendered it less important.

Tomerong is situated where the southern road first passes through the Nowra Sandstone onto the widespread Wandrawandian Siltstone. The change is marked by a noticeable improvement in the soil, and this in turn has led to the growth of spotted gums and turpentine, in contrast to the poorer types growing on sandstone soils. The sawmills around Tomerong and Wandandian capitalise on this forest wealth and provide local employment.

North and west of Tomerong are outcrops of the overlying sandstone and the Berry Formation. Elsewhere, the Wandrawandian Siltstone is the dominant rock type, except along the shores of Jervis Bay, where a dome structure has brought the Conjola Formation to the surface. The same structures seen west of Nowra have folded the strata south to the ocean at Wreck Bay; in addition the Parma Monocline has acted as a line of uplift west of Tomerong.

Excursion 8a

Upper Parma Creek (18 miles return)

Interesting erosional features and the effect of minor folding are the main things seen on this excursion.

Route: Tomerong-Blackbutt Range-Hell Hole-Parma Creek Falls-Turpentine Road-Tomerong

Take the highway north from Tomerong. Immediately north of the town, there are road cuttings where the Wandrawandian Siltstone and a large dyke are exposed.

Stop 1. The dyke, about 60 feet wide, is composed of olivine dolerite and shows up in the cutting because of its different weathering characteristics. The strata it intrudes are typically bowed up by the dyke, a feature visible near all of these large intrusions. This particular dyke may be traced for several miles, seldom varying from its straight path.

The road ascends into the Nowra Sandstone, here much siltier and thinner than at Nowra. Cuttings exposing the Berry Formation are seen near the top of the climb, and these contain typical marine fossils.

Stop where a poorly defined track leaves on the left, 0.6 miles past the dyke.

Stop 2. The lower part of the Nowra Sandstone is exposed in an old quarry, ¼ mile along this track. The siltstone in the quarry and down the gully abounds in fossils. The majority are preserved in calcite and some excellent specimens may be obtained here.

Return to the highway and continue another mile towards Nowra. Turn left along the Blackbutt Range fire road. After 2 miles through typical spotted gum forest, the road begins to rise where the Parma Monocline has elevated the strata. Turn right along Parma Creek Road. Timber tracks off to the left, now largely overgrown, lead out to the Hell Hole, ½ mile west of the road.

Stop 3. Hell Hole is a bottleneck canyon, similar to the Grose Valley in the Blue Mountains. It is bounded by cliffs of sandstone, about 40 feet high, and the dip of the strata has caused Parma Creek to carve its valley in the unusual form shown on the map.

Continue to where the road leaves the Berry Formation and crosses the sandstone bed of Parma Creek.

Stop 4. There are many interesting things to be seen by walking downstream for ½ mile, The Nowra Sandstone is divided by a siltstone bed, as it is at Falls Creek. Both the upper and lower sandstones have been responsible for waterfalls, by whose retreat a mile long gorge has been created. Below the second fall, a sizeable tributary joins Parma Creek and it too has waterfalls where these beds outcrop.

Parma Creek waterfall November 1967

The Wandrawandian Siltstone outcrops below the falls and contains many fossil brachiopods. Other fossils are to be found in loose blocks of rock in the creek bed.

There are numerous potholes in the creek and one of these is large enough to swallow most of the stream when the water is low. In this way the creek constantly lowers its bed.

Pothole in Parma Creek Bed November 1967

Return to the Blackbutt Range fire road and turn right. After two miles, this leads to the Turpentine Road, 5 miles from Tomerong. There are two steep descents along the Turpentine Road and these are the only places where the Nowra Sandstone is seen. The first of these is due to the Parma Monocline and at the second, the road descends to the Wandrawandian Siltstone in a similar fashion to the descent on the highway north of Tomerong.

Excursion 8b

Jervis Bay and St George's Basin

This excursion takes in a long stretch of coastline, from Huskisson to Sussex Inlet. The underlying rocks belong to the Wandrawandian Siltstone and the Conjola Formation.

Route: Most places of interest are along the coast and will be considered southwards in order from Huskisson. There is little variety in the geology other than a few dykes on the Wreck Bay shore.

Huskisson. The Wandrawandian Siltstone is exposed for ½ mile along the shore from Currumbene Creek to Tapalla Point. It has a north easterly dip and is most notable for the numerous glendonites it contains. These are accompanied by marine fossils and erratics of schist, quartzite and granite. In 1886, a bore was put down at Huskisson in search of coal, poor seams of which were struck at a depth of 840 feet. The discovery of coal in the Clyde River gorge had created considerable interest and it was hoped that Jervis Bay might be developed as a port, but the plans came to nothing following an unfavourable government report in 1890. The coal seams were studied in every available outcrop and by the sinking of a new bore west of Tomerong. This bore penetrated coal seams of no commercial value and no further action has been taken towards coal mining near Jervis Bay.

Vincentia. Sandstone of the Conjola Formation outcrops from Vincentia southwards, with the exception of a small outlier of siltstone at Lamb's Point. The north easterly dip increases towards Hyam's Beach, reaching 15° or more. This is the result of folding parallel to the Parma

Monocline; in this case the dominant structure is the Bhewherre Anticline, also seen just west of Nowra.

Commonwealth Territory. The southern headland of Jervis Bay, like the northern, is composed of sandstone blanketed by extensive deposits of wind blown sand. Sandstone cliffs exceeding 400 feet in height front the Tasman Sea and present an unforgettable sight to the mariner. In 1770 Cook noted these cliffs and named Cape St George because of the date of its discovery (24th April). Cook reported the entrance to Jervis Bay but thought it not worth the trouble to go out of his way to enter it. So, because Cook was too far out to sea, Jervis Bay was passed up in favour of Botany Bay and the course of Australian history altered. Had the 'Endeavour' anchored here, then Sydney might have been founded where the RAN College stands today.

The places referred to below may be located by their corresponding letters on the map.

Green Patch (A) is a popular picnic spot. Nearby was the now vanished settlement of New Bristol, one of many attempts to develop this impressive bay as a major port.

Hole in the Wall (B) is an example of the combined effect of wind scour and salt laden spray. A natural sandstone wall has been effectively perforated by the process.

Bowen Island (C) is separated from the mainland by a narrow and dangerously shallow channel.

Stoney Creek (D) is a well known fishing spot where access may be had to the extensive rock platforms near Cape St George.

At **Steamer's Beach** (E) the cliffs are the highest in the district and the sandstone exceeds 450 feet in thickness. Sand hills spill right down the steep slope into the sea at this beach.

Boat Harbour or **Whiting Beach** (F) has formed by the erosion of a dolerite intrusion. It resembles the Tomerong dyke in the way it has arched the sandstone, but in this case there has been considerable contact metamorphism and the adjoining sandstone has become hard quartzite. Minor black sand deposits occur on this beach, containing ilmenite, zircon and rutile.

Summer Cloud Bay (G) takes its name from a barque wrecked here in 1870. A weathered out dyke may be seen in the cliff face.

Cave Beach (H) is so named because of a weathered out dyke on the southern headland. This dyke has eroded into a tunnel of larger than usual dimensions.

The Clay Pits (J) have yielded quarts crystals similar to those found near Currarong (see Chapter 7).

Lakes McKenzie and Windermere (K) are the result of streams being dammed by shifting sand hills.

St George's Basin (M) This body of water lies along the same syncline as that seen at Cabbage Tree Creek, on the Yalwal road. Its origin seems to be the same as the other coastal lagoons in the area. The lower valleys of Wandandian and Tomerong Creeks have been drowned and the bay formed has been blocked by sand hills. Only Sussex Inlet now provides access to the sea.

Sporadic outcrops of the Wandrawandian Siltstone occur along the northern shore of the Basin and occasionally fossils may be found in these.

Questions

1. Show how folding has led to the disposition of rock types seen in upper Parma Creek.
2. Compare the Nowra Sandstone outcrops near Tomerong with those seen at Nowra. What is the main difference?
3. Give evidence for the existence of a series of parallel folds extending through Jervis Bay, the Commonwealth Territory and St George's Basin.
4. Discuss the effect of sand hills in modifying an existing topography.
5. Suggest reasons why a major port has not developed at Jervis Bay.
6. Compare the landscape characteristically produced from each member of the Shoalhaven Group in the Tomerong district.

Nowra High School Year 11 Geology excursion to the Little Forest Plateau June 1966

Chapter 9: Ettrema and Beyond – the Great Gorges

One must never underestimate the erosive power of running water. Almost as fast as the uplifting process begins, many streams large and small begin to level the land again. Nowhere is this better seen than in the gorge country west of Nowra, where scrubby sandstone plateaux give way to great canyons, and tinkling waterfalls demonstrate the ceaseless battle between the two.

From sea level at Nowra, the sandstone surface rises, almost imperceptibly, to a height of 2,500 feet in the west. The Shoalhaven River and its tributaries have removed this resistant layer along their courses and exposed the older rocks below. Unlike Kangaroo Valley, these gorges have little to attract the settler since their few level areas are comparatively infertile and access is difficult indeed. It has taken the discovery of minerals – gold, silver, and lead – to cause man to descend into them.

Much of the higher land remains undissected, still bearing its shield of Nowra Sandstone or even part of the overlying Berry Formation. These in turn have been further protected from erosion by a covering of basalt, poured out in a time before the great gorges had formed and now about to be carried away to the sea by streams which may not have then existed.

Settlement is sparse in the area bounded by the Shoalhaven River, Danjera Creek, and the Braidwood road. In all of this country, an area of hundreds of square miles, there are only four or five isolated farms. The rest of the landscape is a confusion of bare rock, sandstone cliffs, and wild valleys – a scenic area well worthy of preservation in the form of a National Park.

Beneath the Permian sediments lies an interesting series of older Palaeozoic rocks. These have already been met in Chapter 6, where the rocks at Yalwal took the form of granite and an Upper Devonian sequence. Similar rocks, as well as older Silurian and Ordovician sediments, are found in all the valleys west of Yalwal. This sequence of older rocks was eroded to a near sea level surface in early Permian times and later buried by the marine sediments we call the Shoalhaven Group. Much of the land surface west of the Shoalhaven River, for example near Bungonia, appears to be this old surface exhumed from beneath the Permian sediments.

Because of the rough nature of the country, roads are necessarily few, and this restricts the places of interest which may be reached by car. The grandeur of the scenery may only be appreciated by those willing to walk. It is likely that no-one has ever set foot on some of these remote hill tops, nor ever examined the rocks in some of the deep valleys, so there is much to attract the curious visitor. However, some words of caution: this is dangerous country for inexperienced hikers, and the possibility of rockslides and flash floods is always present. Only those who are physically fit and sufficiently experienced should leave the beaten track.

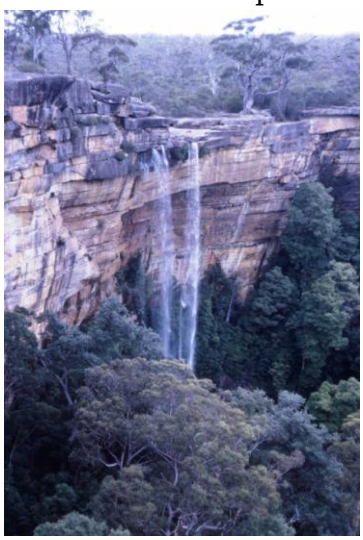
Excursion 9a

The Sassafras Tableland (27 miles return)

The Braidwood road, which may be traversed from either Tomerong or Nowra, follows the divide between the Shoalhaven tributaries on the north and those of Wandandian Creek and the Clyde and Endrick Rivers on the south. Its surface, essentially that of the Nowra Sandstone, rises gradually from near Nowra Hill (200 feet) to Sassafras (2,500 feet). Basalt outliers are dominant in the west; otherwise the surface is formed from the Nowra Sandstone or the Berry Formation.

Route: Tianjara Falls via the Braidwood road to the descent at the western edge of the plateau.

Stop 1. Tianjara Falls is the only place along this road where the encroaching valleys may be examined with ease. The water drops about 100 feet over a cliff of Nowra Sandstone, at which point Tianjara Creek changes its name to Yarramunmun Creek. Some aspects of the geology of the older rocks exposed further down the valley were studied in Chapter 6.



Tianjara Falls December 1963

Typical potholes are exposed just above the falls; some of the water (most of it in dry seasons) vanishes into one of these and emerges some way down the cliff face. The creek above the falls is flowing in an old valley which apparently predates the present cycle of erosion.

The cliff top on the right may be followed for 1 mile before it veers to the east. A descent of 800 feet into the valley at this point will reveal typical Ordovician slates beneath the Permian strata. On the western side it is possible to descend with care at several points not far from the falls. It is a hike of 15 miles along the top from here to Yalwal. Care should be taken to keep to the ridge between Yarramunmun and Boolijah Creeks to avoid unnecessary detours. A fire road extends along part of this route, and this provides magnificent views of the valleys on both sides.

Proceed towards Braidwood. After 1 ½ miles, the road crosses Boolijah Creek, here not much more than a swampy watercourse. It is, in fact, the main headwater of Danjera Creek. There seems to be good evidence for the theory that Danjera Creek has captured part of the upper Clyde River. The whole of this plateau is besieged on all sides by encroaching valleys. Those on the coastal side appear to be the most effective, since their streams flow down the dip of the sandstone.

Stop at Stony Hill, the only prominent hill seen along this road, 4 miles from Tianjara Falls.

Stop 2. Silty sandstone of the Berry Formation outcrops here. The rock differs noticeably from the Nowra Sandstone and also from the typical Berry siltstone seen near Nowra. Evidently the larger particles brought into the Permian sea at this stage were not carried more than 10 miles from the shore, with the result that there is a gradation within the Formation from sandstone in the west to siltstone in the east.

Just past Stony Hill, the road ascends the Sassafras basalt outlier. The change in soil type is obvious enough, and with it goes a change in vegetation. Stop 0.6 miles past Stony Hill, where basalt outcrops are seen by the roadside.

Stop 3. This is a typical olivine basalt. It was probably poured out as a flow fairly late in the Tertiary period. This event may have occurred before the uplift and certainly before the Shoalhaven Gorge was carved. Some geologists have suggested that a fault or monoclinal fold has elevated the country around Sassafras. Although this has not been substantiated, there does seem to be a change in the dip of the strata in this vicinity.

Beyond Sassafras, where rich farmlands provide a welcome change from the monotonous sandstone country, the road passes over similar terrain for 5 miles until the Touga road is reached. Excursion 9b leaves here. Some 1.3 miles further on, the road begins to descend to the Endrick River. Stop where the road drops beneath cliffs of sandstone on the right.

Stop 4. This marks the western edge of the Shoalhaven Group sediments. The Nowra Sandstone is similar in most respects to its outcrops further east and cross bedding is quite common. Marine fossils appear to be absent, however.

A short climb and walk to the west will reveal a view of the Endrick River valley, the Shoalhaven River, and the distant hills towards Goulburn. South of the road is the valley of Bainbrigge's Creek, a tributary of the Endrick River.

Excursion 10a commences here, but otherwise the same route must be followed to return to the coast.

Excursion 9b

Touga, Tolwong, and the Ettrema Gorge (70 miles return)

The spectacular scenery of this country has been explained earlier. Most of the features of geological interest are to be found in the older rocks, beneath the Permian cover. This is the most mineralised area in the Shoalhaven district and one suspects that great mineral wealth lies undetected beneath hundreds of feet of Permian sandstone.

Route: Sassafras-Touga-Quiera-Tolwong

Leave the Braidwood road about 5 miles past Sassafras and 1.3 miles before the descent to the Endrick River.

The road passes over sandstone of the Berry Formation for about 3 miles and then over the Nowra Sandstone at a place locally called 'The Jumps'. The narrow ridge along which the road passes is besieged on both sides by deep valleys, which at this point have eaten away a large part of the sandstone. This road is part of a route used by bullock teams and drovers in earlier days, taking a rather direct route to Sydney.

Turn left for Touga 2 miles further on. The right branch leads to Tolwong. It is nearly six miles from here to the homestead and as most of this is in private property, visitors should ask permission from the landowner before leaving the road. Places of geological interest will be treated in their order from the Tolwong road.

The road passes over extensive areas of bare rock just before outcrops of slate are reached, 3.4 miles from the fork.

Stop 1. There is a marked unconformity between the Shoalhaven Group sediments and the underlying Ordovician metamorphic rocks. From graptolites found in the locality, these rocks are known to be of Upper Ordovician age.

Continue towards Touga. Stop at the second gate after Stop 1.

Stop 2. A view of the Shoalhaven gorge may be had in this vicinity. Copper was discovered nearby in the late nineteenth century. The site of the old diggings is about ½ mile east of the road, just below the junction of Touga and Quiera Creeks. This is the only major creek junction in the area and lies about 350 feet below the road.

Copper stained slate marks the outcrop of several bodies of quartzose chalcopyritic ore. The largest of these is a vein 2 ½ feet thick and it proved to be patchy and uneconomical to mine. Alluvial gold occurs in Touga Creek down to its junction with the Shoalhaven. This is about 5 miles downstream and a considerable amount of prospecting has been carried out towards the junction.

Continue towards Touga. Outcrops of a granitic rock may be seen on the left.

Stop 3. Instead of the expected granite, the rock proves to be a variety of gabbro called norite. It consists largely of pyroxenes and plagioclase with smaller amounts of olivine. Creeks draining this intrusion also carry alluvial gold. After so many miles of barren sandstone country, it is quite a change to reach this open country, with its views of the Shoalhaven River and the hilly country beyond.

Touga homestead is about 1 mile past the first norite outcrop.

Stop 4. There is much to be seen by walking due west towards the gorge. The river follows a fault, separating Touga from a similar igneous body across the valley. From the homestead to the river is a drop of over 1,200 feet, mostly by precipitous slopes. Immediately opposite is the impressive canyon of Nerrimunga Creek, which has cut a great gash in the side of the Shoalhaven gorge.

Return to the Tolwong road, turn left and stop 1 mile further on where the road crosses an extensive area of bare rock.

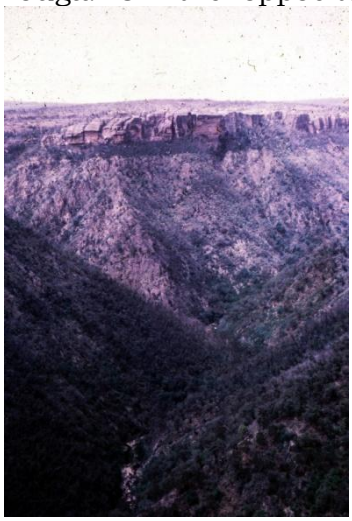
Stop 5. This is the nearest any road approaches to the Ettrema gorge, which can be seen less than a mile to the east. The return walk to the cliff edge takes about an hour. Keep to the right of the small valley to avoid dense undergrowth. The sandstone ridge is thick with many varieties of wildflowers, which add interest to the walk.

Ettrema Creek lies 1,200 feet below this fine vantage point and it is less than a mile to the opposite cliff. Downstream, the gorge becomes even narrower and deeper. Its very existence demonstrates that the uplift of this country occurred in comparatively recent times – otherwise the valley would have widened considerably.

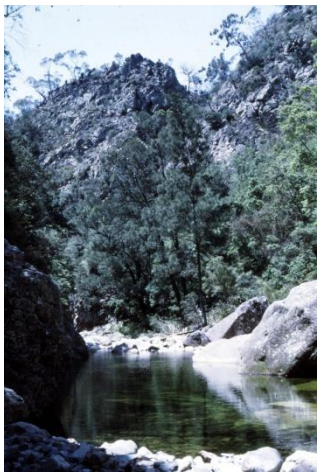
Ettrema Gorge January 1969

There is a great deal to be learned by descending into the gorge (allow 4 hours return) but this is not an easy climb nor are the most interesting features immediately below this point. The cliff may be avoided by walking southwards until a gap is found, where a small stream has carved a notch. Even so, some scrambling must be done.

Only the Nowra Sandstone is present here, resting on the same kind of Ordovician slate seen at Touga. On the opposite side of the gorge, however, it appears that older members of the Shoalhaven Group lie beneath the sandstone. The slate soon gives way to quartzite and reddish siltstone of probable Upper Devonian age, similar to the rocks seen at Yalwal and east of Nerriga. These persist all the way to the bottom, where a surprisingly small stream trickles over a rubble choked bed. There are dangerous scree slopes to be avoided on the descent. If these were to be set in motion any climber in the vicinity would be in an awkward position.



Ettrema Gorge November 1967



Ettrema Gorge November 1967

Great cliffs of limestone occur along the creek 3 miles further downstream. These beds are probably of Silurian age, like the Bungonia and Marulan limestones and appear to be separated from the surrounding

Devonian strata by a north trending fault. This appears on aerial photographs as a great gash, which seems to have faulted the Permian strata as well. The Ettrema fault is parallel to that previously mentioned at Touga and another at South Marulan.

The limestone is known to contain caves, but little is know about them. There has been extensive mineralisation in the limestone and the old Ettrema Mine was opened up here many years ago. A complex sulphide ore body outcrops in Jones' (or Rolfe's) Creek, about 1 mile above its junction with Ettrema Creek. It occurs as a replacement deposit in the limestone and its principal minerals are sphalerite, arsenopyrite, galena, and chalcopyrite. Tin and silver are also present. Some ore was mined, but because of the difficulty in removing it from the gorge, most of it remains there to this day.

Continue towards Tolwong. About 1 ½ miles further on, the road passes onto an outlier of basalt.

Stop 6. The Quiera basalt, at an elevation of 2,400 feet, strongly resembles that seen at Sassafras and Tolwong. These all appear to be remnants of a former sheet which extended south from the Moss Vale district before the uplift.

The cleared ground, with its rich soil, is a pleasant change from the miles of poor country around it.

About 4 miles past Quiera, the track descends to a small outcrop of basement rocks near Tullyangela Creek.

Stop 7. The total thickness of the Shoalhaven Group seldom exceeds 300 feet in this area, which evidently lay near the edge of the Permian sea. Erosion has exposed granite and slate, similar to that seen near Touga. The peculiar course of Tullyangela Creek may be due to recent stream capture or the re-excavation of an old valley buried under the Permian sediments.

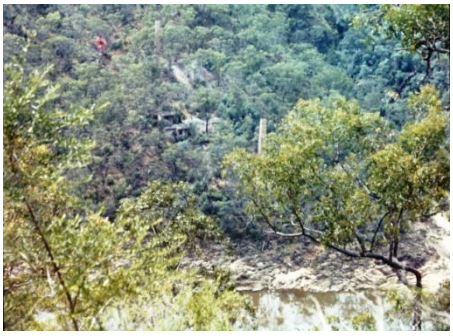
Tolwong homestead lies about 7 miles further on, where there are extensive areas of basalt country. Enquiries should be made here before proceeding further.

Stop 8. The basalt extends almost to the edge of the gorge, about 500 yards north of the homestead. Tallowal Creek has cut a steep valley which descends 1,800 feet to the Shoalhaven River. The track continues on for 3 more miles to a point above Badgery's Crossing, which was an important stock crossing in the early days of settlement.

The Tolwong mines are reached by turning left just before Tolwong itself. The track is poorly defined and crosses fairly level, timbered country for 4 or 5 miles until the edge of the Berry Formation is reached. A well defined foot track then descends to the river, passing the various mines in a gradual 1,500 feet descent.

Stop 9. The main ore body resembles the Ettrema lode in its mineral composition. It is first met with as an outcrop of green copper-stained slate about half way down. From this point on, the lode varies in width from a few inches to over 8 feet. It appears to have been deposited as a vein within Ordovician slates by an unexposed igneous body and is one of the best documented lodes of its type in NSW. The main ore mineral is arsenopyrite, with lesser amounts of galena, sphalerite, chalcopyrite, and stannite. Quartz and fluorite are prominent gangue minerals. Specimens of all of these may be had from the various mine adits and natural outcrops or from mullock heaps near the river.

The old workings are unsafe and should not be entered, nor should the creek water be drunk because of its arsenic content. In several places, water flowing from abandoned tunnels is richly coloured by copper.



Tolwong Mine ruins December 1974

Like many similar ventures, this mine failed because of its difficult access and the complexity of its ore. The brick chimneys and roasting ovens by the river are evidence of an attempt to mine the ore about 60 years ago. Across the river, the scar left by an old flying fox cable is still plain today.

The Blockup Shoalhaven River Tolwong December 1974

This is difficult country for the prospector, but mineral wealth may yet be extracted here. It is about 3 miles from here to Bungonia Caves, and 7 to Long Point Lookout at Tallong. Both walks are rather strenuous and involve crossing the river, but cover some very scenic country. Alluvial gold may be washed from the river gravel, especially when the water level is low.

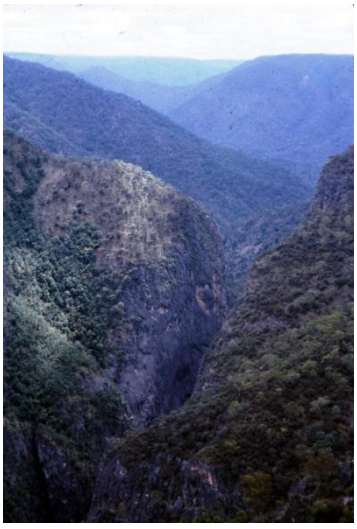
Excursion 9c

Bungonia, South Marulan and Tallong

These are just a few of the places of interest across the river, which are worth a visit as part of excursions to the Goulburn district.

Bungonia Caves

An extensive area of Silurian limestone crops out from South Marulan over a distance of 7 miles in a south westerly direction. The caves are reached by travelling east from Bungonia village. Part of the area is in a reserve and was formerly maintained for tourists until visitor numbers dropped as people preferred to visit the more spectacular caves elsewhere in NSW.



Bungonia Gorge from Adam's Lookout December 1963

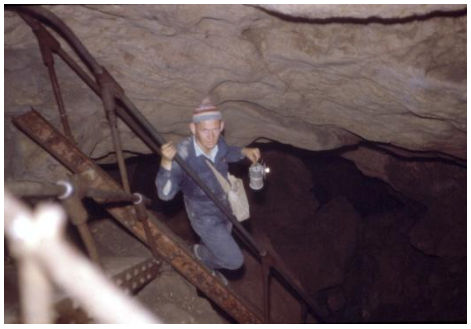
The Lookdown is the best known feature here. There is a very sharp drop of 1,200 feet to Bungonia Creek. This may be descended with care to the right of the lookout. The limestone here contains typical Silurian fossils, particularly the coral Favosites. Grykes or solution grooves are also prominent.

Bungonia Creek from the Lookdown December 1963

Adam's Lookout is even more spectacular, especially if Bungonia Creek is in flood. The creek runs through a very narrow gorge known as The Slot. With care, the descent to the creek may be made, but scree slopes should be avoided.

There are numerous caves, many of which open up from the bottom of depressions or sink holes. These are identified by a number at their entrance and should not be entered except by

experienced speleologists with proper equipment. There have been a number of fatalities here in recent years, caused by inexperience or fatigue.

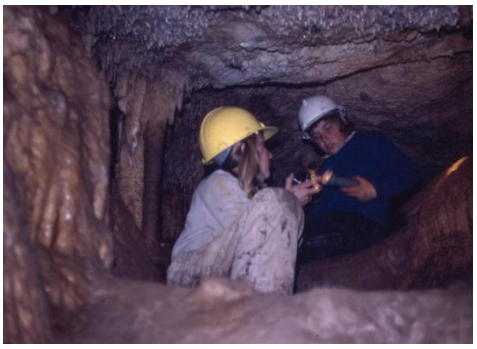


The author in the Grill Cave January 1968

Fossil Cave (B4) contains water worn passages exposing fossils in the limestone. It connects with B5.

Hogan's Hole (B5) contains several long drops.

Bungonia Cave (Grill Cave) (B9) was formerly a tourist cave and is now badly defaced. There are still some attractive parts in its more remote corners. Ladders and wire netting from the tourist days remain in place. Foul air can be a problem in the lower levels.



Moss Vale High School students in the Grill Cave November 1973

Drum Cave (B13) has a drop of 140 feet just beyond the entrance. The passages below contain interesting formations but are better known for their bat colonies and foul air.

The Efflux (B67). This is a stream cave where water escapes from the plateau above. Patient excavation over a long period has still not allowed access to the extensive passages believed to exist upstream.

Dykes cutting through marble South Marulan December 1966

South Marulan

From Marulan, a road leads out, over granodiorite of the Marulan batholith, to the edge of the Shoalhaven gorge. In the quarries of the Southern Portland Cement Company, the limestone has been converted to a coarse granular marble. At the northern end of the quarry, just below the offices, several basic dykes intrude the marble as well as a poorly defined ore body containing pyrite, arsenopyrite and chalcopyrite.

South Marulan quarry July 1975

Slate is exposed on the eastern side of the quarry. This appears to be separated from the limestone by a major fault.

Upturned strata in the Shoalhaven Gorge December 1978

Tallong

The Big Bend Shoalhaven River at Tallong June 1960

At Long Point Lookout, there is a superb view of the Shoalhaven gorge. The track descending to the lookout exposes black slate in which occasional Upper Ordovician graptolites may be found. The track leading south from the lookout reveals several

small outliers of Permian conglomerate resting on the slate.

The Shoalhaven at this point bends sharply to the east. Many geologists believe that the river formerly ran north to join the Wollondilly River and that some time after the uplift, a stream eroding inland from the coast captured this part of the river, along with Budgong Creek, Kangaroo River and Tallowal Creek. Old gravel on the present surface near Tallong has been regarded as evidence for this hypothesis.

From Tallong railway station, Caoura road runs for 15 miles through basalt country, leading eventually to a point above the junction of the Shoalhaven and Kangaroo Rivers. See Excursion 4d, Diversion 2. Opalised wood and agate have been found beneath the basalt and the trip is worthwhile for the extensive views obtained en route.

Questions

1. Discuss the mineralisation of the basement rocks north of Sassafras.
2. Outline in detail an unconformity observed in this area.
3. Account for the present distribution of basalt at Sassafras, Quiera, Tolwong, and Caoura.
4. Present evidence for river capture in the Tolwong district.
5. Give reasons for the sparse population of the Ettrema-Sassafras-Tolwong areas.
6. Suggest reasons for the persistence of the Nowra Sandstone over such a wide area.
7. Discuss the probability of further mineral discoveries in the Ettrema, Touga, and Tolwong districts.

Calcite at South Marulan quarry September 1966

Chapter 10: The Wandandian and Conjola Districts

This is largely an area of uncleared bushland. Features of interest lie along the highway or on the coastal strip. Other than the Wandrawandian Siltstone and the Conjola Formation, the only variation in the geology is provided by an occasional dyke or inlier of basement rocks.

Several dolerite dykes will be seen on these excursions; they are all similar, being composed of a bluish-black olivine dolerite with phenocrysts of plagioclase up to 1 inch across. The dykes are up to 60 feet wide and are traceable for several miles.

The deep valleys of Wandandian and Conjola Creeks have exposed highly folded strata of unknown age, usually taken to be Ordovician like the metamorphic rocks of Tolwong and Nerriga. These have been intruded by granite, with which a small amount of mineralisation is associated, probably in the Devonian period.

Excursion 10a

Tomerong-Conjola (17 miles)

The main interest lies in the outcrops of basement rocks seen west of the highway. The excursion includes both the Wandrawandian Siltstone and the Conjola Formation, a dolerite dyke, a granite intrusion and copper and tin mineralisation in Ordovician slates.

Route: Prince's Highway south from Tomerong.

Stop 1. The Bewong dyke crosses the highway immediately past Bewong Creek, 4 miles past Tomerong. It intrudes the Wandrawandian Siltstone, but all that is seen here is a poor outcrop of dolerite boulders. They show typical labradorite phenocrysts, each displaying multiple twinning. The phenocrysts are aligned, probably parallel to the sides of the dyke. The line of boulders, which is the usual outcrop of the dyke, may be traced for several miles in either direction.

The spotted gum forest, indicative of the underlying Wandrawandian Siltstone, gives way to scribbly gum near Wandandian school. This marks the first outcrop of the Conjola Formation. Diversion may be made to the right at Wandandian; many timber roads lead off the main logging road, some leading down below the Conjola Formation into the underlying slates and others up through the Nowra Sandstone onto the Turpentine Road.

Four miles past the Sussex Inlet turnoff a track leads down to the old Jerrawangla tin prospect.

Stop 2. The easiest approach is via the overgrown track shown on the map. Mining leases were held over a length of ½ mile, extending south west from the highway.

Tin was discovered here about 1914, both as alluvial in gullies draining into Venandree and Wandandian Creeks and to a lesser extent in quartz lodes beneath the Permian sandstone.

It is possible to wash a little alluvial tin in the creek. Vein quartz in the slate is unlikely to reveal any cassiterite, but may show a little chalcopyrite or bornite. Some excellent examples of small scale folding may be seen in the slate and quartzite in the creek bed.

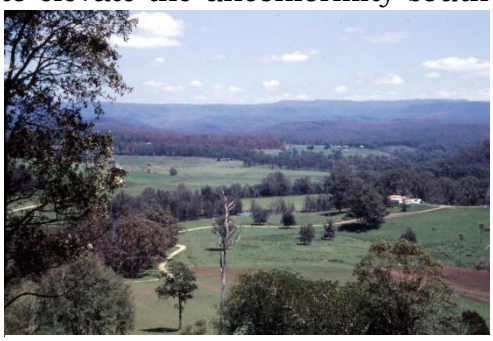
One mile further south, a road to the right leads to Jerrawangla Lookout and eventually to Tianjara Falls (see Excursion 11a). It ascends to the cliff top through the Nowra Sandstone, which displays its usual characteristics here. The observation tower at the top affords views of the coast for many miles in both directions. Fire roads off to the right between the lookout and

the highway lead close to Wandandian Creek, where granite outcrops make a contrast to the familiar scene.

The highway descends to Conjola Creek 7 ½ miles past the Sussex Inlet turnoff. A good section of the Conjola Formation is seen on the descent and should be examined on foot if it is to be studied in detail. A weathered dyke outcrops at one point.

Stop at a convenient point near the Conjola Creek bridge.

Stop 3. A small granite inlier outcrops in the creek beneath the bridge. It may only be seen when the creek level is low. The granite is overlain by typical Conjola sandstones and the unconformity seems to be comparatively level. When compared with the level of the slate at the Tin Mine, this suggests that an island may have existed temporarily in the Permian sea near Jerrawangla. The prevailing dip of the Permian strata could have been expected to elevate the unconformity south of Jerrawangla; evidently the old land surface was far from level.



Conjola Creek valley January 1969

Other small granite inliers occur just east of this outcrop and a small area of slate lies upstream from the bridge.

An interesting diversion may be made to the Conjola Copper Mine by turning right just past the bridge.

Diversion. (9 miles return)

Turn right from the highway and then immediately turn left. After 1.6 miles, turn right. The left branch may be followed for several miles into the heart of the McDonald State Forest.

Stop 0.3 miles beyond the fork.

Stop 1. The unconformity between the sandstone and slate is not very marked, but beyond this point slate becomes dominant. Notice how there is considerable soil creep on the slope and the slate blocks have been overturned.

Stop at the creek crossing ½ mile further on.

Stop 2. Conjola Creek drains a large inlier of Ordovician strata, outcrops of which are seen here in the creek bed. The gravel includes large quantities of quartzite and spotted slate, but no igneous rocks.

The road rises very sharply beyond the creek and in wet weather would be difficult to negotiate. Stop 1.9 miles further on where an old bulldozed timber track may be seen descending on the left. The road branches just after this spot.

Stop 3. Slate is still found here at an elevation of 600 feet. This is probably due to the irregularity of the old buried land surface, since Permian sandstone occurs 500 feet lower only ½ mile south. The road ahead continues towards Jerrawangla Lookout.

Follow the bulldozed track down to the creek and then head upstream for ½ mile. Copper stained slate fragments may turn up in the creek now and again. Turn left at the first major tributary and locate the old workings on the right a short distance upstream.

Stop 4. Very little was done here beyond some surface testing. The lode proved to be inferior and no actual mining was attempted. Some chalcopyrite may be found here, but the outcrop is

largely oxidised. From the amount of green stained slate found downstream, it seems certain that this is not the only place shedding the mineral.

Return to the road and then to the Prince's Highway. Continue for ½ mile further south to Cooloo Creek (Bunnair Swamp).

Stop 4. Granite outcrops in the creek at the bridge and on the grassy hill opposite. By walking back up the hill towards Conjola, it will be seen that the granite gradually passes vertically into arkose and finally sandstone. This is a classic example of an unconformity and the fact that the granite surface is at the same level as that in Conjola Creek (Stop 3) suggests that the granite forms the basement over a much larger area than actually appears by its outcrops.

Excursion 10b

The coast from Sussex Inlet to Lake Conjola

Most places of interest are found on the coast, where outcrops of the Conjola Formation and Ulladulla Mudstone are dominant. Well preserved marine fossils are found in the Mudstone and several igneous bodies add to the interest of this attractive area. Each locality will be treated in order, from north to south.

Sussex Inlet

Sussex Inlet sand hills January 1953

The rock platform at the entrance may be reached by walking around the beach from the "Alamein" camping area, or by a new road leading out to Cudmirrah Beach. Siltstone and silty sandstone are the dominant sediments and belong to the Ulladulla Mudstone. Sandstone at the eastern tip of the rock platform and forming a small reef are though to belong to the Conjola Formation. The map show the main features of interest, from the Cudmirrah end to The Haven.

Sussex Inlet rock platform October 1961

A. The siltstone here contains quite a few solitary corals, mainly in blocks recently fallen from the cliffs.
B. Large numbers of brachiopods occur in the sandstone at the base of this unit.
C. There appears to be a raised rock platform here, now about 15 feet above sea level.
D. A thin conglomerate bed includes numerous irregular blocks of granite, slate, and quartzite. Some of them show striations on their surfaces, rather like those at Crookhaven Heads (see Excursion 3c).
E. Fossils are common here, particularly crinoid stems, and fronds of polyzoa. Spherical concretions like those at Culburra are also abundant.
F. Fossils are less abundant here. The sandstone is thought to be the top of the Conjola Formation.
G. A small fault is visible in the cliff face.
H. Shells in the sand hills are probably part of an aboriginal midden.

Erratics in siltstone at Sussex Inlet October 1961

The Springs, Swan Lake

The water level in this lake, like most lagoons on the south coast, seems to have fallen in the recent past. There is a drop of about 15 feet down a steep bank to the present beach, which may be 100 yards away in some places.

The grey siltstone contains numerous marine fossils, particularly where the road drops down to the lake shore.

Cudmirrah and Berrara

There are a lot of interesting things to be seen on a walk along this section of coast. It is best to start at the southern end of the rocks, where Canal Lagoon (Berrara Creek) runs into the sea. Sandstone and silty sandstone, dipping gently to the north, are seen for the first few hundred yards. A few fossils may be found in them. Then follows a large dolerite dyke, striking approximately at right angles to the coast. It is about 60 feet wide and composed of the same porphyritic dolerite seen at Bewong Creek. The sediments are arched up by the intrusion. This dyke may be traced inland and for some distance out to sea on aerial photographs.

North of the dyke, fossils become more and more abundant until one thin bed of calcareous siltstone is reached, packed with a variety of marine fossils. Some parts of the rock are almost solid limestone, and contain large numbers of brachiopod spines.

Cudmirrah Faunal Reserve

This is another in the important chain of reserves designed to protect a large variety of habitats. Off the southern end of the beach, the 'Walter Hood' was wrecked in a storm on April 26th, 1870. A monument on the hill reminds us of the 11 men who lost their lives in this disaster. Fragments of tiles, glass, and other scraps may be found on this beach, washed ashore from the wreck.

Red Head (Bendalong)

Extensive outcrops of volcanic rocks occur on the headland. There appear to be several flows, intersected by numerous dykes. The whole is probably of Tertiary age. Most of the rock is very weathered; the appearance of the cliffs from the sea gave the locality its name.

The remains of an old jetty remind us of the silica industry, established here about 1920. The volcanic rocks, in the form of flows and dykes, have caused extensive metamorphism of the underlying Conjola sandstone. This has largely taken the form of silicification. Quartz has been deposited from solutions accompanying the intrusion which converted the sandstone into a hard, compact quartzite.

Today, instead of being shipped to Port Kembla, the silica is taken by road to be made into refractory furnace bricks. Extensive quarries are still being operated.

Questions

1. Discuss the nature of the basement in the Conjola district.
2. Describe the field occurrence of dykes in this area.
3. Discuss the sedimentary structures observed in the siltstones at Sussex Inlet and Berrara.
4. Present evidence for the postulated existence of granite beneath the Permian sediments at Wandandian.

5. Why has there been little agricultural development along this part of the coast? What other industries have developed?
6. What effect is the present development of coastal holiday resorts having on the natural assets of this area?

Wreck Bay from the entrance to Sussex Inlet January 1953

Chapter 11: Tianjara and the Little Forest Plateau

Amongst the landmarks of the Shoalhaven district is the Tianjara group of mesas. They lie about 5 miles south of the Braidwood road, near Tianjara Falls. Their flat surfaces, bounded by cliffs and steep slopes make them obvious from all directions, but particularly from the north. They are easily visible from Bundanoon, Saddleback, and Durras Mountain.

Extensive outliers of the Berry Formation cap the coastal hills south from Tianjara Falls to the Little Forest Plateau. This is uninhabited country, used as a military practice area and out of bounds from time to time. The sediments of the Berry Formation are rather coarser than those further north. The presence of the mesas may be due to the peculiar resistance of the strata in this area. Some geographers have suggested that they may be relics of a former land surface, uplifted and largely removed before the more recent uplift which has been responsible for such features as Tianjara Falls and the Ettrema Gorge.

The views of the Clyde River gorge, the surrounding sandstone cliffs and the panoramas of beaches and coastal lakes make this good bushwalking country. There is a minimum of undergrowth on the higher land, but the valleys tend to be thickly vegetated.

Excursion 11a

Tomerong-Tianjara- Rotary Lookout (34 miles)

The Tianjara mesas and spectacular examples of cliff recession are the main features of this excursion. The road may not be passable south of the mesas; however the features to be seen at the other end can be approached via the Pointer Gap just as easily (see Excursion 11b).

Route: The Braidwood road from Tomerong to a point 0.8 miles before Tianjara Falls, then south to the Porter's Creek Dam road, near the Rotary Lookout.

Take the Braidwood road from Tomerong. The road soon rises from the well timbered Wandrawandian Siltstone country through the Nowra Sandstone onto the Berry Formation. Some 2 ½ miles further west, the Parma Monocline is ascended. Sandstone is seen for a short distance, but the road continues on the Berry Formation at an elevation of 600 feet for several more miles until it reaches Flat Rock Creek.

Stop 1. The Nowra Sandstone outcrops here in the creek. It shows well developed cross bedding. One mile downstream, the creek leaves the swamp country by way of a waterfall and joins Parma Creek in the upper part of Hell Hole (see Excursion 8a, Stop 3).

The Wandrawandian Bore, sunk in 1890 in search of coal, is located near Condy's Creek, about 1 mile south of the bridge.

Continue towards Braidwood. At the Turpentine Corner, the road joins the Braidwood road from Nowra. The Berry Formation is widespread along the ridge and is responsible for some very fine forest land along the Turpentine Range. Shortly after the corner, the Dean's Gap fire road leads off on the right towards Yalwal (see Excursion 6d).

A distant view of Jervis Bay may be seen from the road 4.6 miles past Turpentine. Gravel pits along the road are extracting iron enriched sandstone and weathered siltstone. Several fire roads on the left in this vicinity lead, by way of steep descents, to the Prince's Highway near Wandandian.

A diversion may be made along a fire road leading off to the right 5.6 miles past Turpentine. It follows the sandstone ridge separating Yarramunmun and Boolijah Creeks and eventually divides, giving access to both valleys. In both cases, after a descent of 800 feet, slate is found unconformably underlying the Permian sediments.

The Old Wool Road branches to the left 6.9 miles from the Corner. It leads down to Wandandian by way of a complex series of logging roads (see Excursion 10a, Stop 1).

Views of the main Tianjara mesa are seen ahead soon after this, and the road branches off the Braidwood road 9.1 miles from Turpentine and O.8 miles before Tianjara Falls.

The left hand branch 4 miles from the Braidwood road leads to Jerrawangla Lookout (The twelve Mile Road: see excursion 10a, stop 2). Keep to the right and stop after the road has ascended the steep side of Kangaroo Hill.

Stop 2. This is the smallest of the mesas, reaching just over 2,300 feet above sea level. The silty sandstone outcropping here contains a few marine fossils. A good view of the whole countryside may be had from the top of the hill.

One mile further south, the road approaches the largest mesa.

Stop 3. The climb to the summit is only about 300 feet, but the view is greater than might have been expected. In the north, the gradual slope towards Nowra is most remarkable while the Clyde River gorge is just a short distance away to the west. Outcrops of silty Berry Formation sandstone are common near the top of the hill.

The highest mesa, on which Tianjara trig stands (2,520 feet), is a short distance further south. Stop where the road reaches its highest point just west of the hill.

Stop 4. The land surface is very swampy and gives the impression of being a 'fossilised landscape' much older than the nearby canyon of the Clyde. A view of the Clyde may be had by walking 1 ½ miles west from the road. It was in this part of the valley that coal was discovered about 1886. This locality may be reached by way of a gully 1 mile west of Tianjara Trig. The Coal Measures occupy the river bed for a short distance and several tunnels have been driven into coal seams by prospectors.

The Clyde Coal Measures are first encountered in the river bed at the foot of a small waterfall. The Shoalhaven Group sediments overlie the Coal Measures with a noticeable angular unconformity. Recent investigations indicate that the Clyde coal seams are older than the Greta Coal Measures in the Hunter Valley, with which they were formerly correlated.

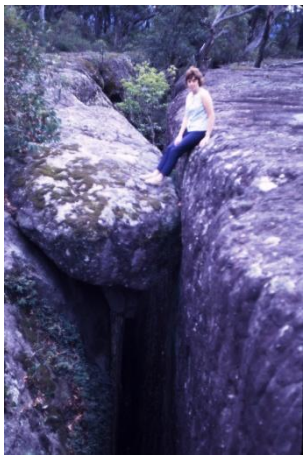
Permian plant fossils (Glossopteris, Gangamopteris and Noeggerathiopsis) occur in the shales below the unconformity. A thickness of 135 feet of sediment lies below this point before the basement rocks are met at an elevation of 1,260 feet. Numerous plies of coal, including a seam 3 feet thick, may be seen by following the river downstream. An adit has been driven on this seam for about 40 feet. Elsewhere, other tunnels have been driven to prospect the coal, which is generally of good quality. The variable thickness of the seams and the unpredictability of their extent made mining an impossibility.

Return to the Tianjara road and continue south from the mesas. Three miles further on, the road reaches a narrow defile with steep slopes on either side.

Stop 5. This is the Second Devil's Pinch. Claydon's Creek is encroaching from the west and the head of Conjola Creek is eating away the plateau from the east. Large open joints show the process by which the cliffs retreat.

Views of the Clyde River and The Castle open up as the road approaches a second defile, where a further stop may be made.

Stop 6. At the First Devil's Pinch, prominent open joints are very obvious on both sides of the road. On the eastern side, the slope drops 1,600 feet to Conjola Creek in a distance of 2 miles. The Conjola Copper Mine is in this vicinity.



At the First Devil's Pinch April 1968

Several miles further south, the road meets the Porter's Creek Dam road (Excursion 11b). Turn left and then right to the Rotary Lookout.

Stop 7. From the Lookout there is an extensive coastal panorama. Of particular interest is the large area of cleared ground where the Milton Monzonite intrusion occurs. Its better soils are in marked contrast to those typically formed from the Permian sediments. The Pointer Mountain, part of the intrusion, rises prominently one mile to the east.

The sandstone scarp may be descended on foot by way of Egan's Gap, ¾ mile along the cliff top. From here a track leads down to Little Forest Road and so to the Prince's Highway (7 miles from Rotary Lookout).

Cleared land on the Milton intrusion June 1966

Excursion 11b

The Little Forest Plateau (18 miles return)

The whole of the Shoalhaven Group from the base to the Berry Formation may be examined on this excursion. In addition, a small part of the Milton intrusion and outcrops of the Clyde Coal Measures and basement rocks are seen.

The views from the Plateau are very worthwhile and there is an extensive area of good bushwalking country available which does not involve strenuous climbing.

Route: Porter's Creek Dam road from the Prince's Highway. Turn west from the highway, 5 miles north of Milton.

Stop 1. Outcrops of a basic rock occur here. They may be part of a dyke or of the Milton intrusion. The level surface of the Little Forest Plateau is very marked from here. Further north, the Tianjara mesas are prominent.

Proceed towards the mountains. Within a mile, the road turns sharply to the left and then to the right. An intrusion of monzonite outcrops alongside the road and on the hillside above.

Stop 2. The monzonite forms part of a large intrusion, which outcrops north, west, and south of Milton. The intrusion is evidently a multiple laccolith and this is part of its northern outcrop.

The rock itself is typically porphyritic, the phenocrysts being of andesine or labradorite felspar.

A short distance further on, the road descends to a tributary of Bunnair Creek.

Stop 3. A small inlier of Ordovician slate occurs just upstream from the bridge and may be reached by following the creek or by turning left off the road 200 yards up the next hill.

Continue up the hill. Turn right along the forestry road (Calgaroo Road) 500 yards further on. Stop where the road reaches the bottom of a hill a short distance from the Porter's Creek road.

Stop 4. Bunnair Creek is a short distance below the road on the left. Several exposures of Coal Measures sediments occur in the creek bed, associated with an inlier of slate. The lowest outcrop contains several seams of coal, up to 15 inches thick. Upstream, a second exposure in the creek bed is surrounded by slate, but contains no coal. A third exposure lies even further up, in the bed of the left hand branch. This locality can also be reached from the Porter's Creek road, ¾ mile from Calgaroo Road. Coal and carbonaceous shale form the bulk of this small outcrop.

The discontinuous nature of these Coal Measures exposures suggests that they formed in scattered small basins only and that minable coal is not likely to exist. It is possible that the basins may have been depressions in a glaciated plain, rather like the peat bogs of Canada and other areas recently covered by ice. A rise in sea level eventually submerged the whole plain and the marine sediments of the Shoalhaven Group began to form. It appears that this submergence began first in the south and west of Milton before gradually covering all the low lying ground.

Continue towards the plateau. The road gradually ascends through the Conjola Formation and then rises more sharply through the Wandrawandian Siltstone. Several enormous blocks of Nowra Sandstone lie on their sides by the road and finally the Sandstone is reached at a point where the gradient of the road is quite steep. Stop at the crest of the hill, just past a large isolated block of sandstone on the right.

Stop 5. This locality is correctly called The Pointer Gap but the name 'Porter's Gap' has come into use in confusion with Porter's Creek, a mile or so to the west.

The road builders excavated a large quantity of fossiliferous sandstone and siltstone. Many fossils may still be found on the rubble-strewn slope below the road. Because of the unstable nature of the rock pile, this place is not recommended as a collecting ground. Some superb marine fossils were collected here during the original excavations.

The Nowra Sandstone may be studied here to advantage. It shows the usual cross bedding towards the top, but the siltstone towards the base is not always seen elsewhere. It is possible that the prominent siltstone outcrop alongside the road corresponds to exposures towards the base of the Sandstone at Nowra, Parma Creek, and Yerriyong. Further sandstone underlies it before the Wandrawandian Siltstone is met with a little lower down the mountain.

A little past Pointer Gap, the road to the Rotary Lookout branches off to the left (see Excursion 11a, Stop 7 for details). Turn left at the next branch. The other road leads to the Devil's Pinches and Tianjara (Excursion 11a). A little over 1 mile further south, the road swings to the right towards the dam. At this point, turn left along a track which goes almost to the cliff edge a short distance away.

Stop 6. Little Forest Trig., elevation 1,832 feet, affords extensive views and particularly points out the fertility of the Milton district. In the far south may be seen Durras Mountain with Mt Dromedary near the horizon. Immediately below lies the dairying country based on the Milton Monzonite. The roughly circular nature of the outcrop around Milton is best seen from here.

The cliff may be descended 500 yards south of the Trig. station. A vehicular track leads from the Trig. station track. It goes to the southern edge of the Little Forest Plateau, 2 miles further south, where the view of the Pigeon House from the cliff is probably the best available. The deep gorges of Jindelara and Pigeon House Creeks add to the grandeur of the scene.

Porter's Creek Dam under construction March 1967

Proceed to Porter's Creek Dam.

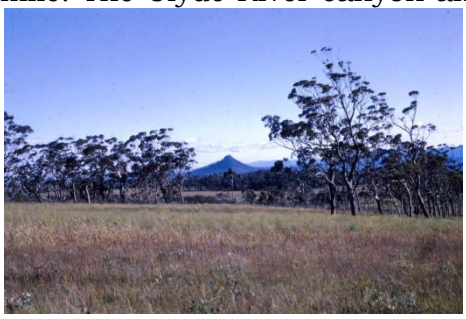
The water of Porter's Creek is fed through a tunnel into a pipeline which then descends to supply Milton and Ulladulla. The dam wall is 50 feet high and 812 feet wide. It is built into solid sandstone and is unusual in that it stands within a few hundred yards of a 150 foot cliff.

Walk downstream along the right bank of the creek. The view of the falls and Mount Talaterang in the background is well worth the effort. The cliff is of typical Nowra Sandstone and there is little chance of descending it in this vicinity.

Mount Talaterang, elevation 2,585 feet, is an extensive outlier of the Nowra Sandstone and Berry Formation. There is a thickness of at least 500 feet of cliff forming Berry sandstones on the highest parts of the mountain. It is possible to ascend Talaterang from the northern end of the mountain, but the climb is very arduous. From Porter's Creek, it would be necessary to skirt the cliff top for 5 miles before the ridge leading to the mountain is reached. A better route would be via the Tianjara road to a point ½ mile south of the First Devil's Pinch, then in a south westerly direction. From the summit, the land drops over 2,000 feet into Pigeon House Creek in less than a mile. The Clyde River canyon and The Castle group of monoliths are prominent in the west.

Mt Talaterang April 1968

The Clyde River valley and
The Castle June 1966



The Pigeon House August 1966

Questions

1. Discuss the nature and possible origin of the Clyde Coal Measures.
2. Give an account of the Milton intrusion as seen on this excursion.
3. Why was the Milton water supply dam built on Porter's Creek rather than on one of the more accessible coastal streams, such as Conjola Creek?
4. What is the possible origin of the Tianjara mesas?
5. Compare the Berry Formation sandstone with the Nowra Sandstone.

Chapter 12: The Milton-Ulladulla District

The Milton intrusion dominates the geology of this part of the country. Its rich soils lie conveniently close to Ulladulla Harbour and settlers began to arrive here about 1830. However, apart from the country underlain by the Milton Monzonite, the rest of the landscape has changed little since Cook first viewed it in 1770.

Apart from the igneous rocks near Milton, The Conjola Formation is dominant in this area. In recent years there has been a revision in the nomenclature of the Formation and it is now known to consist of sediments of widely varying ages, all within the lower Permian. Contrary to earlier ideas, the lower beds are equivalent to the lower part of the Dalwood Group in the Hunter Valley. Some parts of what has been called the Conjola Formation are as young as the lower Maitland Group. Research into this aspect of Shoalhaven district Geology is still in progress.

Excursion 12a

Milton-Ulladulla (17 miles)

Included in this excursion are splendid exposures of the Milton intrusion, richly fossiliferous Permian sediments, and Tertiary Volcanics in the form of dykes and flow remnants.

Route: Yatteyatah-Little Forest-Milton-Ulladulla-Mollymook-Bannister's Point-Narrawallee-Milton

The excursion commences at the junction of the Prince's Highway and the Porter's Creek Dam road. The road south skirts the edge of a northerly part of the Milton intrusion. A diversion may be made to Lake Conjola entrance, by turning left 1 mile south. Silica has been quarried in that area.

Through Yatteyatah, the road descends to the lush pastures of the Milton district. At first the road crosses alluvial soils, but shortly after reaches outcrops of monzonite. Stop where the rock is exposed in a deep cutting.

Stop 1. The rock here is rather weathered and better specimens may be obtained on nearby hillsides. The entire Milton intrusion varies greatly, in places (as here) resembling dolerite while elsewhere it grades into more typical monzonite or even trachyte.

Turn right along Little Forest Road, half a mile further south. The road soon leaves the intrusion and continues towards the Little Forest Plateau through poorer country. Three miles from the highway, turn right. The road then descends to Little Forest Creek.

Stop 2. Another small exposure of Ordovician slate is exposed here. The unconformity may be examined by walking up the road on either side of the creek until slate is replaced by sandstone. Upstream, a small inlier of the Coal Measures may be found by following the creek for half a mile. Beyond Little Forest Creek, the road rises sharply onto that part of the intrusion seen from the Rotary Lookout (see Excursion 11a, Stop 7).

Return to the highway. One mile further south the road climbs sharply through monzonite. Stop where a small quarry is seen on the left towards the top of the hill.

Stop 3. The rock here is fairly typical of the intrusion, being a variety of porphyritic monzonite. The large felspar phenocrysts are noteworthy. The rock face also displays a number of aplitic and pegmatitic veins.

The view to the west shows the level Nowra Sandstone horizon behind Little Forest, with the Tianjara mesas further north. Mt Kingiman blocks the view towards Pigeon House in the south west.

Continue through Milton towards Ulladulla. The Nelligen road (Excursion 12b) is marked by a sign pointing to the blue metal quarries.

Stop at a point 2.2 miles further south, just before Mollymook.

Stop 4. Olivine basalt, part of a flow remnant, occurs here in the road cutting. It is very weathered and good examples of spheroidal weathering may be seen. Building excavations nearby in Mollymook have revealed large masses of resinous opalised wood beneath the basalt. These appear to have been logs buried beneath the flow and thus preserved. Any new excavations in this locality are worth checking for further occurrences.

Continue towards Ulladulla. Stop along the waterfront where a large tourist map has been erected.

Stop 5. Ulladulla Harbour may have been formed by the erosion of a number of east-west dykes, traces of which have been found at the northern end of the beach. It has become a haven for fishing craft and is the safest anchorage between Jervis Bay and Bateman's Bay.

Warden's Head lighthouse may be reached by passing through the camping area or by following Deering Street, which turns left at the top of the hill through Ulladulla. The lighthouse is approximately one mile east of the highway.

Stop 6. Warden's Head is a well-known collecting ground for Permian fossils and a whole day could be spent here. A track descends to the rock platform a little south of the lighthouse. From the cliff top, observe the prominent north-south strike of the strata below, which has led to the formation of bomboras just off the platform. The sediments, mainly siltstone, dip towards the west at this point, but there is a considerable local variation in this.

At the point where the track reaches the rock platform, the beds are much disturbed. A small clastic dyke may be seen a few feet to the west and there is abundant evidence of slumping within the siltstone. Fossils may be found in the rocks to the south but more especially to the north. If time permits, walk right around to Ulladulla harbour. Spherical concretions (cannonballs) occur here and there are several glendonite beds, resembling those at Huskisson and Crookhaven. The sediments are richly fossiliferous and the superabundance of fossils has made some of the beds into impure limestone. Some of this proves to be largely made of the spines of small brachiopods, such as Strophalosia and Terrakea.

Permian marine fossils November 1963

Return to Ulladulla. The return trip to Milton may be made by way of Mollymook, Bannister's Point and Narrawallee. At Bannister's Point, silica has been quarried extensively. A large dyke occurs near the ruined jetty on the northern side of the headland, and this seems to be the origin of the quartz solutions which formed the quartzite. The sandstone at Bannister's Point has a prominent easterly dip, which can be clearly seen from the road.

Excursion 12b

Milton, Woodburn and Lake Burrill (20 miles)

This excursion includes features similar to those covered in the previous one, with the addition of several large dykes and scenic mountain areas.

Route: Nelligen road from Milton, thence via the Wheelbarrow Road to the Prince's Highway at Lake Burrill and return to Milton.

From Milton, the Nelligen road goes south across the monzonite for 4 miles. Good views of the Little Forest Plateau, The Castle, Mt Kingiman, and the top of the Pigeon House are to be had near Milton. Stop at the blue metal quarries, 5 miles from Milton. Request permission to enter.

Stop 1. The quarry being worked to the right of the road exposes a pale porphyritic monzonite, rather different to that seen at Milton. There are few veins or cavities and the jointing is irregular. The older quarry, on the left a little further south, shows considerable variation in the rock fabric. Much of it has been serpentinised, evidently by solutions rising from below. Most of the rock is finer grained than that seen in the other quarry, apparently because it is nearer the edge of the intrusion. Labradorite phenocrysts, however, are still plentiful.

Just past the quarries, a view of Burrill Lake reveals a small delta at its northern end. Lakes Conjola and Burrill are both examples of drowned valleys. A little further on, the road passes onto the Conjola Formation and outcrops of sandstone may be seen in road cuttings and in a quarry beside the road. Three miles past the monzonite quarries, the road to Mt Kingiman branches to the right.

Diversion 1. Some 1.6 mile along this road, there is a further branch. The left branch leads to Jindelara Creek and the right to Mt Kingiman. Keep to the right branch. The road climbs steadily. Outcrops of the Wandrawandian Siltstone may be seen after 1 ½ miles and loose blocks of Nowra Sandstone beyond this. The road skirts the western edge of the mountain for a further 1 ½ miles before becoming impassable. At any suitable point, the sandstone ridge above may be climbed, from which superb views of Milton, the Pigeon House, and the Little Forest Plateau may be obtained.

Return to the other branch and turn right. Stop at an old bridge 1 mile further on.

This area was burned out by severe bush fires in 1968 and the bridge was badly damaged. Immediately below the bridge is a fine waterfall, flowing over sandstone of the Conjola Formation. The track ahead may be followed to the Pigeon House. Take the left fork near Jindelara Creek 1 ½ miles ahead. The distance from the falls to the summit is about 5 ½ miles. Return to the Nelligen road and continue in a southerly direction. Turn right 1.3 miles further on.

Diversion 2. This road leads to a group of small farms situated on part of the Termeil Essexite intrusion (see Excursion 13a). This area drains into Boyne Creek which probably carries alluvial gold similar to that found on Murramarang Beach.

Views of the Pigeon House are frequent along this road. Turn left just past a bridge after 1.3 miles. Shortly after, cleared country is reached and essexite boulders are plentiful. Return to the Nelligen road. Turn right along the Wheelbarrow Road, which descends to the Prince's Highway near Burrill Lake. Turn left along the highway and right to Dolphin Point just before the bridge over the lake. This leads out to the coast south of Burrill Entrance.

The coast from Burrill Entrance south to Lagoon Point has many features of interest.

The rocks are principally siltstones and sandstones of the Conjola Formation, and closely resemble the outcrops at Warden's Head, 4 miles to the north. They contain numerous fossils and exceptionally large erratics composed of all kinds of metamorphic rocks.

Two large porphyritic dolerite dykes strike east-west across the rock platform about 500 yards south of the entrance. Both have arched up the intruded rocks in a similar fashion to the Berrara dyke. The northern dyke has a width of 45 feet and the southern 120 feet, making it one of the largest recorded dykes on the south coast. There is a very marked bleached zone on both sides of these dykes, where the igneous rock has been altered by solutions derived from the sedimentary rocks.

Further south, a number of erratics project prominently from the surface of the platform. Some of these are composed of highly contorted quartzite, others of granite and of intermediate volcanic rocks. They are known to bear some resemblance to the rock types still outcropping south west of the Sydney basin towards Canberra and they may have been brought from that direction.

Glendonites and concretions occur in the siltstone south towards Lagoon Point (1 mile from the large dyke). Good examples of marine fossils are abundant along the shore and some fine examples of crinoids have been found in this area.

Questions

1. Is there any evidence to support the suggestion that the Milton intrusion is older than the Shoalhaven Group? Give support for the contrary view.
2. Give an account of the origin of the sedimentary structures seen at Warden's Head.
3. Construct a geological history of the Milton-Ulladulla district.
4. Discuss the petrology of the Milton intrusion, using data gained from the outcrops studied on these excursions.
5. The base of the Nowra Sandstone stands at 1,500 feet near Little Forest, 2,100 feet at the Pigeon House but only 1,200 feet at Mt Kingiman. Suggest reasons for this situation.

Mollymook Beach January 1958

Chapter 13: The Termeil and Durras Districts

Until tourism brought the present growth of holiday resorts, this part of the coast remained relatively unknown. Much of it is still unspoiled and every effort should be made to keep it that way. This is especially true of the coastline between Pebbly Beach and Pretty Beach, where the slopes of the Murramarang Range fall steeply to the sea and tiny islets lie inshore. The whole of the country from Bawley Point south to Bateman's Bay is thickly covered by spotted gum forest and has been reserved as a State Forest. The only use of the land for farming has been near Termeil, Murramarang and Durras Mountain; the rest is virgin bush.

The Conjola Formation dominates the geology and considerable progress has been made recently towards the unravelling of its stratigraphy. There is a greater thickness of sedimentary rock here than has been measured over most of the area north of Ulladulla and it has been subdivided into several members.

Associated with the Permian sediments are a number of isolated flow remnants, resembling those of the Gerringong Volcanics further north. It is possible that there was volcanic activity here early in the history of the Sydney Basin as well as in the Hunter Valley.

The Termeil Essexite intrusion extends for 5 miles along the coast from Bawley Point and it appears to have formed about the same time as the Milton Monzonite intrusion. It is also possible that it is related to the flow remnants mentioned above.

The basement rock is most often the same Ordovician slate seen in many places in the Shoalhaven district. Underlying the Permian near Durras Lake is another group of metamorphic rocks, the Wagonga Beds. They are composed of highly folded dark slate and quartzite of supposedly Cambrian age. Their outcrop extends north from the Narooma district, where they form spectacular coastal exposures.

Excursion 13a

Termeil- Murramarang (40 miles)

The Termeil Essexite and the Durras Flow are the principal features of this excursion, which also includes large areas of the Conjola Formation.

Route: Burrill Lake-Tabourie Lake-Termeil-Bawley Point-Murramarang-Kioloa-Merry Beach-Durras Mountain-Termeil

From Burrill Lake, the highway runs south past extensive pine forests to the small inlet of Tabourie (or Toubouree) Lake. The plantations were considerably damaged by fire several years ago and many of the trees did not recover. Turn left just before the lake and stop at Toubouree Point.

Stop 1. Crampton Island is composed of sandstone and conglomerate dipping gently to the east. It is frequently linked to the shore by a sand spit or tombolo. Wairo Beach separates Lake Tabourie from the sea in much the same way as Bhewherre Beach cuts off St George's Basin. The coast south to Bawley Point is as yet unspoiled by encroaching 'development' and it is to be hoped that at least some of it can be preserved in its present state.

Continue south along the highway. Turn left at Termeil and proceed to Bawley Point.

Stop 2. The little beach at Bawley Point has outcrops of Conjola sandstone at its northern end and essexite at its southern. Unfortunately, no contact between the two can be seen, either here or anywhere else along the coast. By inference, the essexite is assumed to be an intrusion.

The headland south of the beach is bordered by superb outcrops of essexite. It is quite coarse, being visibly composed of black pyroxene and pale labradorite. Olivine and nepheline are less common. It more closely resembles gabbro than any other common rock. On weathered surfaces, the rock shows an unusual mottled appearance.

From Bawley Point, a road parallels the coast for several miles. Turn left at Rosemary Avenue, 1 mile south, and then veer right until the road reaches Murramarang Beach.

Stop 3. This is a place of exceptional interest. The essexite exposures here are similar to those at Bawley Point. Black sand has accumulated at the extreme northern end of the beach where a small creek runs into the sea. The heavy minerals in it are probably derived from the nearby intrusion and are more concentrated here than elsewhere.

Many years ago, an attempt was made to mine gold from the sand on this beach. Recent applications to mine have been rejected. The black sand is mainly magnetite and ilmenite and is noticeably darker than the rutile bearing sands of the north coast of NSW. It is possible to wash very fine gold containing a little platinum using a prospector's dish.

Just beyond the small creek is one of the largest aboriginal middens in NSW. Acres of sand hills are strewn with shell fragments, charcoal, and rock chippings. The visitor should take care not to despoil this site especially since it has not been thoroughly studied by archaeologists.

Brush Island lies just off the southern end of the beach. It is the largest of the numerous small islands along this part of the coast and is a prominent landmark from places like Warden Head and Durras Mountain. The waters around the island are very popular with spear fishermen.

Continue south towards Kioloa. The old homestead on the right is 'Murramarang' from which the locality takes its name. The range of hills behind contains scattered outcrops of a basaltic lava flow, the Murramarang Flow. The entire coastal fringe, where not sand covered, is composed of essexite, outcrops of which may be seen at Kioloa, O'Hara Head, and Merry Beach.

Turn left at Merry Beach. The small hill to the left of the road is composed of essexite.

Stop 4. Essexite forms the outcrops at the northern end of Merry Beach and Conjola sandstones the southern end. The Conjola Formation contains fine and coarse conglomerate in this vicinity and their pebbles have produced some outstanding pebble beaches (see Excursion 13b).

Near the Pretty Beach turnoff the road leaves the coast and winds through spotted gum forests towards the Prince's Highway. After 3 miles, keep to the left where the road turns right at a forestry hut.

By following these forestry roads, the summit of Durras Mountain is eventually reached, 5 miles from Pretty Beach.

Stop 5. The Durras Flow occupies the highest part of the range, for a distance of about a mile. The rock is a type of porphyritic andesite, resembling the latites of Kiama. As the summit is private property, the landowner's consent should be sought before entering.

Durras Mountain has an altitude of 930 feet, and affords unsurpassed views in all directions. The sea and a beautiful stretch of coastline lie close below to the east. The northern view takes

in the coast as far as Kiama, where Saddleback Mountain may be seen. In the south, Durras Lake, Bateman's Bay, and Mt Dromedary are prominent. In the west is the Pigeon House and nearby sandstone mountains, as well as the Budawang Range extending southwards through Currockbilly and Clyde Mountain towards Araluen.

Return to the Merry Beach road and continue towards the highway. The sandstone eventually gives way to the Ordovician basement and this continues along the highway towards Termeil. Three miles south of Termeil, and a similar distance north along the highway, the Conjola Formation may be again be seen outcropping.

Excursion 13b

North Durras and Pebbly Beach (18 miles)

The Conjola Formation along this part of the coast contains many examples of sedimentary structures, which are better seen here then elsewhere in the Shoalhaven district.

Route: East Lynne-North Durras-Depot Beach-Pebbly Beach-Prince's Highway

Leave the highway at East Lynne, 10 miles south of Termeil. The road passes over poorly exposed slate for 1 ½ miles and then over the Conjola Formation. Keep to the right 3 miles from the highway. One mile further on, the road passes through Lovell's Pass, where poorly fossiliferous sandstone and siltstone is exposed. Shortly after, the road divides. The left branch leads to Depot Beach. Take the right branch, which leads to North Durras.

Stop 1. Durras Lake is another of the coastal lagoons which resulted from the postglacial rise in sea level. Point Upright, so named by Cook in April 1770, is a landmark to the north and may be approached via the beach. From the entrance to the lake to Depot Beach is a walk of 2 miles. Many of the features of interest may be approached from the Depot Beach end with less effort.

The strata here belong to the lowest part of the Conjola Formation, which has been correlated with the Dalwood Group (Lower Marine) of the Hunter Valley. The sediments are mainly siltstone and shale with prominent interbedded conglomerate. The conglomerates contain the typical angular blocks common in the Shoalhaven Group. The finer sediments display many interesting features which illustrate their origin. Wash outs, ripple marks, and worm tracks suggest shallow water sedimentation. Such features have rarely been observed elsewhere in the Shoalhaven district.

Proceed to Depot Beach.

Stop 2. A good view of Grasshopper Island may be had from Depot Beach. There are several small sandstone islets along this part of the coast, though there seems to be no good reason for their concentration here. The rock platform at the southern end of the beach may be followed around to Point Upright (Stop 1). Similar sediments are exposed north of the beach but are less accessible.

Return along the road towards the highway. Turn right after 2 ½ miles and again 1.4 miles further on. From here the road descends sharply to Pebbly Beach.

Stop 3. Sediments of the Conjola Formation outcrop here also. There is little of interest in the siltstones at the northern end of the beach. Conglomerates outcrop near the southern end and these have given rise to extensive pebbly beaches south of the camping ground. These pebbles, being derived from the neighbouring conglomerates, are largely composed of the rock types found in them – quartz, quartzite, chert, various types of hornfels, rhyolite, and other resistant

rocks. Agate and chalcedony are occasionally found and these, along with other attractive pebbles, are often collected for lapidary work.

Fossilised logs, some of them preserved as coal, may be seen in the cliffs and on the rock platform. These apparently floated from the nearby shore, since these sediments are definitely of marine origin.

Return to the highway by ascending the hill and turning right (5 miles).

Excursion 13c

North Head and South Durras (27 miles return)

The southernmost Sydney Basin sediments and their associated unconformities are features of exceptional interest seen on this excursion.

Route: Bateman's Bay-Benandrah-South Durras-North Head-Flat Rock-Dark Beach-South Durras-Benandrah-Bateman's Bay

Proceed north along the Prince's Highway from the Clyde River bridge at Bateman's Bay. Road cuttings expose lower Palaeozoic slate and phyllite. Turn right along Berrima Parade, 1 mile north of the river. This leads to New Haven Surfside Beach on Bateman's Bay.

Stop 1. Outcrops of highly folded and faulted siltstone occur on the shore and an aboriginal midden is located behind the beach.

Return to the highway and continue northwards. Two miles further on, a road branches right to Long Beach, where folded strata may be examined. Turn right at Benandrah, 5 miles from Bateman's Bay, along the South Durras road and turn right off this onto the North Head fire road 1 mile from the highway. This leads, after 5 miles, to a point above the sea where fine views are to be had both up and down the coast.

Stop 2. Rounded gravel occurs here about 100 feet above sea level. This may represent a raised beach, evidence of a former higher sea level, or it may be the remnants of an outlier of Permian conglomerate.

A track leads down to the sea where outcrops of hard black slate form rugged outcrops and present an entirely different appearance to the familiar Permian exposures. Pebble beaches have formed from these hard rocks and similar pebbles are abundant in nearby Permian outcrops, indicating that these rocks were exposed to erosion even then.

Breccia bed in the lowermost Permian at Flat Rock November 1967

Take the Coast Road northwards. Three miles from North Head, a branch leads out to a grassy point where the most southerly exposure of Sydney Basin sediments may be examined.

Stop 3. From this locality, known as Flat Rock because of a number of small

sandstone stacks off the point, an extensive view extends south to Mt Dromedary and north to Brush Island. The strata dip noticeably to the north, but their base is not visible. However, basement rocks are exposed south of the little beach.

The sediments are quite coarse and are frequently composed of blocky breccia beds, with boulders up to 3 feet across. These are of hard slate and quartzite, identical to the adjoining outcrops.

Continue towards South Durras. Another side track leads into Dark Beach, about 1 mile north of Flat Rock.

Stop 4. A classic unconformity is exposed along the southern edge of this tiny beach. The Permian strata rest on an uneven surface composed of nearly vertical Wagonga beds. Elsewhere around the inlet, extensive breccia beds merge into sandstone above (belonging to the Conjola Formation) and slate below, without any clear cut boundary. The invasion by the sea in Permian time evidently bared some areas of accumulated debris and deposited this in nearby depressions.

Base of the Permian resting on the Wagonga Beds at Dark Beach November 1967

South Durras is only a short distance north of this point, about 1 mile by road.

Stop 5. The Conjola sediments exposed in the rock platform at South Durras resemble those at Point Upright, 2 miles to the north. The same sedimentary structures and fossils may be found, but much of the pebbly sandstone is littered with slate fragments, indicating that outcrops of basement were close.

Wasp Island, composed of similar sandstone, lies just offshore and is well seen by walking from the southern end of the south beach towards Dark Beach.

The return trip to Bateman's Bay via Benandrah includes a further example of an unconformity, 1 mile from South Durras, but this is much less convincing than that seen at Dark Beach.

Questions

1. Discuss the evidence in favour of Permian volcanic activity in the Termeil district.
2. Compare the sediments seen at Flat Rock, Point Upright and Crampton Island.
3. What do the sedimentary structures observed at Point Upright and South Durras tell us about the depositional environment which prevailed then?
4. The present edge of the Permian sediments tends to rise away from the present coastline. Why is this so?
5. Suggest reasons why islands are more common between Bateman's Bay and Ulladulla than elsewhere south of Sydney.

Chapter 14: The Nerriga District

The Permian sediments reach their highest level east of Nerriga and it is in this area that spectacular examples of erosion are most common.

Extensive denudation has exposed the underlying basement rocks over a wide area. These are a continuation of the rocks exposed at Yalwal and Ettrema in the north.

The Budawang Range reaches a height of 3,711 feet at Currockbilly Mountain and a similar height at Mount Budawang a little further south. This prominent ridge is the backbone of the basement, consisting essentially of a narrow belt of resistant Devonian strata flanked by Ordovician slates. Marine fossils occur in both these groups as well as sporadic mineralisation. Alluvial gold has been extensively mined, but reefs have rarely proved profitable.

The core of the area described in these pages is a wild confusion of deep valleys and remarkable sandstone peaks. It is a place to be seen only by the bushwalker and not for the ordinary tourist. It is beyond the scope of this book to describe any but the most accessible places, but the geological features of these are representative of the whole.

Excursion 14a

Quilty's Mountain (18 miles return)

From Sassafras, a road runs south towards the Clyde River. It provides access to many fine views of the Clyde and its tributaries. Quilty's Mountain is remarkable for its aboriginal Borah Ground, one of the few reminders of the former inhabitants of this district.

Route: Sassafras-Round Hill-The Vines-Quilty's Mountain

Turn left from the Braidwood road 1 mile past Stony Hill and 34 miles from Nowra (see Excursion 9a).

For the first mile, the road crosses basalt country, outcrops of which may be examined in many places. Thereafter, the sandstone-basalt boundary is crossed several times and great contrasts in their respective vegetations can easily be seen.

Some 3.7 miles from Sassafras, a view to the east opens up, including the Tianjara mesas. The uppermost part of the Clyde gorge lies in between, a short distance to the east. Stop at Round Hill, a prominent residual beside the road a little further on.

Stop 1. The sandstone outcropping here is typical of the Berry Formation in this area. It resembles that seen at Stony Hill and Tianjara. From the summit (2,412 feet) there is a panorama of the Clyde gorge, the Endrick River, and the mountain ranges in the south. Mt Talaterang and the top of the Pigeon House are also visible.

A little further south the road skirts Newhaven Gap which provides access to the Clyde canyon, emerging upstream from the Coal Measures exposures (see Excursion 11a, Stop 4). The road reaches its closest point to the gorge 2.2 miles south of Round Hill.

Stop 2. The cliff edge is only a few minutes walk from the road. There are numerous open joints in the sandstone, some of which yawn like great caves well back from the cliff and provided a convenient disposal unit for the sawmill which formerly operated here.

It is possible to descend into the valley by way of some of the more accessible joints. Far below, the base of the Permian sediments is marked by a prominent bed of sandstone, below which outcrop the slates of the basement.

The Clyde River gorge from near Newhaven Gap April 1969

The road deteriorates past this point and the next 2 miles should be covered on foot. Basalt is reached after the track has descended a wide gap in the sandstone plateau. Shortly afterwards, the track swings to the north.

Stop 3. This locality, known as The Vines, is covered by thick vegetation, in contrast to the scrubby sandstone country nearby. A narrow belt of basalt may be traced northwards into the valley of the Endrick River as far as Nerriga. Apparently the lava flowed down the valley in earlier times from a point south of The Vines and since then the Endrick River has removed most of it by erosion.

Quilty's Mountain (or Mount Endrick) lies just west of this point. A track ascends to the bare rock outcrops near the summit, where aboriginal motifs in the form of native animals are depicted on the ground by heaps of small stones. This locality should be treated with all the respect it deserves as a historic monument and none of the stones should be moved.

From The Vines, the track may be followed to Nerriga (12 miles). Otherwise, the return journey must be made over the same route.

Excursion 14b

Nerriga-Braidwood (68 miles)

The Permian sediments reach their western limit at Nerriga and their present boundary with the basement rocks trends towards the coast, reaching it at Bateman's Bay. On this excursion, outcrops of Upper Ordovician and Upper Devonian rocks are prominent and occupy most of the surface.

Route: Nerriga-Oallen-Corang River-Charley's Forest-Mongarlowe-Braidwood

This excursion begins where Excursion 9a finishes – at the western edge of the sandstone plateau, east of Nerriga. The base of the Nowra Sandstone is easily found. The unconformity with the Ordovician basement is 0.7 miles further down the hill at a point where the road bends to the right.

Stop 1. There is no marked unconformity visible as such, but there is a distinct change of slope and in vegetation at this point. The basement rocks consist of quartzite and phyllite intersected by numerous quartz veins.

From this point on, the road descends more steeply and soon the Endrick River is reached. Cars may be parked on the left just before the bridge.

Stop 2. The river gravel is representative of the rocks upstream and of no particular interest. The road cutting, however, reveals an interesting section of steeply dipping slates, with many quartz veins, overlain unconformably by semi-consolidated river gravel. This strongly resembles that in the nearby stream and is plainly of recent origin. Notice its irregular base, representing part of the old river bed.

From the Endrick River, the road ascends to a comparatively level, fertile area underlain by the same Tertiary basalt seen at The Vines (see Excursion 14a, Stop 3). Outcrops may be seen on the right 0.6 miles from the river. Silicified logs are known to occur beneath the basalt west of the road and enquiries at nearby farmhouses should yield further information. The Endrick River drops over a large waterfall just beyond these paddocks and copper minerals have been found in the gorge below.

Continue through Nerriga and turn right along the Goulburn road 2 miles past the town. This road passes through an area where alluvial gold was once extensively mined. Jerricknora Creek was one of the chief centres, especially towards its confluence with the Shoalhaven River. Stop where some old mine heaps may be seen on the left, 5 miles from the Braidwood Road.

Stop 3. A series of shafts on the hill side mark the outcrop of a quartz reef; quartz and slate are plentiful on the heaps. Alluvial gold found in the nearby creek was probably traced to this outcrop. Similar small mines abound in the area, but most of them are of little interest.

Continue to the Shoalhaven River at Oallen Crossing.

Stop 4. This is a favourite place for fossicking. Gold may be panned from gravel in the river itself or from the extensive gravel deposits alongside the road just before the bridge. There is nearly always someone here to give advice about the best places to try!

From Oallen, the road may be followed on to Bungonia (26 miles) and thence to Bungonia Caves (see Excursion 9c). Otherwise, the road should be retraced to Nerriga (7 miles) and then right towards Braidwood again. Stop at the Corang River 5 miles further on.

Stop 5. Some alluvial gold may be washed here. The river gravel consists mainly of the local low grade metamorphic rocks with some pieces of Permian conglomerate. A ½ mile past the bridge the road crosses the remains of an old water race. Built in the 1890's, this channel carried water 24 miles from the upper Corang River through tunnels and across bridges to supply a head of pressure for the hydraulic sluicing of gold bearing gravels. The race is visible for miles upstream from the bridge.

New road cuttings south of the Corang River reveal good exposures of steeply dipping slate. Blocks of red jasper occur 2 miles south and in this vicinity there are many outcrops of old river gravel.

Turn left for Mongarlowe 2.7 miles beyond the river. The road crosses Wog Wog Creek and begins to climb slowly. Outliers of Permian sandstone may be seen a mile or so to the east. Stop at a gate on the left 2.4 miles from the creek. It is possible to drive a short distance along this track.

Stop 6. Access may be had from this point to the Corang group of outliers and the underlying Upper Devonian strata. The track leads down to a creek crossing and shortly after a branch leads up the hill to the right. Outcrops here are mainly of slate. About ½ mile from the creek, the first Devonian rocks are met. These are rhyolites and they form a narrow belt a few hundred yards across. Much of the rhyolite is silicified and has become masses of chalcedony containing cavities filled with small quartz crystals. Common opal also occurs.

Beyond the rhyolite, beds of sandstone strike north-south across the track. These dip steeply to the east and are intersected by numerous quartz veins. They belong to the Upper Devonian Merimbula Formation and marine fossils have been found in the sandstone in this vicinity. The location is to the right of the track, 400 yards beyond the rhyolite boundary.

Should it be desired to climb Corang Peak, the track must be followed for another ½ mile before a left branch is taken towards the mountain. Corang consists largely of the Nowra Sandstone. The Yadboro Conglomerate forms the lowest outcrops of the Permian here. The view south from Corang reveals Wog Wog Mountain in the near distance with Currockbilly beyond. The axis of the Budawang Range is essentially that of a syncline in which the Devonian rocks have been preserved. Quartzite ridges are prominent along the range and form the highest points.

Return to the Mongarlowe road. Some 2.2 miles further south, First Curradux Creek is crossed. Stop just before the second crossing where there is a small roadside quarry on the left.

Stop 7. Steeply dipping beds of black siltstone contain Upper Ordovician graptolite fossils. These are confined to one narrow zone in the middle of the quarry, where the rock is fairly soft and quite fissile. It is interesting to speculate on the sparseness of fossil evidence in these ancient rocks. Without these rare discoveries, the age of these beds would be only vaguely known. Do not remove, from this or any other place, any fossil material for which you have no use.

Occasional pieces of agate may be found in the creek, brought down from rhyolite outcrops a short distance upstream. Continue towards Mongarlowe. Good views of the Budawang Range and Corang are seen a little further south. Notice the thin vegetation on this side of the range. The coastal side is much more thickly clad, presumably because of its higher rainfall.

Stop at a roadside quarry a little over 3 miles further south, near Charley's Forest.

Stop 8. Greenish altered rhyolite and shale outcrop here. It is possible that the rhyolite has been faulted against the Ordovician slates here, as a considerable area of quartz occurs near the boundary just north of the road.

Eight miles south of Sapling Yard Creek, the road passes through Mongarlowe. This was once a prosperous gold mining centre and the Mongarlowe River was extensively dredged.

The left branch of the road leads to Monga and Clyde Mountain, while the right goes to Braidwood (8 miles). On the Monga road there is much evidence of former mining activity. The Braidwood road passes onto granite 5 miles from the town, from which point on there is a marked change in topography and vegetation.

Questions

1. Discuss the changes observed in the topography when passing from (a) basalt to sandstone at Sassafras, (b) sandstone to slate at the Endrick River and (c) slate to granite near Mongarlowe.
2. Put forward theories to explain the joints seen in the sandstone near the edge of the Clyde gorge.
3. What evidence is there to suggest that there has been volcanic activity in the Endrick River area since the uplift of the country began?
4. Compare the shapes of Corang Peak and Currockbilly. What has caused this essential difference?
5. What observations could be used to distinguish an outcrop of Upper Devonian sandstone from a Permian one?

Chapter 15: The Clyde River Valley

Taking its rise at an elevation of 2,500 feet near Sassafras, this small river flow south and descends by way of a great canyon to a level of 200 feet at Yadboro. It does this in less than 20 miles, yet it is a further 40 miles to the sea downstream. This is a peculiar result of the dip of the Shoalhaven group sediments. At one time, these must have extended further south than at present. When the area was uplifted, it was tilted to the north, so that the ancestral Clyde River had to erode its bed against this trend.

This undoubtedly led to the formation of many waterfalls and the evolution of the canyon upstream from Yadboro.

The southern edge of the sandstone scarp presents a bold face and is broken into numerous outliers. Some such as The Castle and the Pigeon House are well known to bushwalkers, but there are many others. They all have a similar structure, being capped by cliffs of the Nowra Sandstone or sometimes part of the Berry Formation, with cliffs of lower units below this level.

The basement rocks are of presumed Ordovician age, flanked on the west by the Devonian group near Currockbilly. There has been some mineralisation and gold has been won from many places near Bateman's Bay and Nelligen. Some copper and lead prospects have also been recorded.

This chapter deals mainly with places accessible by road. The numerous bushwalks based on Yadboro have not been treated since they are taken by relatively few tourists. Only the Pigeon House has been included, partly because of its historic and romantic interest, but also because its geology is typical of all the sandstone peaks.

Excursion 15a

Yadboro and Pigeon House Mountain (34 miles return)

Captain Cook sighted Pigeon House Mountain (the Pigeon House or Pigeon Top) on April 21st 1770. At first it was mistaken for a distant island, as only its sandstone cap could be seen. The 'Endeavour' was probably off Moruya at the time. Its identity was established the following day and its name given because it resembled the dovecotes familiar to Cook in England.

Route: Termeil-Boyne Creek-Pigeon House-Yadboro

Turn right off the Prince's Highway along Woodburn Road, 4 ½ miles south of Lake Tabourie.

One mile from the highway, the road crosses a small inlier of slate, which may be examined on the left of the road. For the next mile the road climbs through the lower Conjola Formation and extensive outcrops of siltstone may be seen near the crest of the range. This probably corresponds to the silty member at Point Upright. The highest point in this area, Boyne Trig., is capped by sandstone and this is possibly equivalent to the outcrops at Crampton Island, Bannister Point, and Jervis Bay.

Turn left on the Brooman road 3.4 miles from the Prince's Highway and right on the Yadboro forestry road 2.3 miles further on. The base of the Permian is not very noticeable and the road passes over slate country northwards towards the Pigeon House. Stop at Boyne Creek, 4 miles along the Yadboro road.

Stop 1. Slate is the dominant rock type in the creek gravel, with lesser amounts of quartzite and conglomerate. Boyne Creek possibly carries alluvial gold in small quantities. This creek is the last good place for obtaining drinking water before the ascent of the Pigeon House.

Continue towards Yadboro. Park on the left where the Pigeon House track leaves on the right, 2.3 miles from Boyne Creek.

Stop 2. This area was burned out late in 1968 and the road towards Pigeon House became impassable. Before then, it was possible to drive one mile towards the mountain. The vehicular track ends at the bottom of a steep slope, at an elevation of 750 feet. The only rock outcrops at this level are of slate, intersected by quartz veins.

At the top of the steep slope, the base of the Shoalhaven Group outcrops at 1,200 feet. The Yadboro Conglomerate, full of slate fragments, is the lowest member at this point. Skirt the cliff to the left and climb to the plateau above a few hundred yards further on. By now a fine view of the mountain, a little over a mile ahead, will have opened out. The other prominent sandstone peaks and the Budawang Range have also come into view.

Outcrops of the Conjola Formation persist towards the base of the mountain until the Wandrawandian Siltstone is reached at a height of 1,700 feet. Fossils occur in this and the lower part of the overlying Nowra Sandstone. Climb up to the base of the sandstone and around the left side to the northern end. The route to the summit (2,361 feet) is clearly marked and involves scrambling up several steep pebbly slopes and scaling a few wooden ladders in the more difficult places. The view is as comprehensive as any in NSW. Perhaps the valley of the Clyde River, immediately to the north commands the greatest attention.

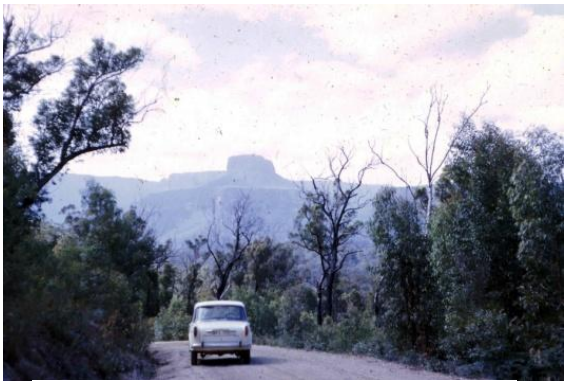
The Clyde River valley from the summit of the Pigeon House January 1969

The entire walk from the road and the return journey takes 4-5 hours. The climb is not difficult except for the final pyramid of sandstone, which would daunt the average hiker.

NOTE: *This is the only place in this work where I think a comment on developments since it was written is essential. In 1971 I led a group of students from Erina High School to this spot. The old route to the summit had been superseded by a set of steel ladders and the track was more clearly marked. This made it possible for many who would have baulked at the old ascent to reach the summit.*

Continue on to Yadboro, where the Clyde River is reached, 6 miles beyond Boyne Creek.

Stop 3. When subsidence began early in the Permian period (or perhaps the late Carboniferous period), this area was the first to be seriously affected. The earliest sediment to be deposited, the Pigeon House Creek Siltstone, is found only in the neighbourhood of Yadboro, as is the overlying conglomerate. Later on, the whole area west to the Budawang range began to subside and the rest of the marine beds accumulated.



The Castle from the Yadboro Road October 1967

Yadboro is the centre from which numerous bushwalks radiate. The Clyde River itself may be followed upstream on the eastern side of the bridge. The road across the bridge leads into a network of timber tracks. Yadboro Creek, the western tributary of the Clyde in this area, carries rhyolite and the Devonian rocks derived from the Budawang Range exposures.

Excursion 15b

Brooman, Nelligen and the Lower Clyde (51 miles)

Ordovician basement rocks form the surface over the entire lower Clyde valley. This is an area of extensive gold mineralisation, one where many lonely prospectors hoped to strike it rich but few succeeded.

Route: Milton-Brooman-Shallow Crossing-Brimberamala-Currowan Creek-Nelligen

Pigeon House Mountain from the Brooman Road
September 1967

Take the Nelligen road from Milton, as in Excursion 12b. Fine views of the Pigeon House are seen 10 miles south of Milton. Note the contrast with the hills of Devonian rocks in the background. The road from Termeil is passed on the left 13 miles south (see Excursion 14a). Shortly after, the sandstones are left behind and the slate is seen for the first time. Any creeks from here on could yield alluvial gold.

Brooman, 21 miles from Milton, was the site of a minor gold rush, which led to very little gold being found. The Clyde River presents a very fine appearance alongside the road. Stop at Shallow Crossing, 7 miles from Brooman, where a concrete causeway fords the river.

Stop 1. Alluvial gold has been dredged for the Clyde in this vicinity, but the amateur prospector cannot hope to find much in a place like this. The gravel in the river includes slate, quartzite, and rhyolite, the latter having come down via Yadboro Creek.

Turn right along Mare's Hill fire road, ½ mile south of Shallow Crossing. Take the right branch 4.2 miles further on. Stop at the old mullock heaps by the roadside 0.8 miles north.

Stop 2. The Brimberamala mines were good small scale producers many years ago. This area is dotted with numerous mine dumps and pitted with shafts. The creek carries alluvial gold, which undoubtedly led to the discovery of quartz reefs on this hill side. Some of the slate shows the interesting effects of extreme folding.

Either return to the Nelligen road the same way, or turn right from the Brimberamala road and follow the main roads back to the Nelligen road further south (5.6 miles).

Granite-slate contact on the Clyde Mountain road
September 1967

From Currowan Creek, the road passes through pleasant wooded country alongside the Clyde River until the Braidwood road is reached 7 ½ miles further on.

Stop 3. The slate here is seen to be isoclinally folded and numerous small faults and fold axes can be detected. Quartz veins run through the whole mass.

At Nelligen the Clyde River is crossed by a fine new bridge replacing the old ferry which formerly operated here. The Prince's Highway at Bateman's Bay is 5 miles further on (see Excursion 13c).

Questions

1. Give an account of the formations met with between Boyne Creek and the summit of the Pigeon House.
2. Explain the existence of numerous sandstone outliers in the upper Clyde valley.
3. Suggest reasons why the Clyde River parallels the coast before turning east near Bateman's Bay.
4. Granite occurs a few miles west of Nelligen. Relate this fact to the occurrence of gold in this area. Why is gold uncommon in the older rocks north of Brooman?

The Clyde River ferry at Nelligen October 1963

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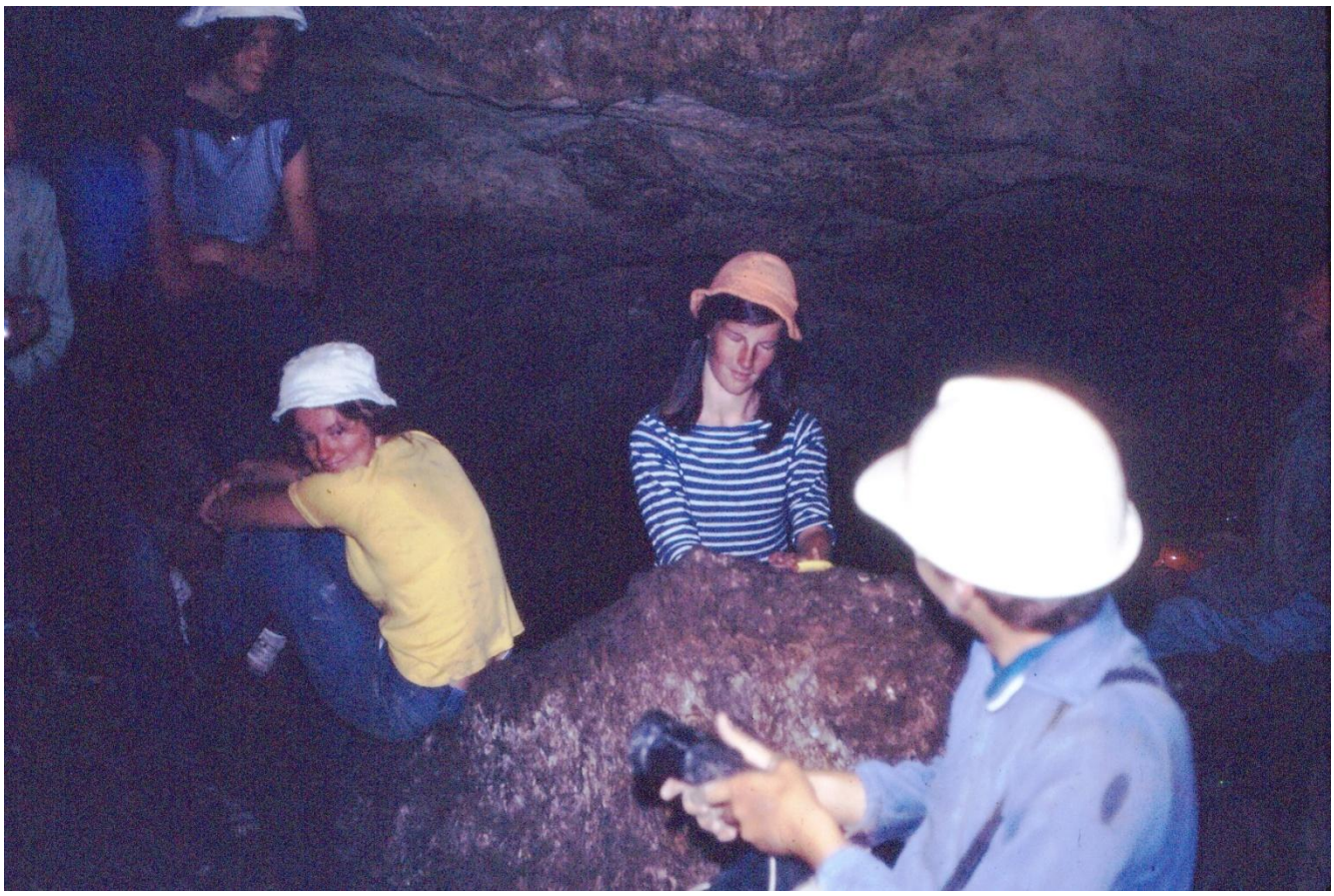
Glossary: Rock and Mineral Names

AGGLOMERATE	Coarse, angular, pyroclastic rock
AMETHYST	Purplish variety of quartz
AMPHIBOLES	Mineral group, complex aluminosilicates
ANDESINE	Member of the plagioclase family of felspars
ANDESITE	Volcanic rock composed mainly of andesine and ferromagnesian minerals
APLITE	Fine grained dyke rock often found intruding coarse igneous rocks
ARKOSE	Sedimentary rock rich in felspars; may be derived from weathered granite
ARSENOPYRITE	Mineral, FeAsS, commonly called mispickel or arsenical pyrites
AUGITE	Dark mineral of complex formula, one of the pyroxene group
BASANITE	Volcanic rock resembling basalt, but containing minerals such as nepheline in addition
BIOTITE	Common dark coloured variety of mica
BORNITE	Peacock copper ore, Cu_5FeS_4, frequently displays an iridescent purple tarnish
BRECCIA	Fragmental rock composed of angular fragments. May be pyroclastic but finer than agglomerate
CASSITERITE	Mineral, SnO_2, tin oxide, stream tin
CHALCEDONY	Waxy variety of quartz composed of microscopic crystals
CHALCOPYRITE	Golden copper ore, $CuFeS_2$
CHERT	Sediment or residue composed largely of minute quartz particles
CHLORITE	Green micaceous mineral, commonly formed during metamorphism or weathering
DOLERITE	Common basic igneous rock of medium crystal size
ESSEXITE	Igneous rock resembling gabbro, but containing some nepheline
FELSPAR	Large group of aluminosilicate minerals, present in most rocks
FLUORITE	Mineral whose formula is CaF_2
GABBRO	Plutonic igneous rock composed mainly of plagioclase, olivine, and pyroxenes
GALENA	Common lead mineral, PbS
HAEMATITE	Common iron ore, Fe_2O_3
HORNBLENDE	Dark mineral of complex formula, one of the amphibole group
HORNFELS	Fine grained metamorphic rock, the result of the intense heating of a silty sedimentary rock
ILMENITE	Mineral whose formula is $FeTiO_3$
JASPER	Coloured impure of chalcedony
LABRADORITE	One of the plagioclase family of felspars
LAMPROPHYRE	Intrusive igneous rock rich in phenocrysts of ferromagnesian minerals
LATERITE	Residue of weathering, rich in iron and aluminium oxides
LATITE	Volcanic rock containing approximately equal parts of plagioclase and potassium felspars
LITHIC SANDSTONE	Sandstone composed largely of rock fragments
MAGNETITE	Dark magnetic iron mineral, Fe_3O_4
MONZONITE	Plutonic rock, similar in composition to latite
NEPHELINE	Rock forming mineral, (Na,K)Al SiO_4
NORITE	Variety of gabbro
OLIVINE	Common family of greenish rock forming minerals, $(Fe,Mg)_2SiO_4$
ONYX	Variety of chalcedony composed of coloured, parallel bands
ORTHOCLASE	Potassium felspar, $KAlSi_3O_8$
PEGMATITE	Coarse igneous dyke rock usually found intruding bodies of granite
PHYLLITE	Metamorphic rock, midway between slate and schist
PLAGIOCLASE	Family of sodium-calcium felspars, ranging from $NaAlSi_3O_8$ (albite) to

	Ca $Al_2Si_2O_8$ (anorthite)
PYRITE	Common brassy mineral, FeS_2 iron pyrites, fool's gold
PYROLUSITE	Manganese dioxide, MnO_2
PYROXENES	Mineral group, represented by $ABSi_2O_6$ where A and B are metals
QUARTZ FELSPAR PORPHYRY	Common intrusive rock, containing phenocrysts of quartz and felspars
QUARTZITE	Metamorphic rock derived from sandstone
RHYOLITE	Flow banded volcanic rock related to granite in composition
RUTILE	Titanium dioxide, TiO_2
SCHIST	Metamorphic rock in which micaceous minerals are dominant
SHALE	Fine grained, layered sedimentary rock
SILTSTONE	Fine grained sedimentary rock in which layering is not prominent
SLATE	Fine grained metamorphic rock notable for its well developed cleavage
SPHALERITE	Zinc blende, ZnS
SPOTTED SLATE	Slate in which individual crystals are prominent
STANNITE	Complex ore mineral, Cu_2FeSnS_4
SYENITE	Plutonic igneous rock, composed essentially of orthoclase and ferromagnesian minerals
TRACHYTE	Volcanic rock related to syenite
TUFF	Fine grained pyroclastic sediment
ZEOLITES	Group of hydrated aluminosilicate minerals
ZIRCON	Zirconium silicate $ZrSiO_4$



Moss Vale High School Field Geology Club members at Bungonia Caves December 1972

Glossary: Descriptive terms

ACIDIC	As applied to igneous rocks, containing more than 66% SiO2 by analysis
ADIT	Horizontal mine passage from the surface
AMGYDALOIDAL	Applied to volcanic rocks, meaning contains cavities (amygdales) filled with secondary minerals
ANTICLINE	Fold in which strata are arched upwards
BASEMENT	Older, more altered rocks lying beneath a sedimentary basin
BASIC	As applied to igneous rocks, containing less than 52% SiO_2 by analysis, but more than 45%
BATHOLITH	Large body of intrusive igneous rock, commonly granitic in appearance
BRACHIOPODS	Group of marine invertebrates, having two dissimilar shells (valves), each of which is bilaterally symmetrical
CLASTIC DYKE	Body of sediment forced by pressure into cracks in the beds above or below
COLUMNAR JOINTING	Pattern of cracks caused by cooling which breaks a body of rock into columns, commonly hexagonal
CONCRETION	Body of mineral formed around a nucleus within the fabric of a rock
CORRELATE	The determination of the age equivalence of various rock formations
CRINOIDS	Group of marine organisms characterised by a cup, with radiating arms, attached to the sea floor by a stem
CROSS BEDDING	Arrangement of strata at an angle to the horizontal caused by current deposition
DEUTERIC	Term applied to alteration of an igneous rock by solutions after crystallisation has ceased
DYKE	Intrusive body cutting across adjacent rocks
ERRATIC	Applied to transported rock fragments foreign to the area where found
ESTUARINE	Applied to the region where fresh water drainage systems meets the sea
FACIES	As applied to sediments, the nature of the sedimentary material
FERROMAGNESIAN	Containing iron and magnesium
FLUORESENCE	Emission of visible light by a substance when exposed to ultraviolet rays
GANGUE	The nonmetalliferous components of an ore body
GLENDONITE	Type of concretion common in Permian sediments which crystallised in near freezing bottom mud
GRAPTOLITES	Extinct group of marine organisms, found in floating colonies
GROUNDMASS	Material between the phenocrysts in a porphyritic rock
GRYKE	Solution groove on a limestone surface
HYDRATION	Combination with water
IGNEOUS	Formed from the molten or partially molten state
INLIER	Body of rock surrounded by younger rocks, produced by erosion
INTERMEDIATE	As applied to igneous rocks, containing between 52 and 66% SiO_2 by analysis
INTRUSION	A body of igneous rock invading an older rock
ISOCLINAL	Applied to folds in which the limbs are practically parallel
JOINT	Rock fracture
LACCOLITH	Sill-like intrusion which has domed up the overlying rocks
MESA	Flat topped, cliff bound mountain
METAMORPHIC	Applied to rocks which have been formed by the effect of heat, pressure etc on existing rocks
MIDDEN	Aboriginal refuse heap
MOLLUSC	Marine organism characterised by a fleshy foot
MONOCLINE	Local steepening of the dip of strata

NORMAL FAULT	Displacement of strata resulting from tension within the rock
OROGENIC	Mountain building
OUTLIER	Body of rock surrounded by older rocks, produced by erosion
OXIDISED	As applied to ore bodies, the uppermost, weathered region
PALAEONTOLOGY	Study of former life as revealed by fossils
PHENOCRYSTS	Relatively large crystals in an igneous rock, usually ones which crystallised earlier
PLUTONIC	Formed deep within the earth
POLYZOA	Group of marine, colonial organisms
PORPHYRY	Igneous rock containing phenocrysts
PSEUDOMORPH	Crystal produced by the alteration or replacement of another mineral, but retaining the original shape
PYROCLASTIC	Applied to sediments produced by explosive volcanic activity
RACE	Channel cut to convey water, usually for alluvial mining
REVERSE FAULT	Displacement of strata caused by compression within the rock
SEDIMENTARY	Applied to rocks deposited in layers
SERPENTINE	Rock forming minerals frequently derived from the alteration of ferromagnesian minerals
SILICIFIED	Replaced or cemented by silica
SILL	Body of igneous rock forced between strata
SINK HOLE	Depression caused by solution in a limestone body
SLUMP	Sediment that has moved down a slope, causing disturbance of the original bedding
SPHEROIDAL WEATHERING	Type of weathering which causes outer layers to peel off, forming rounded boulders
STACK	Small coastal island not yet removed by marine erosion
STRATIGRAPHY	Study of layered sedimentary rocks
STRIATIONS	Subparallel grooves, sometimes caused by glacial movement
STRIKE	Course or bearing of an outcrop, usually applied to sedimentary rocks, dykes, veins etc
SYNCLINE	Fold in which strata are arched downwards
TECTONIC	Applied to the deformation of the Earth's crust
TERRACE	Benches produced by deposition and erosion of sediment
TOPOGRAPHIC	Term applied to the surface relief of the Earth
TUFF	Fine grained pyroclastic material
TWINNING	Tendency of crystals, when growing, to share faces, edges etc
ULTRABASIC	As applied to igneous rocks, containing less than 45% SiO_2 by analysis
ULTRAVIOLET RADIATION	Rays lying outside the violet end of the visible spectrum
UNCONFORMITY	Erosional surface separating younger and older rocks; a time gap
VESICULAR	Containing small gas cavities or vesicles
VUGH	Cavity in a rock frequently lined with crystals
WASHOUT	Channel cut through sediment which is later filled in itself
WATER TABLE	Surface below which rock openings are filled with water
XENOLITH	Applied to foreign rock material found within a body of igneous rock